100% Design
Sub-Slab Depressurization System
Second-Phase Expansion – Building A
Lockheed Martin Middle River Complex
2323 Eastern Boulevard
Middle River, Maryland

Prepared for:

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

APPENDICES

LIST OF TABLES

ACRONYMS

µg/m^3	micrograms per cubic meter
%	percent
cis-1,2-DCE	*cis*-1,2-dichloroethene
CQCP	construction quality control plan
COMAR	Code of Maryland Regulations
ºF	degrees Fahrenheit
FMEA	failure mode and effects analysis
GAC	granular-activated carbon
HASP	health and safety plan
HVAC	heating, ventilation, and air conditioning
lbs/day	pounds per day
Lockheed Martin	Lockheed Martin Corporation
MDE	Maryland Department of the Environment
p/n	part number
OM&M	operation, maintenance, and monitoring
PVC	polyvinyl chloride
RTO	remedial technical operations
SCFM	standard cubic feet per minute
SSD	sub-slab depressurization
TCE	trichloroethene
Tetra Tech	Tetra Tech, Inc.
TO-15	Toxic Organic Method-15
USEPA	United States Environmental Protection Agency
VMP	vapor monitoring point
VOC	volatile organic compound
WC	water column
WMP	waste management plan

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Section 1
Introduction

Tetra Tech, Inc. (Tetra Tech) has prepared this 100% design on behalf of Lockheed Martin Corporation (Lockheed Martin) to describe the proposed second-phase expansion of the sub-slab depressurization (SSD) system currently operating in Building A of the Middle River Complex in Middle River, Maryland. The system has been operating since its installation in March 2008; it applies vacuum under the concrete floor in areas where elevated volatile organic compounds (VOCs) are found in the soil gas. The sub-slab vacuum draws volatile organic compounds from extraction points, and maintains a negative pressure below the slab (relative to the room space), thus minimizing the migration of chemicals from sub-slab soil into indoor air.

The system originally included two horizontal vapor extraction trenches (the "north" and "south" extraction laterals) in the former plating shop (i.e., the current "lay-up" room in the western side of the building). The system location is shown on Drawing G2 in Appendix A. Vapor monitoring points (VMPs) were installed, as were a regenerative blower, a moisture separator, two 200-pound granular-activated carbon (GAC) drums, and an exhaust stack that extends above the roof of the building. The system's "blowers skid" (blower, moisture separator, control panel, filters, and appurtenances), granular-activated carbon drums, and exhaust stack are on the loading dock just outside the lay-up room.

A first-phase system expansion completed in October 2010 addressed elevated sub-slab volatile organic compounds detected in the middle area of the Building A basement. During the first-phase expansion, two horizontal vapor extraction trenches (i.e., the "basement-north" and "basement-south" extraction laterals) were also installed, and the 200-pound granular-activated carbon drums were replaced with 400-pound drums. In addition, three stand-alone indoor-air filters (IQAir GC™ Series-GC VOC) were installed in January 2015 near vapor monitoring points 093-A and 138-A, and indoor air monitoring location 093-A-X in the Building A basement (south of the vapor

extraction trenches; refer to Drawing G2). The filters are continuously operated to address trichloroethene (TCE) concentrations possibly above its screening level in indoor air.

The proposed second-phase system expansion will include replacement of the existing blower skid, and installation of new extraction and vapor monitoring points to address areas along the eastern side of Building A (near VMPs 136-A, 079-A, and 117-A), where elevated concentrations of volatile organic compounds were detected in the sub-slab in 2014-2015. Design criteria for this second-phase expansion include performance and sizing requirements (e.g., radius of influence, vacuum, extraction-well diameter, vapor-flow rate, and pressure drop through the system).

This report is organized as follows:

Section 1—Introduction: Briefly describes the history of the existing sub-slab-depressurization system in Building A.

Section 2—Basis of Design: Presents the technical basis for the expansion design.

Section 3—100 Percent Design: Describes the components of the system expansion.

Section 4—Performance Monitoring: Describes the planned system startup, operation, monitoring, and proposed project schedule.

Section 5—References: Lists the references used in this design document.

Section 2
Basis of Design

The design objective for the second-phase expansion of the sub-slab depressurization (SSD) system is to mitigate potential vapor migration into the target areas of Building A by maintaining a negative pressure of at least 0.01 inches water column (WC) in the sub-slab at all times, regardless of heating, ventilation, and air conditioning (HVAC), or variation in barometric conditions. The target areas (basement and western and eastern areas of Building A) are shown on the design drawings in Appendix A. To achieve the system expansion objective, five[1] vertical, vapor-extraction points and eight vapor-monitoring points (VMPs) were installed the week of November 9, 2015, and the existing blower skid and its control panel will be replaced following approval of the 100% design.

The location of the new extraction points and VMPs are shown on Drawings G1 and G2 in Appendix A. These locations were selected based on the elevated sub-slab vapor sampling results detected at VMPs 136-A, 079-A, and 117-A during sub-slab vapor sampling events in 2014-2015 (discussed in the *Basis of Design Report* [Tetra Tech, 2015a]). The locations were reviewed with the facility on October 27, 2015, and cleared with a geophysical utility-investigation on November 3-4, 2015 (additional details are in Section 3). The radius of influence for induced vacuum at each new extraction point is expected to extend approximately 25 feet, based on current operation of the SSD system.

[1] Six points were originally planned, but one was abandoned because utilities in that area were so numerous that a safe, nearby offset location could not be selected.

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Section 3
100-Percent Design

The second-phase expansion for the sub-slab depressurization (SSD) system includes the following:

- Installing five vertical vapor extraction points (SSD-34-A through SSD-38-A) in the eastern target area of Building A (installed November 9-13, 2015)
- Installing eight vapor monitoring points (VMPs) (160-A through 167-A) near the new vapor extractions points (installed November 9-13, 2015)
- Installing an elevated six-inch diameter Schedule 40 polyvinyl chloride (PVC) header pipe that connects the new vapor extraction points to the SSD system
- Replacing the existing blower skid (at the same location) with a higher capacity blower unit that will accommodate the flow from ten soil-vapor extraction points (including the four existing horizontal trenches and five new vertical extraction points)
- Hard-wiring the three indoor-air filters in the Building A basement directly into the facility emergency power system

Drawings showing the new extraction points, VMPs, and proposed piping runs are in Appendix A. The design of each expansion component is discussed below.

3.1 VAPOR EXTRACTION POINTS

The proposed vapor-extraction point locations were reviewed with Bob Kuhn of Middle River Aircraft Systems (MRAS) during an on-site meeting on October 27, 2015. Enviroscan, Inc. subsequently cleared the agreed upon locations via a geophysical utility-investigation on November 3-4, 2015 (see the utility clearance report in Appendix B). Per Lockheed Martin Corporation and facility approval, Tetra Tech, Inc. (Tetra Tech) proceeded with the installation of the points. Five of six planned extraction points, SSD-34-A through SSD-38-A, were installed in the eastern target area of Building A on November 9-13, 2015. SSD-39-A was not installed because numerous utilities running behind the drywall in that area could not be traced. For this reason, a nearby off-set location could not be cleared with certainty. Drawing G2 in Appendix A shows the locations of the installed VMPs and extraction points.

Each new vertical extraction point was constructed using two-inch-diameter 0.020-inch slot Schedule 40 PVC pipe (screen), and two-inch diameter solid Schedule 40 PVC pipe (riser) in a six-inch diameter borehole. The screen extended from the bottom of the slab to a depth of 12 to 18 inches. The annular space was filled with clean pea gravel and a two-inch thick bentonite grout seal was placed above the screen and gravel to prevent short-circuiting (extracting indoor air).

The vapor extraction points were located as close to a wall or column as possible, so that cutting the concrete slab (other than for coring at the vapor extraction point) was avoided, and the extraction point and piping were placed outside normal traffic flow in the facility. The riser pipes from the new extraction points were brought above ground at the columns/walls shown on Drawing G2 in Appendix A, and were covered with a PVC cap until piping to the blower skid is installed. SSD-37--A and SSD-38-A, located in a driving aisle, were installed using a horizontal extension pipe connected at a 90-degree angle within the floor slab to keep the piping away from the driving aisle. The extension pipe, a solid, 1.5-inch diameter steel pipe, was installed approximately 3.5 inches below grade. A three-foot high, four-inch diameter steel pipe sleeve was placed on the riser pipe for SSD-35-A, and one two-inch diameter steel bollard was installed at SSD-34-A and SSD-36-A to prevent ground-level damage.

The concrete around each point was finished in a manner equal to or better than surrounding areas, as required by Lockheed Martin. The new extraction points and VMPs are in areas with no floor coverings. Extraction point and bollard details are on Drawing G2 in Appendix A.

3.2 PIPING

The riser pipes from the extraction points will be supported on the columns/walls shown on Drawing G2 (Appendix A) with pipe supports placed near valves, elbows, fittings, and joints. Each riser pipe will have a measuring point for sampling, flow, and vacuum monitoring, and a lockable diaphragm valve for throttling or shutting off flow. The pipe will be connected to an elevated, six-inch-diameter Schedule 40 PVC pipe installed overhead. Sub-slab soil vapor from the five new extraction points will be routed into the common header to the blower skid, where it will be joined with vapor from the four existing extraction trenches before heading to the moisture separator.

The six-inch-diameter header pipe will be run along wall and ceiling sections in the eastern area of Building A (see Drawing G2 in Appendix A), and will be tied-in to the existing SSD system before

the moisture separator. Specifically, the header pipe will run approximately 90 feet from the SSD system along the interior west wall of the loading dock to the loading dock bay door (near column D19A), through a window above the bay door, and then approximately 210 feet east along an interior wall to column B19A. From there, the header pipe will split and run (a) south along the wall (for approximately 160 feet) to column D25 near VMP 079-A, and (b) north, then east, along the ceiling (for approximately 245 feet) to column A14 near VMP 136-A. The header pipe will be installed at a height of 20-30 feet using wall brackets and pipe hangers placed next to existing support brackets used for steel piping in the ceiling. The six-inch diameter header is sized to allow total system flows up to 290 standard cubic per minute (SCFM)[2], with 25 SCFM average flow per vertical extraction point, and a combined 140 SCFM from the extraction trenches.

All header piping will be level, or sloped back toward the vapor extraction points or toward header-pipe condensate sumps, to prevent condensate accumulation in low points in pipe runs. Condensate sumps will be installed to remove liquid accumulated in any piping low points that cannot be avoided. All piping will also be labeled with green color "vacuum" self-sticking vinyl pipe markers. The header piping will be installed in high-traffic areas; therefore, exclusion zones of appropriate size will be set up to ensure that no one can enter the work zone. Alternative routes will be available for all blocked traffic areas. Header piping will be installed as quickly as possible, without jeopardizing employee and project safety, to avoid unnecessary disruption to facility operations.

Most of the planned pipe runs will be in areas that have been recently renovated, so the pipe runs can use existing racks and supports as coordinated with the facility. If pipe runs in the loading dock area may potentially disturb lead-based paint, the material will be contained, removed, and disposed of per all requirements. If pipe runs may potentially disturb asbestos-containing materials, the pipe will be rerouted, where possible, or work will stop and the facility will be contacted to coordinate abatement. We anticipate no new wall penetrations will be needed to complete the expansion.

[2] If needed, one additional extraction point could be added.

3.3 MODIFICATIONS TO EXISTING SSD SYSTEM

Required modifications to the main system are:

- replacing the current blower and moisture separator and installing a new blower skid with larger units and add a heat exchanger (mounted on the new skid) to reduce the temperature of the vapor stream from the blower prior to the vapor treatment units
- hard-wiring three indoor-air filters in the Building A basement directly into the facility's emergency power system

The current blower skid will be replaced with a skid that includes one AMETEK® Rotron® regenerative blower model DR909BB72W rated for 300 SCFM at 75 inches of water column (WC) suction. A new moisture separator (Gasho Model GX-100DL) will be provided with the new skid. The replaced blower skid will be returned to the supplier (Gasho, Inc.) for recycling. A heat exchanger (Xchanger, Inc. model AA-400) will be installed before the granular-activated-carbon (GAC) units to protect the GAC units and PVC pipe from potential temperatures higher than 140 degrees Fahrenheit (ºF). The heat exchanger is rated to reduce 250 SCFM of air from 200ºF to approximately 110ºF.

Other components on the new blower skid will be similar to those of the existing skid. A temperature switch (set at 215ºF) will be placed approximately 2-3 feet before the heat exchanger to protect the blower, and a second temperature switch (set at 140ºF) following the heat exchanger will protect the downstream GAC units and PVC pipe. These two temperature switches, Ashcroft part number T424-T050303, and a high-level switch, low-vacuum switch (Dwyer part number [p/n] 1950P-5-2F set at three inches WC vacuum), and high-pressure switch (Dwyer p/n 1950-P set at 55 inches WC), will be tied into the new control panel. All alarms will be normally closed, and will be programmed into a new eight-channel auto-dialer on the new equipment skid. Upon activation of any alarm, the auto-dialer will call the system operator and up to three backup personnel until the alarm is acknowledged. Technical information and specifications of key components of the skid are in Appendix C. Drawing G-3 shows the skid components and the process and instrumentation diagram for the expanded system.

Two existing vapor-phase GAC adsorbers (Vent-Scrub® VSC400) in series, capable of a maximum flow of 300 SCFM, will continue to treat the extracted vapors before discharge to the atmosphere.

The three IQAir® GC™ VOC indoor-air filters operating near indoor air monitoring point 093-A-X and VMPs 093-A and 138-A in the Building A basement will be hard-wired directly to the facility emergency power supply so that power outages will not shut them off. The approximate routing of the conduit from the filters to the emergency power supply is shown on Drawing G2 (Appendix A). The conduit will be field-run along existing pipe supports, where possible.

The technical specifications for the modifications and the corresponding equipment cut sheets are in Appendix C. Electrical requirements are described in the blower-skid control-panel drawings in Appendix C. The control panel and heat exchanger will be connected to power at the breaker box near the blower skid location. We will coordinate this work with the facility.

After the second-phase system expansion is completed, we anticipate a vapor flow rate of 265 SCFM, with average extraction rates of 35 SCFM each from the current vapor extraction trenches, and 25 SCFM from each of the new points. The target vapor-flow rate of 265 SCFM will produce minimal friction losses in both the individual extraction pipes and the header pipe. Friction loss was estimated at 0.011 inches WC per foot of pipe in the two-inch-diameter vapor-extraction trenches and points, and less than 0.003 inches WC in the six-inch-diameter header for the five new extraction points (combined). Under a worst-case scenario, we estimate that a vacuum-side filter loss of approximately 18-inches WC will result in total losses of approximately 28 inches WC. The pressure-side head loss is less than 37 inches WC. These are acceptable levels for system performance. Pressure loss calculations are in Appendix D.

3.4 VAPOR MONITORING POINTS

Eight of nine VMPs proposed were installed on November 9-13, 2015 using Cox-Colvin and Associates, Inc.'s stainless steel Vapor Pins™. VMP 168-A was not installed because extraction point SSD-39-A was not installed. Data from these new VMPs and existing VMPs will be used to monitor the induced vacuum near the new soil-vapor extraction points. The radius of influence for the induced vacuum at each new extraction point is expected to be about 25 feet, based on the operating parameters of the current SSD systems at the site (in Building A and Building C). Vapor-extraction-point flow rates will be adjusted to maximize vacuum influence within the target area, and to achieve the system-expansion design criteria, where possible. The concrete floor slab will be checked for short-circuiting at joints and perforations, and any pathways will be sealed.

VMPs that will be used to monitor the performance of the expanded system are listed in Table 3-1. Additional VMPs will be proposed and added as needed after the second-phase expansion to further define the area of induced vacuum. Monitoring will be discontinued at VMPs that are not useful for monitoring system performance; those VMPs will be left in place for future monitoring if needed.

3.5 ESTIMATED MASS EXTRACTION AND PERMITS

Volatile organic compound (VOC)[3] mass removal rates of approximately one-quarter pound per day are anticipated at expansion startup. Removal rates are expected to decrease to about 0.05 pounds per day or less after the first month of operation. These estimated removal rates are based on soil-vapor concentrations in existing SSD system influent and VMPs, and concentration decline rates observed during initial operation of the Building A and Building C SSD systems in 2008. The two existing 400-pound capacity GAC drums (lead and lag) will be used to adsorb VOCs in the discharge line of the system before the treated vapors are discharged to the atmosphere. We expect to switch-out the lead 400-pound GAC drum during the first two months of operation. GAC usage is expected to decrease to about one unit every nine months thereafter.

Sub–slab vapor samples will be collected for laboratory analysis of VOCs at each new vapor extraction point 24 hours after start-up of the expanded system. During the first month of operation, the system influent, mid-point and effluent will be sampled and analyzed every other week for VOCs; thereafter, these samples will be collected monthly. All sub–slab vapor samples will be submitted to TestAmerica in Knoxville, Tennessee for VOC analysis by United States Environmental Protection Agency (USEPA) Toxic Organic Method 15 (TO-15).

Table 3-2 lists the estimated initial mass extraction rates (in pounds per day) for the expanded system, based on current system influent concentrations and sampling results at VMPs 079-A, 117-A, and 136-A (discussed in Section 2.2). Even without GAC treatment, the estimated mass-extraction rates (91.25 pounds of VOCs per year) are below the Title 5 emission level (25 tons VOCs per year) regulated by Maryland Department of the Environment (MDE), and found in Code of Maryland Regulations (COMAR) 26.11.02.01C. Telephone communication with the MDE Air Quality Permits Section in November 2007 (at system startup) indicated that no air permit would be

[3] mainly trichloroethene (TCE) and cis-1,2-dichloroethene (cis-1,2-DCE)

required for the emission rates associated with the SSD system. An e-mail communication on September 22, 2015 from Mr. Nolan Penney of the MDE Air Quality Permits Section (Appendix E) reconfirmed that no permit would be needed, and that extraction rates less than one pound per day qualify for the *de minimus* exemption under COMAR 26.11.02.10X. Therefore, no air permit is required for the second-phase expansion of the SSD system (MDE, 2015). We will provide the Middle River facility with total annual emission volumes for their reporting requirements. Based on discussions with the facility during previous SSD system installations, no building or other permits are required for the proposed second-phase system expansion.

3.6 FAILURE-MODE AND EFFECTS ANALYSIS

Tetra Tech, Lockheed Martin, and its remedial technical operations (RTO) contractor conducted a failure mode and effects analysis (FMEA) on December 8, 2015 via a virtual (online) meeting. The purpose of the FMEA is to examine work for single or multiple point failures that could cause a release of untreated soil vapors to the environment or cause damage to the SSD system. The results of the FMEA have been incorporated into the design document and include adding (normally closed) circuits in the control panel for the new blower skid, and updating the system's operation, maintenance, and monitoring (OM&M) manual (Tetra Tech, 2015b). FMEA documentation is in Appendix F.

3.7 PROPOSED CONSTRUCTION SCHEDULE AND WORK PLANS

Construction work plans have been prepared by Tetra Tech to guide the construction work and include a construction quality control plan (CQCP) (Tetra Tech, 2016a), a site and temporary facilities plan (Tetra Tech, 2016b), and a project-specific health and safety plan (HASP) (Tetra Tech, 2016c) that includes an Emergency Response Plan. A waste management plan (WMP) was not prepared for the second-phase system expansion work as the wastes can be managed in accordance with the facility's current investigation–derived WMP (Tetra Tech, 2015c).The CQCP presents the approach for confirming that the system is installed consistent with the design intent. The site and temporary facilities plan details the temporary facilities required to advance work and the best management practices that will be used to limit impact to Building A tenants and operations. The HASP includes procedures used to protect workers and the public from potential hazards during construction and system OM&M. The emergency response plan, included in the HASP, outlines

emergency procedures. The system's OM&M manual has been updated to include the new extraction points, VMPs, and new equipment skid. The work plans and updated OM&M manual are available under separate cover.

The preliminary construction schedule for construction of the system expansion is in Appendix G, and is based on approval of the 100% design documents on or before February 2016.

Table 3-1

New Vapor Extraction Points and Associated Monitoring Points
Building A SSD System Second-Phase Expansion
Lockheed Martin Middle River Complex, Middle River, Maryland

New vapor extraction point	Associated monitoring points
SSD-34-A	136-A-S, 163-A
SSD-35-A	136-A,136-A-N, 160-A, 161-A
SSD-36-A	162-A, 121-B
SSD-37-A	117-A, 164-A, 165-A
SSD-38-A	166-A, 079-A, 119-A, 167-A

Table 3-2

Estimated Mass Extraction Rates
Building A SSD System Second-Phase Expansion
Lockheed Martin Middle River Complex, Middle River, Maryland

Vapor extraction point	Estimated average flow (SCFM)	Estimated VOC concentration (µg/m^3)	Estimated initial^ mass extraction (lbs/day)
Existing horizontal extraction trenches/laterals			
North (former plating shop)	140 combined	1183[a]	0.015
South (former plating shop)			
Basement-north			
Basement-south			
Proposed vertical extraction points			
SSD-34-A	25	32123 [b]	0.072
SSD-35-A	25	32123 [b]	0.072
SSD-36-A	25	32123 [b]	0.072
SSD-37-A	25	303 [c]	0.001
SSD-38-A	25	3873 [d]	0.009

^VOC concentrations at proposed vapor extraction points are expected to decrease up to 90% during the first month of operation
lbs/day – pounds per day
µg/m^3 – micrograms per cubic meter
SCFM – standard cubic feet per minute
SSD – sub-slab depressurization
VOC – volatile organic compounds

Mass Extraction (lbs/day) = µg/L x L/min x 1,440 min/day x 1 lb/4.54 x 10^{-6} µg
[a] Based on total VOC influent SSD system concentrations in August 2015
[b] Based on total VOC sub-slab vapor concentrations at vapor monitoring point (VMP) 136-A in February 2015
[c] Based on total VOC sub-slab vapor concentrations from VMP 117-A in February 2014
[d] Based on total VOC sub-slab vapor concentrations from VMP 079-A in February 2015

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Section 4
Performance Monitoring

4.1 SYSTEM STARTUP AND OPERATION

After the second-phase system expansion is installed, the system will be rebalanced by taking vacuum and flow rate measurements from each extraction point and induced vacuum monitoring point, and adjusting the diaphragm throttling valves, to pull about 35 standard cubic feet per minute (SCFM) from each of the current vapor extraction trenches, and 25 SCFM from each of the new points. To rebalance the system, each individual extraction point will initially be run alone to establish its vacuum-flow relationship. The vacuum applied at each extraction point will vary considerably to achieve the target flow rates. A wellhead vacuum may be as high as 40 inches of water column (WC) for some extraction points, while others may be less than 20 inches water column. Multiple iterations are needed before the entire well set is balanced and the system is functional.

Once the extraction points are set to pull the target flows (or as close as possible), the system vacuum and flows will be adjusted to achieve the design criterion of a vacuum of 0.01 inches water column or greater at each vapor monitoring point within the radius of influence, when possible. A photoionization detector will be used to check for volatile organic compounds (VOC) at each extraction point during startup, and one sample from each point (collected 24 hours after startup) will be submitted for laboratory analysis. Moisture accumulation will also be monitored during startup.

System checks will occur weekly during the first month of operation, and every two weeks thereafter. System checks will include applied vacuum and flow rate at each extraction point, and induced vacuum at vapor monitoring points (VMPs). Maintenance will be conducted per manufacturer recommendations. System vapor samples (influent, midpoint, and effluent) will be collected and analyzed every two weeks for volatile organic compounds during the first month of operation; thereafter, these samples will be collected monthly. All sub–slab vapor samples will be

submitted to TestAmerica in Knoxville, Tennessee for analysis of currently agreed list of target compounds by United States Environmental Protection Agency (USEPA) Toxic Organic Method 15 (TO-15). The resulting data will be used to determine mass removal trends, and to verify that breakthrough of the granular activated-carbon units has not occurred. Typically, a sub-slab depressurization (SSD) system removes relatively high levels of VOC mass in the initial few days of operation, followed by a substantial drop in mass removal rates thereafter.

4.2 SYSTEM MONITORING

System checks after the first month of operation will be completed by following these steps:

- Measure and record the vacuum and air velocity from each extraction point using a manometer and velocity meter, respectively, and adjust as needed.
- Replace the lead granular activated-carbon unit when 50% or higher breakthrough is observed in the midpoint air sample, or at Tetra Tech's discretion (with concurrence from Lockheed Martin Corporation), to minimize total volatile organic compound discharge and minimize carbon usage. Install lag units as lead units, and install new canisters in the lag position.
- Record effluent blower temperature and pressure.
- Check induced vacuum at vapor monitoring points.
- Empty condensate in moisture separator and sumps into properly labeled transportable drums, as needed.
- Check vacuum gauges, pressure gages, piping, and fittings for leaks and signs of heat stress.

The system checklist used to document system monitoring is provided under separate cover in the updated operation, maintenance, and monitoring (OM&M) manual.

4.3 INDUCED VACUUM MONITORING

During startup of the new extraction points, induced vacuum will be monitored at nearby vapor monitoring points by collecting single, instantaneous readings with a manometer. Weekly monitoring of induced vacuum (single readings) will be conducted for the first month of operation, and monitoring frequency will decrease to every two weeks thereafter. Table 4-1 lists the points that will be monitored; their locations are shown on Drawing G2 in Appendix A. Monitoring in the lay-up room (former plating shop in western area of Building A) will continue at SSD-1-A, SSD-12-A-X, SSD-11-A-X, SSD-13-A-X, SSD-2-A-X, SSD-16-A-X, 015-A-X, and SSD-3-A-X.

Monitoring in the basement target area will continue at SSD-19-A, SSD-20-A, SSD-21-A, and SSD-22-A. Existing or new points will be proposed and added as needed to define the induced vacuum in target areas. Extraction-point flow rates will be adjusted to maximize vacuum influence within the target area, and to achieve the design criteria, if possible. The slab will be checked for short-circuiting at joints and perforations by listening/feeling for air flow through any cracks in slab while the system is running; any short-circuiting pathways will be sealed.

Table 4-1

Induced Vacuum Monitoring Locations
Building A SSD System Second-Phase Expansion
Lockheed Martin Middle River Complex, Middle River, Maryland

Vapor extraction point	Associated induced vacuum vapor-monitoring points*
Eastern Target Area Vertical Extraction Points*	
SSD-34-A	136-A-S163-A
SSD-35-A	136-A-N 136-A 160-A 161-A
SSD-36-A	162-A 121-B
SSD-37-A	117-A 164-A 165-A
SSD-38-A	079-A 166-A 119-A 167-A
Western Target Area Extraction Trenches/Laterals	
North (lay-up room [former plating shop]) South (lay-up room [former plating shop])	SSD-1-A SSD-12-A-X SSD-11-A-X SSD-13-A-X SSD-2-A-X SSD-16-A-X 015-A-X SSD-3-A-X
Basement Extraction Trenches/Laterals	
Basement-north Basement-south	SSD-19-A SSD-20-A SSD-21-A SSD-22-A

* Proposed for the second-phase expansion and installed in November 2015.
SSD– sub-slab depressurization

Section 5
References

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2. Maryland Department of the Environment (MDE), 2015. Email communication between Mr. Nolan Penney (MDE Air Quality Permits Section) and Ms. B. Chang Lee (Tetra Tech) regarding permit exemption based on anticipated mass extraction rates. September 22, 2015.

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4. Pace Analytical Services (Pace), 2015a. *Report of Laboratory Analysis, Pace Project No. 10297484*. March 10.

5. Pace Analytical Services (Pace), 2015b. *Report of Laboratory Analysis, Pace Project No. 10297491*. March 10.

6. Tetra Tech, Inc. (Tetra Tech), 2015a. *Basis-of-Design Report Sub-slab Depressurization-System Second-Phase Expansion—Building A, Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland*. October 21.

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8. Tetra Tech, Inc. (Tetra Tech), 2015c. *Investigation-Derived Waste Management Plan, Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland*. May.

