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December 21, 2015 **VIA PRIVATE CARRIER**

Mr. James R. Carroll
Program Administrator
Land Restoration Program
Land Management Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite 625
Baltimore, Maryland 21230

Subject: Transmittal of the Basis-of-Design Report
Sub-slab Depressurization-System Second-Phase Expansion—Building A
Lockheed Martin Middle River Complex, Middle River, Maryland

Dear Mr. Carroll:

For your information, please find enclosed two hard copies with CD of the above-referenced document. This basis-of-design report describes 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.

Please let me know if you have any questions. My office phone is (301) 548-2227.

Sincerely,

Tom Blackman signed for

Lynnette Drake
Remediation Analyst, Environmental Remediation

Enclosures:

cc: (via email without enclosure)
Gary Schold, MDE
Mark Mank, MDE
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Jann Richardson, Lockheed Martin

Basis-of-Design Report
Sub-slab Depressurization-System
Second-Phase Expansion—Building A
Lockheed Martin Middle River Complex
2323 Eastern Boulevard
Middle River, Maryland

Prepared for:

Lockheed Martin Corporation

Prepared by:

Tetra Tech, Inc.

December 2015

Michael Martin, P.G.
Regional Manager

Peter A. Rich, P.E.
Principal Engineer

TABLE OF CONTENTS

APPENDICES

TABLE OF CONTENTS (continued)

LIST OF TABLES

ACRONYMS

BODR	basis-of-design report
cis-1,2-DCE	*cis*-1,2-dichloroethene
COMAR	*Code of Maryland Regulations*
GAC	granular activated-carbon
HVAC	heating, ventilation, and air conditioning
in. WC	inches of water column
J	estimated value
lbs/day	pounds per day
Lockheed Martin	Lockheed Martin Corporation
MDE	Maryland Department of the Environment
$\mu g/m^3$	microgram(s) per cubic meter
ND	non-detect
PVC	polyvinyl chloride
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

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Section 1
Introduction

Tetra Tech, Inc. (Tetra Tech) has prepared this basis-of-design report (BODR) 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 a 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 the 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 was 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 “blower skid” (blower, moisture separator, control panel, filters, and appurtenances), granular activated-carbon drums, and exhaust stack are on the loading dock just outside the former plating shop.

A first-phase system expansion was completed in October 2010 to address elevated sub-slab volatiles detected in the middle part 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 installed and the 200-pound granular activated-carbon drums were replaced with 400-pound drums. Three stand-alone indoor-air filters (IQAir GC™ Series-GC VOC) were installed in January 2015 in the Building A basement near vapor-monitoring points 093-A and 138-A and indoor-air monitoring location 093-A-X (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 address areas along the eastern side of Building A near VMPs 136-A, 079-A, and 117-A, where elevated concentrations of volatiles were detected in the sub-slab in 2014–2015. Vertical extraction points and vapor monitoring points will be installed during the second-phase expansion, and the existing equipment skid will be replaced. 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—Technical Approach: Presents the technical basis for the expansion design.

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

Section 4—Required Design Documents: Lists the construction/expansion design drawings and specification sections that will be included in the 60%, 90%, and final design packages.

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

Section 2
Technical Approach

2.1 SYSTEM EXPANSION OBJECTIVE

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 constant negative pressure of at least 0.01 inches water column (in. WC) in the sub-slab, 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 conceptual drawings in Appendix A. To achieve the system expansion objective, six vertical vapor-extraction points and eight vapor-monitoring points (VMPs) will be installed, and the existing blower skid and its control panel will be replaced. The three indoor air filters operating in the Building A basement will be hard-wired to the new blower-skid control panel.

New vertical vapor-extraction points will be installed at the proposed locations 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 (discussed below in Section 2.2), during sub-slab-vapor sampling in 2014–2015. Facility operations were also considered when choosing new extraction point locations. The proposed locations will be reviewed with the facility and cleared by means of a geophysical utility-investigation before installation. Current operations of the SSD system suggest that the radius of influence for the induced vacuum at each new extraction point would be expected to extend approximately 25 feet.

2.2 VAPOR-INTRUSION MONITORING RESULTS

Semi-annual vapor-intrusion monitoring at the facility includes both indoor-air and sub-slab-vapor sampling. The February 2015 monitoring event included indoor air samples collected at VMPs 079-A, 117-A, and 136-A. Sub-slab vapor was sampled at VMP 117-A in February 2014, and at VMPs 136-A and 079-A in February 2015 (Pace, 2014, 2015a, 2015b).

Relevant indoor-air monitoring results are summarized in Table 2-1; the sub-slab-vapor monitoring results are summarized in Table 2-2. Trichloroethene (TCE) was not detected in the referenced indoor air samples, but was detected in sub-slab vapor at concentrations above its screening level (293 μg/m^3)[1] at two VMPs: 136-A and 079-A.

Table 2-1

Indoor Air Sampling Results (Hits Only), February 2015
Lockheed Martin Middle River Complex, Middle River, Maryland

Chemical	Indoor air screening level* (μg/m^3)	Location		
		117-A (μg/m^3)	136-A (μg/m^3)	079-A (μg/m^3)
Benzene	16	0.64	0.94	0.57
Chlorodifluoromethane	220,000	0.93*J*	3.7	1.1*J*
Dichlorodifluoromethane	440	2.2	3.1	2.4
Methylene chloride	2,600	ND	51.7	1.0*J*
Naphthalene	3.6	ND	ND	2.6*J*
Toluene	22,000	0.81*J*	2.7	1.3
m&p-Xylene	440	ND	0.75*J*	0.83*J*
Total VOCs	—	4.58	63	10

Notes:

Samples collected on February 19, 2015 (Pace, 2015a)
* Screening levels are specified in the facility's *Vapor-Intrusion Management Plan* (Tetra Tech, 2014)
J—estimated value
μg/m^3—microgram(s) per cubic meter
ND—non-detect
SSD—sub-slab depressurization
VOCs—volatile organic compounds

[1]Screening levels are specified in the facility's *Vapor-Intrusion Management Plan* (Tetra Tech, 2014).