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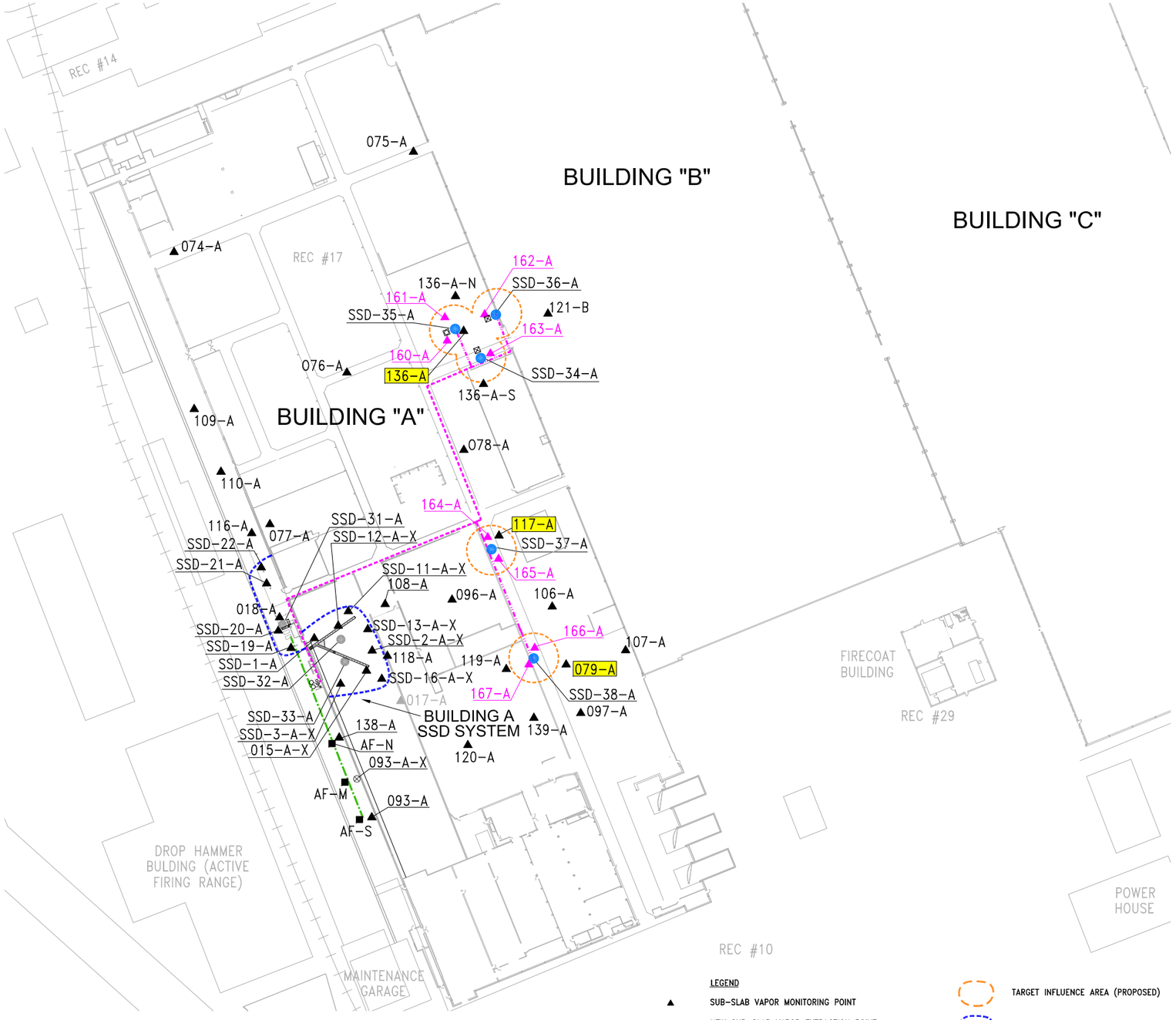
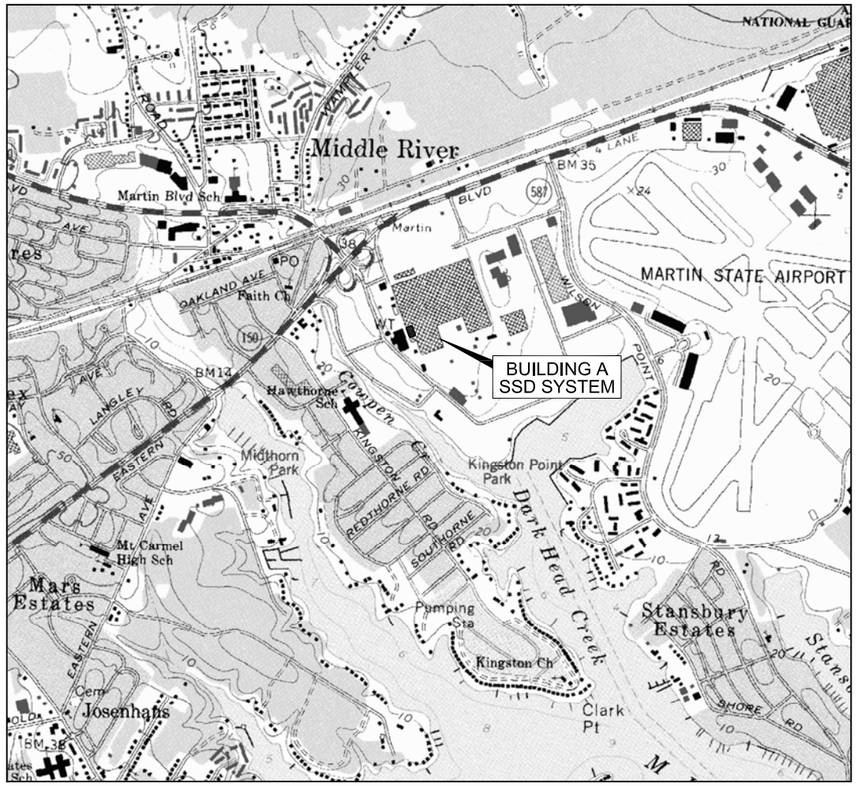
APPENDIX A—DESIGN DRAWINGS





SITE LOCATION MAP

LEGEND

- SUB-SLAB VAPOR MONITORING POINT
- NEW SUB-SLAB VAPOR EXTRACTION POINT
- SUB-SLAB VAPOR EXTRACTION POINT (USED IN PREVIOUS PILOT TEST)
- INDOOR AIR SAMPLING POINT
- NEW SUB-SLAB VAPOR MONITORING POINT
- SSD — SUB-SLAB DEPRESSURIZATION
- PROPOSED EXTRACTION POINT PIPING (2" DIA. SCH 40)
- PROPOSED HEADER PIPE (6" DIA. SCH 40)
- INDOOR AIR FILTER CONNECTION TO EMERGENCY POWER SUPPLY (FIELD RUN)
- TARGET INFLUENCE AREA (PROPOSED)
- APPROXIMATE EXISTING INFLUENCE AREA
- INDOOR AIR FILTER
- EXISTING SSD BLOWER SKID
- EXISTING SUB-SLAB VAPOR EXTRACTION LATERAL
- 079-A — SUB-SLAB VAPOR SAMPLING POINT
- STEEL PIPE SLEEVE (4" DIA.)
- PIPE BOLLARD (2" DIA.)

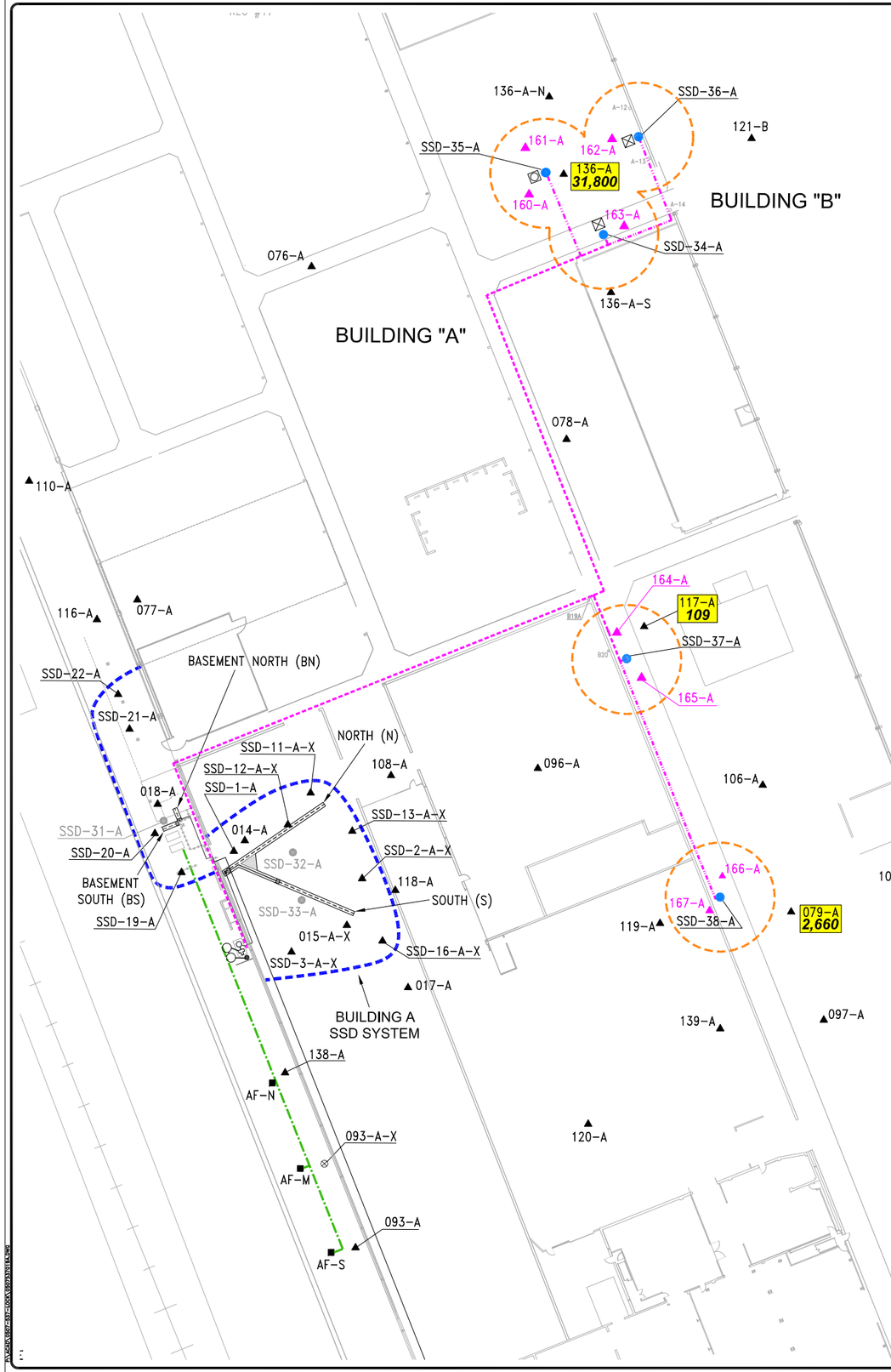
APPROVED BY:	DATE	REVISION	APRVD.

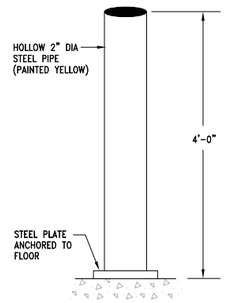
TITLE: **PLAN OVERVIEW**
100% DESIGN
SSD SYSTEM SECOND-PHASE EXPANSION - BUILDING A

LOCATION: **LMC Middle River Complex**
Middle River, Maryland

TETRA TECH

APPROVED	PAR	DRAWING:
DRAFTED	CMP	G1
PROJECT#	117-0512124	
DATE	2-22-16	





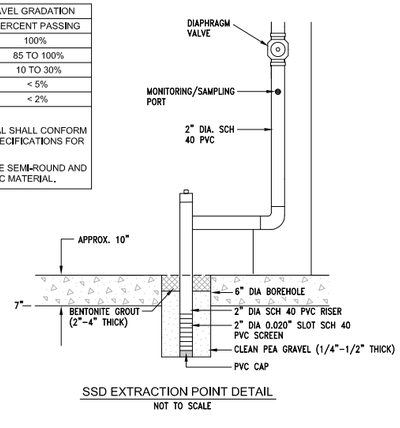
PIPE BOLLARD DETAIL
NOT TO SCALE

WASHED PEA GRAVEL GRADATION	
SIEVE SIZE	PERCENT PASSING
1/2"	100%
3/8"	85 TO 100%
#4 (4.75MM)	10 TO 30%
#8 (2.36MM)	< 5%
#20 (0.85MM)	< 2%

NOTES:

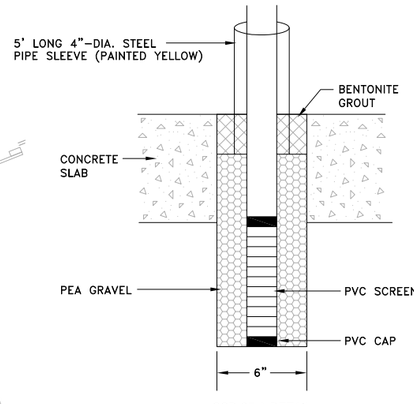
A. GRAVEL MATERIAL SHALL CONFORM TO ASTM C-33 SPECIFICATIONS FOR 3/8" AGGREGATE.

B. GRAVEL SHALL BE SEMI-ROUND AND FREE OF ORGANIC MATERIAL.

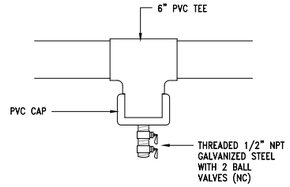


SSD EXTRACTION POINT DETAIL
NOT TO SCALE

NOTE: EXTRACTION POINT PIPING SUPPORTED ON WALL OR COLUMN WITH PIPE SUPPORTS.

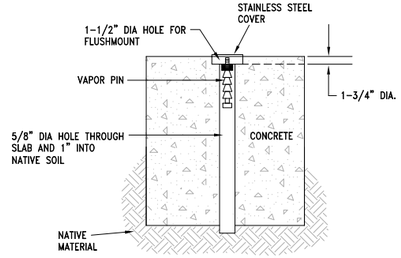


SSD-35-A DETAIL
NOT TO SCALE

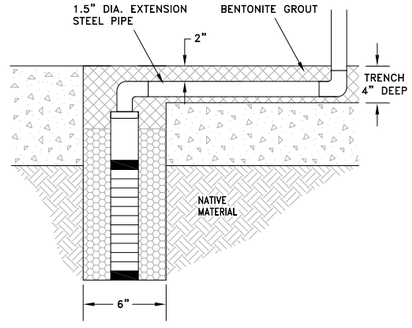


NOTE: INSTALL AT PIPING LOW POINT AS NEEDED. SUMP DEPTH KEPT TO A MINIMUM DUE TO FACILITY HEIGHT CLEARANCE REQUIREMENTS.

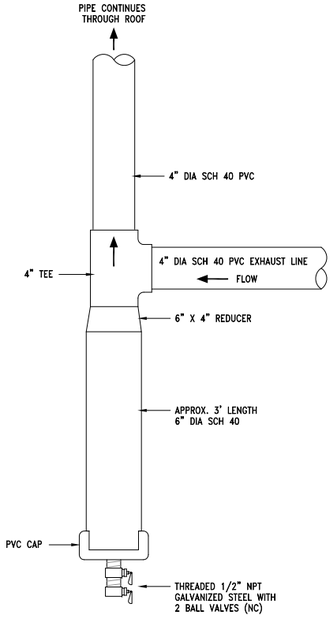
PIPE SUMP DETAIL
NOT TO SCALE



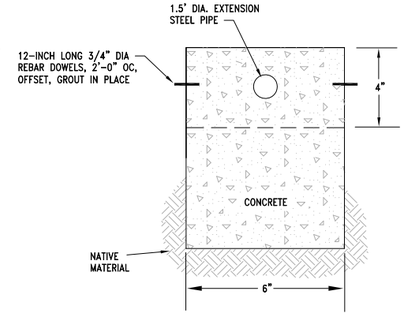
VAPOR MONITORING POINT DETAIL
NOT TO SCALE



SSD EXTRACTION POINT WITH EXTENSION PIPE DETAIL
(SSD-37-A AND SSD-38-A ONLY)
NOT TO SCALE



EXHAUST STACK SUMP DETAIL
NOT TO SCALE



EXTENSION PIPE TRENCH DETAIL
NOT TO SCALE

LEGEND

- ▲ SUB-SLAB VAPOR MONITORING POINT
- ● NEW PROPOSED SUB-SLAB VAPOR EXTRACTION POINT
- ● SUB-SLAB VAPOR EXTRACTION POINT (USED IN PREVIOUS PILOT TEST)
- ⊗ INDOOR AIR SAMPLING POINT
- ▲ NEW PROPOSED SUB-SLAB VAPOR MONITORING POINT
- 2,660 TCE CONCENTRATION ($\mu g/m^3$) SUB-SLAB SAMPLING FROM FEBRUARY 2015
- SSD SUB-SLAB DEPRESSURIZATION
- PROPOSED EXTRACTION POINT PIPING (2" DIA. SCH 40)
- PROPOSED HEADER PIPE (6" DIA. SCH 40)
- INDOOR AIR FILTER CONNECTION TO EMERGENCY POWER SUPPLY (FIELD RUN)
- TARGET INFLUENCE AREA (PROPOSED)
- APPROXIMATE EXISTING INFLUENCE AREA
- ■ INDOOR AIR FILTER
- EXISTING SSD BLOWER SKID
- EXISTING SUB-SLAB VAPOR EXTRACTION LATERAL
- 079-A SUB-SLAB VAPOR SAMPLING POINT
- ⊡ STEEL PIPE SLEEVE (4" DIA.)
- ⊠ PIPE BOLLARD (2" DIA.)

NOTE:
PIPE HANGERS PLACED NEXT TO EXISTING SUPPORT BRACKETS FOR STEEL PIPING IN CEILING APPROX. 6-12 FT APART.

N

0 30 60 90
SCALE IN FEET

APPROVED BY:

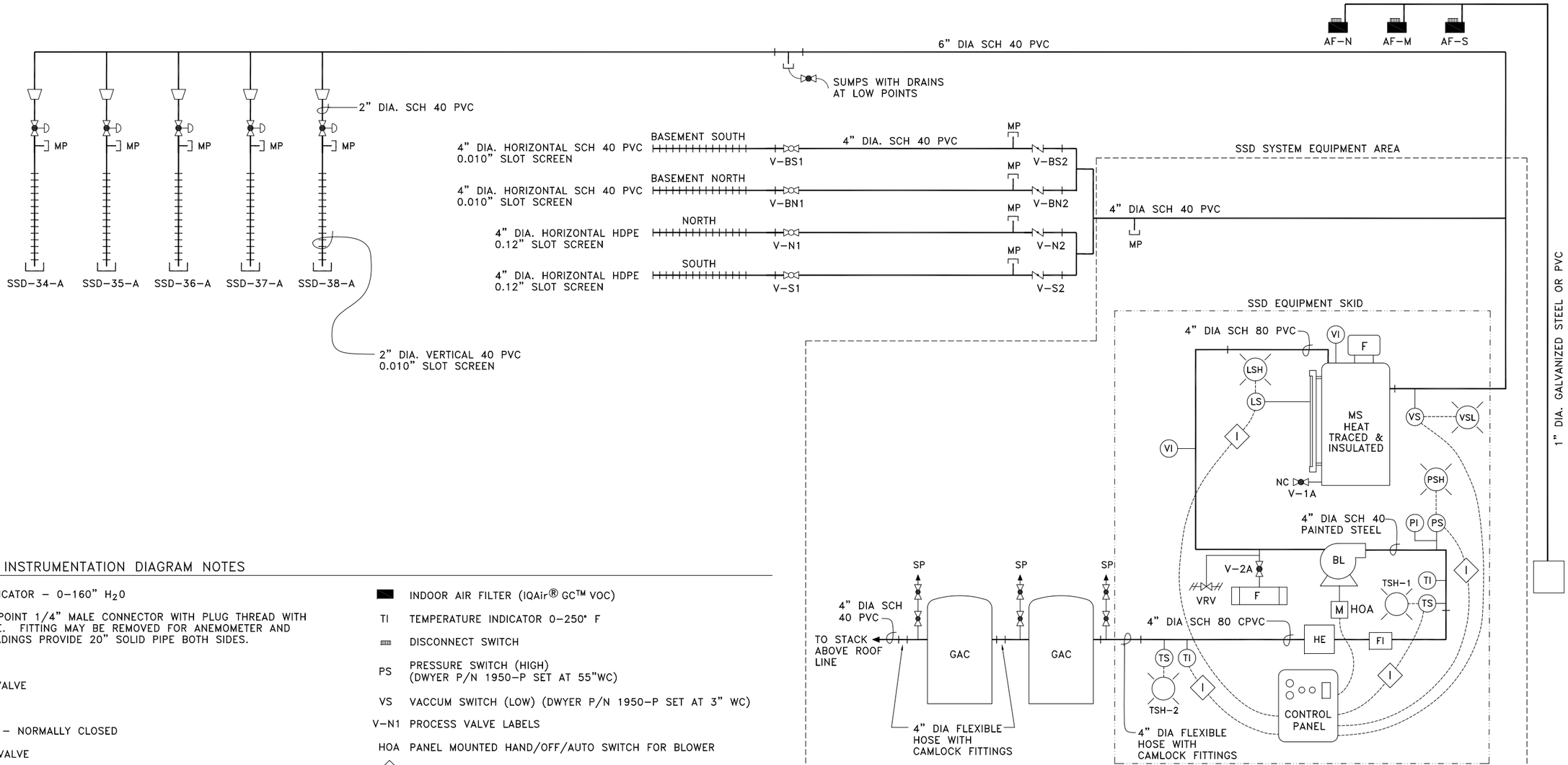
DATE	REVISION	APRVD.

TITLE:
PIPING LAYOUT AND DETAILS
100% DESIGN
SSD SYSTEM SECOND PHASE EXPANSION - BUILDING A

LOCATION: LMC Middle River Complex
Middle River, Maryland

TETRA TECH

APPROVED	PAR	DRAWING:
DRAFTED	CMP	G2
PROJECT#	117-0512124	
DATE	2-22-16	



PROCESS AND INSTRUMENTATION DIAGRAM NOTES

- VI — VACUUM INDICATOR – 0–160" H_2O
- MP — MEASURING POINT 1/4" MALE CONNECTOR WITH PLUG THREAD WITH TEFLON TAPE. FITTING MAY BE REMOVED FOR ANEMOMETER AND VACUUM READINGS PROVIDE 20" SOLID PIPE BOTH SIDES.
- REDUCER
- BUTTERFLY VALVE
- BALL VALVE
- BALL VALVE – NORMALLY CLOSED
- DIAPHRAGM VALVE
- FI — FLOW INDICATOR (DIRECT 70–350 SCFM READING)
- F — INLET AIR FILTER
- HE — HEAT EXCHANGER (XCHANGER AA–400)
- MS — MOISTURE SEPARATOR (GASHO GX–100DL) WITH 40 GALLON CAPACITY, SLIGHT TUBE, REMOVABLE TOP, DRAIN VALVE
- LS — LEVEL SWITCH
- VRV — VACUUM RELIEF VALVE – 2" (SET AT 100" WC)
- SP — SAMPLE PORT 1/4" DIAMETER
- BL — AMETEK®, ROTRON® 909BB72W 10 HP MOTOR, 300 SCFM @ 75" H_2O
- PI — PRESSURE INDICATOR 0–160" H_2O
- TS — TEMPERATURE SWITCH (ASHCRAFT P/N T424–T050303; TSH–1 SET AT 215° F AND TSH–2 SET AT 140° F)
- GAC — GRANULAR ACTIVATED CARBON VAPOR TREATMENT (SIEMENS VENT SCRUB® VSC400, VOCARB® 48C)
- INDOOR AIR FILTER (IQAir® GC™ VOC)
- TI — TEMPERATURE INDICATOR 0–250° F
- DISCONNECT SWITCH
- PS — PRESSURE SWITCH (HIGH) (DWYER P/N 1950–P SET AT 55"WC)
- VS — VACCUM SWITCH (LOW) (DWYER P/N 1950–P SET AT 3" WC)
- V–N1 — PROCESS VALVE LABELS
- HOA — PANEL MOUNTED HAND/OFF/AUTO SWITCH FOR BLOWER
- I — INTERLOCK BLOWER SHUTDOWN
- LOCALLY MOUNTED INSTRUMENT
- PANEL ALARM LIGHT
- H — HIGH
- L — LOW
- SSD — SUB–SLAB DEPRESSUIZATION
- M — MOTOR

APPROVED BY:	DATE	REVISION	APRVD.

TITLE: **PROCESS & INSTRUMENTATION DIAGRAM**
100% DESIGN
SSD SYSTEM SECOND PHASE EXPANSION - BUILDING A

LOCATION: **LMC Middle River Complex**
MIddle RIver, Maryland

TETRA TECH

APPROVED	PAR
DRAFTED	CMP
PROJECT#	117–0512124
DATE	2–22–16

DRAWING: G3

APPENDIX B— GEOPHYSICAL UTILITY-INVESTIGATION REPORT

November 17, 2015

Ms. Dawn Monico
Tetra Tech, Inc.
51 Franklin Street
Suite 400
Annapolis, MD 21401

RE: Geophysical Survey
Utility Clearance – Middle River Complex
15 Borings in Building A
Middle River, MD
Enviroscan Reference Number 111520

Dear Ms. Monico:

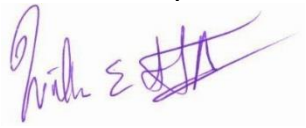
On November 2 and 4, 2015, Enviroscan, Inc. visited the above-referenced site with the purpose of locating underground metallic and non-metallic utilities adjacent to 15 proposed penetrations in a concrete floor. The floor penetrations, for the installation of vapor monitoring points, were located in Building A.

The above-referenced site was scanned with a Radiodetection C.A.T.^{3} and GSSI Utility Scan DF ground penetrating radar (GPR) system. Potential utilities were marked on the floor surface with adhesive tape.