Table 2-2

Sub-slab Vapor Sampling Results (Hits Only), February 2014/2015
Lockheed Martin Middle River Complex, Middle River, Maryland

Chemical	Sub-slab screening level* ($\mu g/m^3$)	Location (date)		
		117-A ($\mu g/m^3$) (February 2014)	136-A ($\mu g/m^3$) (February 2015)	079-A ($\mu g/m^3$) (February 2015)
Benzene	533	ND	5.5	1.1
Chlorodifluoromethane	7,333,333	0.80	2.7	3.9
Chloroform	177	ND	211	9.0
Dichlorodifluoromethane	14,667	1.5*J*	1.5*J*	2.4
1.1-Dichloroethane	2,567	ND	1.3*J*	1.5*J*
1.1-Dichloroethene	29,333	ND	0.78*J*	1.1*J*
cis-1,2-Dichloroethene	8,667	ND	33.3	968
trans-1,2-Dichloroethene	8,667	ND	17.2	193
Ethylbenzene	1,633	2.1	ND	ND
Methylene chloride	86,667	40.4	ND	3.1*J*
Naphthalene	120	95.1	3.6*J*	3.6*J*
Tetrachloroethene	6,000	10.3	22.4	12.7
Toluene	733,333	9.9	3.6	1.4*J*
1,1.1-Trichloroethane	733,333	5.1	2.7	1.8
1,1.2-Trichloroethane	29	ND	1.2	ND
Trichloroethene	293	109	**31,800****	**2,660****
1,2,3-Trimethylbenzene	NA	4.5	2.6	2.0
1,2,4-Trimethylbenzene	NA	5.8	5.9	2.8
1,3,5-Trimethylbenzene	NA	ND	2.8	1.3*J*
m&p-Xylene	14,667	9.7	2.9*J*	2.4*J*
o-Xylene	14,667	8.3	1.6*J*	2.1
Total VOCs	—	303	32,123	3,873

Notes:

Samples 136-A and 079-A collected on February 19, 2015 (Pace, 2015b)
Sample 117-A collected on February 25, 2014 (Pace, 2014)
*—Screening levels are specified in the facility's *Vapor-Intrusion Management Plan* (Tetra Tech, 2014)
**—concentration is above the TCE screening level of 293 $\mu g/m^3$
J—estimated value
$\mu g/m^3$—microgram(s) per cubic meter
N/A—not available
ND—non-detect
SSD—sub-slab depressurization
VOCs—volatile organic compounds

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Section 3
Conceptual Design

The second-phase expansion will include the following tasks:

- installation of six vertical vapor-extraction points in the eastern target area of Building A (SSD-34-A through SSD-39-A)
- installation of nine vapor-monitoring points (VMPs) near the new vapor-extraction points (160-A through 168-A)
- installation of an elevated six-inch-diameter Schedule 40 polyvinyl chloride (PVC) header pipe to connect the new vapor-extraction points to the SSD system
- replacement of the existing blower skid (at the same location) with a higher capacity blower unit that will accommodate the flow from 10 soil-vapor extraction points (including the four existing horizontal trenches and six new vertical extraction-points)
- hard-wiring of three indoor-air filters in the Building A basement into the control panel on the blower skid

Conceptual drawings showing the locations of proposed extraction points, VMPs, and piping runs are in Appendix A. The design of each expansion component is discussed in the following sections.

3.1 VAPOR-EXTRACTION POINTS

Three of six vertical soil-vapor extraction points (SSD-34-A, SSD-35-A, and SSD-36-A) will be installed near existing VMP 136-A. One extraction point (SSD-37-A) will be installed near VMP 117-A, and two (SSD-38-A and SSD-39-A) will be installed near VMP 079-A (see Drawing G2 in Appendix A). These proposed locations will be reviewed with Lockheed Martin Corporation (Lockheed Martin) and tenant representatives (Middle River Aircraft Systems [MRAS]) before the VMPs are installed. Once approved, the locations will be confirmed by a geophysical utility-investigation to be conducted by Enviroscan, Inc.

Each new vertical extraction point will be constructed using a 12- to 18-inch length of two-inch-diameter, 0.020-inch slot, Schedule 40 PVC pipe, and two-inch-diameter solid Schedule 40 PVC pipe (riser) in a four-inch-diameter borehole. The screen will extend from the bottom of the slab to a depth of 12–18 inches. The annular space will be filled with clean pea gravel and a bentonite grout seal will be placed above the screen and gravel to prevent short-circuiting (extracting indoor air). Each vapor extraction point will be 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 is avoided and the extraction point and piping are placed outside normal traffic flow in the facility. Each extraction point will extend above the ground close to the column/wall columns/walls, as shown on Drawing G2 in Appendix A, to avoid ground-level damage.

Flow and vacuum will be monitored, and samples will be collected, via a measuring/sampling port on the riser pipe at each vapor extraction point; a lockable diaphragm valve for throttling or shutting off flow is also on each riser. The concrete around each point will be finished in a manner equal to or better than surrounding areas, as required by Lockheed Martin. A bollard might be installed to protect piping at proposed vapor extraction points, if Lockheed Martin agrees it would be worthwhile. Extraction point design and bollard details are on Drawing G2 in Appendix A.

3.2 PIPING

Soil-vapor extracted at each new extraction point will be pulled through the two-inch-diameter riser pipe via the throttling valve and measuring devices associated with each point. Vapor will then travel along an elevated six-inch-diameter Schedule 40 PVC header installed overhead. Vapor from the six new extraction points will be routed in 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. 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. If pooling in low points is observed, condensate sump(s) will be installed to remove the accumulated liquid.

The six-inch-diameter header pipe will be run along wall and ceiling sections in the eastern area of Building A to the new extraction points (see Drawing G2 in Appendix A). 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 south along the wall for approximately 160 feet to column D25 near VMP 079-A, then north, and 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 for steel piping in the ceiling. Tetra Tech will review the proposed extraction point locations with Lockheed Martin Corporation (Lockheed Martin) and MRAS, and also discuss the potential need to inspect the loading dock area for and remove asbestos-containing materials and lead-based paint.

Header piping will be installed in high-traffic areas. 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.

3.3 MODIFICATIONS TO EXISTING SSD SYSTEM

The second-phase expansion will require replacement[2] of the current blower skid with a moisture separator, gauges, switches, filters, control panel, and auto-dialer. The current blower skid includes a blower rated for 125 standard cubic feet per minute (SCFM) at a vacuum of 80 inches of water column (in. WC). The new blower skid will include the AMETEK® Rotron® regenerative blower model DR909BB72W, which is rated for 300 SCFM at 75 in. WC of suction. The current 30-gallon-capacity moisture separator and four-channel auto-dialer will be replaced with a 40-gallon-capacity moisture separator and eight-channel auto-dialer. Cut sheets for the new blower and moisture separator are in Appendix B.

Other components on the new blower skid will be similar to those of the existing one. The control panel on the new blower skid will accommodate hard-wiring of the three (IQAir® GC™ VOC) indoor-air filters operating near VMPs 093-A and 138-A and indoor-air monitoring point 093-A-X in the Building A basement. The two existing in-series vapor-phase granular-activated-carbon (GAC) adsorbers (Vent-Scrub® VSC400) are comprised of 400-pound drums rated for a maximum flow of 300 SCFM; they will continue to treat the extracted soil-vapor before discharge

[2] The replaced blower skid will be returned to the supplier, Gasho, Inc., for recycling.

to the atmosphere. A heat exchanger will be added to the skid to protect the granular-activated-carbon and PVC pipe from potential temperatures higher than 140 degrees Fahrenheit (140ºF).

We anticipate a vapor-flow rate of 290 SCFM after the second-phase system expansion has been completed, with average extraction rates of 35 SCFM from each of the current vapor-extraction trenches, and 25 SCFM from each of the new points. The target vapor-flow rate of 290 SCFM will produce minimal friction losses in the individual extraction pipes and in the header pipe. Friction losses per foot of pipe are estimated at 0.011 in. WC per foot in the two-inch-diameter vapor-extraction trenches and points, and less than 0.003 in. WC in the six-inch-diameter header for the six new extraction points (combined). Under a worst-case scenario, we estimate a vacuum-side filter loss of approximately 18 in. WC will result in total losses of approximately 28 in. WC. The pressure-side head loss is less than 37 in. WC. These are acceptable system performance levels. Pressure-loss calculations are in Appendix C.

3.4 VAPOR-MONITORING POINTS

Nine new VMPs will be installed where gaps exist in the induced-vacuum data. The new VMPs will be used along with the existing VMPs to monitor the induced vacuum around 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, if possible. The concrete floor slab will be checked for short-circuiting at joints and perforations, and any pathways will be sealed. The existing 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 to define the area of induced vacuum. VMPs will be removed from the monitoring program if they are not useful for monitoring system performance.

3.5 ESTIMATED MASS-EXTRACTION AND PERMITS

Removal rates for VOC mass (mainly trichloroethene [TCE] and *cis*-1,2-dichloroethene [*cis*-1,2-DCE]) of approximately one-quarter pound per day are anticipated at startup. Removal rates are expected to decrease to about 0.05 pounds per day or less after the first month of expanded system operation. These estimated removal rates are based on soil-vapor concentrations in the existing system influent and VMPs, and on rates of decline observed during initial operation of the Building A and Building C SSD systems in 2008. Two 400-pound capacity GAC drums (lead and lag) will be used to adsorb the VOCs on 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 for VOCs at each of the new vapor extraction points 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 biweekly 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 presents the estimated initial mass-extraction rates (in pounds per day) for the expanded system, based on current system-influent concentration- and sampling-results at VMPs 079-A, 117-A, and 136-A (discussed in Section 2.2). Even without GAC treatment, the estimated system mass-extraction rates shown (91.25 pounds of VOCs per year) are below the Title 5 emission level (25 tons VOCs per year), per Maryland Department of the Environment (MDE) guidance 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 required for the emission rates associated with the SSD system. An email communication on September 22, 2015 from Mr. Nolan Penney of the MDE Air Quality Permits Section 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 permit is required for the second-phase expansion of the SSD system (MDE, 2015). We will provide the facility with total annual volumes of VOC emissions, for their reporting requirements.

Table 3-1

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

Proposed extraction point	Associated monitoring points*
SSD-34-A	136-A-N, 163-A
SSD-35-A	136-A-S, 160-A, 161-A
SSD-36-A	136-A, 162-A, 121-B
SSD-37-A	117-A, 164-A, 165-A
SSD-38-A	166-A, 167-A
SSD-39-A	079-A, 107-A, 139-A, 168-A

* 160-A, 161-A, 162-A, 163-A, 164-A, 165-A, 166-A, 167-A, and 168-A are proposed vapor-monitoring points.

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 ($\mu g/m^3$)*	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
SSD-39-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
$\mu g/m^3$—microgram(s) per cubic meter
SCFM—standard cubic feet per minute
SSD—sub-slab depressurization
VOC—volatile organic compounds
mass extraction (lbs/day) = $\mu g/L \times L/min \times 1{,}440\ min/day \times 1\ lb/4.54 \times 10^{-6}\ \mu g$
[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
Required Design Documents

Upon approval of this basis-of-design report (BODR) by Lockheed Martin Corporation (Lockheed Martin), Tetra Tech, Inc. (Tetra Tech) will develop 60%, 90%, and 100% design packages for the second-phase expansion of the Building A sub-slab-depressurization (SSD) system. The following is a preliminary list of drawings that will be included in the design packages:

- Drawing G1—Plan Overview: will include a site map and show the planned layout for the piping, vapor-extraction points, and vapor-monitoring points (VMPs).
- Drawing G2—Piping Layout and Details: will show a detailed view of the area around each proposed vapor-extraction point and will include vapor-extraction-point design details.
- Drawing G3—System Process and Instrumentation Diagram: will depict vapor extraction points, piping, equipment, gauges, failsafe switches, wiring, and treatment unit details and layout.
- Drawing G4—Indoor Air Filter Layout and Details: will include the layout and wiring details for installation of three indoor air filters to the blower-skid control panel.

A preliminary list of the specification sections included in the design packages is below:

- SECTION 01010—Summary of the Work
- SECTION 01620—Storage and Protection of Materials
- SECTION 01650—Field Testing and Startup
- SECTION 05503—Anchor Bolts, Expansion Anchors, and Concrete Inserts
- SECTION 13825—Special Equipment
- SECTION 15050—Piping
- SECTION 15060—Pipe Hangers and Supports
- SECTION 15100—Valves, General
- SECTION 16050—Electrical Equipment

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Section 5
References

1. Maryland Department of the Environment (MDE), 2007. Telephone communication between Mr. Dave Mummert (MDE Air Quality Permits Section) and Ms. B. Chang Lee (Tetra Tech) regarding anticipated volume of emissions at site not requiring an air permit. November 16.

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.

3. Pace Analytical Services (Pace), 2014. *Report of Laboratory Analysis, Pace Project No. 10259332*. April 17.

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), 2014. *Vapor-Intrusion Management Plan, Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland*. May 19.