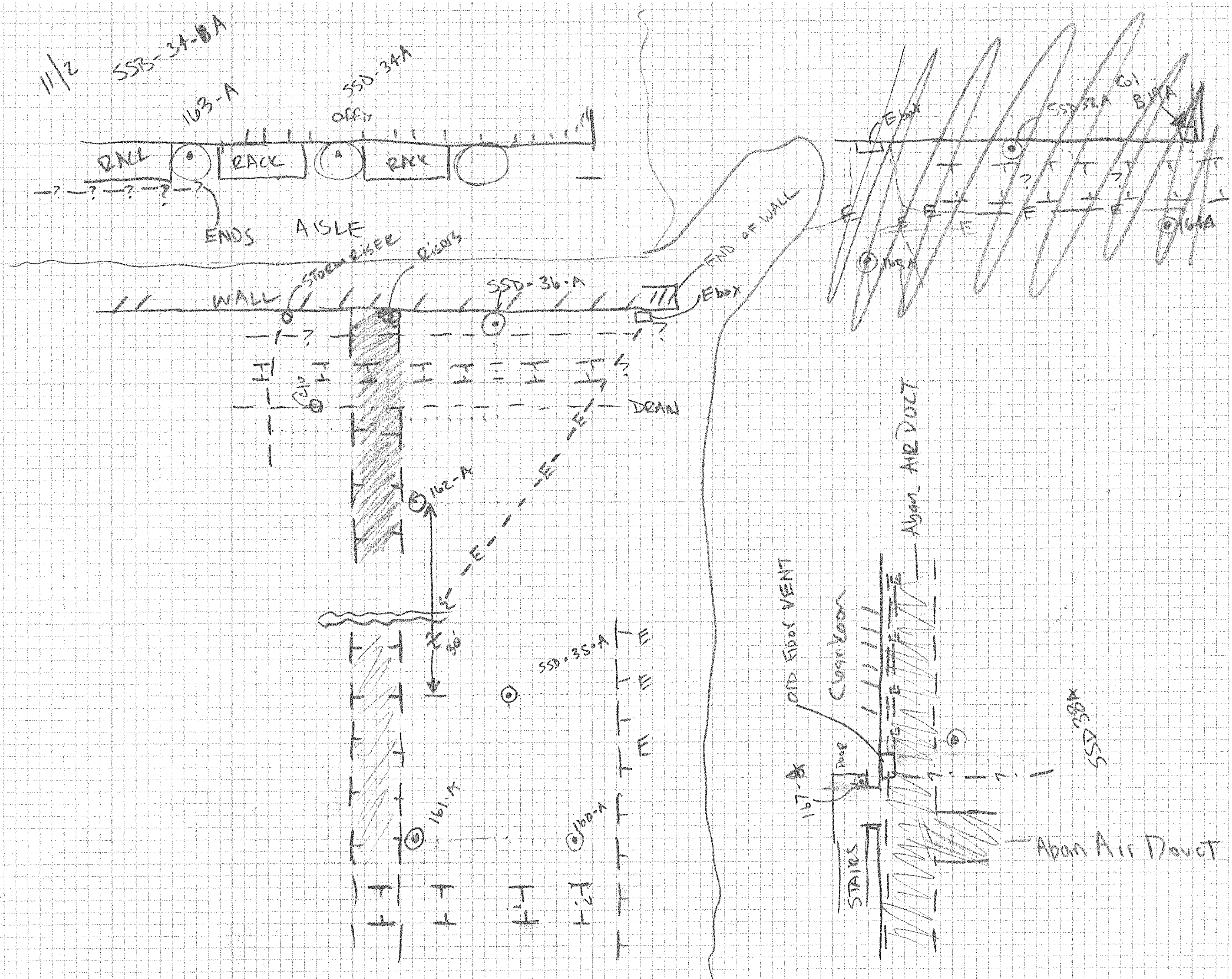
The above-referenced geophysical survey was completed using standard and/or routinely accepted practices of the geophysical industry and equipment representing the best available technology. Enviroscan does not accept responsibility for survey limitations due to inherent technological limitations or unforeseen site-specific conditions. However, we make every effort to identify and notify the client of such limitations or conditions. In addition, please note that the completion of this survey does not relieve any party of applicable legal obligations to notify the appropriate One-Call center prior to digging or drilling.

As always, we appreciate this opportunity to have worked with you again. If you have any questions, please do not hesitate to contact me.

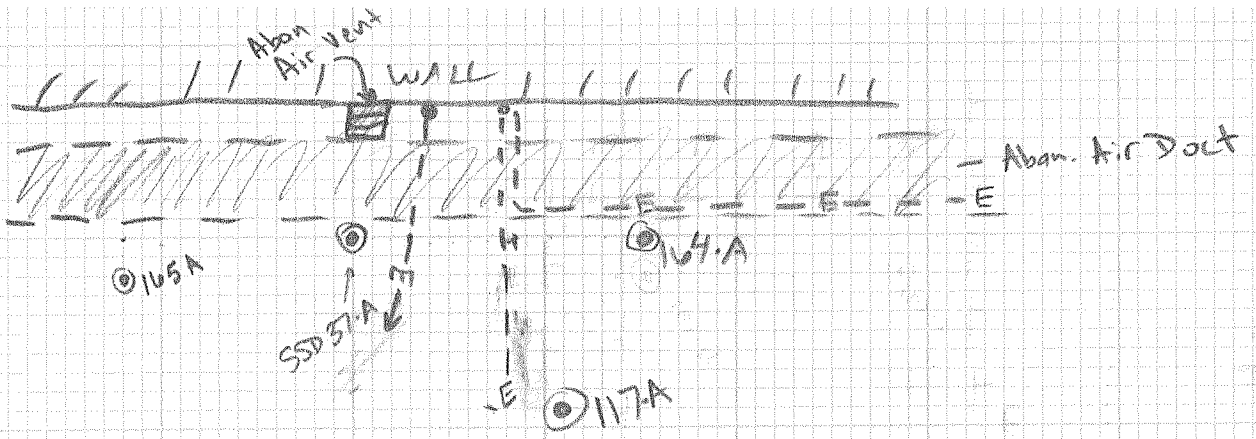
Sincerely,
Enviroscan, Inc.



William E. Steinhart III, M.Sc., P.G.
Senior Geophysics Project Manager



11/2
SSB-34-BA
163-A
SSD-34A
Offic
RACK
RACK
RACK
ENDS
AISLE
WALL
Storm riser
Risers
SSD-36-A
END of WALL
Ebox
DRAIN
162-A
30'
SSD-35-A
161-A
160-A
SSD 38A
165A
164A
Old Floor VENT
Cloakroom
Door
167-B
STAIRS
Aban Air Duct
Aban. Air Duct


Aban Air vent
WALL
Aban. Air Duct
165A
SSD37.A
117.A
164.A

APPENDIX C— EQUIPMENT LIST, CUT SHEETS, AND TECHNICAL SPECIFICATIONS

EQUIPMENT LIST

1. Cox-Colvin and Associates, Inc.'s stainless steel Vapor Pins™

2. New Blower and Equipment Skid with the following major components:
    a. Blower: AMETEK® Rotron® model R909BB72W, 10 horsepower, 340 standard cubic feet per minute (SCFM) at 75 inches water column (WC) suction, and the following associated fittings and valves:
        i. 3-inch diameter Solberg inline filter
        ii. 3-inch diameter universal dilution valve
        iii. 2½-inch diameter Apollo butterfly valve
        iv. 2-inch diameter Fisher vacuum relief valve
    b. Heat exchanger: Xchanger, Inc. model AA-400
    c. Moisture separator: Gasho, Inc. model GX-100DL with level switch
    d. Flow meter: AMETEK® Rotron® model 550606
    e. Control Panel: 460V, 3-phase, with NEMA 4 enclosure
    f. Auto-dialer (8-channel): Sensaphone® 800 Monitoring System, part number FGD-0800

3. PVC piping:
    a. 300 feet, Schedule 40, 2-inch diameter
    b. 700 feet, Schedule 40, 6-inch diameter
    c. Couplings, elbows, tees, caps, reducers
    d. Saddle fittings, Schedule 40, 6-inch diameter

4. Diaphragm valves: 2-inch diameter construction PVC, 150 pounds per square inch (PSI) rating
5. Primer: PVC primer
6. Cement: heavy bodied universal cement

<u>Equipment Cut Sheets or Details Included for Reference Only</u>

1. Assembly details for granular activated-carbon units (existing)

The Vapor Pin™ has a variety of applications, including but not limited to:

Sub-slab soil gas sampling, de-pressurization studies/testing, stray gas evaluations, source area characterization and mitigation progress monitoring.

CONTRACTOR KIT SHOP PRODUCTS

In Australia, orders may be placed with

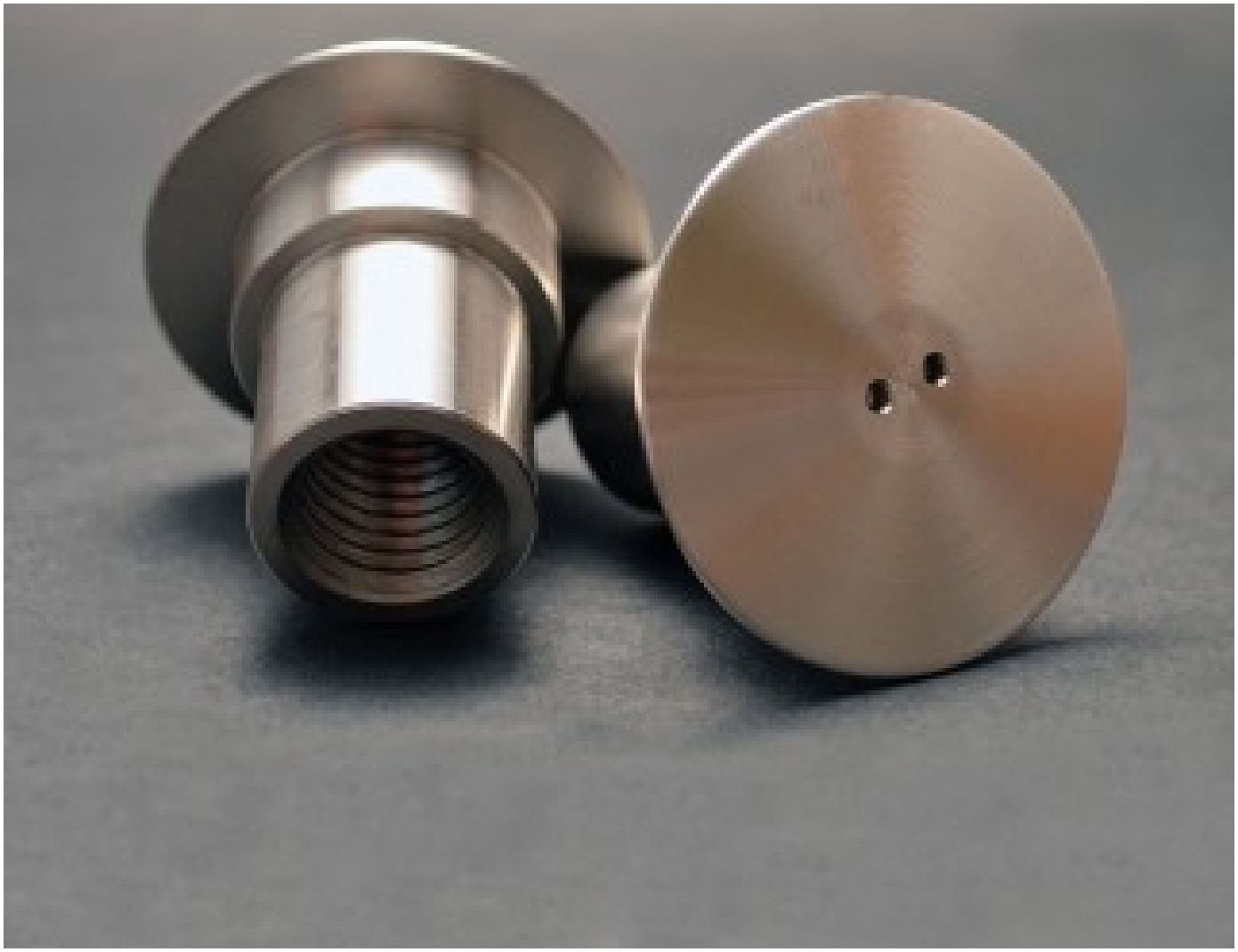
ERR Environmental Remediation Resources

Stainless Steel Vapor Pin® VPIN0522SS

★★★★★

Vapor Pin® Extension 1.5″

Stainless Steel Secured Cover



Cox-Colvin & Associates, Inc. has developed the Vapor Pin®, a unique, patented, re-usable sub-slab soil-gas sampling device. Traditional sub-slab soil-gas sampling methods are time consuming, expensive, and prone to leaks. Cox-Colvin designed the Vapor Pin® specifically to eliminate many of the problems associated with traditional sub-slab soil gas sampling methods. Advantages of the Vapor Pin®over traditional methods include:

- unique patented design reduces the potential for leaks during sample collection, improving sample quality;
- built-in disposable seal eliminates the need for grout, increasing productivity;
- connects easily to sampling equipment;
- easily installed, sampled, and retrieved for reuse;
- reduces damage to the slab;
- improves diagnostic testing;
- improves spatial resolution;
- reduces sampling time allowing collection of more samples for less cost, and thus provides a better understanding of site conditions.

The patented design of the Vapor Pin®provides environmental professionals a means of collecting high-quality, low-cost soil gas samples within minutes. Plus, the Vapor Pin® is made in the USA. Protected under US Patent # 8,220,347 B2

Products

ALL PRODUCTS
VAPOR PIN™ KITS
INDIVIDUAL PARTS
SECURED COVERS
TUBING
MISCELLANEOUS
SHOPPING CART
CHECKOUT

Contractor Vapor Pin® Kit

$765.00–$865.00

Material Choose an option

SKU: N/A

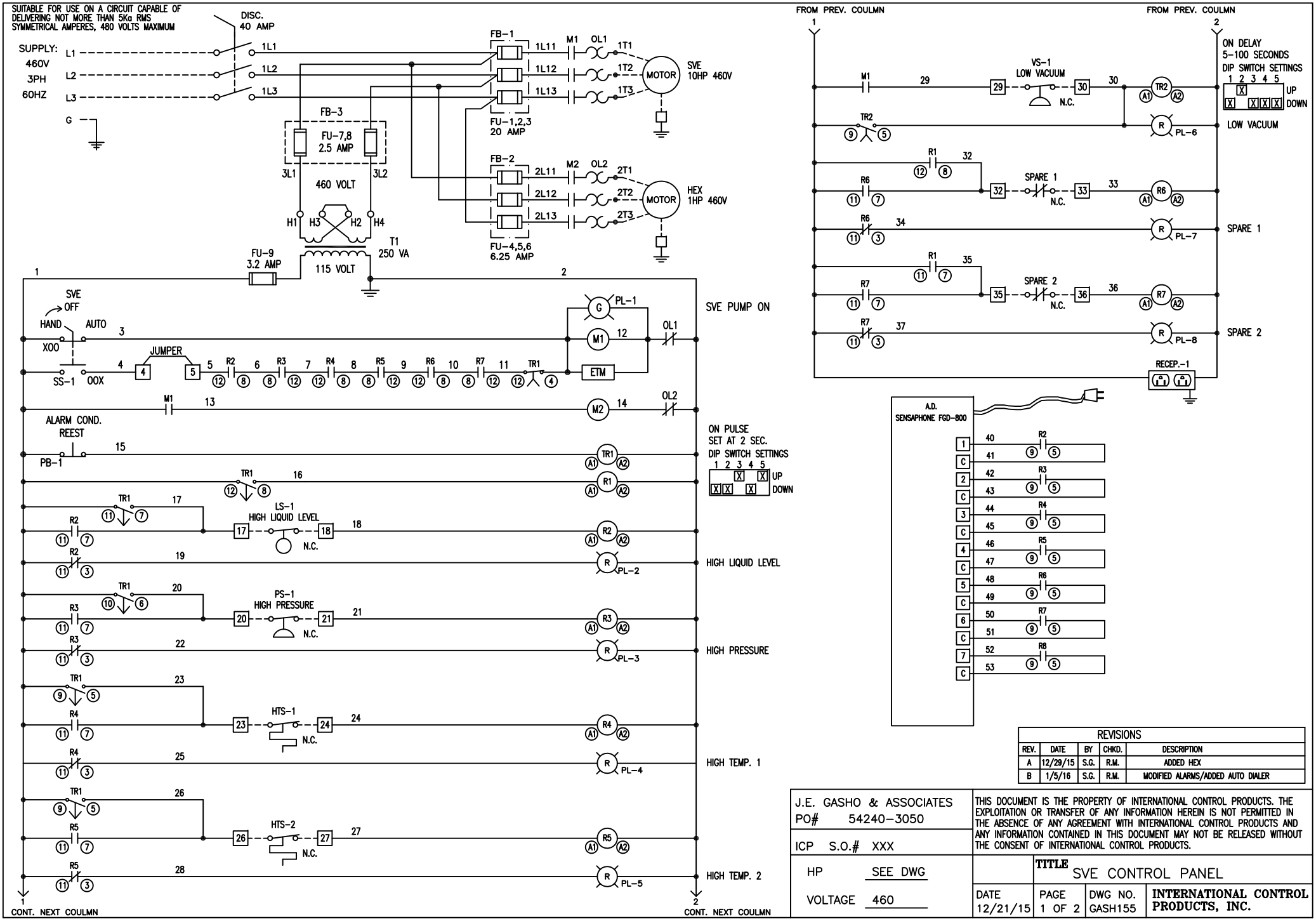
Category: Vapor Pin™ Kits

Tags: Brass, Stainless Steel

Description | Additional Information | Reviews (0)

Product Description

10 Vapor Pins™ (Brass or Stainless Steel);
20 Vapor Pin™ Sleeves;
20 Vapor Pin™ Caps;
10 Secure Flush Mount Covers;
1 Spanner Screwdriver;
1 Stainless Steel Drilling Guide;
1 Installation/Extraction Tool;
1 Bottle Brush;
1 Water Dam for leak testing;
1 Vapor Pin™ SOP; and
Hard-sided carrying Case.



REVISIONS				
REV.	DATE	BY	CHKD.	DESCRIPTION
A	12/29/15	S.G.	R.M.	ADDED HEX
B	1/5/16	S.G.	R.M.	MODIFIED ALARMS/ADDED AUTO DIALER

J.E. GASHO & ASSOCIATES
PO# 54240-3050

ICP S.O.# XXX

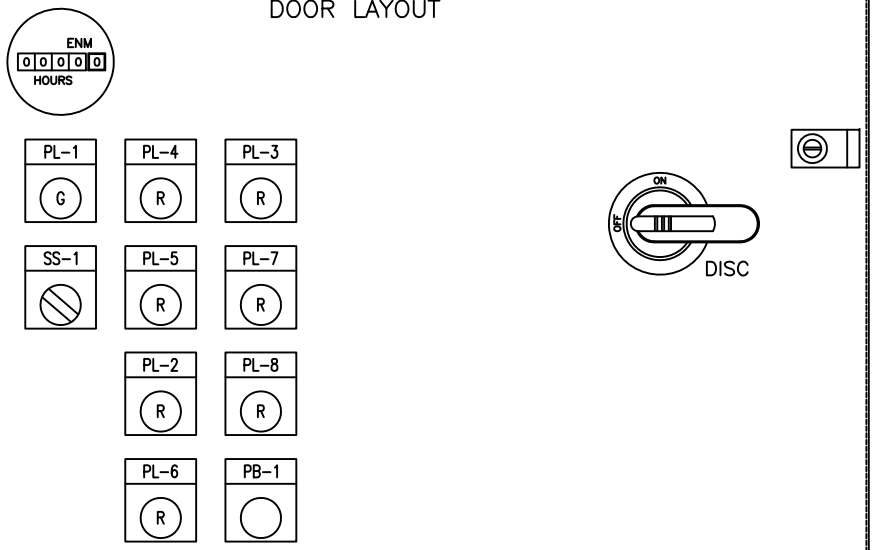
HP SEE DWG

VOLTAGE 460

TITLE: SVE CONTROL PANEL

DATE	PAGE	DWG NO.	
12/21/15	1 OF 2	GASH155	INTERNATIONAL CONTROL PRODUCTS, INC.

DOOR LAYOUT



PL-1 – SVE PUMP ON
PL-2 – HIGH LIQUID LEVEL
PL-3 – HIGH PRESSURE
PL-4 – HIGH TEMPERATURE 1
PL-5 – HIGH TEMPERATURE 2
PL-6 – LOW VACUUM
PL-7 – SPARE 1
PL-8 – SPARE 2
SS-1 – SVE HAND-OFF-AUTO
PB-1 – ALARM CONDITION RESET

NOTES:

1. ☐ INDICATES TERMINAL BLOCK
2. ○ INDICATES COMPONENT TERMINAL POINT
3. USE COPPER WIRE ONLY
4. REPLACE WITH LIKE FUSES ONLY
5. HTS – INDICATES TEMPERATURE SWITCH
6. LS – INDICATES LEVEL SWITCH
7. PS – INDICATES PRESSURE SWITCH
8. VAC – INDICATES VACUUM SWITCH
6. ALL CONTACTS SHOWN WITH POWER OFF
7. UL LISTED CONTROL PANEL
8. TORQUE TERMINAL BLOCKS TO 5-7 LB-IN

REVISIONS				
REV.	DATE	BY	CHKD.	DESCRIPTION
A	12/29/15	S.G.	R.M.	ADDED HEX
B	1/5/16	S.G.	R.M.	MODIFIED ALARMS/ADDED AUTO DIALER

BILL OF MATERIALS

ITEM	QTY	ITEM LABEL	MFG.	DESCRIPTION	PART NUMBER
1	1	ENCL	RITTAL	30x24x8 NEMA 4 ENCLOSURE	AE1076.500
2	2	ENCL	RITTAL	SCREWDRIVER INSERT	SZ2464
3	1	DISC.	ABB	40A 3P NON-FUSED DISC. SWITCH	OT40F3
4	1	DISC.	ABB	NEMA 4 DISCONNECT HANDLE	OHB65L6
5	1	DISC.	ABB	DISCONNECT SHAFT	OXP6X210
6	1	FB-1	MERSEN	3P 30A CLASS J FUSE BLOCK	60308SJ
7	3	FU-1,2,3	MERSEN	20 AMP CLASS J FUSE	AJT-20
8	1	FB-2	MERSEN	3P 30A CLASS CC FUSE BLOCK	30323R
9	3	FU-4,5,6	MERSEN	6.25 AMP CLASS CC FUSE	ATDR-6 1/4
10	1	M1	SIEMENS	25 AMP IEC CONTACTOR	3RT2026-1AK60
11	2	M1	SIEMENS	1 N.O. AUX. CONTACT	3RH1921-1CA10
12	1	OL1	SIEMENS	OVERLOAD RELAY (14-20 FLA)	3RU2126-4BB0
13	1	M2	SIEMENS	7 AMP IEC CONTACTOR	3RT2015-1AK61
14	1	OL2	SIEMENS	OVERLOAD RELAY (1.4-2 FLA)	3RU2116-1BB0
15	1	SS-1	ABB	3 POS. S.S. SPRG. RET. L TO C (2 N.O.)	M3SS7-30B-20
16	1	PL-1	ABB	GREEN F.V. PILOT LIGHT – 120V	CL-100G
17	7	PL-2-->8	ABB	RED F.V. PILOT LIGHT – 120V	CL-100R
18	1	PB-1	ABB	BLACK FLUSH P.B. (1 N.C.)	MP1-30B-01
19	1	ETM	ENM	ELAPSED TIME METER	T50B2-12
20	1	1T	SIEMENS	250 VA CONTROL TRANSFORMER	MT0250A
21	1	FB-3	MERSEN	2P 30A CLASS CC FUSE BLOCK	30322R
22	2	FU-7,8	MERSEN	2 1/2 AMP CLASS CC FUSE	ATDR-2 1/2
23	1	FU-9	MERSEN	3 2/10 AMP TIME DELAY FUSE	TRM-3 2/10
24	1	TR1	FINDER	4 POLE TIMER – 120V	85.04.0.125.0000
25	1	TR1	FINDER	4 POLE TIMER SOCKET	94.74
26	1	TR2	FINDER	2 POLE TIMER – 120V	85.02.0.125.0000
27	1	TR2	FINDER	2 POLE TIMER SOCKET	94.82
28	7	R1-->7	FINDER	4 POLE RELAY – 120V	55.34.8.120.0040
29	7	R1-->7	FINDER	4 POLE RELAY SOCKET	94.74
30	1	A.D.	SENSAPHONE	8 CHANNEL AUTO DIALER	FGD-800
31	1	RECEP.-1	LEVITON	DUPLEX RECEPTACLE	7899-3W
32	1	RECEP.-1	RED DOT	DUPLEX RECEPTACLE BOX	RIH31LM
33	18	T.B.'S	PHOENIX	TERMINAL BLOCK	3004362
34	1	T.B.'S	PHOENIX	TERMINAL BLOCK END COVER	3003020
35	2	T.B.'S	PHOENIX	DIN RAIL END RETAINER	0800886
36	2	GROUND	BURNDY	14-2 AWG GROUND LUG	DLA2

J.E. GASHO & ASSOCIATES
PO# 54240-3050

ICP S.O.# XXX

HP SEE DWG

VOLTAGE 460

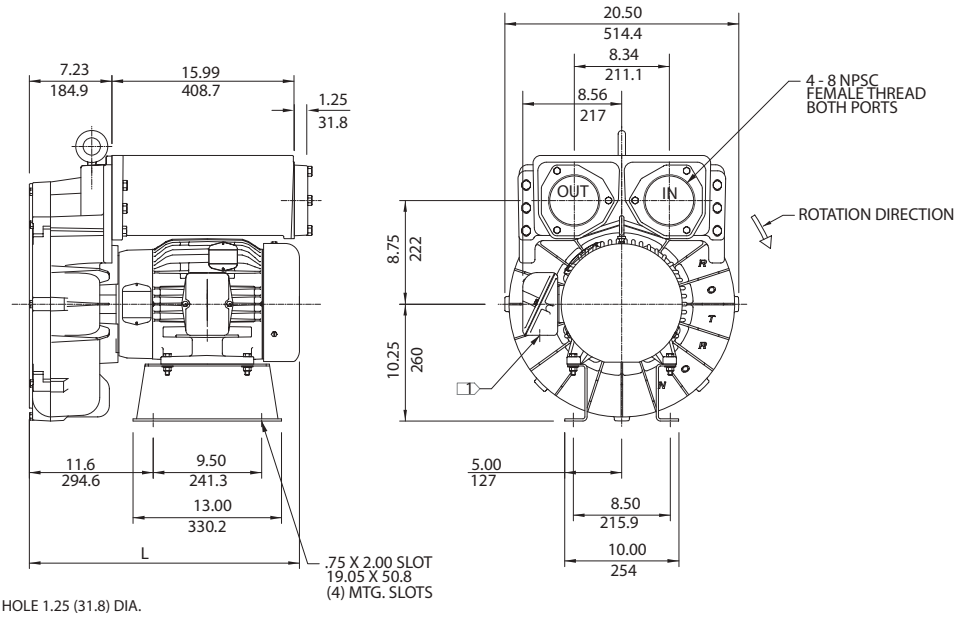
TITLE SVE CONTROL PANEL

DATE	PAGE	DWG NO.	
12/21/15	2 OF 2	GASH155	INTERNATIONAL CONTROL PRODUCTS, INC.

DR 909 & CP 909

ROTRON®

10.0 / 15.0 HP Regenerative Blower



IN
MM

NOTES
1. TERMINAL BOX CONNECTOR HOLE 1.25 (31.8) DIA.
2. DRAWING NOT TO SCALE, CONTACT FACTORY FOR SCALE CAD DRAWING.
3. CONTACT FACTORY FOR BLOWER MODEL LENGTHS NOT SHOWN.

MODEL	L(IN/MM)
DR909BE72W	23.57/598.7
DR909BB72W	23.38/593.8

		Part/Model Number					
		DR909BE72W	DR909BE86W	DR909BB72W	DR909BB86W	CP909FJ72WLR	HiE909BE72W
Specification	**Units**	**081737**	**081739**	**081738**	**081744**	**038632**	**081735**
Motor Enclosure - Shaft Mtl.	-	TEFC-CS	TEFC-CS	TEFC-CS	TEFC-CS	Chem TEFC-SS	TEFC-CS
Horsepower	-	15	15	10	10	15	10
Voltage	AC	208-230/460	575	230/460	575	208-230/460	208-230/460
Phase - Frequency	-	Three-60 hz	Three-60 hz	Three - 60 Hz	Three-60 hz	Three-60 hz	Three-60 hz
Insulation Class	-	F	F	F	F	F	F
NEMA Rated Motor Amps	Amps (A)	41.5-37.6/18.8	14.6	26/13	10.5	41.5-37.6/18.8	41.5-37.6/18.8
Service Factor	-	1.15	1.15	1.15	1.15	1.15	1.15
Max. Blower Amps	Amps (A)	42/21	17	34/17	13.0	42/21	42/21
Locked Rotor Amps	Amps (A)	318/159	164	162/81	65	318/159	318/159
NEMA Starter Size	-	2/2	2	2/1	1	2/2	2/2
Shipping Weight	Lbs	400	400	400	400	400	400
	Kg	181.4	181.4	181.4	181.4	181.4	181.4
Model (Base Mount)	-	DR909BE72X	DR909BE86X	DR909BB72X	DR909BB86X		
Part Number (Base Mount)	-	038622	038626	038623	080183		

Voltage - ROTRON motors are designed to handle a broad range of world voltages and power supply variations. Our dual voltage 3 phase motors are factory tested and certified to operate on both: **208-230/415-460 VAC-3 ph-60 Hz** and **190-208/380-415 VAC-3 ph-50 Hz**. Our dual voltage 1 phase motors are factory tested and certified to operate on both: **104-115/208-230 VAC-1 ph-60 Hz** and **100-110/200-220 VAC-1 ph-50 Hz**. All voltages above can handle a ±10% voltage fluctuation. Special wound motors can be ordered for voltages outside our certified range.

Operating Temperatures - Maximum operating temperature: Motor winding temperature (winding rise plus ambient) should not exceed 140°C for Class F rated motors or 120°C for Class B rated motors. Blower outlet air temperature should not exceed 140°C (air temperature rise plus inlet temperature). Performance curve maximum pressure and suction points are based on a 40°C inlet and ambient temperature. Consult factory for inlet or ambient temperatures above 40°C.

Maximum Blower Amps - Corresponds to the performance point at which the motor or blower temperature rise with a 40°C inlet and/or ambient temperature reaches the maximum operating temperature.

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

Industrial / Chemical Processing Blowers

DR 909 & CP 909

ROTRON®

10.0 / 15.0 HP Regenerative Blower

FEATURES

- Manufactured in the USA - ISO 9001 and NAFTA compliant
- CE compliant - Declaration of Conformity on file
- Maximum flow: 600 SCFM
- Maximum pressure: 137 IWG
- Maximum vacuum: 106 IWG
- Standard motor: 15 HP, TEFC
- Cast aluminum blower housing, impeller & cover; cast iron flanges (threaded)
- UL & CSA approved motor with permanently sealed ball bearings
- Inlet & outlet internal muffling
- Quiet operation within OSHA standards when properly piped and muffled

MOTOR OPTIONS

- International voltage & frequency (Hz)
- Chemical duty, high efficiency, inverter duty or industry-specific designs
- Various horsepowers for application-specific needs

BLOWER OPTIONS

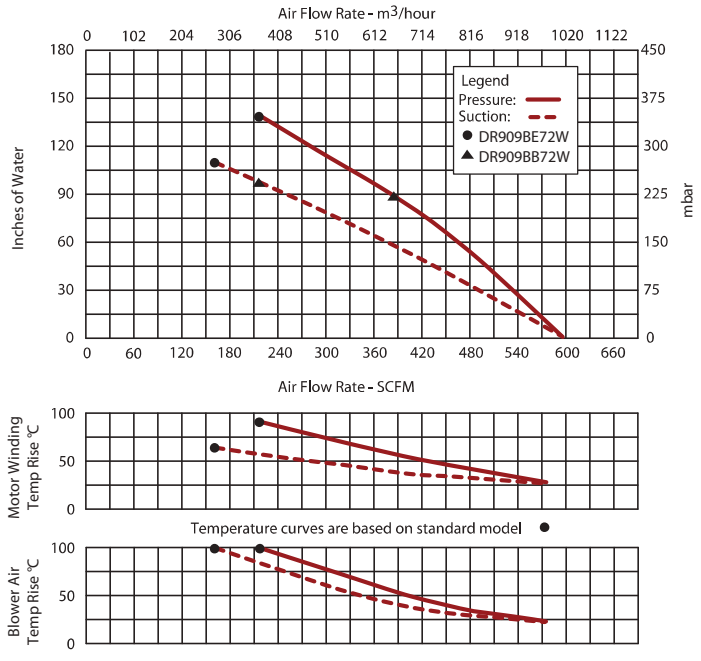
- Corrosion resistant surface treatments & sealing options
- Remote drive (motorless) models
- Slip-on or face flanges for application-specific needs

ACCESSORIES

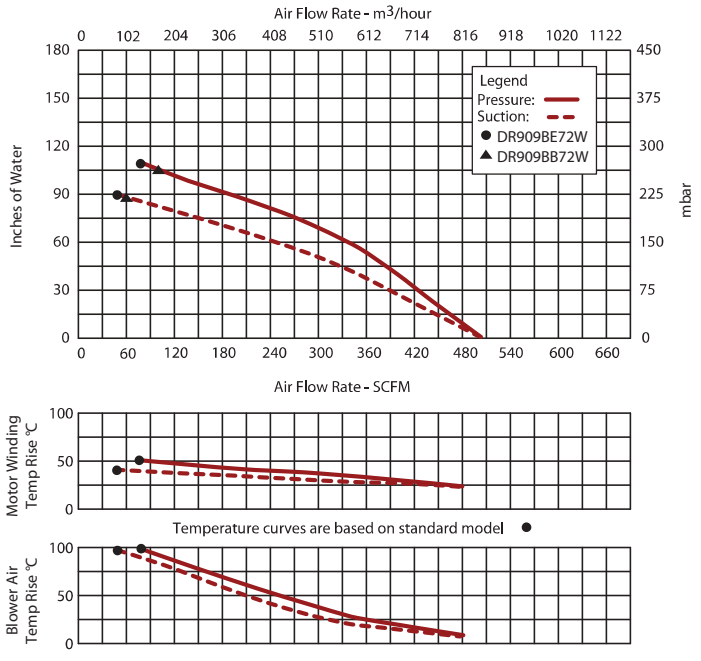
- Flowmeters reading in SCFM
- Filters & moisture separators
- Pressure gauges, vacuum gauges, & relief valves
- Switches - air flow, pressure, vacuum, or temperature
- External mufflers for additional silencing
- Air knives (used on blow-off applications)
- Variable frequency drive package

Blower Performance at Standard Conditions

60 Hz



50 Hz



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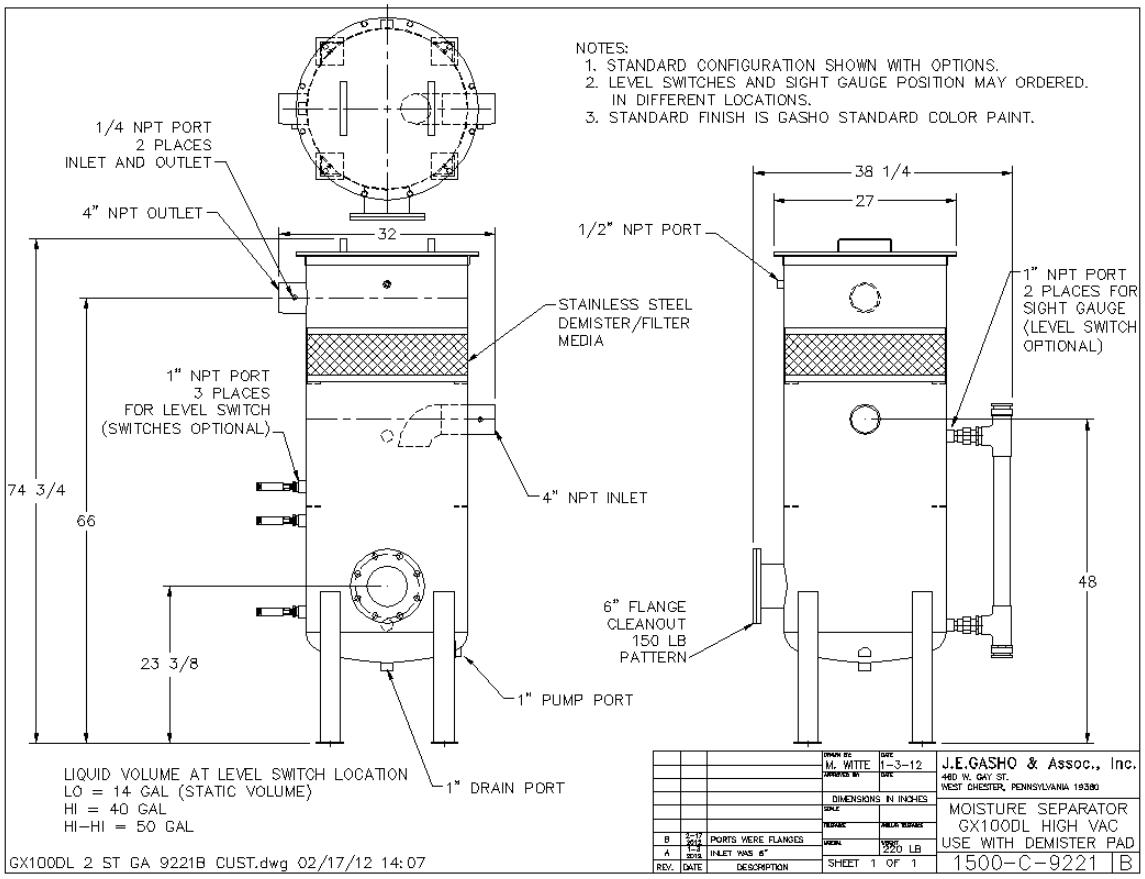
AMETEK®
TECHNICAL & INDUSTRIAL PRODUCTS

The Leader in Blower & Vacuum Solutions
460 West Gay Street
West Chester, PA 19380

GX100-DL Moisture Separator, 400 CFM Specification

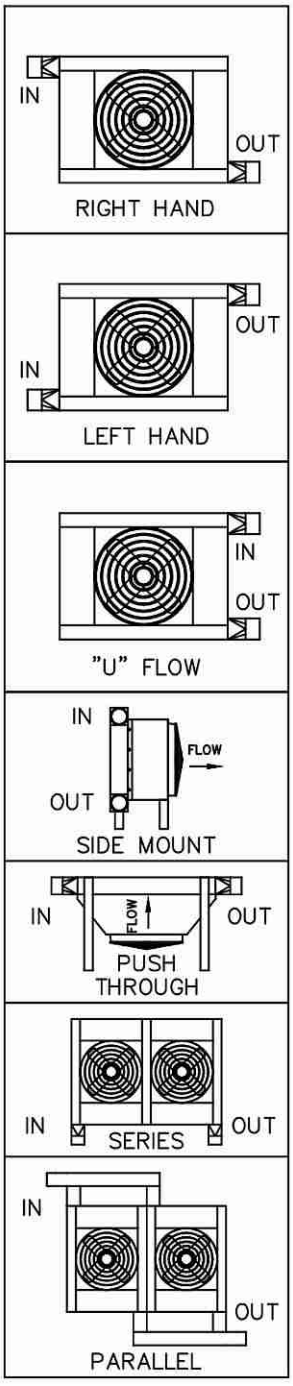
100 gallon vessel with approx. 40 gallons of storage
Flow Rate- 400 ICFM, Vacuum rating 28" Hg
Integral SS demister / filter media, 99.5% entrained water removal
Pressure drop through clean media = .25 IWC
Welded steel construction, reinforced for high vacuum
External Site Gauge
Level Switch Ports- (3) 1" NPT ports, 6" 150 Lb. Flange Cleanout port with clear cover
4" NPT inlet, and outlet
Standard External finish is alkyd paint, inside is left uncoated
Optional coatings available

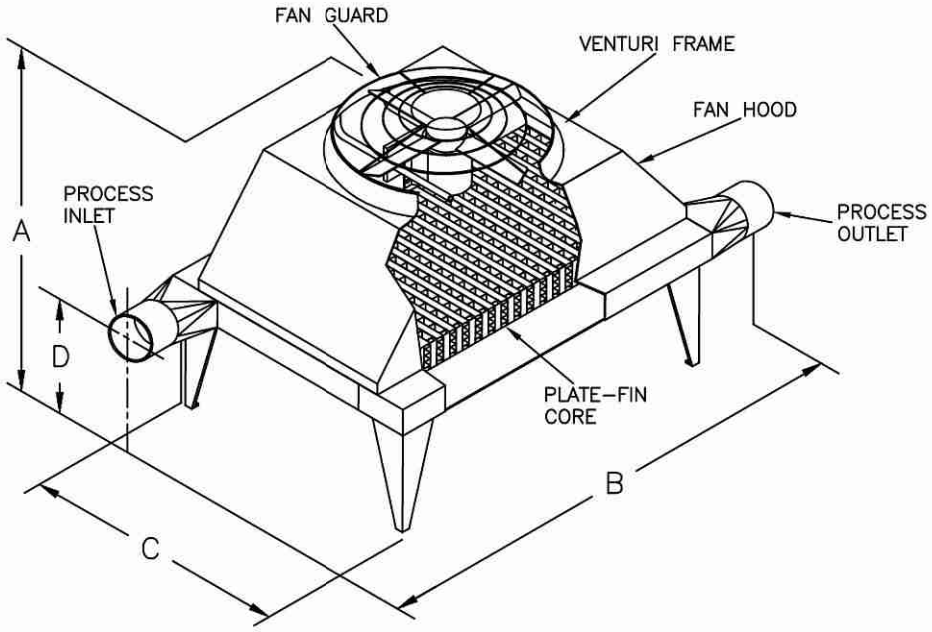


INDUSTRIAL HEAT EXCHANGERS
XCHANGER
1401 7th STREET S.
HOPKINS, MN 55343
952-933-2559
XCHANGER.COM

AA Series Heat Exchanger

AA Series exchangers cool low pressure air streams using fan-drafted ambient air. Air flows to 3,500 CFM from vacuum to 75 PSI can be cooled near ambient, with under 0.2 PSI pressure loss. AA Series exchangers are ideal for installation outdoors where cooling water is unavailable or undesirable due to freezing temperatures. Indoor installations should be well ventilated. The process air should be filtered and pulsating flow, such as that produced by rotary lobe blowers, should be dampened by a chambered silencer prior to entering the heat exchanger.





SEE LINE #54 OF DATA SHEET FOR APPROXIMATE DIMENSIONS

Design Options:

- Connection types: tube, pipe, flange, NPT, ferrule, etc
- Materials of construction:
  Core: aluminum (others available with our LC series)
  Propeller, venturi, and shroud: aluminum, painted, galvanized, or stainless steel
- Motors: any available
- Epoxy phenolic coating for corrosion protection of the core
- Units can be built to required dimensions
- Multiple cores combined together to make a single unit

Accessories:

• Instrument Coupling	$ 60
• Thermometer (Includes Coupling)	$ 90
• Differential Pressure Gauge	$ 280
• Service side filters	Ask
• Others available upon request	

Xchanger, Inc. **Rating for Model AA-400 ref #125244**

Engineer: David Wangensteen — October 20, 2015

Prepared for:

J.E. Gasho & Associates, Inc.

Jim Gasho Jr.

PERFORMANCE	HOT SIDE	COLD SIDE
Fluid Circulated	Air	Air
Volumetric Flow Rate	400.0 Std. ft^3/min	1,031.0 Std. ft^3/min
Total Fluid Entering	1,800.1 lb/hr	4,639.5 lb/hr
Liquid		
Vapor		
Non-Condensibles	1,800.1 lb/hr	4,639.5 lb/hr
Vaporized or (Cond.)		
Temperature In	180.0 °F	90.0 °F
Temperature Out	109.7 °F	117.3 °F
Inlet Pressure (Absolute)	12.770 lb/in^2	11.770 lb/in^2
Velocity (Standard)	1,916 ft/min	1,126 ft/min
Pressure Loss	4.2 in. water	1.2 in. water
Fouling Factor	0.0001 ft^2-°F-hr/BTU	0.0001 ft^2-°F-hr/BTU

Total Heat Exchanged: 30,374 BTU/hr

AVERAGE MEDIA PROPERTIES		
Thermal Conductivity	0.017 BTU/hr-ft-°F	0.016 BTU/hr-ft-°F
Specific Heat	0.240 BTU/lb-°F	0.240 BTU/lb-°F
Viscosity	0.049 lb/ft-hr	0.046 lb/ft-hr
Density (MW)	(29.0)	(29.0)
Latent Heat of Vapor		

CONSTRUCTION		
Design Temperature	200 °F	Not Applicable
Design Pressure (Gauge)	15 lb/in^2	Not Applicable
Test Pressure (Gauge)	15 lb/in^2	Not Applicable
Cyclic Pressure	No	Not Applicable
Flow Direction	Right Hand Horizontal	Vertical Up/Pull Through
Coating	None	None

Plate-Fin Core	: Aluminum	Fan Hood	: Galvanized Steel
Fan Guard	: Coated Carbon Steel	Venturi Frame	: Coated Carbon Steel
Drawing Number	:	Weight	: 165 lb

CONNECTIONS

Process Inlet : 4 inch 150 lb. ANSI pattern FFF, 3/8" thick

Process Outlet : 4 inch 150 lb. ANSI pattern FFF, 3/8" thick

Instrument :

MECHANICAL EQUIPMENT

Fan Diameter	: 12 inch	Motor	: 1.00 HP TEFC
Fan Qty/Speed	: 1 / 3450 RPM	Motor Qty/Speed	: 1 / 3450 RPM
Fan Type	: 4 Blade Mill Galv. St	Motor Electrical	: 208-230/460/3/60

NOTES

Approximate unit dimensions (inches): A = 33, B = 32, C = 24, D = 14

Construction material suitability must be determined by customer.

The process flow must be uniform, smooth and free of pulsation.

This unit is not designed for cycling process gas pressure.

A motor access panel is included in the fan hood.

Measurement Accessories

Blower Connection Key
NPT – American National Standard Taper Pipe Thread (Male)
NPSC – American National Standard Straight Pipe Thread for Coupling (Female)
SO – Slip On (Smooth – No Threads)

Air Flow Meter

FEATURES

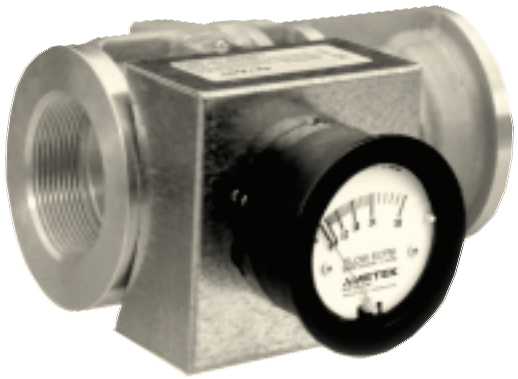
- Direct reading in SCFM
- Low pressure drop (2-4" typical) across the flow meter
- Non-clogging, low impedance air stream
- Light weight aluminum
- No moving parts
- Large easy-to-read dial
- Accurate within 2% at standard conditions
- Good repeatability
- Available in 2", 3" and 4" sizes
- Factory configured for quick installation
- .048" Allen key supplied for gauge adjustment

OPTIONS

- For 4-20 mA outputs and digital readouts see page G-9
- High temperature version (above 140°F)
- Corrosion-resistant version with Chem-Tough™ or in stainless steel
- FDA-approved Food Tough™ surface conversion
- High pressure version (100 PSI)

BENEFITS

- OPTIMIZE SYSTEM EFFICIENCY
  Measuring the correct air flow can assist you in fine-tuning to your system's optimal efficiency.
- BALANCE MULTI-PIPING SYSTEMS
  When evacuating CFM from more than one pipe, different run lengths or end system impedance can cause one pipe to handle more CFM than the other. With an accurate CFM reading, piping can be balanced by bleeding air in/out or by creating an extra impedance.
- DETECT CHANNELING OR PLUGGING
  For systems in which channeling or plugging can occur, a change in the CFM measured can help indicate the unseen changes in your system.

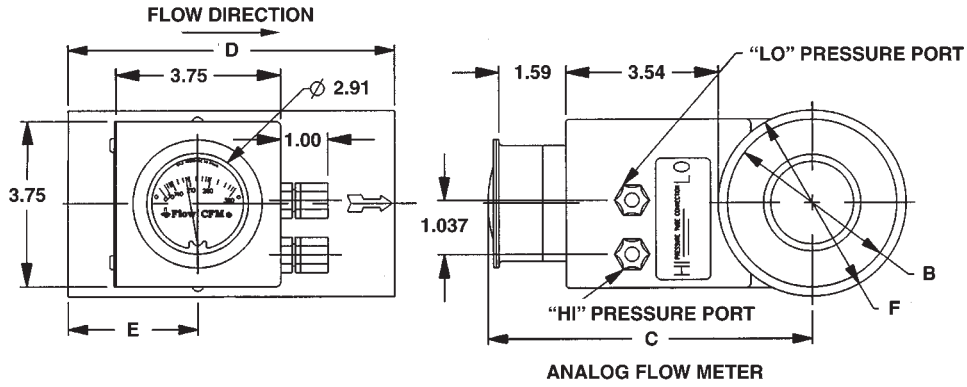


Current Models		Flow Range	B	C	D	E	F
Model	Part #	(SCFM)	Threads	Length	Width		
FM20C030Q	550599	6-30	2" - 11.5 NPSC	7.18"	7.0"	2.0"	3.75"
FM20C045Q	550600	9-45					
FM20C065Q	550601	13-65					
FM20C125Q	550602	25-125			5.6"		
FM20C175Q	550603	35-175					
FM20C225Q	550604	45-225					
FM30C250Q	550605	50-250					
FM30C350Q	550606	70-350	3" - 8 NPSC	7.52"	7.4"	2.5"	4.43"
FM30C475Q	550607	95-475					
FM40C450Q	550608	90-450	4" - 8 NPSC	8.00"	7.7"	2.7"	5.43"
FM40C600Q	550609	120-600					
FM40C850Q	550610	170-850					

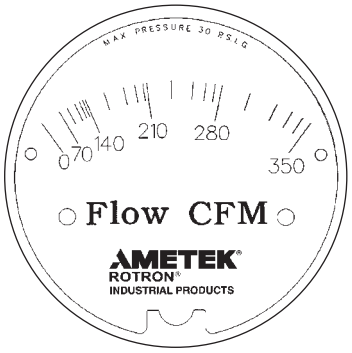
Blower Model Reference Key	
A = SPIRAL	E = DR/EN/CP 656, 6, 623, S7
B = DR/EN/CP 068, 083, 101, 202	F = DR/EN/CP 707, 808, 858, S9, P9 (Inlet Only)
C = DR/EN/CP 303, 312, 313, 353	G = DR/EN/CP 823, S13, P13 (Inlet Only)
D = DR/EN/CP 404, 454, 513, 505, 555, 523	H = DR/EN/CP 909, 979, 1223, 14, S15, P15 (Inlet Only)

Measurement Accessories

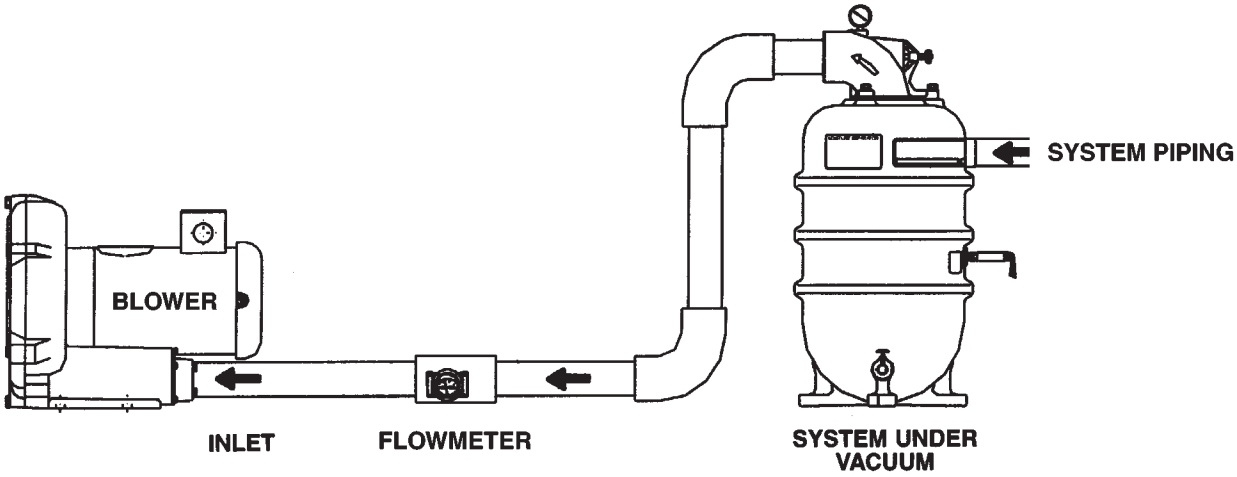
TYPICAL FLOW METER ARRANGEMENT



ANALOG FLOW METER



TYPICAL GAUGE FACE



HIGH TEMPERATURE/PRESSURE CORRECTION

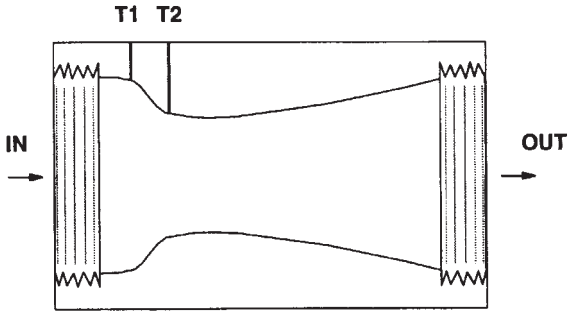
$$SCFM_2 = \frac{SCFM_1}{\sqrt{\left(\frac{14.7}{Pf_2}\right) \times \left(\frac{530}{Tf_2 + 460}\right)}}$$

Pf_2 = Absolute Pressure in PSIA

Tf_2 = Temperature in °F

- Use on inlet to limit need to correct for high pressure or elevated outlet temperature
- Standard model limits = 140°F and 30 PSIG

HOW IT WORKS



Rotron's flow meter is a venturi style design. After air enters the inlet, the pressure is measured in the T1 tap. The second tap, T2, measures the pressure at the throat. The differential between T1 and T2 registers across a special calibrated CFM gauge to provide accurate readings. The throat is then expanded back to the original size to keep pressure loss to under 2-4 IWG.

VM Series Manual Diaphragm Valves

Features:

- Limited-maintenance design
- Valve body materials: PVC, CPVC, PVDF, polypropylene
- Diaphragm materials: EPDM, PTFE, FKM
- High C_V value, low pressure drop
- Compact and rugged construction
- Easy diaphragm replacement
- Crevice-free outer surface
- Position indicator
- Accessories: manual locking option
- Electric position indicator
- Also available with flanged ends

Note: Other materials and constructions for special applications (e.g., gas barrier) available on request.

VM Series Actuated Diaphragm Valves

Features:

- Pneumatically actuated
- High C_V value, low pressure drop
- Compact and rugged construction
- Easy diaphragm replacement
- Valve body materials: PVC, CPVC, polypropylene, PVDF
- Diaphragms: EPDM, PTFE or FKM
- Available flanged ends. Part numbers shown are for normally closed actuators. Normally open and double acting are also available.