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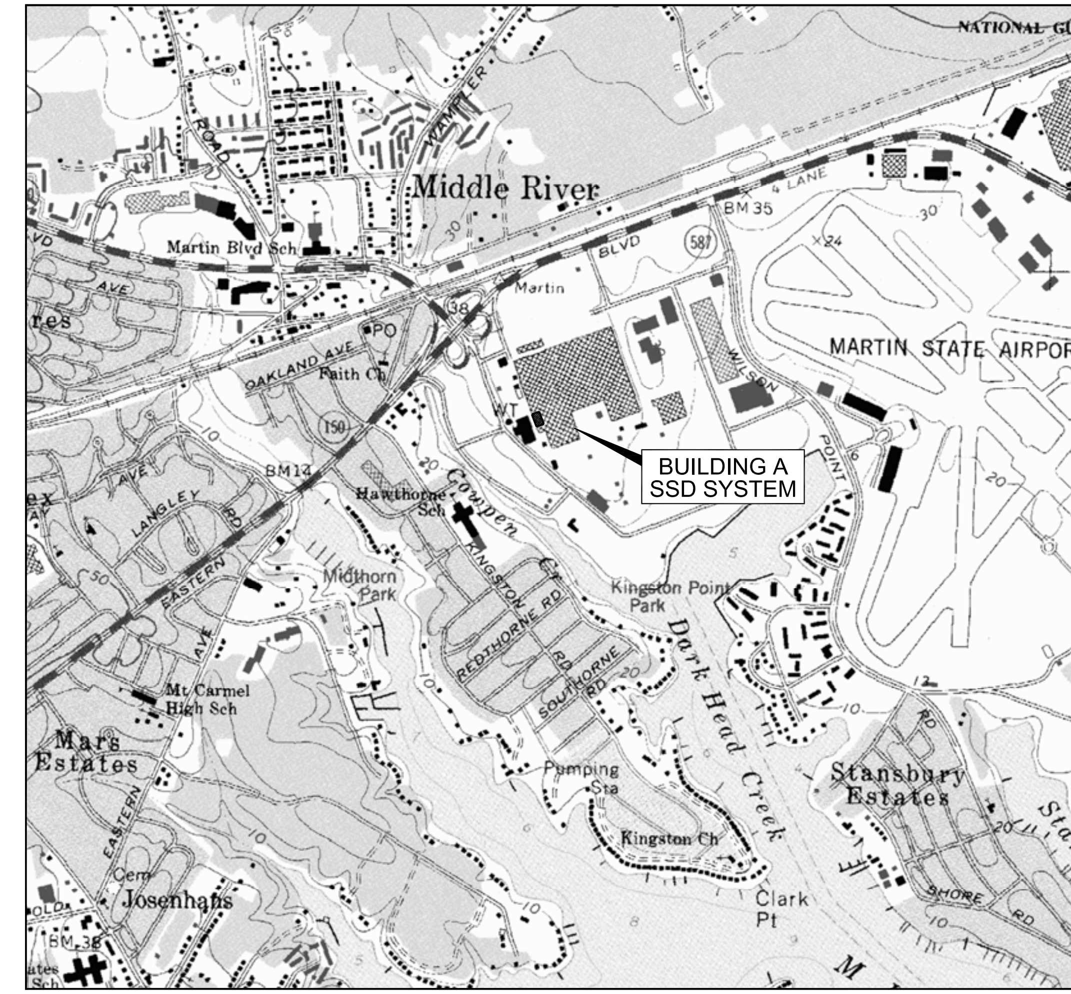
APPENDIX A—CONCEPTUAL DESIGN DRAWINGS

LEGEND

▲	SUB-SLAB VAPOR MONITORING POINT
●	PROPOSED SUB-SLAB VAPOR EXTRACTION POINT
●	SUB-SLAB VAPOR EXTRACTION POINT (USED IN PREVIOUS PILOT TEST)
⊗	INDOOR AIR SAMPLING POINT
▲	PROPOSED SUB-SLAB VAPOR MONITORING POINT
SSD	SUB-SLAB DEPRESSURIZATION
	PROPOSED EXTRACTION POINT PIPING (2" DIA. SCH 40)
	PROPOSED HEADER PIPE (6" DIA. SCH 40)
	TARGET INFLUENCE AREA (PROPOSED)
	APPROXIMATE EXISTING INFLUENCE AREA
■	INDOOR AIR FILTER
	EXISTING SSD BLOWER SKID
	EXISTING SUB-SLAB VAPOR EXTRACTION LATERAL
079–A	INDOOR AIR SAMPLING POINT



SITE LOCATION MAP

0 1000 2000 3000
SCALE IN FEET

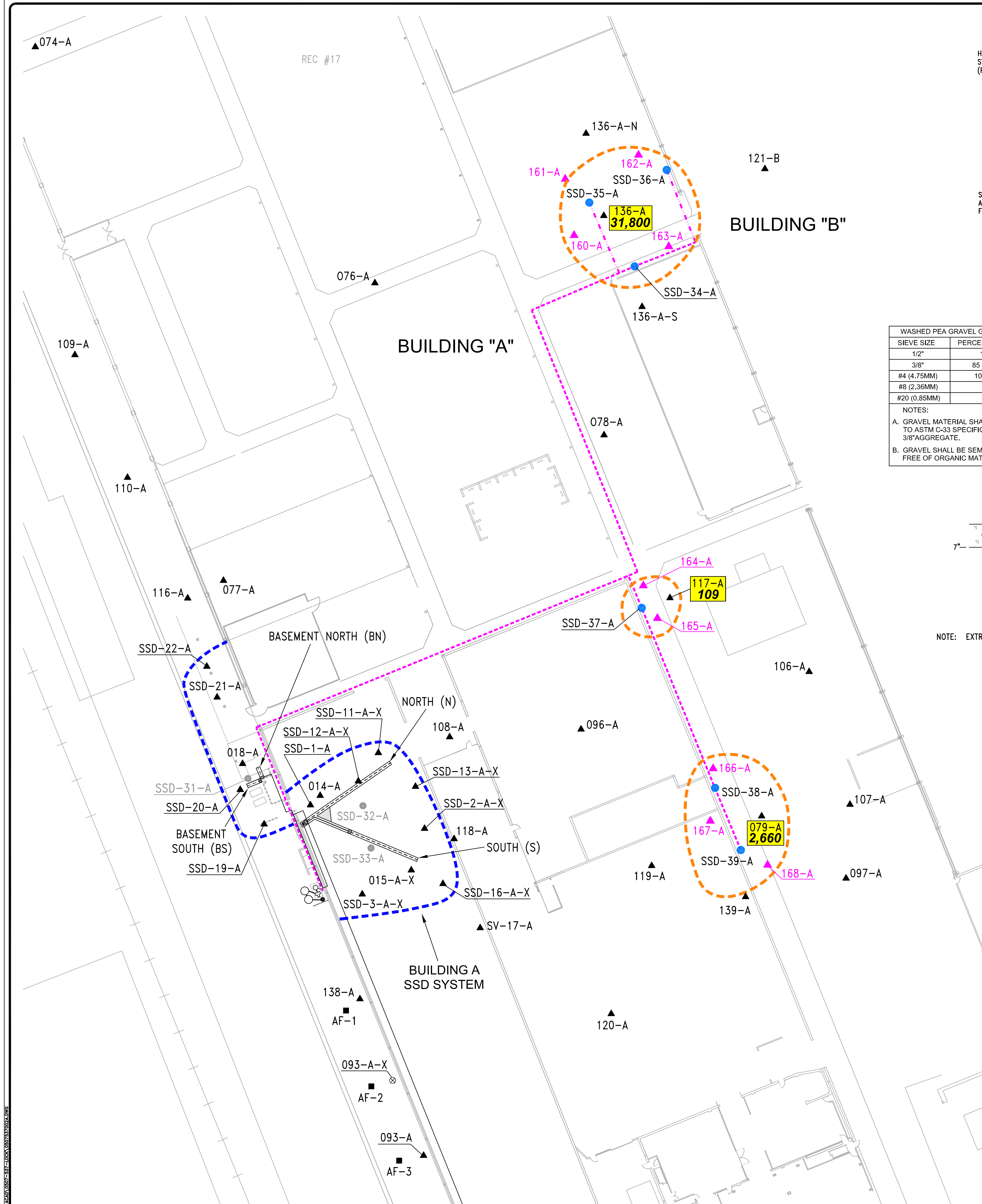
APPROVED BY:	DATE	REVISION	APRVD.