Options:

- Stroke limiters, position indicators and emergency manual override
- Electromechanical position indicator on/off (microswitches)
- Directly mounted pilot valve

VM Series Manual Diaphragm Valves

Size (In.)	Part Number w/EPDM Diaphragm	List Price Ea. ($)	Part Number w/PTFE Diaphragm	List Price Ea. ($)
PVC body with true union ends, socket and threaded				
½	VMUV103	129.45	VMUV303	258.75
¾	VMUV104	143.50	VMUV304	277.95
1	VMUV105	176.60	VMUV305	312.95
1¼	VMUV106	213.40	VMUV306	421.55
1½	VMUV107	290.25	VMUV307	503.40
2	VMUV108	361.90	VMUV308	615.20
PVC body with spigot ends				
½	VMYV103	99.70	VMYV303	215.95
¾	VMYV104	108.00	VMYV304	227.60
1	VMYV105	134.55	VMYV305	250.85
1¼	VMYV106	169.45	VMYV306	337.10
1½	VMYV107	217.60	VMYV307	393.60
2	VMYV108	267.40	VMYV308	479.90
2½	VMYV109	576.20	VMYV309	846.80
3	VMYV110	700.60	VMYV310	972.70
4	VMYV111	962.95	VMYV311	1,285.00
CPVC body with true union, socket and threaded				
½	VMUC103	246.25	VMUC303	377.30
¾	VMUC104	265.90	VMUC304	397.10
1	VMUC105	278.55	VMUC305	411.40
1¼	VMUC106	404.30	VMUC306	598.20
1½	VMUC107	445.60	VMUC307	641.40
2	VMUC108	564.20	VMUC308	829.85
CPVC body with spigot ends				
½	VMYC103	203.15	VMYC303	327.75
¾	VMYC104	220.20	VMYC304	346.45
1	VMYC105	227.05	VMYC305	353.35
1¼	VMYC106	307.30	VMYC306	491.50
1½	VMYC107	344.70	VMYC307	534.15
2	VMYC108	404.55	VMYC308	657.00
2½	VMYC109	873.70	VMYC309	1,172.30
3	VMYC110	1,016.55	VMYC310	1,322.45
4	VMYC111	1,383.85	VMYC311	1,731.91

VM Series Actuated Diaphragm Valves

Size (In.)	Part Number w/EPDM Diaphragm	List Price Ea. ($)	Part Number w/PTFE Diaphragm	List Price Ea. ($)
PVC body with true union ends, socket and threaded				
½	VMUV103-NC	449.25	VMUV303-NC	573.35
¾	VMUV104-NC	477.25	VMUV304-NC	603.05
1	VMUV105-NC	503.40	VMUV305-NC	629.30
1¼	VMUV106-NC	665.85	VMUV306-NC	854.60
1½	VMUV107-NC	711.35	VMUV307-NC	910.60
2	VMUV108-NC	992.75	VMUV308-NC	1,232.10
PVC body with spigot ends				
½	VMYV103-NC	405.20	VMYV303-NC	516.40
¾	VMYV104-NC	426.75	VMYV304-NC	537.90
1	VMYV105-NC	445.00	VMYV305-NC	556.25
1¼	VMYV106-NC	592.80	VMYV306-NC	758.75
1½	VMYV107-NC	621.00	VMYV307-NC	787.00
2	VMYV108-NC	870.00	VMYV308-NC	1,072.55
2½	VMYV109-NC	1,358.10	VMYV309-NC	1,630.30
3	VMYV110-NC	1,678.45	VMYV310-NC	1,950.70
4	VMYV111-NC	1,944.05	VMYV311-NC	2,265.45
CPVC body with true union, socket and threaded				
½	VMUC103-NC	625.20	VMUC303-NC	754.45
¾	VMUC104-NC	643.15	VMUC304-NC	776.00
1	VMUC105-NC	655.65	VMUC305-NC	788.60
1¼	VMUC106-NC	917.90	VMUC306-NC	1,113.70
1½	VMUC107-NC	959.25	VMUC307-NC	1,156.80
2	VMUC108-NC	1,332.80	VMUC308-NC	1,598.60
CPVC body with spigot ends				
½	VMYC103-NC	563.25	VMYC303-NC	686.00
¾	VMYC104-NC	578.55	VMYC304-NC	704.75
1	VMYC105-NC	585.35	VMYC305-NC	711.60
1¼	VMYC106-NC	795.25	VMYC306-NC	981.20
1½	VMYC107-NC	832.75	VMYC307-NC	1,018.70
2	VMYC108-NC	1,136.40	VMYC308-NC	1,388.95
2½	VMYC109-NC	1,585.15	VMYC309-NC	1,882.05
3	VMYC110-NC	1,924.70	VMYC310-NC	2,225.00
4	VMYC111-NC	2,255.75	VMYC311-NC	2,626.00

Dimensions & Pressure Ratings

PVC Pipe

Schedule 40 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/8	0.405	0.249	0.068	0.051	810
1/4	0.540	0.344	0.088	0.086	780
3/8	0.675	0.473	0.091	0.115	620
1/2	0.840	0.602	0.109	0.170	600
3/4	1.050	0.804	0.113	0.226	480
1	1.315	1.029	0.133	0.333	450
1 1/4	1.660	1.360	0.140	0.450	370
1-1/2	1.900	1.590	0.145	0.537	330
2	2.375	2.047	0.154	0.720	280
2-1/2	2.875	2.445	0.203	1.136	300
3	3.500	3.042	0.216	1.488	260
3-1/2	4.000	3.521	0.226	1.789	240
4	4.500	3.998	0.237	2.118	220
5	5.563	5.016	0.258	2.874	190
6	6.625	6.031	0.280	3.733	180
8	8.625	7.942	0.322	5.619	160
10	10.750	9.976	0.365	7.966	140
12	12.750	11.889	0.406	10.534	130
14	14.000	13.073	0.437	12.462	130
16	16.000	14.940	0.500	16.286	130
18	18.000	16.809	0.562	20.587	130
20	20.000	18.743	0.593	24.183	120
24	24.000	22.544	0.687	33.652	120

Schedule 80 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/8	0.405	0.195	0.095	0.063	1,230
1/4	0.540	0.282	0.119	0.105	1,130
3/8	0.675	0.403	0.126	0.146	920
1/2	0.840	0.526	0.147	0.213	850
3/4	1.050	0.722	0.154	0.289	690
1	1.315	0.936	0.179	0.424	630
1-1/4	1.660	1.255	0.191	0.586	520
1-1/2	1.900	1.476	0.200	0.711	470
2	2.375	1.913	0.218	0.984	400
2-1/2	2.875	2.290	0.276	1.500	420
3	3.500	2.864	0.300	2.010	370
3-1/2	4.000	3.326	0.318	2.452	350
4	4.500	3.786	0.337	2.938	320
5	5.563	4.768	0.375	4.078	290
6	6.625	5.709	0.432	5.610	280
8	8.625	7.565	0.500	8.522	250
10	10.750	9.493	0.593	12.635	230
12	12.750	11.294	0.687	17.384	230
14	14.000	12.410	0.750	20.852	220
16	16.000	14.213	0.843	26.810	220
18	18.000	16.014	0.937	33.544	220
20	20.000	17.814	1.031	41.047	220
24	24.000	21.418	1.218	58.233	210

Schedule 120 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/2	0.840	0.480	0.170	0.236	1010
3/4	1.050	0.690	0.170	0.311	770
1	1.315	0.891	0.200	0.464	720
1-1/4	1.660	1.204	0.215	0.649	600
1-1/2	1.900	1.423	0.225	0.787	540
2	2.375	1.845	0.250	1.111	470
2-1/2	2.875	2.239	0.300	1.615	470
3	3.500	2.758	0.350	2.306	440
4	4.500	3.574	0.437	3.713	430
6	6.625	5.434	0.562	7.132	370
8	8.625	7.189	0.718	11.277	380

SDR 13.5 - Max W.P. 315 PSI*(all sizes)

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
1/2	0.840	0.696	0.062	0.110

SDR 21 - Max W.P. 200 PSI*(all sizes)

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
3/4	1.050	0.910	0.060	0.136
1	1.315	1.169	0.063	0.180
1-1/4	1.660	1.482	0.079	0.278
1-1/2	1.900	1.700	0.090	0.358
2	2.375	2.129	0.113	0.550
2-1/2	2.875	2.581	0.137	0.797
3	3.500	3.146	0.167	1.168
3-1/2	4.000	3.597	0.190	1.520
4	4.500	4.046	0.214	1.927
5	5.563	5.001	0.265	2.948
6	6.625	5.955	0.316	4.185
8	8.625	7.756	0.410	7.069

SDR 26 - Max W.P. 160 PSI*(all sizes)

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
1	1.315	1.175	0.060	0.173
1-1/4	1.660	1.512	0.064	0.233
1-1/2	1.900	1.734	0.073	0.300
2	2.375	2.173	0.091	0.456
2-1/2	2.875	2.635	0.110	0.657
3	3.500	3.210	0.135	0.966
3-1/2	4.000	3.672	0.154	1.250
4	4.500	4.134	0.173	1.569
5	5.563	5.108	0.214	2.411
6	6.625	6.084	0.255	3.414
8	8.625	7.921	0.332	5.784
10	10.750	9.874	0.413	8.971
12	12.750	11.711	0.490	12.620
14	14.000	12.860	0.538	15.205
16	16.000	14.696	0.615	19.877
18	18.000	16.533	0.692	25.156
20	20.000	18.370	0.769	31.057
24	24.000	22.043	0.923	44.744

SDR 41 - Max W.P. 100 PSI*(all sizes)

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
18	18.000	17.061	0.439	16.348
20	20.000	18.956	0.488	20.196
24	24.000	22.748	0.585	29.064

CPVC Pipe

Schedule 40 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/4	0.540	0.344	0.088	0.096	780
3/8	0.675	0.473	0.091	0.128	620
1/2	0.840	0.602	0.109	0.190	600
3/4	1.050	0.804	0.113	0.253	480
1	1.315	1.029	0.133	0.371	450
1-1/4	1.660	1.360	0.140	0.502	370
1-1/2	1.900	1.590	0.145	0.599	330
2	2.375	2.047	0.154	0.803	280
2-1/2	2.875	2.445	0.203	1.267	300
3	3.500	3.042	0.216	1.660	260
3-1/2	4.000	3.521	0.226	1.996	240
4	4.500	3.998	0.237	2.363	220
5	5.563	5.016	0.258	2.874	190
6	6.625	6.031	0.280	4.164	180
8	8.625	7.942	0.322	6.268	160
10	10.750	9.976	0.365	8.886	140
12	12.750	11.889	0.406	11.751	130
14	14.000	13.073	0.437	13.916	130
16	16.000	14.940	0.500	18.167	130
18	18.000	16.809	0.562	22.965	130
20	20.000	18.743	0.593	29.976	120
24	24.00	22.544	0.687	37.539	120

NOTE *Pressure ratings are for water, non-shock, @73°F. Threaded pipe requires a 50% reduction in the pressure ratings stated for plain-end pipe @ 73°F. Threading recommended for Schedule 80 or heavier walls only. Maximum service temperature for PVC is 140°F. Maximum service temperature for CPVC is 200°F. The pressure rating of the pipe must be derated when working at elevated temperatures.

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water.

Schedule 80 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/4	0.540	0.282	0.119	0.117	1,130
3/8	0.675	0.403	0.126	0.162	920
1/2	0.840	0.526	0.147	0.238	850
3/4	1.050	0.722	0.154	0.322	690
1	1.315	0.936	0.179	0.473	630
1-1/4	1.660	1.255	0.191	0.654	520
1-1/2	1.900	1.476	0.200	0.793	470
2	2.375	1.913	0.218	1.097	400
2-1/2	2.875	2.290	0.276	1.674	420
3	3.500	2.864	0.300	2.242	370
3-1/2	4.000	3.326	0.318	2.735	350
4	4.500	3.786	0.337	3.277	320
5	5.563	4.768	0.375	4.078	290
6	6.625	5.709	0.432	6.258	280
8	8.625	7.565	0.500	9.506	250
10	10.750	9.493	0.593	14.095	230
12	12.750	11.294	0.687	19.392	230
14	14.000	12.410	0.750	23.261	220
16	16.000	14.213	0.843	29.891	220
18	18.000	16.014	0.937	37.419	220
20	20.000	17.814	1.031	45.879	220
24	24.000	21.418	1.218	64.959	210

Refer to chemical resistance and installation data. All PVC piping is produced from NSF approved compounds conforming to ASTM D1784 and is NSF listed for potable water use.

ASTM Standard D1784 Material equivalents:
Cell classification 12454 = PVC Type I Grade I = PVC1120
Cell classification 23447 = CPVC Type IV Grade I = CPVC4120

Schedule 40, 80 & 120 PVC pipe is manufactured in strict compliance with ASTM D1785. Schedule 40 & 80 CPVC pipe is manufactured in strict compliance with ASTM F441.

Temperature De-rating

The pressure ratings given are for water, non-shock, @ 73°F. The following temperature de-rating factors are to be applied to the working pressure ratings (W.P.) listed when operating at elevated temperatures.

Multiply the working pressure rating of the selected pipe at 73°F, by the appropriate de-rating factor to determine the maximum working pressure rating of the pipe at the elevated temperature chosen.

Solvent-cemented joints should be utilized when working at or near maximum temperatures of the material selected. Harvel Plastics does not recommend the use of standard threaded connections at temperatures above 110°F for PVC or at temperatures above 150°F for CPVC; use specialty reinforced adapters, flanged joints, unions or roll grooved couplings where disassembly is necessary at elevated temperatures.

Threading of Schedule 40 pipe (PVC or CPVC) is not a recommended practice due to insufficient wall thickness. Thread only Schedule 80 or heavier walls. Threading requires a 50% reduction in pressure rating stated for plain end pipe @73°F.

Chemical resistance data should be referenced for proper material selection and possible pressure de-rating when working with fluids other than water. Refer to Harvel's chemical resistance guide for additional information.

PVC Pipe

Operating Temp (°F)	De-Rating Factor
73	1.00
80	0.88
90	0.75
100	0.62
110	0.51
120	0.40
130	0.31
140	0.22

EX: 10" PVC SCHEDULE 80 @ 120°F = ?
230 psi x 0.40 = 92 psi max. @ 120°F

CPVC Pipe

Operating Temp (°F)	De-Rating Factor
73-80	1.00
90	0.91
100	0.82
110	0.72
120	0.65
130	0.57
140	0.50
150	0.42
160	0.40
170	0.29
180	0.25
200	0.20

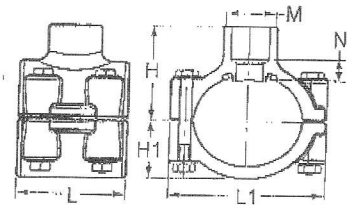
EX: 10" CPVC SCHEDULE 80 @ 120°F = ?
230 psi x 0.65 = 149.5 psi max. @ 120°F

PVC WHITE SCHEDULE 40 FITTINGS UNIONS & SADDLES

CLAMP-ON SADDLE x SOCKET SINGLE OUTLET (continued)

Dimensions Also Applicable to
466S-XXX 466E-XXX 466SE-XXX

Pressure Rating
2" - 4" 235 psi @ 73° F
6" 200 psi @ 73° F
8" - 12" 150 psi @ 73° F



Part Number	Size	H	H1	L	L1	M	N	Approx. Wt. (Lbs.)
466-336	3x1-1/4	4-1/32	2-1/16	4-3/32	4-5/8	3	1-1/32	1.47
466-337	3x1-1/2	4-1/32	2-1/16	4-3/32	4-5/8	3	29/32	1.41
466-338	3x2	3-5/8	2-1/16	4-3/32	4-5/8	3	3/8	1.25
466-415	4x1/2	4-3/32	2-5/8	3	5-9/16	2-3/8	31/32	1.31
466-416	4x3/4	4-3/32	2-5/8	3	5-9/16	2-3/8	27/32	1.28
466-417	4x1	3-13/16	2-5/8	3	5-5/8	1-11/16	7/16	1.24
466-418	4x1-1/4	4-13/32	2-5/8	4-3/32	5-5/8	2-3/8	29/32	1.70
466-419	4x1-1/2	4-1/8	2-5/8	4-3/32	5-9/16	2-3/8	1/2	1.63
466-420	4x2	4-3/16	2-5/8	4-1/8	5-5/8	3	7/16	1.70
466-421	4x2-1/2	5	2-5/8	5-7/16	5-23/32	4-9/32	3/4	2.82
466-422	4x3	4-5/8	2-19/32	5-7/16	5-11/16	4-1/4	1/2	2.41
466-523	6x1/2	5-13/32	3-7/8	3	7-3/4	1-11/16	1-7/32	2.35
466-524	6x3/4	5-7/16	3-7/8	3	7-3/4	1-11/16	1-1/8	2.33
466-525	6x1	5-1/8	3-7/8	3	7-15/16	1-11/16	11/16	2.29
466-526	6x1-1/4	5-15/16	3-7/8	4-1/8	7-3/4	3	1-3/8	3.26
466-527[1]	6x1-1/2	5-23/32	3-7/8	4-1/8	7-31/32	3	1-1/32	3.20
466-528	6x2	5-1/2	3-7/8	4-1/8	7-3/4	3	11/16	3.04
466-529	6x2-1/2	6-7/16	3-7/8	6	7-15/16	4-1/4	1-1/8	4.75
466-530	6x3	5-15/16	3-7/8	6	7-15/16	4-1/4	25/32	4.33
466-532	6x4	6	3-29/32	6	7-15/16	5-3/16	5/8	5.12
466-573	8x1/2	8-3/32	4-7/8	8-1/2	10-1/8	5-1/4	2-3/16	9.35
466-574	8x3/4	8-3/32	4-7/8	8-1/2	10-1/8	5-1/4	2-3/4	9.36
466-575	8x1	8-3/32	4-7/8	8-1/2	10-1/8	5-1/4	2-5/8	9.37
466-576	8x1-1/4	8-3/32	4-7/8	8-1/2	10-1/8	5-1/4	2-1/2	9.39
466-577	8x1-1/2	8-3/32	4-7/8	8-1/2	10-1/8	5-1/4	2-3/8	9.32
466-578	8x2	7-11/16	4-7/8	8-1/2	10-1/8	5-1/4	1-7/8	9.17
466-579	8x2-1/2	8-1/8	4-7/8	8-1/2	10-1/8	5-1/4	1-11/16	9.24
466-580	8x3	7-1/16	4-7/8	8-1/2	10-1/8	5-1/4	1-7/16	9.15

[1] Outlet sized with bushing

Made in the U.S.A.

Schedule 40 Steel Pipe Sizes & Dimensions ASME/ANSI B36.10/19

Fluid Flow Table of Contents
Hydraulic and Pneumatic Knowledge
Fluid Power Equipment

This chart gives dimensional - size data for American National Standard Schedule 40 Welded and Seamless Steel Pipe.

Reference ANSI/ASME B36.10M-1995 Wrought Steel Pipe seamless and welded.

Diameter (Inches)			Wall	Weight per Foot, (Lbs)	Properties of Sections		
Nominal	Inside	Outside	Thickness (in)	Pipe	Moment of Inertia (in^4)	Radius of Gyration	Section Modulus (in^3)
1/8	.269	.405	.068	.24	.00106	.122	.00525
1/4	.364	.540	.088	.42	.00331	.163	.01227
3/8	.493	.675	.091	.57	.00729	.209	.02160
1/2	.622	.840	.109	.85	.01709	.261	.4070
3/4	.824	1.050	.113	1.13	.03704	.334	.07055
1	1.049	1.315	.133	1.68	.08734	.421	.1328
11/4	1.380	1.660	.140	2.27	.1947	.539	.2346
1 1/2	1.610	1.900	.145	2.72	.3099	.623	.3262
2	2.067	2.375	.154	3.65	.6658	.787	.5607
21/2	2.469	2.875	.203	5.79	1.530	.947	1.064
3	3.068	3.500	.216	7.58	3.017	1.163	1.724
31/2	3.548	4.000	.226	9.11	4.788	1.337	2.394
4	4.026	4.500	.237	10.79	7.233	1.510	3.215
5	5.047	5.563	.258	14.62	15.16	1.878	5.451
6	6.065	6.625	.280	18.97	28.14	2.245	8.496
8	7.981	8.625	.322	28.55	72.49	2.938	16.81
10	1.020	1.750	.365	40.48	160.7	3.674	29.91
12	11.938	12.750	.406	53.52	300.2	4.364	47.09
16	15.000	16.000	.500	82.77	732.0	5.484	91.50
18	16.876	18.000	.562	104.7	1172.0	6.168	130.2
20	18.812	20.000	.594	123.1	1706.0	6.864	170.6
24	22.624	24.000	.688	171.3	3426.0	8.246	285.5
32	30.624	32.000	.688	230.1	8283.3	11.07	518.7
34	32.624	34.00	.688	244.77	9991.6	11.78	587.7
36	34.5	36.00	.750	282.35	12906.1	12.466	717.0
42	40.5	42.00	.750	330.00	20689	14.59	985.2

Pipe attached to 1/4-inch steel diamond plate - anchor type.

GRAINGER
FOR THE ONES WHO GET IT DONE

Pipe Marker, Vacuum, Grn, 2-1/2 to 7-7/8 In

Pipe Marker, Legend Vacuum, Legend Color White, Background Color Green, Fits Pipe O.D. 2-1/2 to 7-7/8 In., Height 2-1/4 In., Width 14 In., 1 Markers per Card, Material Pressure Sensitive Vinyl, Marker Attachment Style Self-Adhesive, Standards ASME (ANSI) A13.1

Grainger Item #	6M602
Price (ea.)	**$2.78**
Brand	BRADY
Mfr. Model #	7292-1
Ship Qty.	1
Sell Qty. (Will-Call)	1
Ship Weight (lbs.)	0.01
Availability	Typically in Stock
Catalog Page No.	2930

Price shown may not reflect your price. Log in or register.

Additional Info

Self-Sticking Vinyl Pipe Markers

Meet ANSI A13.1 standards when used with directional flow arrow tape, sold separately below. Made of durable indoor/outdoor vinyl.

Tech Specs

Item: Pipe Marker
Legend: Vacuum
Legend Color: White
Background Color: Green
Fits Pipe O.D.: 2-1/2 to 7-7/8"
Height: 2-1/4"
Width: 14"
Markers per Card: 1
Material: Pressure Sensitive Vinyl
Marker Attachment Style: Self-Adhesive
Standards: ASME (ANSI) A13.1

Notes & Restrictions

There are currently no notes or restrictions for this item.

MSDS

This item does not require a **Material Safety Data Sheet (MSDS).**

Optional Accessories

Banding Tape, Green, 2 In. W, 90 ft. L

Item #: 4T140
Brand: BRADY
Usually Ships: Typically in Stock
Price (ea): $47.40

Arrow Tape, White/Green, 1 In. W

Item #: 4T562
Brand: BRADY
Usually Ships: Typically in Stock
Price (ea): $29.95

Arrow Tape, White/Green, 2 In. W

Item #: 4T564
Brand: BRADY
Usually Ships: Typically in Stock
Price (ea): $58.25

Vent-Scrub® Vapor Phase Adsorbers

Applications

The Vent-Scrub® adsorbers have been proven to be the simplest and most cost effective way to treat malodorous and VOC emission problems. Sturdy steel construction and specially formulated corrosion resistant internal coating ensures long service life and low maintenance. Applications for Vent-Scrub® adsorbers include:

- API separator vents
- VOC control from soil vapor extraction (SVE) systems and airstrippers
- Wastewater and product storage tank vents
- Process vents
- Refinery and chemical plant wastewater sewer vents
- Laboratory hood exhausts

Installation, Startup and Operation

Siemens can provide a total service package that includes utilizing OSHA trained personnel providing on-site carbon changeouts, packaging and transportation of spent carbon for recycling at our reactivation facilities, where the contaminants are thermally destroyed.

We provide instructions on sampling the spent carbon and completion of our spent carbon profile form. Spent carbon acceptance testing can be performed at our certified laboratory.

When requested, a certificate of reactivation will be issued.

Benefits and Design Features

- Durable, carbon steel construction.
- Abrasion and corrosion resistant baked epoxy lining; urethane exterior finish (Vent-Scrub® 1000, 2000, 3000, 8000 adsorbers).
- Ready-to-use systems: simple installation and operation.
- Applications to 3750 SCFM.
- The Vent-Scrub® 1000, 2000, 3000 and 8000 adsorbers have forklift channels for easy handling.
- The Vent-Scrub® 200, 400, 1000 and 2000 adsorbers are UN/DOT approved transportation containers for RCRA hazardous spent carbon.
- Hose kit and pipe manifold options are available to simplify installation and operation.

Piping Manifold (Optional)

- 2"/3" sch 80 PVC piping and valves (optional carbon steel and stainless steel piping).
- Series or parallel operation.
- Sampling ports and pressure gauges.
- Flexible hoses with Kamlock fittings allow easy installation and removal during service exchange operations (Vent-Scrub® 200, 400, 1000 and 2000 adsorbers).

Specification					
Vent-Scrub® Adsorber Model No.	200	400	1000/2000	3000	8000
Dimensions, diameter x overall height	22″ x 34″	32″ x 43″	48″ x 59″/48″ x 95″	60″ x 112″	96″ x 131″
Inlet Connection	2″ FNPT	4″ FNPT	4″ FNPT	10″ Flange	16″ Flange
Outlet Connection	2″ MPT	4″ FNPT	4″ FNPT	10″ Flange	16″ Flange
Manway	Top	Top	18″ Top	16″ Top	20″ Top/Side
Internal Distribution(1)	PVC	PVC	PVC	FRP/PPL	FRP/PPL
Interior Coating	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy
Exterior Coating	Enamel	Enamel	Epoxy/Urethane	Epoxy/Urethane	Epoxy/Urethane
Carbon Fill Volume (Cu.ft.)	6.8	14	34/68	107	273
Cross Sectional Area (sq.ft.)	2.8	4.9	12.3	19.6	50.2
Approx. Carbon Weight (lbs)	200	400	1000/2000	3000	8000
Empty Vessel Weight (lbs)	50	80	890/1190	2500	5500
Flow, CFM (max.)	100	300	500	1500	3750
Pressure, psig (max.)	3	3	14.9	5	5
Temperature, deg. F (max)(4)	140	140	140	140	140
Vacuum, in. Hg (max.)	N/A	N/A	12/12(2)	6(3)	12(3)

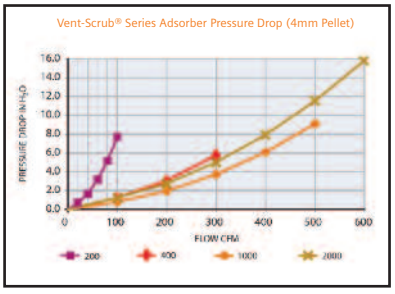
[1]*Carbon steel and stainless steel internals are also available.*
[2]*For vacuum greater than 12 in. Hg on Vent-Scrub® 2000 Adsorber, contact your Siemens representative.*
[3]*For vacuum service on Vent-Scrub® 3000 and 8000 Adsorber, contact your Siemens representative.*
[4]*For higher temperatures, stainless and carbon steel internals are available.*
For detailed dimensional information or drawings, contact your local Siemens sales representative.

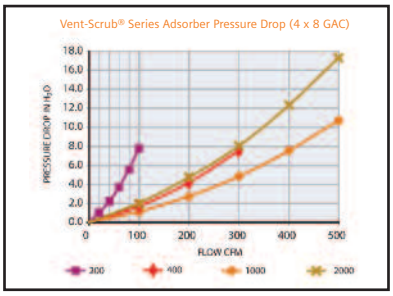
Warning

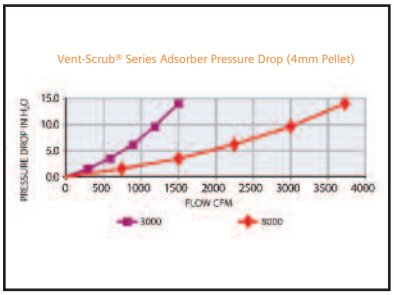
The adsorption of organic compounds onto activated carbon generates heat. In rare instances, adsorbed compounds may also react on the carbon surface to generate additional heat. If these heat sources are not properly dissipated, the carbon bed temperature may rise to the point where the carbon can ignite, leading to a fire or other hazardous condition. A description of industry-accepted engineering practices to assure the dissipation of heat and safe operation of the carbon bed can be provided upon request. In certain applications where the risk of ignition is significant, activated carbon may not be a recommended treatment technology. Please contact your Technical Sales Representative for more details.

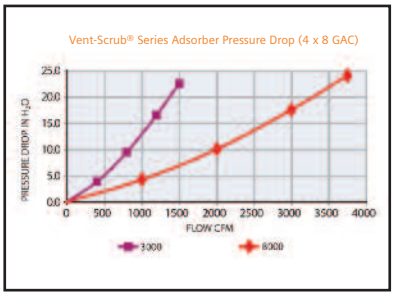
Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated storage areas. Workers should follow all applicable state and federal safety guidelines for entering oxygen depleted areas.

All information presented herein is believed reliable and in accordance with accepted engineering practices. Siemens makes no warranties as to the completeness of this information. Users are responsible for evaluating individual product suitability for specific applications. Siemens assumes no liability whatsoever for any special, indirect or consequential damages arising from the sale, resale or misuse of its products.