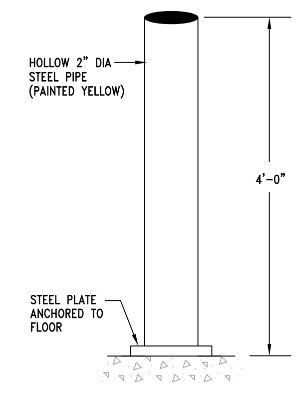
TITLE: **CONCEPTUAL PLAN OVERVIEW**
BASIS OF DESIGN
SSD SYSTEM SECOND-PHASE EXPANSION - BUILDING A

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

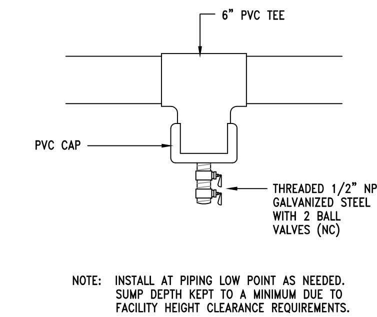
TETRA TECH

APPROVED	PAR	DRAWING:
DRAFTED	CMP	
PROJECT#	117-0512124	G1
DATE	10-20-15	



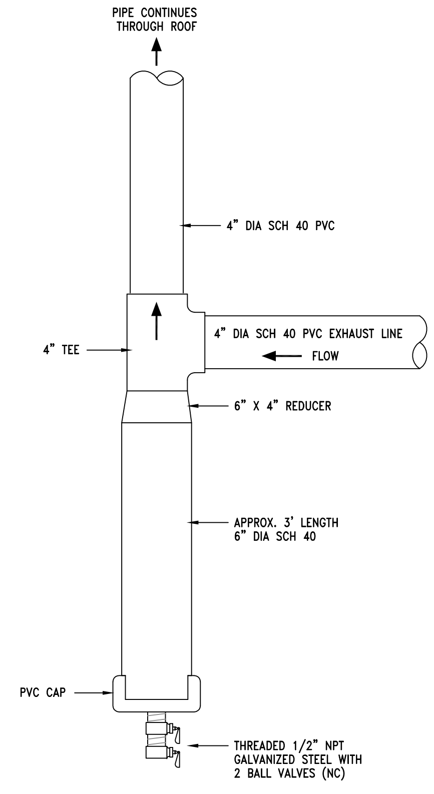


PIPE BOLLARD DETAIL
NOT TO SCALE



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



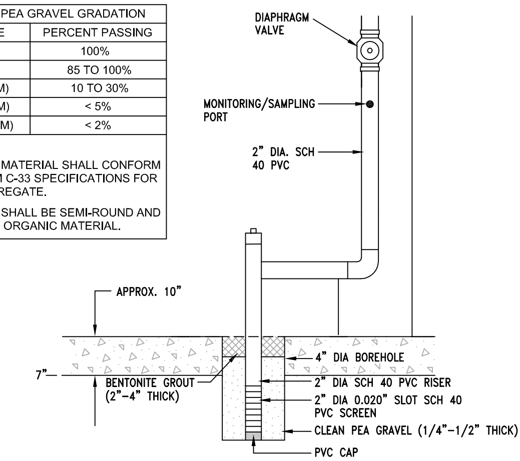
EXHAUST STACK SUMP DETAIL
NOT TO SCALE

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:

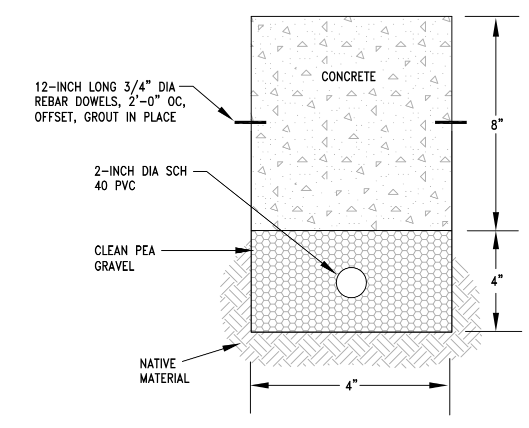
A. GRAVEL MATERIAL SHALL CONFORM TO ASTM C-33 SPECIFICATIONS FOR 3/8"AGGREGATE.

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.

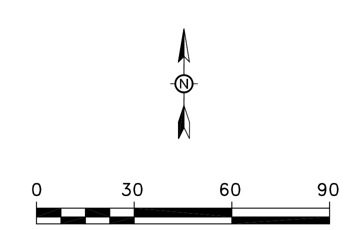


TRENCHING DETAIL
NOT TO SCALE

LEGEND

- SUB-SLAB VAPOR MONITORING POINT
- PROPOSED SUB-SLAB VAPOR EXTRACTION POINT
- SUB-SLAB VAPOR EXTRACTION POINT (USED IN PREVIOUS PILOT TEST)
- INDOOR AIR SAMPLING POINT
- 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)
- TARGET INFLUENCE AREA (PROPOSED)
- APPROXIMATE EXISTING INFLUENCE AREA
- INDOOR AIR FILTER
- EXISTING SSD BLOWER SKID
- EXISTING SUB-SLAB VAPOR EXTRACTION LATERAL
- 079-A — INDOOR AIR SAMPLING POINT

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



APPROVED BY:	DATE	REVISION	APRVD.