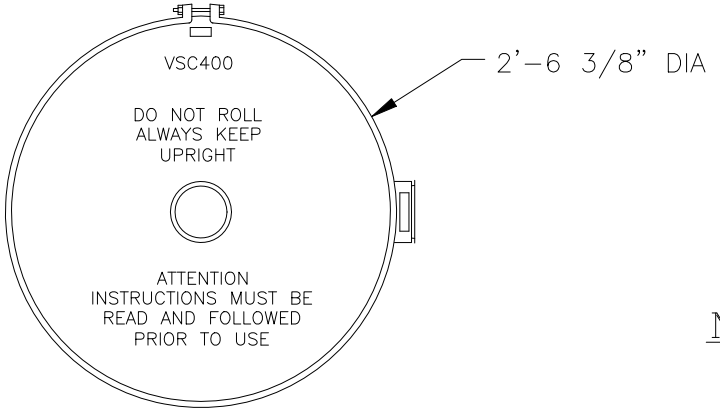




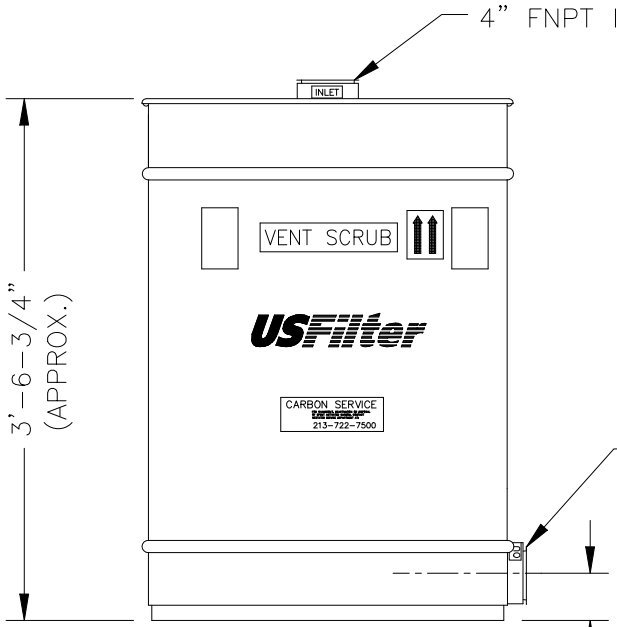
Siemens
Water Technologies
2430 Rose Place
Roseville, MN 55113
800.525.0658 phone

WS-VSCdr-DS-0509

STD: 2-0600-8X11A	INTL REF:	



PLAN VIEW



ELEVATION

NOTES:

1. CARBON:
   AS REQUIRED.
2. MATERIALS OF CONSTRUCTION:
   VESSEL: .....CARBON STEEL
   EXTERNAL COATING: .....HIGH GLOSS PAINT, WESTATES BLUE
   INTERNAL COATING: .....CURED EPOXY
   INTERNAL DISTRIBUTION: .....PVC
3. SPECIFICATIONS:
   FLOW * - CFM (MAX): 300
   PRESSURE - PSIG (MAX): 3
   TEMPERATURE - DEG F (MAX): 140
   CARBON FILL VOLUME - CU FT: 14.0
   CROSS SECTION - SQ FT: 4.9
   SHIPPING WEIGHT - LBS: (APPROX,) 480
   OPERATING WEIGHT - LBS: (APPROX,) 480

(SBV) AS REQUIRED FOR SPECIFIC CONTAMINANTS.

DESIGNER	DATE
AJA	11-2-01
CHECKER	DATE
ENGINEER	DATE
MANAGER	DATE
FILE:	
SCALE:	

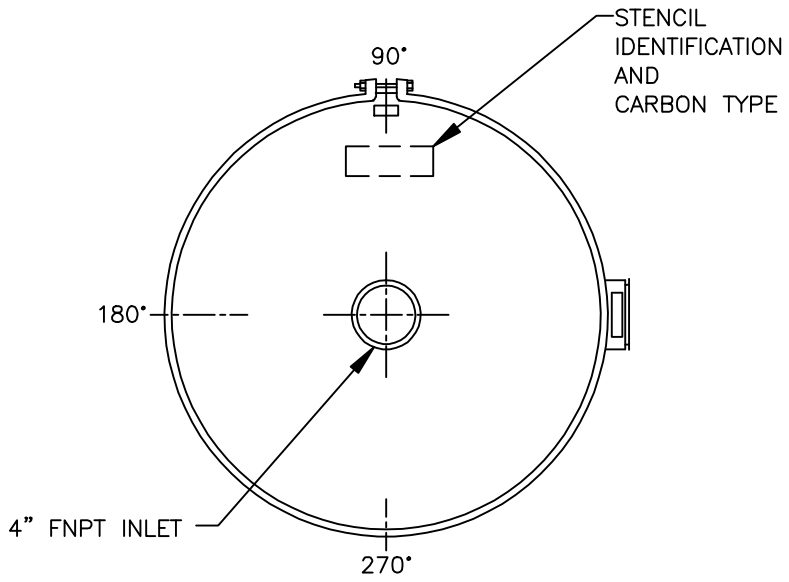
TITLE: VSC400 GENERAL ASSEMBLY

CLIENT:

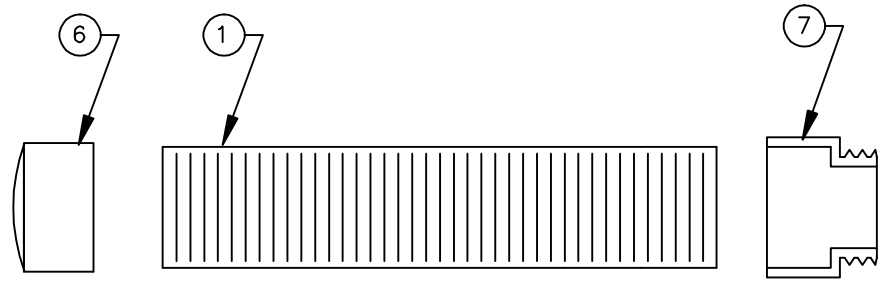
USFILTER/WESTATES
RED BLUFF, CA
1-800-795-2664

PROJECT	DRAWING	SHEET	REV
	VSC400GENASSY.DWG	1 OF 1	

SCHEDULE MATERIALS			
ITEM	QTY	PART #	DESCRIPTION
1	1		4" X 25" PVC JOHNSON SCREEN
2	1		DRUM, 110 GAL, COATED
3	1		ENVELOPE, INSTRUCTION SHEET & MSDS
4	1		DECAL, SIEMENS
5	1		DECAL: CARBON SERVICE 3" X 8" MYLAR, WHITE W/BLUE LETTERS
6	1		CAP 4" PVC SCH/40
7	1		ADAPTER 4" PVC MALE

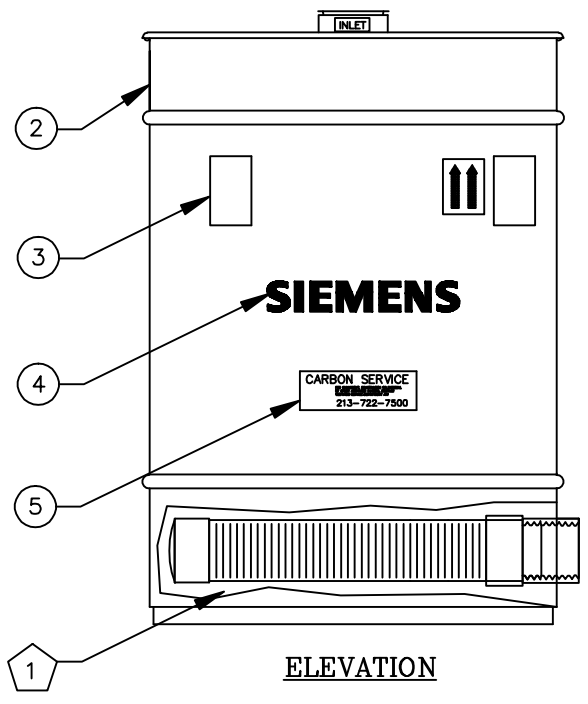


PLAN



1 INTERNAL ASSEMBLY DETAIL

NOT TO SCALE



ELEVATION

NOTES: 1. ESTIMATED WEIGHT: 480 LBS.

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

DESIGNER	CAR
DATE	10-21-05
CHECKER	
DATE	
ENGINEER	
DATE	
MANAGER	
DATE	
FILE:	
SCALE:	NONE

TITLE: VSC400
ADSORBERS 400 SERIES

CLIENT

SIEMENS Water Technologies
RED BLUFF, CA

PROJECT	CODE	DRAWING	SHEET	REV
		VSC400	1 OF 1	0

STD: BORDER-0106-24X36D1 | INTL REF: | BAR = 1" AT PLOT SCALE

TECHNICAL SPECIFICATIONS

SECTION 01010 – SUMMARY OF THE WORK

PART 1 - GENERAL

1.1 PROJECT/WORK IDENTIFICATION

A. General: Project name is Sub-Slab Depressurization (SSD) System Second-Phase Expansion, Building A, Lockheed Martin Middle River Complex, Middle River, Maryland.

B. Summary of Work by Reference: The work of the Contract includes, but is not necessarily limited to, the following Contract Documents:

1. Contractual Legal Requirements

2. Drawings as listed in the Schedule of Drawings

3. Technical Specification – Section 01010 – Summary of the Work

C. Addenda and Modifications: The work of the Contract also includes addenda and modifications to the Contract Documents issued subsequent to the initial printing of the Contract Documents and include, but are not necessarily limited to, printed matter referenced by any of these.

D. Abbreviated Written Summary: Briefly, and without force and effect upon Contract Documents, and including, but not necessarily limited to, printed matter referenced by any of the following.

1. The project is generally described as construction of a second-phase expansion to an existing SSD System. The work includes:

i. Installing five sub-slab soil vapor extraction points (completed by others)

ii. Installing eight vapor monitoring points (completed by others)

iii. Installing header piping from the loading dock to the extraction points

iv. Installing piping to connect the extraction points to the header piping

v. Installing the new blower skid at the current blower skid location and removing the old skid

vi. Hard-wiring the existing indoor air filters in the Building A

basement to the facility's emergency power system

vii. Pilot-testing and startup testing of the expanded system

2. The CONTRACTOR will connect the 2-inch diameter Schedule 40 PVC pipe from each new extraction point to a new 6-inch diameter Schedule 40 PVC header line, and will run the 6-inch header line to the blower skid location to tee into the existing extraction pipe influent line.

3. The CONTRACTOR will remove the existing "blower skid" (blower, moisture separator, control panel, and appurtenances) and replace it with a new blower skid, and reconnect the influent and effluent lines with vapor treatment units to the new blower skid.

4. The CONTRACTOR will connect the control-panel power wire to the same breaker box supplying power to the existing system skid.

5. The CONTRACTOR will hard-wire the three existing indoor-air filters (IQAir GC™ Series-GC VOC) operating in the Building A basement to the facility's emergency power system.

6. After the expansion is installed, the SSD System will be rebalanced by adjusting the throttling valves to pull approximately 25 SCFM from the new vertical extraction points and 35 SCFM from each of the new and existing extraction trenches/laterals. Startup of the expanded system will include readings of induced vacuum, applied vacuum, flow rate, and photoionization detector (PID) readings. Moisture accumulation will be monitored during startup.

1.2 DRAWINGS

The general character and scope of the work is illustrated by the listed drawings. Any additional detail drawings and other information deemed necessary by the ENGINEER will be furnished to the CONTRACTOR when required by the work.

Drawing No.	Drawing Title
G-1	Plan Overview, 100% Design, SSD System Second-Phase Expansion – Building A
G-2	Piping Layout and Details, 100% Design, SSD System Second-Phase Expansion – Building A
G-3	Process and Instrumentation Diagram, 100% Design, SSD System

Second-Phase Expansion – Building A

PART 2 - PRODUCTS

Refer to Section 13825 – Special Equipment for vapor monitoring point and blower-skid component specifications.

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 01620 – STORAGE AND PROTECTION OF MATERIALS

PART 1 - GENERAL

1.1 GENERAL

A. Store and protect materials in accordance with manufacturer's recommendations and requirements of Specifications.

B. The CONTRACTOR will make all arrangements and provisions necessary for material and equipment storage. All excavated materials, construction equipment, and materials and equipment to be incorporated into the work will be placed so as not to injure any part of the work or existing facilities, and to provide free access to all parts of the work at all times, and to all utility installations in near the work. Materials and equipment will be stored neatly and compactly in locations that will cause the least inconvenience to the OWNER, tenants, and occupants. Storage will be arranged in a manner to provide easy access for inspection.

C. Areas available on the construction site for material and equipment storage will be approved by the ENGINEER and OWNER. Storage areas will be located within the property at locations designated by the OWNER during the pre-construction meeting.

D. Materials and equipment that will become the property of the OWNER will be stored to facilitate their inspection and ensure preservation for work quality and fitness, including proper prevention against damage by freezing and moisture. They will be placed inside storage areas unless otherwise acceptable to the OWNER.

E. Lawns, grass plots, or other private property will not be used for storage purposes without written permission of the OWNER.

F. The CONTRACTOR will be fully responsible for loss or damage to stored materials and equipment.

G. Do not open "manufacturers" containers until installation begins, unless recommended by the manufacturer or otherwise specified.

H. Do not store products in the structures being constructed, unless approved in writing by the ENGINEER.

1.2 UNCOVERED STORAGE

A. The following types of materials may be stored out-of-doors without cover:

1. Bedding/backfill materials

2. Reinforcing steel

3. Piping

4. Precast concrete items

5. Castings

B. Store the above materials (excluding bedding/backfill materials) on wood blocking to prevent contact with the ground.

1.3 COVERED STORAGE

A. The following types of materials may be stored out-of-doors if covered with material impervious to water and ultra-violet light:

1. Granular activated carbon and potassium permanganate media

2. Hose and fittings

B. Tie down covers with rope and slope to prevent accumulation of water on covers. Maintain covers to provide continuous protection from damage.

C. Store materials on wood blocking.

1.4 FULLY PROTECTED STORAGE

A. Store all products not named above in temporary buildings or trailers that have a concrete or wooden floor, a roof, and fully closed walls on all sides.

B. Provide heated storage space for materials that would be damaged by freezing.

C. Protect mechanical and electrical equipment from being contaminated by dust, dirt, and moisture.

1.5 MAINTENANCE OF STORAGE

Maintain periodic system of inspection of sorted products on scheduled basis to ensure that:

A. State of storage facilities is adequate to provide required conditions.

B. Required environmental conditions are maintained on continuing basis.

C. Products exposed to elements are not adversely affected.

1.6 PROTECTION AFTER INSTALLATION

A. Provide protection of installed products to prevent damage from subsequent operations. Remove when no longer needed, before work is complete.

B. Communicate with ENGINEER to coordinate with OWNER traffic control to prevent damage to equipment, materials, and surfaces.

1.7 SECURITY

The OWNER assumes no responsibility for security of the CONTRACTOR's materials or equipment on the property at any time.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 01650 – FIELD TESTING AND STARTUP

PART 1 - GENERAL

1.1 GENERAL

Summary: This section specifies the requirements for field-testing and startup activities to verify operation of the expanded sub-slab depressurization (SSD) system.

1.2 REQUIREMENTS

A. Provide the services of qualified technicians who will provide the following services:

1. Assist in the installation of the equipment.

2. Check the installation of the equipment and make all necessary adjustments before testing begins.

3. Perform equipment and system tests and startup procedures as described herein and in accordance with the project's Construction Quality Control Plan (CQCP).

B. The CONTRACTOR will include sufficient time in the construction schedule to complete all equipment and system testing, troubleshooting, corrections, and startup activities as specified. The ENGINEER will witness and document all field-testing and startup activities.

1.2 CHECKS AND FIELD TESTS

A. The following operations will be conducted as a prerequisite for the field tests:

1. Set, align, and assemble all equipment and systems in conformance with the manufacturer's drawings and instructions.

2. Check equipment for proper rotation.

3. Check motors for no-load current draw.

4. Run the equipment and check equipment for excessive vibration and noise.

5. Complete the equipment checklists in the CQCP.

6. Check all equipment, interconnections, and accessories to verify condition and specified performance capability. Instrumentation and

controls will be tested with the equipment to which they are connected.

B. Field tests of equipment will prove that equipment and appurtenances are free from defects such as overheating, overloading, and undue vibration.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 EXAMINATION AND VERIFICATION OF CONDITION

A. The CONTRACTOR will inspect system equipment for readiness before testing and startup. Hazardous conditions will be corrected by the CONTRACTOR before proceeding.

1. Testing and startup will not proceed using temporary power or temporary instrumentation and control wiring.

2. All electrical and control connections will be permanent and complete, and all such electrical components and equipment fully functional.

3. Clearly identify all energized electrical equipment during testing.

B. The CONTRACTOR will notify the ENGINEER of any startup activities at least 72 hours before the scheduled startup. Notification will be made during normal working hours.

C. All tests and startup will be performed in the presence of the ENGINEER, who will be present for the entire duration of the test. Checklists in the CQCP will be used.

D. The CONTRACTOR is responsible for the performance and operation of the equipment and systems during testing and startup.

E. Any failures of equipment or systems operated under the direction of the CONTRACTOR will be considered deficiencies and will be corrected.

F. The CONTRACTOR will make all adjustments and corrections necessary to achieve normal, stable operation of the system.

3.2 FINAL TESTING AND SYSTEM STARTUP

A. The CONTRACTOR will test the expanded SSD system by operating all system equipment as a unit, including all related piping, valves, electrical controls, instrumentation, and mechanical parts.

B. For a successful test, the system must run trouble free for four (4) continuous hours. The test will prove the system equipment and appurtenances are properly installed, free from defects, and that they meet their operating parameters as specified in the CQCP.

END OF SECTION

SECTION 05503 – ANCHOR BOLTS, EXPANSION ANCHORS AND CONCRETE INSERTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Under this Section, the CONTRACTOR will furnish all labor, materials, equipment, and incidentals required to provide anchor bolts, expansion anchors, and concrete inserts as shown and specified.

B. General: This section includes all bolts, anchors and inserts required for the work but not specified under other sections. Expansion epoxy resin and expansion anchor bolts will be permitted unless shown or specified otherwise.

C. Related work specified elsewhere: Section 15050 Piping

D. The types of work using the bolts, anchors, and inserts include, but are not limited to, the following:

1. Hangers and brackets
2. Equipment
3. Piping
4. Electrical

1.2 QUALITY CONTROL

A. Reference Standards: All equipment and labor furnished under this section will comply with Codes and Standards set forth by the following organizations:

1. ASTM ASTM International
2. ASME American Society of Mechanical Engineers
3. ACI American Concrete Institute
4. API American Petroleum Institute
5. ANSI American National Standards Institute

B. Qualifications of Manufacturers: Products used for performing the work in this section will be produced by manufacturers who are regularly engaged in

the manufacture and/or supply of similar items for at least five (5) years, and have a history of successful production acceptable to the ENGINEER.

C. Qualifications of Installers: Adequate numbers of skilled workmen who are thoroughly trained and experienced in the specified requirements and the methods needed for proper performance of the work of this section will be used.

1.3 SUBMITTALS

A. General: Submit shop drawings in accordance with General Provisions requirement 105.04.01 for ENGINEER review.

B. Product Data:

1. Manufacturer's specifications and other data required to demonstrate compliance with the specific requirements.

2. A complete bill of materials list showing all items to be furnished and installed.

3. Complete shop drawings of all work of this section, showing dimensions and locations of all items including supporting structures and clearance requirements.

1.4 PRODUCT HANDLING

A. Protection: Use all means necessary to protect materials of this section before, during and after installation and to protect installed work and materials of all other trades.

B. Replacement: In the event of damage, immediately make all repairs and replacements necessary to the approval of the ENGINEER and at no additional cost to the OWNER.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

A. When the size, length, or load carrying capacity of an anchor bolt, expansion anchor, or concrete insert is not shown on the Contract Drawings, provide the size, length and capacity required to carry the design load times a minimum safety factor of four.

2.2 MATERIALS

A. General: All materials will be of the very best quality and entirely suited for the service to which they will be subjected. All ferrous inserts and items other than stainless steel that will be embedded in concrete will be hot-dipped galvanized. Except where noted otherwise, all stainless steel angles, bolts and nuts will be type 316.

B. Anchor Bolts: Provide type 316 stainless steel bolts complying with ASTM. Also provide type 316 stainless steel anchor bolts for all equipment. Other AISC types may be used subject to ENGINEER's approval.

C. Expansion and Epoxy Resin Anchors: Expansion shield anchors and epoxy resin (with or without capsule) anchors will be used where shown on Contract Drawings and when permitted by the ENGINEER. Material of all anchor components will be stainless steel, Type 316. They will be Molly Parabolts by USM Corporation, Kwik-Bolt by Hilti Corporation, Kelken-Gold anchor system, or equal. Literature from the manufacturer will be available for all epoxy-resin anchors, and will include information about setting time, strength, and installation. A minimum safety factor of four (4) will be provided for the required working load.

D. Anchors will not be used to resist vibratory loads in tension zones of concrete members. Bolt supplier(s) will submit certified test data verifying that minimum loads indicated in Tables 05503-1 and 05503-2 can be met.

E. Power actuated fasteners and other types of bolts and fasteners not specified herein will not be used unless approved by ENGINEER.

F. Connection Bolts: Materials will be as specified in other sections of the specifications or shown on the Contract Drawings. Where materials are not specified or shown on the Contract Drawings, they will be of Type 316 stainless steel or Monel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Drilling equipment used and installation of expansion anchors will be in accordance with manufacturer's instruction.

B. Ensure that embedded items are protected from damage and are not filled in with concrete.

C. Expansion anchors may be used for hanging or supporting pipe two inches diameter and smaller, except for use in new concrete construction (see F below). Expansion anchors will not be used for larger pipe unless so shown or approved by the ENGINEER.

D. Use concrete inserts for pipe hangers and supports for the pipe size and loading recommended by the insert manufacturer.

E. All inserts, anchor bolts and other miscellaneous metalwork that will be embedded in concrete: concrete will be properly set and the metalwork securely held in position in the forms before the concrete is place, as specified and shown on the Contract Drawings or required for the proper completion of the work.

F. In new concrete construction, expansion anchors and epoxy grouted anchors may be used for hanging or supporting pipe 4 inches diameter and smaller. Expansion anchors and epoxy-grouted anchors will not be used for larger pipe in new concrete construction unless otherwise shown or approved by the ENGINEER.

G. Expansion anchors and epoxy-grouted anchors are also permitted in equipment support pads and at other installations where described on the Contract Drawings, or as approved by the ENGINEER.

H. Expansion bolts will NOT be permitted in lieu of anchor bolts to support piping larger than 4 inches in diameter, except where piping, ductwork, conduit, etc., is of lightweight material, or except where specifically permitted by the ENGINEER.

I. Epoxy shield anchors and epoxy resin (with or without capsule) anchors will be field tested to simulate actual installed conditions to determine their suitability for the intended application. The CONTRACTOR will be responsible for having any epoxy-based anchoring system tested as specified hereafter. Strength testing will be performed at 100% of the minimum pullout loadings for the specific-sized anchor bolt listed in this section of the specifications.

J. If the ENGINEER determines that testing the complete anchoring system (i.e., bolt, epoxy, concrete, etc.) reveals unsatisfactory strength (in a representative number of tests, as determined by the ENGINEER), the CONTRACTOR will be required to perform a full-scale “pullout” testing program. The objective of this program will ascertain the cause of the unsatisfactory strength test results, and verify that the anchoring system does not comply with the specified working strength requirements (including factor of safety). “Pullout” testing

(to failure) will be performed on a random selection of one (1) bolt per ten (10) anchors, or as otherwise determined by the ENGINEER.

K. Testing will be conducted by a testing agency other than the anchor manufacturer and will be certified by a professional engineer with full description and details of the testing program, procedures, results and conclusions. All testing will conform to the requirements of ASTM E488. Results of the testing program will be provided to the ENGINEER.

L. Where depths of embedment and anchor bolt sizes are not shown or specified, the minimum values listed in the following tables will be maintained.

M. Anchors will be installed in accordance with manufacturer's recommendations. Power driven "pin" or "stud" type fasteners will not be permitted.

3.2 CLEANING

Remove protection and clean bolts and inserts after embedding concrete is placed.

TABLE 05503-1: EXPANSION SHIELD ANCHOR

Bolt Dia. (in.)	Allowable Work Load (lb)		Embedment (in.)	Installation Torque (ft-lb)	Min. Spacing (in.)	Min. Edge Distance (in.)
	Tension	Shear				
¼	320	560	3 ¾	7	4	3 ⅜
⅜	430	880	4 ¼	30	5	4 ⅞
½	850	1810	6	75	7	6 ¾
⅝	1250	2800	7	110	8	8 ¼
¾	1550	2880	8	200	9 ½	9 ¾
1	3120	6080	9	450	12	13 ½

TABLE 05503-2: EPOXY RESIN ANCHORS

Bolt Dia. (in.)	Allowable Work Load (lb)		Embedment (in.)	Min. Spacing (in.)	Min. Edge Distance (in.)
	Tension	Shear			
⅜	1560	1070	3 ½	3 ½	5 ¼
½	2660	2090	4 ¼	4 ¼	6 ⅜
⅝	4120	3000	5	5	7 ½
¾	5750	4800	6 ⅝	6 ⅝	10
⅞	6770	9240	7	6 ⅝	10
1	9640	7630	8 ¼	8 ¼	12 ⅜
1 ¼	19380	13070	12	12	18

END OF SECTION

SECTION 13825 – SPECIAL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

This section specifies the requirements for special equipment.

PART 2 - PRODUCTS

2.1 VAPOR MONITORING POINTS

Each vapor monitoring point will be a stainless steel Vapor Pin™ by Cox-Colvin and Associates, Inc. with silicone sleeve, protective cap, and secure cover. A total of eight vapor pins will be installed.

2.2 BLOWER

A. The blower will be a Rotron® regenerative blower model R909BB72Wwith 10 horsepower motor by Ametek Technical & Industrial Products and will be rated for 300standard cubic feet per minute (SCFM) at 75 inches of water column:

1. Voltage: 230/460 AC
2. Phase: 3 Phase, 60 hz
3. Max. Operating Temperature: 140ºC

B. The blower will be provided with the following fittings and valves:

1. 3-inch diameter Solberg inline filter
2. 3-inch diameter universal dilution valve
3. 2½-inch diameter Apollo butterfly valve
4. 2-inch diameter Fisher vacuum relief valve
5. Ametek flow meter part number 550606

6. Vacuum gauges with isolation valves
7. Pressure gauges with isolation valves
8. Temperature gauges

C. The blower will be provided with the following 460v, 3-phase control panel mounted and wired:

1. 30-inch×24-inch×8-inch National Electrical Manufacturers Association (NEMA)-4 enclosure with control panel
2. Main non-fused disconnect with thru-door operator
3. 10 horsepower 460v blower starter with fusing
4. One (1) horsepower 460v heat exchanger (HEX) starter with fusing
5. HEX to run when blower runs
6. Hand-Off-Auto (H-O-A) selector switch for blower and HEX
7. One (1) green run light for blower and heat exchanger
8. Six (6) red fault indicating lights for:
    a. high level (normally closed)
    b. high temperature (normally closed) (2)
    c. high pressure (normally closed)
    d. low vacuum(normally closed)
    e. spare
9. Alarm condition reset button
10. 250va control transformer with fused primary and secondary
11. Eight-channel auto-dialer: Sensaphone® 800 Monitoring System, part number FGD-0800
12. Terminal blocks for remote connections

2.3 HEAT EXCHANGER

The heat exchanger will be model AA-400 by Xchanger Industrial Heat Exchangers rated for 400 SCFM:

A. Design temperature: 200ºF

B. Temperature in: 180ºF

C. Temperature out: 110ºF

D. Connections (inlet and outlet): 4-inch diameter

2.4 MOISTURE SEPARATOR

A. The moisture separator will be model GX-100DL by Gasho, Inc.:

1. Diameter: 27 inches
2. Height: 75 inches
3. Integral demister/inline filter rated for 99.5% entrained water removal
4. Connections (inlet and discharge): 4-inch diameter
5. Liquid capacity: 40 gallons
6. Nominal flow rate: 400 SCFM
7. Level switch
8. Heat traced and insulated

2.5 SWITCHES

A. Two NEMA 4 temperature switches, Ashcroft part number T424-T050303 or approved equal.

B. One NEMA 4 pressure switch, Dwyer part number 1950-P or approved equal.

C. One NEMA 4 low vacuum switch, Dwyer part number 1950P-5-2F or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

The CONTRACTOR will install all equipment specified in accordance with each manufacturer's recommendations. The blower, heat exchanger and associated control panel, piping, valves, and switches will be provided on a prefabricated skid by Gasho, Inc.

3.2 TESTING

The CONTRACTOR will demonstrate in the presence of ENGINEER'S authorized representative that all equipment and controls specified herein function in accordance with their intended purpose and ranges.

END OF SECTION

SECTION 15050 – PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: This section covers the furnishing, installation and testing for all piping, fittings, jointing materials, blocking and all other necessary appurtenances as shown on the Contract Drawings and as specified herein to be furnished and installed by the CONTRACTOR, except where specific requirements are given in other sections.

B. General:

1. The Contract Drawings indicate the required pipe sizes and general arrangement of all piping and equipment. Exact locations will be verified by the CONTRACTOR in the field. The CONTRACTOR will obtain the approval of the ENGINEER before changing the locations of any work due to field conditions. All minor changes approved by the ENGINEER will be made at no additional cost to the OWNER. Under no circumstances will pipe sizes indicated on the drawings be changed without the written approval of the ENGINEER.

2. The CONTRACTOR will determine and be responsible for the proper locations and character of all inserts for hangers, chases, sleeves and other openings in the construction required for the piping work, and will obtain this information well in advance of the construction progress so as not to delay the work. Final locations of all built-in items will be coordinated with work of other trades to prevent interferences.

3. All installed piping will form completely connected systems including connections to valves and equipment specified in other sections of the specifications. No work will be installed until complete shop drawings of such equipment have been approved by the ENGINEER.

4. All vapor extraction piping will be labeled with “vacuum” self-sticking vinyl pipe markers.

1.2 SUBMITTALS

The CONTRACTOR will prepare and submit to the ENGINEER, for review and approval, certificates of compliance on materials furnished and manufacturers' brochures containing complete information and instructions pertaining to the storage, handling, installation, maintenance, and repair of each type of pipe and pipe fitting being furnished. A complete bill of materials, properly referenced, will be included. The bill of materials will show the quantity, size, manufacturer, specifications, etc. of all pipe, fittings, jointing materials, accessories, etc. covered under this section of the specifications.

PART 2 - PRODUCTS

2.1 GENERAL

All pipe will be produced in a plant of recognized reputation and regularly engaged in the production of pipe, conforming to the specified standards.

2.2 PIPE MATERIAL

A. PVC Pipe and Fittings:

1. Pipe: PVC pipe will meet industry standards ASTM D1784/D1785 and ANSI/AWWA C900. PVC pipe will be Schedule 40 unless as otherwise shown on the Contract Drawings.

2. Joints: PVC pipe joints will be solvent welded.

3. Saddle Fittings: Saddle fittings will be Schedule 40 clamp-on saddle x socket, single outlet type, and conform to ASTM D2564. Saddle fittings will be used for tie-ins to the existing header pipe.

4. Fittings: All pipe fittings will be Schedule 40 socket type and conform to ASTM D2467, except for transition or special couplers as noted on the Contract Drawings.

5. Connection Materials: PVC primers conforming to ASTM F656 and PVC solvent cement conforming to ASTM D2564 will be used for socket type connections.

6. PVC Pipe Storage: PVC pipe will be stored or stacked so that damage due to marring, crushing, or piercing is prevented.

Maximum stacking height will be limited to 6 feet. For storage lasting longer than 5 days, a location will be chosen out of direct sunlight or the piping and fittings will be covered.

B. Steel Pipe:

Piping will be Schedule 40 in accordance with ASTM A53/A53M-12.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Installation of piping work will be complete in every respect, ensuring that systems which will operate satisfactorily and quietly. All work will be done by skilled workmen. All cutting, fitting repairing and finishing of concrete and metalwork required for the work under this section will be done by craftsmen skilled in their respective trades and at the expense of the CONTRACTOR. Unless otherwise indicated, all material and equipment will be installed in conformance with the manufacturer's recommendations.

B. Proper and suitable tools and appliances for the safety and convenient handling and installation of the pipe and fittings will be used. Care will be taken to prevent damage to any coatings and linings on pipes and fittings. All pieces will be carefully examined for defects and no defective pieces will be installed. If any defective piece is discovered after it has been installed, it will be removed and replaced with a sound one in a satisfactory manner by the CONTRACTOR at his expense. Pipe and fittings will be thoroughly cleaned before they are accepted in the complete work.

C. All piping connecting to equipment will be provided with unions or companion flanges so that piping may be readily dismantled from equipment. Connections between ferrous and non-ferrous metals in piping systems will be made with dielectric unions.

D. All piping will be installed in such a manner that ensures it will be free to expand and contract without injury to itself or its supporting structure. On all piping, expansion joints will be installed as shown on the Contract Drawings. Guides and anchors will be furnished and installed in an approved manner.

E. All piping passing through walls and floors will be installed in pipe sleeves or wall castings.

F. Installation of Flanged Piping: All joints in flanged piping will be brought to exact alignment and all gaskets and bolts or studs will be uniformly tightened

around the joints. Where stud bolts are used, the bolts will be uniformly centered in the connections and equal pressure applied to each nut on the studs.

G. Installation of Threaded Piping: All threaded joints will have long taper thread that will be made tight with oil and graphite paste applied to external threads only. All pipe 1-1/2 inches and smaller will be reamed to remove scale and dirt. Wrenches on valves and fittings will be applied directly over the joint tightened.

3.2 TESTING OF PIPING SYSTEMS

A. All piping systems installed under this section will be tested in the manner specified herein and in the presence of the ENGINEER. No piping will be concealed until it has been tested to the satisfaction of the ENGINEER. Testing media will be furnished and disposed of by the CONTRACTOR, and all materials, labor and equipment required for the testing procedures will be at his expense. Any leaks or defective piping disclosed by the test will be replaced or repaired, and the test repeated until all piping proves tight. No caulking of defective piping or joints will be permitted.

B. The CONTRACTOR will furnish, install, and remove temporary flanges, plugs, or bulkheads whenever necessary to complete the required pressure tests.

C. Pipe system tightness will be tested at approximately sixty (60) inches of water vacuum. The vacuum will be held for one hour with a maximum 0.5-inch drop. Any leaks will be located and repaired.

END OF SECTION

SECTION 15060 – PIPE HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

This section covers the CONTRACTOR requirements for furnishing and installing all piping support material and hangers.

1.2 RELATED SECTIONS

Section 15050 Piping

Section 15050 Anchor Bolts, Expansion Anchors and Concrete Inserts

1.2 REFERENCES

A. ASTM International (ASTM): ASTM A36/A36M-94Carbon Structural Steel.

B. American Welding Society (AWS):

1.	AWS A5.1-91	Carbon Steel Electrodes for Shielded Metal Arc Welding.
2.	AWS D1.1-94	Structural Welding Code-Steel.

C. Manufacturers Standardization Society (MSS): MSS SP-89-91 Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 QUALITY CONTROL

A. All pipe supports and auxiliary steel will be of bolted or welded construction complying with MSS SP-89. Welded construction will comply with AWS D1.1.

B. Examination: The CONTRACTOR will perform all quality control visual examinations of materials upon delivery to work site.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling:

1. Piping support materials and piping hanger systems will be stored off the ground and handled with care so that physical damage to the materials does not occur.

2. Care will be taken when storing and handling all piping support materials and pipe hanger systems, so that corrosion or contamination by grease, moisture, or other foreign matter does not occur.

3. Welding rods and electrodes will be stored, handled, and identified at all times to ensure the use of the proper welding rod.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Provided equipment will be as manufactured by one of the following, or approved equal:

1. Bergen-Power Pipe Supports, Inc., phone 610-363-3500, fax 610-363-3979.

2. PHS Industries, Inc., phone 504-431-7722, fax 504-431-7900.

2.2 MATERIALS

A. ASTM A36 steel will be used for all plate and structural shape support components.

2.3 FABRICATION

Shop Assembly: Any parts made in the supplier's shop will be completely shop assembled, as far as practical, before they are shipped to the site.

2.4 LABELING

Product Marking: All welding rods and electrodes will be identified with at least one imprint per rod showing an AWS classification number in accordance with AWS

A5.1. In addition, welding rods 1/8-inch diameter and over will be marked or stamped with positive identification marks at intervals of not more than 18 inches. Such marks will be clearly distinguishable and will include the classification number of the welding rod and the trade designation of the manufacturer. Filler metal requirements will conform to AWS A5.1.

PART 3 - EXECUTION

3.1 PRODUCTS/EQUIPMENT

Product Shipping Requirement: The CONTRACTOR will be responsible for the delivery of all job-related materials and/or equipment to the job site. All furnished materials and equipment will be delivered clean, undamaged, and in good condition.

3.2 PREPARATION

A. Protection: All welding/fabricating activities will be protected from inclement weather at all times.

B. Primer and Finish Application: All structural steel pipe-support material systems will be prime-coated after fabrication. The items that are painted as standard by the manufacturer do not require prime coating.

3.3 INSTALLATION

Hangers and support components will be installed in accordance with the manufacturer’s recommended installation procedures.

END OF SECTION

SECTION 15100 – VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:

The CONTRACTOR will provide all labor, equipment and materials necessary to furnish, install, and test all valves required to complete piping systems as shown on the Contract Drawings and specified both in this Section.

B. Related Work Described Elsewhere:

1. Section 15050 Piping

1.2 QUALITY CONTROL

Standards:

A. Comply with AWWA, ANSI, ASTM, NFPA, NEC and all other applicable federal, state and municipal codes and regulations including revisions as of date of Contract.

B. Qualifications of Manufacturers: Products used in the work of this section will be produced by manufacturers regularly engaged in the manufacture of similar items and with a history of successful production acceptable to the ENGINEER.

1.3 SUBMITTALS

Product Data:

A. Manufacturer’s specification and other data required to demonstrate compliance with the specific requirements. Such submittals will include 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.

B. A completed materials list showing all items to be furnished and installed.

1.4 PRODUCT HANDLING

A. Protection: Use all means necessary to protect materials of this section before, during, and after installation and to protect installed work and materials of all

other trades.

B. Replacements: If damage occurs, immediately make all repairs and replacements necessary to the approval of the ENGINEER and at no additional cost to the OWNER.

C. Valve Identification:

Cast marking will appear on each valve, identifying the following:

1. Manufacturer's name or mark
2. Size of valve (pie size)
3. Working pressure
4. Year of valve manufacture
5. Flow direction arrow (required for swing check valves, rate of flow valves, plug valves, pressure-reducing valves and pressure relief valves only)

PART 2 - PRODUCTS

2.1 GENERAL

A. Design:

1. Where used, the names of manufacturers and specific catalog numbers are given only as an indication of the quality of the materials and workmanship to be used. Equal products by other manufacturers approved by the ENGINEER will be acceptable.
2. For uniformity, all valves of a particular type will be furnished by one manufacturer.

B. End Connections: All valve end connections will match the piping to which they will be installed, as described in Section 15050, Piping.

2.2 THROTTLING DIAPHRAGM VALVES

A. Diaphragm valves will be PVC body, manual operation, 2-inch diameter; PTFE diaphragm; by IPEX or approved equal.

PART 3 - EXECUTION

3.1 INSPECTION

Examine the areas and conditions under which work of this section will be installed. Correct conditions detrimental to proper and timely completion of the work. Do not proceed until all unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Interior Installations: Valves installed in interior piping will be supported on both the suction and discharge sides.

B. Cleaning Valves: The inside of all valves will be cleaned by brushing and by thoroughly blowing out with air to remove slag, dirt and other sediment, as well as other foreign materials, before being installed. During installation, sufficient care will be exercised to prevent foreign matter from entering the valves.

C. Handling of Valves:

1. Proper and suitable tools and appliances for the safe and convenient handling and laying of all valves will be used. Care will be taken to prevent the valve coating from being damaged, particularly on the inside of the pipes and fitting and any damage will be remedied as directed. No defective valves will be installed. If any defective valve is discovered after it is installed, it will be removed and replaced with a sound valve in a satisfactory manner by the CONTRACTOR at his own expense.

2. All valves will be laid to proper line and grade. Open ends of valves will be kept plugged with a bulkhead during construction.

3.3 FIELD TESTING

A. Valves will be field-tested as an integral part of the pipeline. Pipe lines including valves will be tested as described in Section 15050, Piping.

END OF SECTION

APPENDIX D—PRESSURE-LOSS CALCULATIONS

SYSTEM-COMPONENT HEAD LOSS

Building A Sub-Slab Depressurization System Second-Phase Expansion
Lockheed Martin Corporation, Middle River Complex

System flow: 265 standard cubic feet per minute (SCFM)

Vacuum-side loss for system components

Component	Loss (inches water column)
Polyvinyl chloride (PVC) pipe	<4
Pipe at blower	<2
Moisture separator	<1
Filter	18 (worst case scenario)
Miscellaneous	<3
Total	**<28**

Pressure-side loss for system components

Component	Loss (inches water column)
PVC pipe	<8
Pipe at blower	<2
Heat exchanger (if needed)	<5
Flow meter	<4
Granular-activated carbon (2)	<15
Miscellaneous	<3
Total	**<37**

BY PAR DATE 10/20/15 PROJECT LOCKHEED MARTIN SHEET NO. 1 OF 2

CHKD. BY BAC DATE 10.21.15 MRC BUILDING A SSDS PROJ. NO.

(2nd Phase Expansion)

DETERMINE WORST CASE FRICTION LOSS AT DESIGN VALUES

SUCTION SIDE

A. SSD-36-A IS FURTHEST FROM SKID (DWG G2)

LATERAL 2" DIA - 100' + (3) 90°EL @ 5' EACH + DIAPHAGM VALVE @ 25' = 140'

25 SCFM - 0.011" LOSS/FT X 140 = 1.54"

(SEE NOMOGRAPH

HEADER 6" DA - 530' + (5) 90° EL @ 15' EACH = 605'

150 SCFM (MAX = <0.0028" LOSS/FT X 605' = <1.69"

PIPE TO BLOWER <4" LOSS

B SUCTION PIPE AT BLOWER SKID

4" DIA PORTS AND PIPE - 10' + (2) 90°EL @ 10' = 30'

290 SCFM - 0.05" X 30 = 1.5" LOSS

C MOISTURE SEPARATOR

GX-100 <4" LOSS

D FILTER 18" WORST CASE FOR FOULED FILTER WILL REPLACE

E MISC, SAFETY 2"

TOTAL SUCTION SIDE LOSS <28"

PRESSURE SIDE

A STACK AND GAC CONNECTING HOSE ARE 4" DIA

~100' + (6) 90°ELs @ 10' = 160'

290 SCFM 0.05" LOSS/FT X 160 = 8"

B PIPE AT BLOWER SKID

5' X (2) 90°EL = 25'

290 SCFM 0.05"/FL X 25 = 1.25

C HEAT EXCHANGER ≤5" (SIMILAR TO BLDG C)

D FLOW METER ≤4" (SEE CUT SHEET)

E GAC ≤7.5" LOSS EACH (SEE CUT SHEET)

F MISC, SAFETY 3"

TOTAL PRESSURE SIDE LOSS ≤ 37"

CHECK

BLOWER CURVE SUCTION 290 SCFM @ ~80" H2O

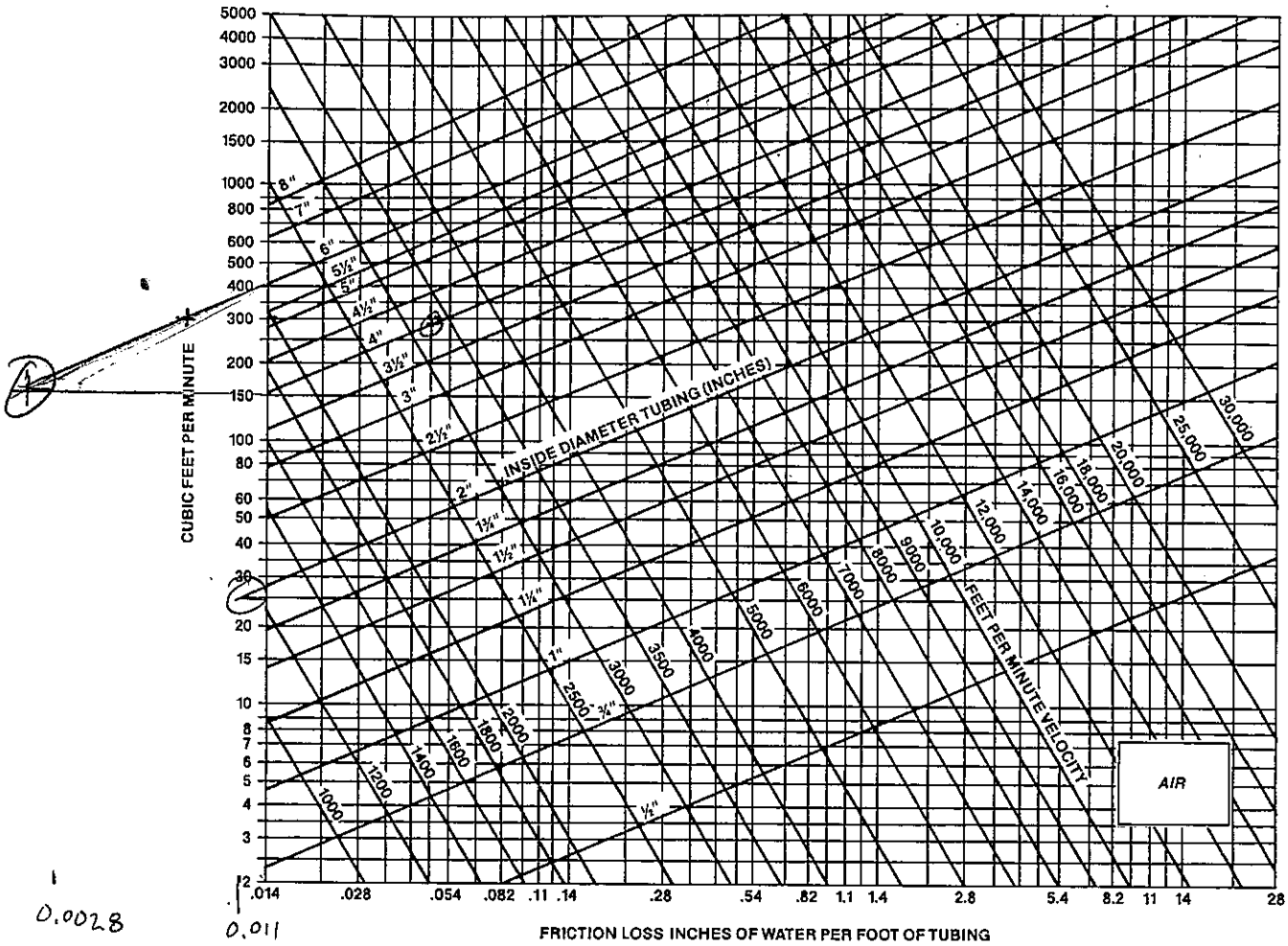
28" LOSS ok ✓

PRESSURE 290 SCFM @ ~115" H2O

37" LOSS ok ✓

Application Engineering Basics

Friction Loss Per Foot of Tubing



Friction Loss in Fittings

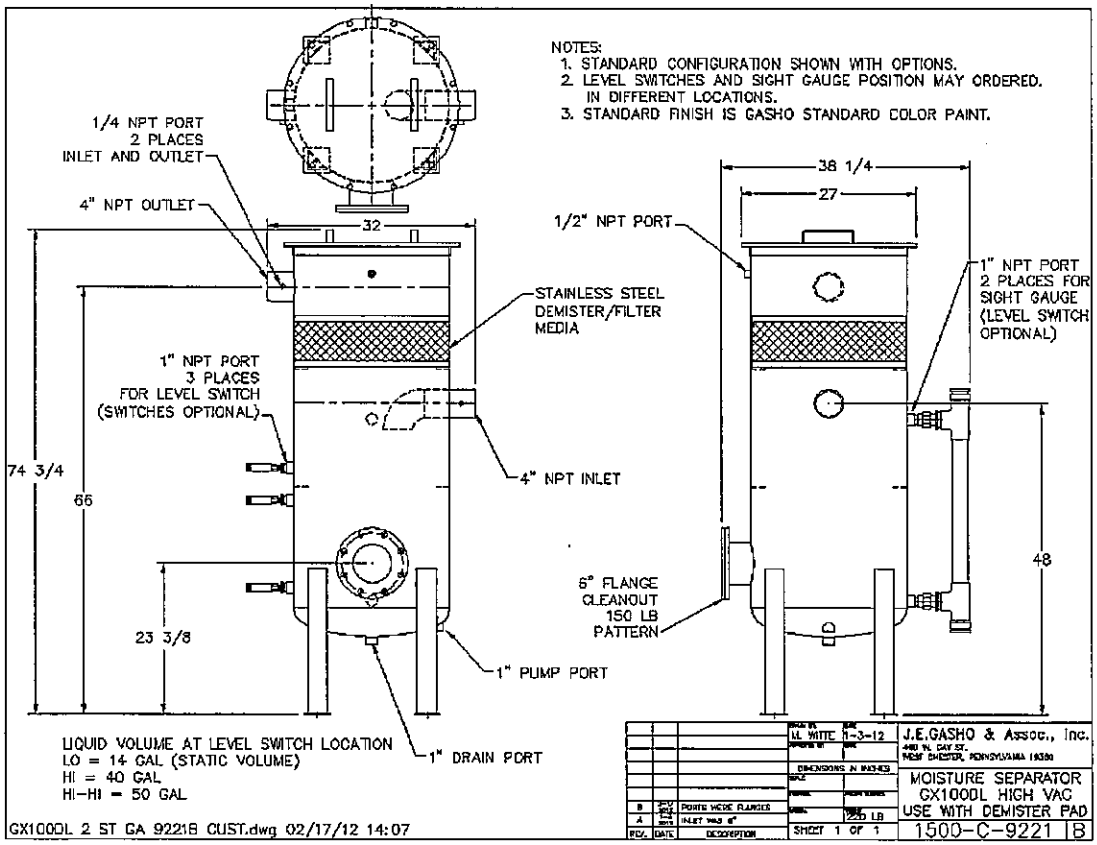
To calculate friction loss in fittings use chart below. This chart will yield equivalent lengths (in feet) of tubing. Use this length with graph above to find friction loss in inches of water column.

NOMINAL PIPE SIZE (INCHES)	EQUIVALENT TUBING LENGTH (FEET)	
	90° EL	45° EL
1 1/4	3	1.5
1 1/2	4	2
2	5	2.5
2 1/2	6	3
3	7	4
4	10	5
5	12	6
6	15	7.5
8	20	10

The Leader in Blower & Vacuum Solutions
460 West Gay Street
West Chester, PA 19380

GX100-DL Moisture Separator, 400 CFM Specification

100 gallon vessel with approx. 40 gallons of storage
Flow Rate- 400 ICFM, Vacuum rating 28" Hg
Integral SS demister / filter media, 99.5% entrained water removal
Pressure drop through clean media = .25 IWC
Welded steel construction, reinforced for high vacuum
External Site Gauge
Level Switch Ports- (3) 1" NPT ports, 6" 150 Lb. Flange Cleanout port with clear cover
4" NPT inlet, and outlet
Standard External finish is alkyd paint, inside is left uncoated
Optional coatings available



Measurement Accessories

Blower Connection Key
NPT – American National Standard Taper Pipe Thread (Male)
NPSC – American National Standard Straight Pipe Thread for Coupling (Female)
SO – Slip On (Smooth – No Threads)

Air Flow Meter

FEATURES

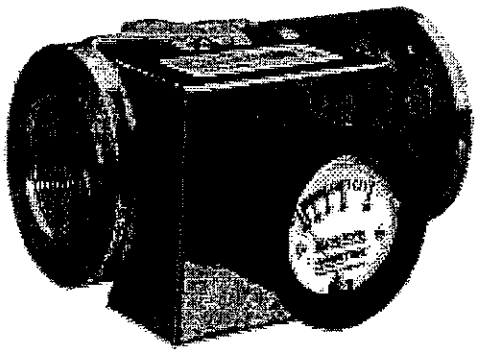
- Direct reading in SCFM
- Low pressure drop (2-4" typical) across the flow meter
- Non-clogging, low impedance air stream
- Light weight aluminum
- No moving parts
- Large easy-to-read dial
- Accurate within 2% at standard conditions
- Good repeatability
- Available in 2", 3" and 4" sizes
- Factory configured for quick installation
- .048" Allen key supplied for gauge adjustment

OPTIONS

- For 4-20 mA outputs and digital readouts see page G-9
- High temperature version (above 140°F)
- Corrosion-resistant version with Chem-Tough™ or in stainless steel
- FDA-approved Food Tough™ surface conversion
- High pressure version (100 PSI)

BENEFITS

- OPTIMIZE SYSTEM EFFICIENCY
  Measuring the correct air flow can assist you in fine-tuning to your system's optimal efficiency.
- BALANCE MULTI-PIPING SYSTEMS
  When evacuating CFM from more than one pipe, different run lengths or end system impedance can cause one pipe to handle more CFM than the other. With an accurate CFM reading, piping can be balanced by bleeding air in/out or by creating an extra impedance.
- DETECT CHANNELING OR PLUGGING
  For systems in which channeling or plugging can occur, a change in the CFM measured can help indicate the unseen changes in your system.



Current Models		Flow Range	B	C	D	E	F
Model	Part #	(SCFM)	Threads	Length	Width		
FM20C030Q	550599	6-30	2" - 11.5 NPSC	7.18"	7.0"	2.0"	3.75"
FM20C045Q	550600	9-45					
FM20C065Q	550601	13-65					
FM20C125Q	550602	25-125			5.6"		
FM20C175Q	550603	35-175					
FM20C225Q	550604	45-225					
FM30C250Q	550605	50-250	3" - 8 NPSC	7.52"	7.4"	2.5"	4.43"
FM30C350Q	550606	70-350					
FM30C475Q	550607	95-475					
FM40C450Q	550608	90-450	4" - 8 NPSC	8.00"	7.7"	2.7"	5.43"
FM40C600Q	550609	120-600					
FM40C850Q	550610	170-850					

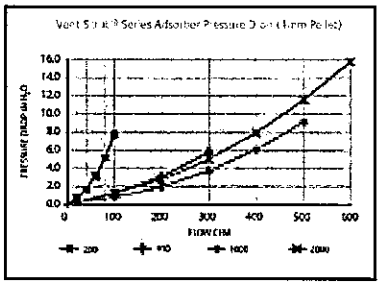
Specification					
Vent-Scrub® Adsorber Model No.	200	400	1000/2000	3000	8000
Dimensions, diameter x overall height	22" x 34"	32" x 43"	48" x 59"/48" x 95"	60" x 112"	96" x 131"
Inlet Connection	2" FNPT	4" FNPT	4" FNPT	10" Flange	16" Flange
Outlet Connection	2" MPT	4" FNPT	4" FNPT	10" Flange	16" Flange
Manway	Top	Top	18" Top	16" Top	20" Top/Side
Internal Distribution[1]	PVC	PVC	PVC	FRP/PPL	FRP/PPL
Interior Coating	Epoxy	Epoxy	Epoxy	Epoxy	Epoxy
Exterior Coating	Enamel	Enamel	Epoxy/Urethane	Epoxy/Urethane	Epoxy/Urethane
Carbon Fill Volume (Cu.ft.)	6.8	14	34/68	107	273
Cross Sectional Area (sq.ft.)	2.8	4.9	12.3	19.6	50.2
Approx. Carbon Weight (lbs)	200	400	1000/2000	3000	8000
Empty Vessel Weight (lbs)	50	80	890/1190	2500	5500
Flow, CFM (max.)	100	300	500	1500	3750
Pressure, psig (max.)	3	3	14.9	5	5
Temperature, deg. F (max)[4]	140	140	140	140	140
Vacuum, in. Hg (max.)	N/A	N/A	12/12[2]	6[3]	12[3]

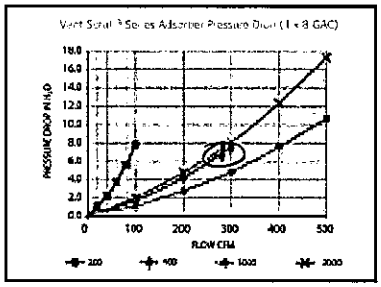
[1]*Carbon steel and stainless steel internals are also available.*
[2]*For vacuum greater than 12 in. Hg on Vent-Scrub® 2000 Adsorber, contact your Siemens representative.*
[3]*For vacuum service on Vent-Scrub® 3000 and 8000 Adsorber, contact your Siemens representative.*
[4]*For higher temperatures, stainless and carbon steel internals are available.*
For detailed dimensional information or drawings, contact your local Siemens sales representative.