TITLE: CONCEPTUAL LAYOUT AND PIPE DETAILS BASIS OF 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	10-20-15

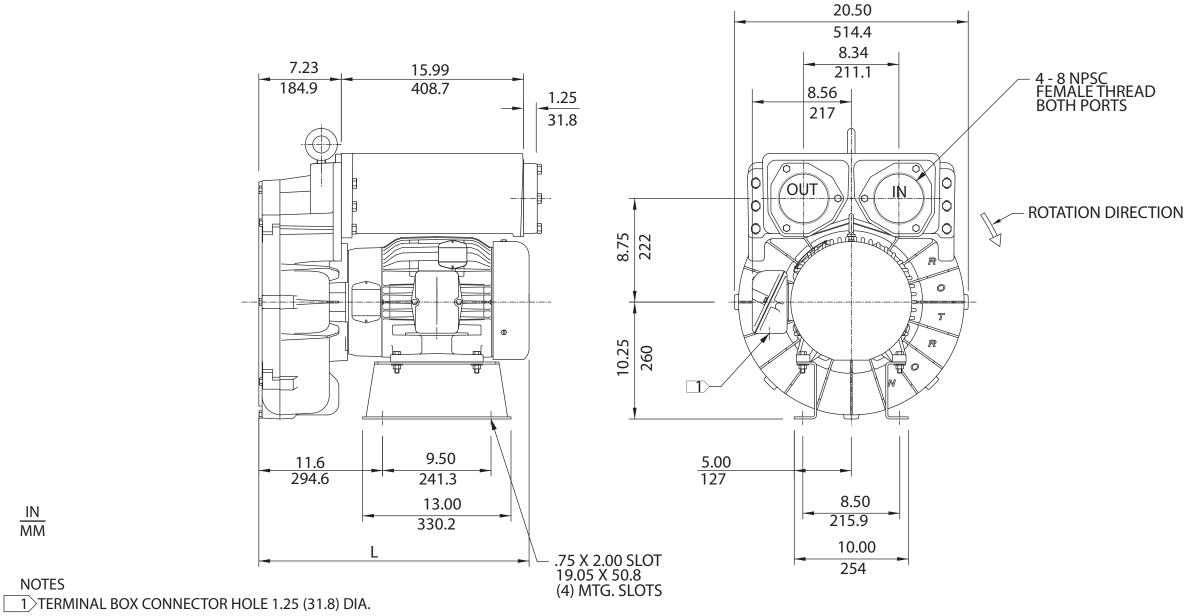
DRAWING: G2

APPENDIX B—EQUIPMENT INFORMATION

DR 909 & CP 909

ROTRON®

10.0 / 15.0 HP Regenerative Blower



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.

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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

AMETEK® TECHNICAL & INDUSTRIAL PRODUCTS

Industrial / Chemical Processing Blowers

ROTRON®

DR 909 & CP 909

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

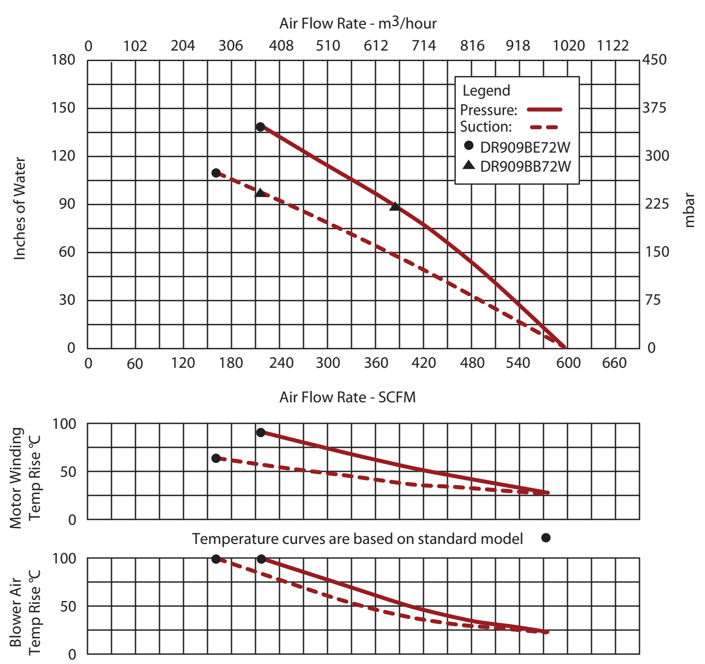
- Corrosion resistant surface treatments & sealing options
- Remote drive (motorless) models
- Slip-on or face flanges for application-specific needs

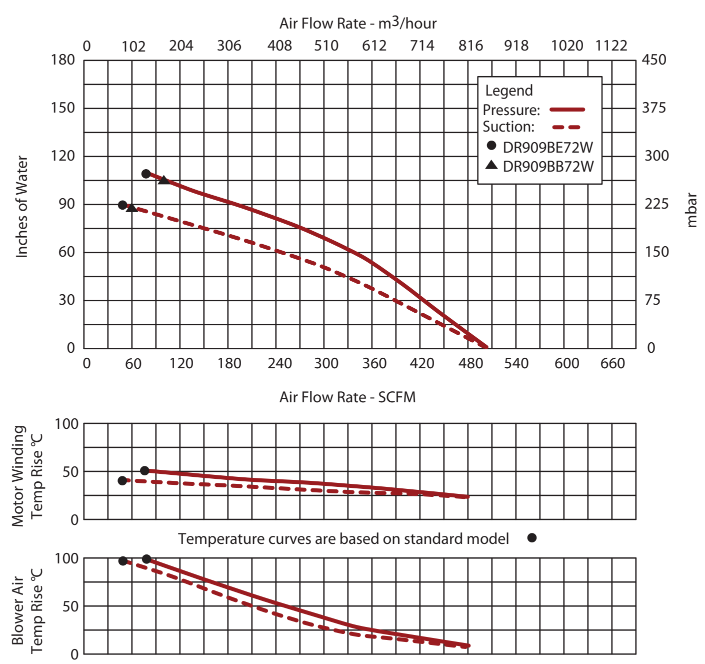
ACCESSORIES

- 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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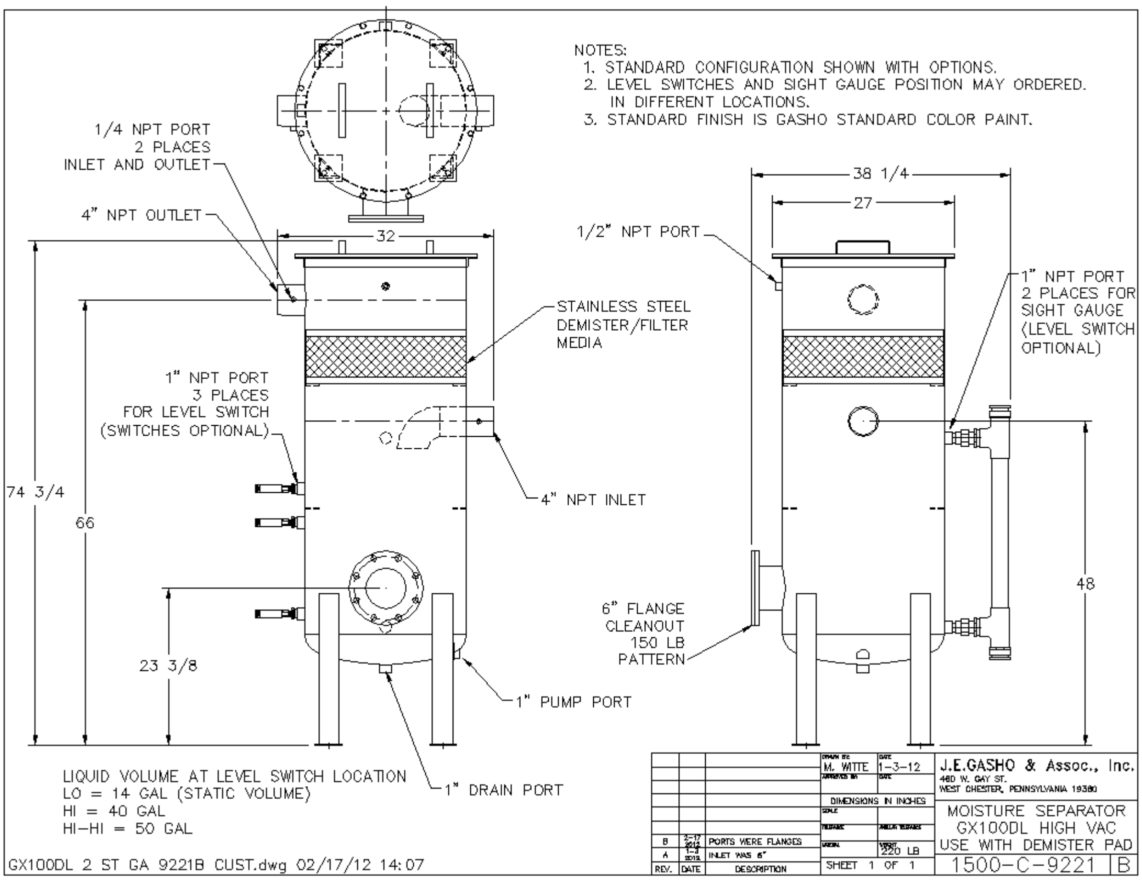
AMETEK® TECHNICAL & INDUSTRIAL PRODUCTS

Gasho
SINCE 1982
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



APPENDIX C—PRESSURE-LOSS CALCULATIONS

SYSTEM COMPONENT HEAD LOSS

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

System Flow: 290 standard cubic feet per minute (SCFM)

Vacuum-Side Loss for System Components

Component	Loss (inches water column)
PVC Pipe	< 3
Pipe at Blower	< 2
Moisture separator	< 1
Filter	18 (worst case scenario)
Miscellaneous	< 3
Total	**<27**

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**

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 = 115'
25 SCFM — 0.011 " LOSS / FT x 115' = 1.27 "
(SEE NOMOGRAPH)

HEADER 6" DIA - 530' + (5) 90°EL @ 15' EACH = 605'
150 SCFM (MAX) - ≤0.0028" LOSS / FT x 605 = <1.69'

PIPE TO BLOWER <3" 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 <1" LOSS

D FILTER 18" WORST CASE FOR FOULED FILTER
WILL REPLACE PRIOR

E MISC, SAFETY 3"

TOTAL SUCTION SIDE LOSS <27"

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"/FT x 25 = 1.25"

BY PAR DATE 9/18/15 PROJECT LOCKHEED MARTIN SHEET NO. 2 OF 4

CHKD. BY ______ DATE ______ MRC BLDG A SSD PROJ. NO. ______

C. HEAT EXCHANGER IF NEEDED SIMILAR TO BLDG C
<5"

D. FLOW METER <4" (SEE CUT SHEET)

E. GAC <7.5" LOSS EACH (SEE CUT SHEET)

F. MISC. SAFETY 3"

TOTAL PRESSURE LOSS <37"

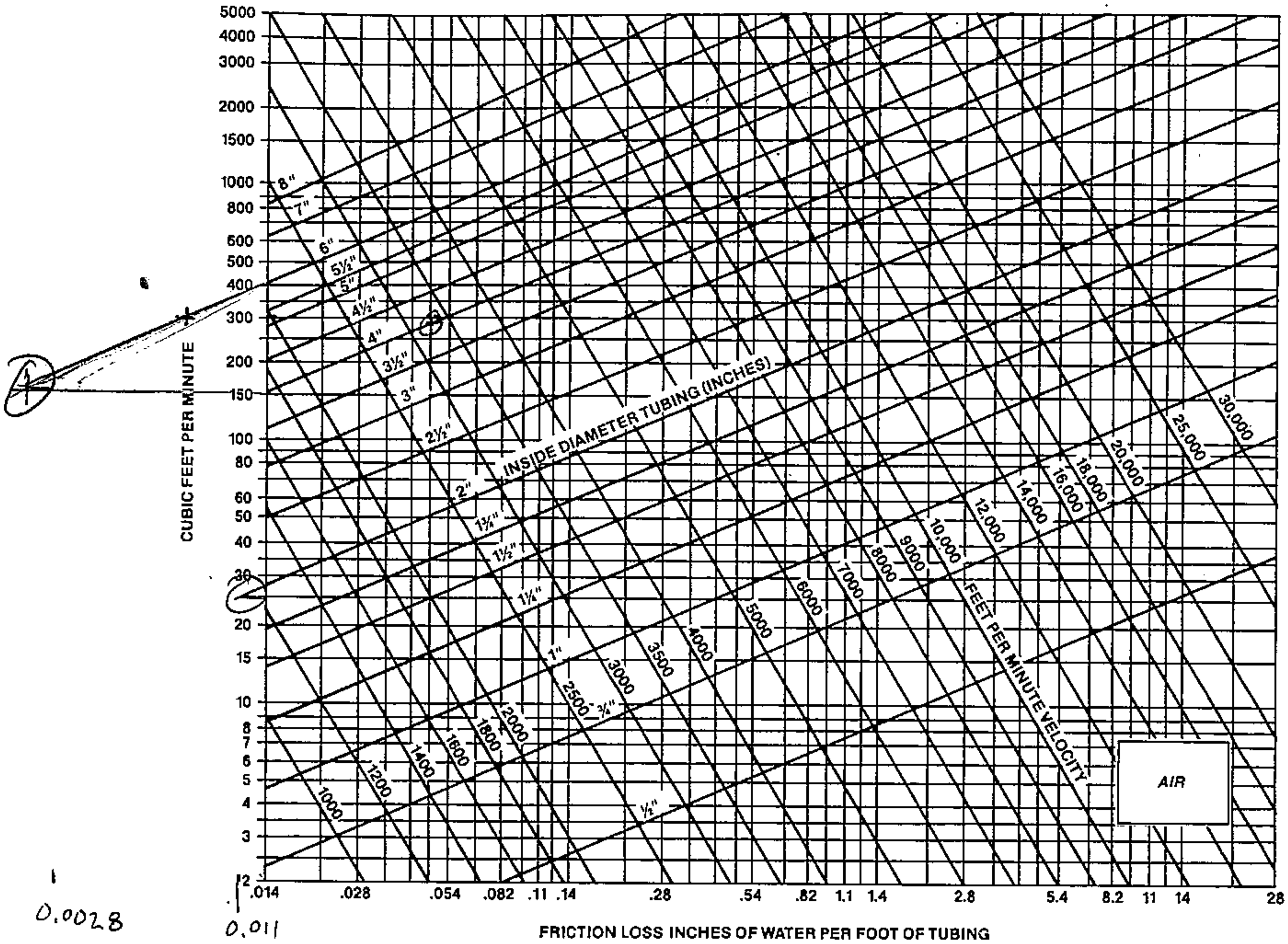
BLOWER CURVE SUCTION 290 SCFM @ ~80" H2O
27" LOSS OK