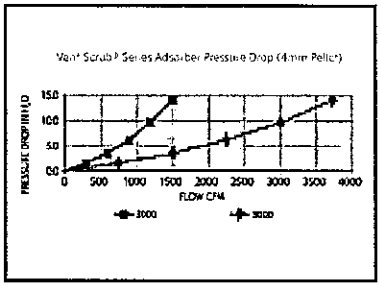
Warning
The adsorption of organic compounds onto activated carbon generates heat. In rare instances, adsorbed compounds may also react on the carbon surface to generate additional heat. If these heat sources are not properly dissipated, the carbon bed temperature may rise to the point where the carbon can ignite, leading to a fire or other hazardous condition. A description of industry-accepted engineering practices to assure the dissipation of heat and safe operation of the carbon bed can be provided upon request. In certain applications where the risk of ignition is significant, activated carbon may not be a recommended treatment technology. Please contact your Technical Sales Representative for more details.

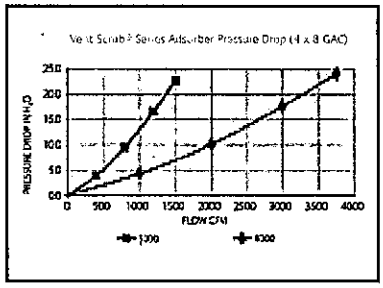
Wet activated carbon readily adsorbs atmospheric oxygen. Dangerously low oxygen levels may exist in closed vessels or poorly ventilated storage areas. Workers should follow all applicable state and federal safety guidelines for entering oxygen depleted areas.

All information presented herein is believed reliable and in accordance with accepted engineering practices. Siemens makes no warranties as to the completeness of this information. Users are responsible for evaluating individual product suitability for specific applications. Siemens assumes no liability whatsoever for any special, indirect or consequential damages arising from the sale, resale or misuse of its products.









Siemens
Water Technologies
2430 Rose Place
Roseville, MN 55113
800.525.0658 phone

APPENDIX E—MDE COMMUNICATION

Chang, Belssi

From: Nolan Penney -MDE- <nolan.penney@maryland.gov>
Sent: Tuesday, September 22, 2015 5:42 AM
To: Chang, Belssi
Subject: Re: Air Permit for Sub-Slab Depressurization System

At an extraction rate of 1 lb per day, that would still qualify for deminimus exemption under COMAR 26.11.02.10X. No permit will be needed.

On Mon, Sep 21, 2015 at 3:44 PM, Chang, Belssi <Belssi.Chang@tetratech.com> wrote:

> Hello Nolan,
>
> We are currently operating a sub-slab depressurization system at a site in Baltimore, MD which extracts less than 0.5 pounds of VOCs per day and uses two 400-pound granular-activated carbon drums in series to treat the extracted soil-vapors prior to discharge to the atmosphere. At the time that system was installed in 2008, I spoke with David Mummert at the MDE who confirmed that a permit was not required to construct and operate the system based on the low emission rates. We are planning to expand the system with additional extraction points and expect the total combined VOC mass extraction rate will be less than 1 pound per day. Would you let me know if a permit is required for the system expansion? Let me know if you require additional information.
>
> Thank you,
>
> **Belssi Chang Lee** | Senior Engineer | Project Manager
>
> Office: 410.990.4607 | Fax: 410.990.4749
>
> belssi.chang@tetratech.com
>
> **Tetra Tech** | Complex World, Clear Solutions™
> 51 Franklin Street, Suite 400, Annapolis, MD 21401 | tetratech.com
>
>

APPENDIX F—FMEA DOCUMENTATION

Charter Summary For: MRC Building A SSDS Trench Expansion Phase II 2015

Goal Statement:

• Evaluate and remove any potential failures modes without appropriate controls for the installation of new vapor extraction and monitoring points, new treatment skid and connection piping to the existing Building A sub slab depressurization system that once installed could impact existing plant operations, and could cause an inadvertent system failure, contaminant release, damage to equipment, and/or injuries to individuals.

Objectives/Deliverables:

• Examine the new expanded system and system modifications for any single and/or multiple point failures which could cause an inadvertent system failure, release of VOC contaminated vapors, damage to equipment, and/or injuries to individuals. If any are found, suggest design changes or devices to "fail safe" the installed system.
•Deliverable: List of single and/or multiple point failures.
•Deliverable: List of design changes and action plan to preclude these failure modes.

Mistake Proofing Scope Information:

Process Start: Installation and operation of the new SSDS extraction trench and ongoing SSDS system operations
Process End: Delivery of extracted vapors to the new Building A SSDS for carbon treatment
Process Elements: PFD, PID, I&C, Electrical, Mechanical, Structural
Triggers: 60% design completion, initiation of installation, startup of new trench into the existing system
LM21 Tools: Failure Modes and Effects Analysis, Brainstorming

SIA Date: 12/08/2015

SIA Type: Failure Modes and Effects Analysis

Champion: Kevin Pearson

Sponsors: Chris Kline

Team Leader: Tom Blackman

LM21 Facilitator:
Lynnette Drake/ Jeff Thomas

Team Members:
Scotty Arrington, Lockheed Martin
Cannon Silver, CDM Smith
Charlie Jutras, CDM Smith
Jack Hoar, CDM Smith
Peter Rich, Tetra Tech
Dawn Monico, Tetra Tech
Mike Martin, Tetra Tech

Agenda – December 8, 2015

- Charter Review / Kickoff – Tom Blackman (if available)
- FMEA Process – Lynnette Drake/Jeff Thomas
- Review Previous FMEAs; some relevant failure modes are in today's matrix
- Kick-off FMEA
  - Define potential failures
  - Recommended actions
- Event schedule – 8:30 am-5:00 pm ET, virtual conference

SSDS Performance Requirements

- MDE guidelines for indoor air concentrations (derived from U.S. EPA)
- NO release of untreated VOCs or condensate water to the environment or building
- 24/7 operation
- Timely notification of system failure and/or system shutdown to Tetra Tech operators and then to CDM Smith and LMC
- Availability for purchase, spare parts for rapid repairs
- Maintaining the design vacuum at the vapor monitoring points
  - With rare exceptions due to periodic subsurface moisture or heterogeneity

Property Owner/ Tenant Requirements

- Design:
  - Locations have been selected in coordination with the Plant
    - Allows for limited impact to occupied spaces for OMM.
    - Limit intrusiveness of the system. (Physical, Visual and Noise)
  - Extraction and Monitoring Points have already been installed; new treatment skid and piping installation remains
- Operation:
  - Hours of Operation: 24/7

Definitions of Significant Failures

LOCKHEED MARTIN

- Vacuum below slab (< -0.01 inch H_2O)
- Release of VOCs to building air
- Release of condensate to environment or building
- Spill of other materials (coolant, etc) to building or Env.
- System shutdown > 4 hrs (goal), 1 day maximum
- Indoor air: greater than 8.8 ug/m^3 industrial TCE exposure; greater than other chemical exposure thresholds
- Fire originating with the treatment system
- Significant release of Carbon dust to environment
- Any Reportable event
- System operation with spent carbon condition (untreated VOCs to the environment)
- Leak in piping system (vacuum side is less effective; pressure side is released to building air or environment)
- Tenant physically damages the system to the point that it would affect the performance of the system (forklift driver)
- Safety incident
- Utility breach/damage

One-Page Summary – MRC Building A SSDS Phase II Expansion 2015

LOCKHEED MARTIN

Problem/Opportunity…

- We are currently at the 60% design stage for installation of the new points and treatment skid (points already installed). Now is the time to identify and correct potentially significant failure modes and develop appropriate controls to reduce the risk of inadvertent system failure, contaminant release, damage to equipment, or injury to personnel.

Results/Benefits…

- The Previous SSDS FMEAs were reviewed to understand changes identified during this modification and identify top risks and potential design changes that should significantly reduce them.
- Individual failure modes were identified and evaluated.
- Relevant RPN failures were identified and will be corrected before final design and installation review
- An FMEA spreadsheet was developed.

Picture of FMEA

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Prob	Current Design Controls	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date
Influent Trench	Existing Pipe could break or leak during construction	inadvertent discharge of untreated water	4	Age of existing pipe unknown - damage during new pipeline installation or park lot work	3	none for low leaks	5	60	consider additional monitoring measures during construction.	
Influent Trench	Electrical conduit pierced (480 volts) (existing sytem)	Death	5	Excavation or drilling could impact conduit	5	Access agreement with iPark prior to any ground distrubance and visual inspection of area	2	50	Mark out prior to construction (ours or iPark's). ARCADIS routine inspection of construction work and pre-construction meetings.	
Single wall pipe from Influent Vault to Treatment Bldg	Pipe could leak	Release of untreated water or undermining of bldg foundation (large leak)	4	joint leak differential settlement due to vehicular loads	2	Large leak - pressure/flow detection shuts down system. Small leak annual pressure test.	5	40	consider flexible coupling at new vault and increase freq. of pressure test	
Air Treatment	Short circuting through media	Inadequately treated air release	4	Failure of internal plenums or screen	2	Visual inspection during media change. Monthly effluent vapor samples	4	32		
Pumping Well Vault	inproper setting of manual valves in the line	long term capture zone not maintained or Too much flow result in partially treated water to injection wells	4	Operator error	4	Large error detected by flow/pressure alarms. Thrice daily inspection of scada recorded flow rates.	2	32		
Treatment Building	Hatch on CW 2 not secured	Contaminants could enter CW2	4	Operator error	4	Hatch is sealed and water for bag filter maintance activity is discharged to CW 1	2	32		
Influent Vault	inproper setting of manual valves in the line	long term capture zone not maintained or Too much flow result in partially treated water to injection wells	4	Operator error	4	Large error detected by flow/pressure alarms. Thrice daily inspection of scada recorded flow rates.	2	32		
Influent Trench	Electrical conduit pierced (480 volts) (NEW system)	Death	5	Excavation or drilling could impact conduit	3	iPark agreement, metallic locating tape, new trench concrete encased.	2	30		

LM21 Facilitator: Lynnette Drake, Jeff Thomas

Team Members:

LMC: Tom Blackman, Scotty Arrington

CDM Smith: Charlie Jutras, Jack Hoar.

Tetra Tech: Peter Rich, Dawn Monico, Mike Martin

List Nbr	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Causes	Prob	Detection	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Response	Actions Taken	New Sev	New Occ	New Det	New RPN
1	Extraction trench construction	Intercepting a live high voltage electrical line	Loss of life disruption of operations; loss of life if utility is electrical; environmental release	5	Concrete sawcutting, hand digging under slab	3	Subsurface survey by Enviroscan within 1 foot.	4	**60**	Coordinate with local LMCPI electrician. Lineman gloves and electric hazard rated boots are required during sawcutting. Enviroscan will deploy more sensative antenna for shallow depth interrogation and provide written report. TT modified H&S plan to include the above comments.	Tetra Tech						
29	Filter Effectiveness	Filters do not restore indoor air quality to required concentration	insufficient protection of air quality	4	1. Insufficient filter capacity 2. Increased source	3	semiannual air monitoring	4	**48**	More frequent monitoring conducted Pursuing source investigation in 2016	Performing Contractor, RTO Team, LMC Team						
5	Extraction Points	Water accumulation in the sub slab	Loss of flow from extraction points	2	High groundwater levels (usually 10" below the bottom of the concrete)	4	Inspection conducted every two week, flow measurement from each extraction point	4	**32**	Tetra Tech will install the system expansion and operate to see if problem occurs fequently. Periodic inspection based on vacuum flow.	Tetra Tech						
22	Moisture Separator	Drain Valve on Moisture Separator left open	potential to release contaminated air and water to environment	4	Operator error or MRAS employee tampering	2	Every two week inspection (potential to see leaking water is more likely than to hear the air release)	4	**32**	Added as checklist item for verification of completion. No further action.	Tetra Tech						
32	Moisture Separator	Level Switch High fails to indicate high water with MS (float switch)	Flood the blower (amperage overload on the blower) Shut system down	3	Mechanical failure	3	Tested quarterly to ensure operation, two week sight glass inspection, Blower Low Pressure Switch	3	**27**	No Action							
3	400 pound GAC drums (two in series)	Carbon break through	release to environment	2	operator error not sampling per plan	4	Supervisor reviews the sampling results monthly.	3	**24**	Continue to Sample monthly (influent, midpoint, and effluent sampling) with supervisory review. Tetra Tech revised O&M manual with System Extension Revision to reflect this.	Tetra Tech						24

List Nbr	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Causes	Prob	Detection	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Response	Actions Taken	New Sev	New Occ	New Det	New RPN
4	400 pound GAC drums (two in series)	Inadvertent installation of spent carbon	potential release to environment	2	operator error	4	label drums for shipment, post changeout sampling results reviewed by supervisor.	3	**24**	No further action required per update of O&M manual							
25	Power connection	Water damage	Damage to filter	3	Flooding in basement above 3 inches	2	Filter are elevated above floor on system (approx 8 in.)	4	**24**	No Further Action							
38	Temperature Switch	Temperature Switch fails to trip on high temperature	Desorbs volatiles from carbon bed and potential release to	4	Mechanical failure	2	Every two week inspection, quarterly test	3	**24**	No Action							
6	400 pound GAC drums (two in series)	Seal on the rim fails	release to environment	2	Manufacturer defect (not sealed properly) or Rust	2	Nothing	5	**20**	Inspection at time of delivery, reject on visual. Confirm that this procedure is clearly defined in the O&M manual. No further action.	Tetra Tech						
27	Replacing filters	Power not disconnected	Shock hazard	5	Operator does not observe O&M Manual procedure to close disconnect switch	2	Operator acting in accordance with the O&M Manual	2	**20**	When filters are connected by wire in conduit, each will have a disconnect switch and lock out/tag out requirements. Will be added to O&M manual.	Tetra Tech Performing Contractor						
33	Vacuum Relief Valve	Vacuum Relief Valve failed to open at 110 inches of vacuum	Thermal overload to the system and system shutdown	3	Mechanical failure	2	Every two week inspection; quarterly testing of the valve, Blower Low Pressure Switch	3	**18**	No Action							
36	Blower	Blower/Motor fails	System not operating, no suction	3	Mechanical failure	2	Every two week inspection and shutoff by low pressure switch connected to autodialer	3	**18**	No Action							
7	Piping from extraction points to system (above ground)	Pipe or joint failure	Loss of vacuum in extraction points	2	Material failure or physical damage	2	Inspection conducted every two week	4	**16**	Vertical piping adjacent to existing building column and behind fence. Existing pipe supports used to transport to system. Ballards installed at various points and protected by steel sleeves. No further action.							

List Nbr	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Causes	Prob	Detection	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Response	Actions Taken	New Sev	New Occ	New Det	New RPN
23	Moisture Separator	Break of sight glass on Moisture Separator	potential to release contaminated air and water to environment	4	Operator error or MRAS operator tampering	1	Every two week inspection	4	**16**	Continue inspection every two weeks	Tetra Tech						
26	Replacing filters	Decreased air flow; excess noise	Filter not operating effectively, potentially additional VOCs in indoor air	2	Excessive dust in basement	2	System check every 2 weeks	4	**16**	Extra HEPA pre-filters available for potential change prior to planned quarterly frequency	Tetra Tech Performing Contractor						
30	Filter Effectiveness	Filters restore air quality, are disconnected and subsequent six month monitoring round shows unacceptable air quality	insufficient protection of air quality	4	belief that the problem is solved	1	semiannual air monitoring	4	**16**	No plan to turn off filters unless they are replaced with a more robust system	Tetra Tech Performing Contractor						16
8	4" Hose to GAC following Flow Indicator	Hose failure (crack or fatigue)	release of untreated air to environment	2	stress points (short radius bends)	2	visual inspection every two weeks	3	**12**	Hose lengths minimized as practicable and provide sturdy industrial type hose. Ribbed-plastic steel reinforced high temp braided hose installed. No further action.							12
10	400 pound GAC drums (two in series)	Carbon break through	release to environment	2	supplier provides off-spec carbon	2	sampling every month (influent, midpoint, and effluent sampling)	3	**12**	Continue to Sample monthly (influent, midpoint, and effluent sampling) with supervisory review. Tetra Tech revised O&M manual with System Extension Revision to reflect this.	Tetra Tech						
11	Piping from point to system	Inadvertent closing of the valve	No suction and removal of sub slab VOCs (ineffective system)	2	Operator error or MRAS operator tampering	2	Inspection conducted every two week.	3	**12**	The ball valves are normally open and locked. The butterfly/diaphram valves are adjustable and locked in place. Provide locks for new valves.							
40	Dilution Filter	Valve to the dilution filter	Performance of system would be	2	Operator error or MRAS	2	Every two week inspection	3	**12**	Lock-out valve locked. No further action.							
41	Influent Filter System	Clogged filter	Less influence and capture of vapors in extraction	2	accumulation of moisture or particulate	2	Every two week inspection	3	**12**	Monitor vacuum and change filter when necessary.	Tetra Tech						

List Nbr	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Causes	Prob	Detection	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Response	Actions Taken	New Sev	New Occ	New Det	New RPN
42	Influent Filter System	One of the vacuum gauges across the filter system is faulty	Inability to read the delta P across the filter	2	Mechanical failure	2	Every two week inspection	3	**12**	Gauge and other readings reviewed bi-weekly and guage replaced immediately if the data does not look right	Tetra Tech						12
45	Skid	Damaging new skid during	Possible repair work for skid Schedule delay (~8	3	Loading equipment not suited for	2	Visual inspection of skid pre/during unloading/installat	2	**12**								
34	Extraction points old and new	Water accumulation in the sub slab	Reduction of system effectiveness	2	High Groundwater, plant releasing water affecting subslab, storm	5	High Level Switch in the MS (Moisture Separator). Autodialer	1	**10**	No Action							
47	Safety	Installer falls during aboveground piping installation	Personal Injury	5	Installer error/careless ness	2	Visual - immediate	1	**10**	Ensure TT is following Fall-protection guidance	Tetra Tech						10
15	Vapor Transfer lines from new point to system	Water accumulation in the lines	Reduction of air flow	1	Condensation	3	Inspection of sumps every two weeks	3	**9**	Continue to inspect sumps bi-weekly	Tetra Tech						
17	Low Points Sumps	low point fills with water	system flow is reduced or eliminated from specific extraction points	1	Condensation of water from wells	3	Inspection every two weeks. O&M Manual checklists will identify all checkpoints	3	**9**	Continue to inspect sumps bi-weekly	Tetra Tech						9
35	Blower	Thermal Overload Switch fails	Potential to burn out the motor (system shut	3	Mechanical failure	1	Every two week inspection and shutoff by low	3	**9**	No Action							9
37	Pressure Switch	High Pressure Switch trips at low pressure	Shuts the system down	3	Mechanical failure	1	Every two week inspection, shutoff by low pressure switch connected to autodialer	3	**9**	No Action							9
39	Temperature Switch	Temp Switch trips at low temp	Shuts the system down	3	Mechanical failure	1	Every two weeks inspection, quarterly test and shudown of blower is connected to autodialer	3	**9**	No Action							

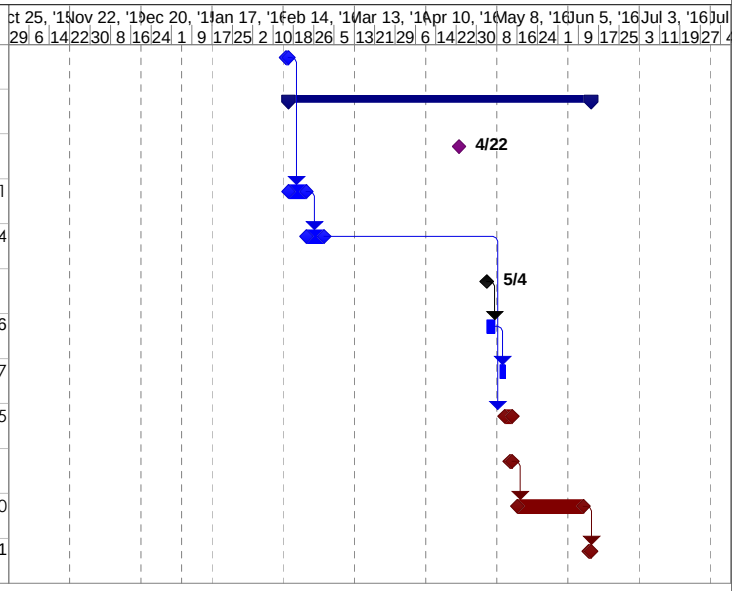
List Nbr	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Causes	Prob	Detection	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Response	Actions Taken	New Sev	New Occ	New Det	New RPN
2	Sample taps	Left open	release to environment	2	Operator error or MRAS operator tampering with sample taps	2	Every two weeks inspection. Quick connects installed (2010), Auto Dialer.	2	**8**	Two independent valves are installed at each location. Quick disconnect automatic shutoff valve systems installed by Tetra Tech to minimize operator error. No further action.	Tetra Tech						
14	Extraction point	Silt clogging of point	Loss of flow from these points	2	Native soil collecting into the extraction point	2	Inspection conducted every two week, flow measurement from each point, trends can detect.	2	**8**	Continue bi-weekly monitoring.	Tetra Tech						8
19	Post heat exchanger high temp. switch	failure of high switch point to occur	premature breakthrough of carbon	2	defective switch or operator adjustment of switch	2	bi-weekly inspection of manual temp. gauge	2	**8**	Continue bi-weekly monitoring and quarterly testing of switch.	Tetra Tech						
20	Heat Exchanger operation	The fan on heat exchanger	effluent temp. would rise	2	motor failure	2	temp. switch that detects high temp. which will cause	2	**8**	temp. switch that detects high temp. which will cause system shutdown . No additional action.							
21	Level switch on air water separator	Water accumulation in separator	saturation of upstream carbon vessels.	2	defective switch	2	high pressure alarm on lower discharge	2	**8**	Continue to conduct quarterly inspections.	Tetra Tech						
24	Extraction Points	Concrete Shrinkage and Cracks	Potential to have loss of vacuum and reduced capture of VOCs	2	Physical damage or intentional breach of concrete	1	GE contract requires notification of LMCPI to do building mods, every two week inspection	4	**8**	Tony attends meetings - dialogue improved							
46	Piping	Utility damage while hanging pipe	Distruption of facility ops	4	Installer error/careless ness	2	Visual - immediate	1	**8**	Coordinated with facility to help avoid utility issues.							
9	4" Hose to GAC following Flow Indicator	Camlock connection fails	release of untreated air to environment	2	Operator error or MRAS operator tampering	3	Cotter Pins to ensure camlocks are in place. Zip ties installed to prevent tampering (2010)	1	**6**	Zip ties installed. No further action.							
12	4" Hose to GAC following Flow Indicator	Camlock barb and hose joint failure	release of untreated air to environment	2	wear or over tightening	1	Every two weeks inspection visual inspection Hoses replaced as necessary	3	**6**	Continue bi-weekly monitoring of hoses and replace as necessary.	Tetra Tech						

List Nbr	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Causes	Prob	Detection	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Response	Actions Taken	New Sev	New Occ	New Det	New RPN
13	4" Hose to GAC following Flow Indicator	Material incompatibility between PVC, CPVC and aluminum	release of untreated air to environment	2	wear or over tightening	1	Every two weeks inspection visual inspection Hoses replaced as necessary	3	**6**	Continue bi-weekly monitoring of hoses and replace as necessary.	Tetra Tech						6
18	balancing flow from well	refuse flow from individual wells	Sub slab controls not in place	2	incorrect adjustment of valves Heterogeneity of subsurface	3	measuring points at each well and diaphragm valve for flow throttling	1	**6**								
31	Uncontrolled shutdown	filters stop running	degraded air quality	3	Power Outage Mechanical Failure	1	Inspection every 2 weeks If outage affects Bldg A SSDS, Tetra Tech will get alarm	2	**6**	Tetra Tech responds to buiding A power alarms(SSDS) in a timely manner and can restart the filters	Tetra Tech						
44	Installation / Decomissioning of skid	Improper removal / installation of electrical equipment	Severe Personal Injury/Electrical Shock	5	Not following LOTO Improper Training Worker carelessness	1	Electrical checks conducted during pre-work	1	**5**	Ensure O&M includes electrical checks and LOTO procedures are followed.	Tetra Tech						5
28	Replacing filters	Spent filters disposed improperly	Reprimand to employee who made mistake	1	Operator does not observe O&M Manual	2	Operator acting in accordance with the O&M Manual	2	**4**	Observe O&M Manual and ensure the operator is properly trained	Tetra Tech						
43	Measurement Vacuum Suction	Faulty gauge used for Vacuum Measurement	Incorrect adjustments to the system (area of influence would potentially be set incorrectly)	2	Mechanical failure	1	Multiple measurement points for gauge. Operator should know that gauge is faulty	2	**4**	No Action							4
48	Startup	Functional test results don't result as designed	Schedule delay - send back faulty equipment to vendor or vendor repair on-site	3	Faulty equipment provided by vendor	1	Visual during startup	1	**3**	No Action							3
16	Fail - Safe Alarms	Normally Open Circuits do not close properly	System would be off/down for a longer period of time.	2	Power Outage	1	Change alarms from NO to NC on both Systems Battery backups installed on alarms (2010) - Checked every two weeks	1	**2**	Make sure that new skid has normally closed circuits.	Tetra Tech						2

APPENDIX G—PRELIMINARY CONSTRUCTION SCHEDULE

Preliminary Construction Schedule
Sub-Slab Depressurization System Second-Phase Expansion
Building A, Lockheed Martin Middle River Complex, Middle River, Maryland

ID	Task Name	Duration	Start	Finish	Predecessors
1	**100% Design Package Approval**	1 day	Mon 2/15/16	Mon 2/15/16	
2	**SSD System Expansion Construction**	**85 days**	**Tue 2/16/16**	**Mon 6/13/16**	
3	Mobilization	5 days	Mon 4/18/16	Fri 4/22/16	
4	Install Header Pipe	5 days	Tue 2/16/16	Mon 2/22/16	1
5	Tie-In Extraction Points to Header Pipe	5 days	Tue 2/23/16	Mon 2/29/16	4
6	Shut system down, remove existing blower skid	0 days	Wed 5/4/16	Wed 5/4/16	
7	Install new blower skid/moisture separators/heat exchanger	3 days	Wed 5/4/16	Fri 5/6/16	6
8	Complete pre-system start-up inspection	2 days	Mon 5/9/16	Tue 5/10/16	7
9	Complete system start-up inspection and balance wells	3 days	Wed 5/11/16	Fri 5/13/16	5
10	Demobilization	1 day	Fri 5/13/16	Fri 5/13/16	
11	Waste Profiling	20 days	Mon 5/16/16	Fri 6/10/16	10
12	Waste Transportation and Disposal	1 day	Mon 6/13/16	Mon 6/13/16	11



Task		External Tasks		Duration-only		External Tasks	
Split		External Milestone		Manual Summary Rollup		External Milestone	
Milestone		Inactive Milestone		Manual Summary		Progress	
Summary		Inactive Summary		Start-only		Deadline	
Project Summary		Manual Task		Finish-only			