PRESSURE 290 SCFM @ ~115" H2O
37" LOSS OK

HSI GEOTRANS

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

Rev. 2/04

Gasho

SINCE 1982

The Leader in Blower & Vacuum Solutions

460 West Gay Street
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GX100-DL Moisture Separator, 400 CFM Specification

100 gallon vessel with approx. 40 gallons of storage
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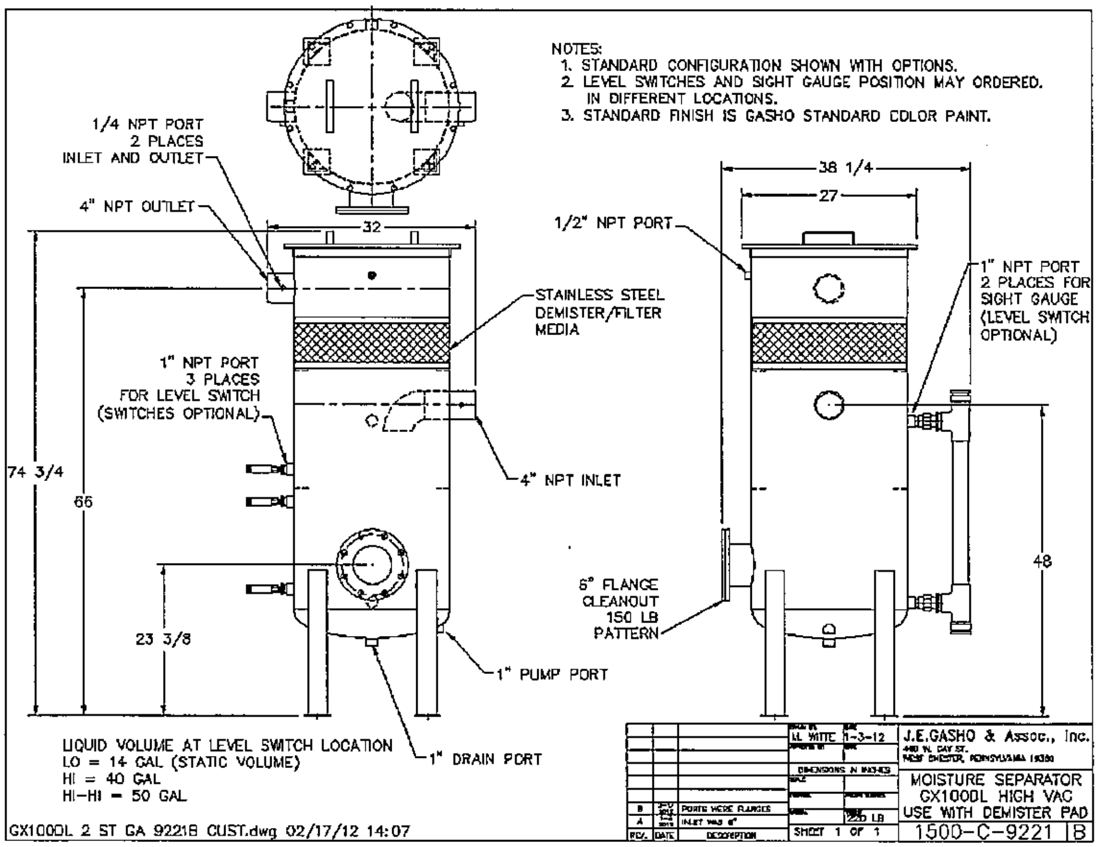
4" NPT inlet, and outlet
Standard External finish is alkyd paint, inside is left uncoated
Optional coatings available



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

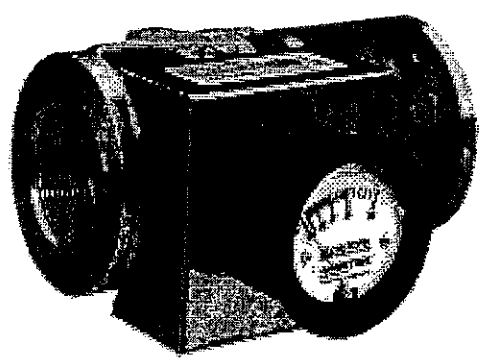
- Direct reading in SCFM
- Low pressure drop (2-4" typical) across the flow meter
- Non-clogging, low impedance air stream
- Light weight aluminum
- No moving parts
- Large easy-to-read dial
- Accurate within 2% at standard conditions
- Good repeatability
- Available in 2", 3" and 4" sizes
- Factory 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					
FM20C045Q	550600	9-45			7.0"		
FM20C065Q	550601	13-65	2" - 11.5 NPSC	7.18"		2.0"	3.75"
FM20C125Q	550602	25-125					
FM20C175Q	550603	35-175			5.6"		
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					
FM40C600Q	550609	120-600	4" - 8 NPSC	8.00"	7.7"	2.7"	5.43"
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)

1Carbon steel and stainless steel internals are also available.
2For vacuum greater than 12 in. Hg on Vent-Scrub® 2000 Adsorber, contact your Siemens representative.
3For vacuum service on Vent-Scrub® 3000 and 8000 Adsorber, contact your Siemens representative.
4For 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.

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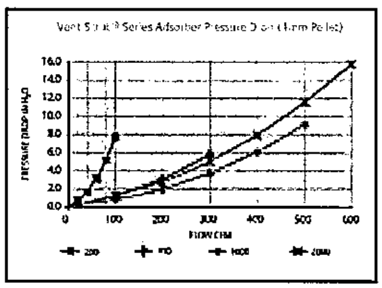

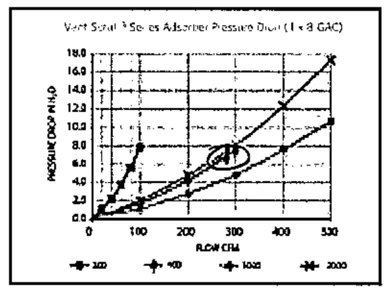

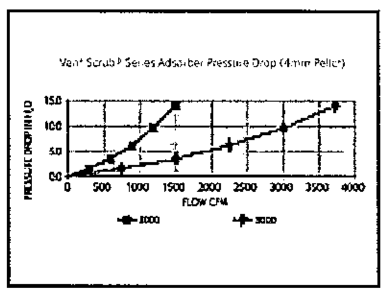

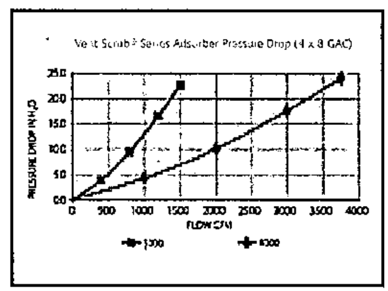

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Roseville, MN 55113
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