LANGAN

201 N Illinois Street, South Tower – Suite 1600, Indianapolis, IN 46204 T: 463.304.8450 F: 463.304.8451

To: Michael Saunders (McCormack Baron Salazar Development, Inc.)

From: Andrew Horwath

Date: 3 October 2025

Re: Certification of Revised Vapor Mitigation System Design
Mill Creek Development Phase I
2600 Governors Drive SW
Huntsville, Alabama
Langan Project No.: 350121101

This memo certifies revisions to the 06 August 2025 Radon Mitigation System design for the Mill Creek Development Phase I, located at 2600 Governors Drive SW, Huntsville, Alabama 35805. The site is situated in EPA Radon Zone 1 and has been subject to a Limited Phase II Environmental Site Assessment identifying elevated concentrations of volatile organic compounds (VOCs) in subsurface soil gas. These VOCs are believed to originate from an offsite source via preferential pathway migration. A summary of the VOC exceedances that were presented to me by Clint Werden of Slosky & Company, Inc., are listed below:

Chemical (VOC)	**Concentration Range** *ug/m3**	**EPA VISL** *ug/m3*	**EPA Target Sub-Slab Level**
Benzene	1.23 – 10.8	0.36	12
Bromodichloromethane	2.81 – 2.94	0.076	2.53
Chloroform	12.9 – 43.7	0.122	4.07
2-Propanol**	6,220 – 69,600	20.9	695
Tetrachloroethene	28.8 – 32.0	4.17	139

Note: * - ug/m3 = micrograms per cubic meter
** - anticipated QA/QC problem, but not resampled or reanalyzed.

DESIGN BASIS AND REVISIONS

The original radon mitigation system design, prepared by Hanley Environmental, PLLC (see Attachment A), will be upgraded to address both radon and VOC intrusion risks. The revised design includes the following key enhancements:

- Vapor Barrier Upgrade: Replacement of the Stego Industries, LLC (Stego) Stego Wrap 15-mil barrier with Stego's Drago Wrap 20-mil vapor barrier, compatible with hydrocarbons, chlorinated VOCs, and radon. Please see Attachment B for details on the Drago barrier.

- Low-VOC Adhesives: All PVC pipe adhesives shall comply with ASTM D2564 and F656 standards and be low-VOC.
- Barrier Termination: Sub-slab barriers may be extended beneath the footer and terminated on the exterior surface of the footings/foundations, provided all terminating edges are sealed per manufacturer specifications. Alternatively, the vapor barrier may be installed up the foundation wall or vertical surfaces interior to the building, terminated at an elevation consistent with the top of the slab or at impediments, and sealed in accordance with Stego's Installation Instructions and ASTM E1643 requirements. Either method can be completed with tape, mastic or terminations bars. See Attachment C for Stego's Drago Wrap Installation Instructions.
- Permanent Monitoring Points: Installation of Vapor Pins® or equivalent (see Attachment D) for long-term pressure field extension (PFE) and vapor monitoring. These Vapor Pins® should be installed at the Temporary Vacuum Monitoring Point locations listed in the original 06 August 2025 design document. PFE readings and vapor monitoring data will be documented.
- Post-Construction Testing: After installation, a Qualified Environmental Consultant (an Alabama-licensed Professional Engineer or Professional Geologist) will oversee a comprehensive sampling event—including sub-slab, vapor, indoor air, and ambient air samples—to confirm the effectiveness of the mitigation system and determine whether passive or active Vapor Mitigation System (VMS) operation is warranted. Chemical concentrations in each sampled medium will be evaluated for all relevant VOCs, as outlined in the project scope, to verify that mitigation objectives are achieved.
- Expanded Operations & Maintenance (O&M) Plan: Appropriate activation protocols, alarm systems, and long-term monitoring schedules for VOCs will be incorporated into the O&M manual post-construction.
- HVAC Coordination: Documentation will confirm that ventilation systems do not create excessive negative pressure zones near foundation walls. Additionally, any roof-mounted HVAC units with fresh air intakes will be evaluated for potential vapor intrusion risks associated with exhaust vent riser pipe discharge locations. Findings from both the foundation wall and HVAC evaluations will be recorded together.
- Labeling and Activation Readiness: Fan-ready infrastructure at the roof-level will include alarm systems and will meet VOC mitigation standards, should active an VMS be operated post-construction.

CERTIFICATION STATEMENT

I, Andrew Horwath, a Professional Engineer licensed in the State of Alabama, have prepared the revised VMS design elements above. Based on the information provided and my professional judgment, I certify that the revised design is suitable for implementation at the Mill Creek Phase I site, pending successful post-construction testing, validation and potential conversion to an active VMS operation.

Andrew Horwath
2025.10.03
15:45:46-04'00'

Andrew D. Horwath, P.E.

ATTACHMENTS

Attachment A – Original Radon Mitigation System Design
Attachment B – Stego Drago Wrap Data Sheet
Attachment C – Stego Drago Wrap Installation Instructions
Attachment D – Vapor Pin® Schematic

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Appendix A Original Radon Mitigation System Design

RADON MITIGATION SYSTEM

MILL CREEK APARTMENTS - PHASE I
2600 GOVERNORS DRIVE SW
HUNTSVILLE, AL 35801

SHEET INDEX	
V1	TITLE SHEET AND SPECIFICATIONS
V2	SUB-SLAB RADON MITIGATION LAYOUT
V3	LEVEL ONE RADON MITIGATION LAYOUT
V4	LEVELS 2-4 RADON MITIGATION LAYOUT
V5	ROOF RADON MITIGATION LAYOUT
V6	RADON MITIGATION SYSTEM DETAILS

PART 1 - GENERAL

1.1 These radon mitigation system design drawings and specifications include requirements for construction quality assurance/quality control, pre-occupancy testing, operation, maintenance, and monitoring which are integral to effective radon mitigation system installation and operation.

1.2 These drawings and specifications are intended to be used for the direction of radon mitigation system components only and are not intended to guide construction of structural, architectural, waterproofing, or other components. Contractor shall verify consistency of design with applicable structural, architectural, mechanical, electrical, waterproofing, and plumbing plans and resolve inconsistencies prior to installation.

1.3 The contractor is responsible for obtaining all required building permits and completing all associated permit requirements, including scheduling and passing inspections as mandated by local building codes.

1.4 Work shall be performed only when weather conditions are within the manufacturer recommendations for the materials and products used.

PART 2 - PRODUCTS

2.1 Soil Gas Collection and Venting System

A. The gas permeable layer (Detail 1 on Sheet V6) shall consist of a layer of at least 4 inches in depth of washed #57 stone with <5% fines, or another gravel that meets ASTM C33 requirements for size numbers 5, 56, 57, or 6.

B. Sub-slab vapor collection system shall consist of the following:

i Low profile geosynthetic mat venting intended for sub-slab vapor transport measuring 12" wide by 1" tall (e.g., American Wick Drain SITEDRAIN Strip 9400, 12" width).

ii 3-inch and 4-inch diameter, Schedule 40 PVC piping, and associated fittings.

C. Exhaust vent piping shall consist of 4-inch diameter, Schedule 40, solid PVC piping meeting local plumbing code.

D. Exhaust vent piping shall be capped with an Aura Model AV-4-PVC ventilation cap.

2.2 Radon Mitigation Barrier

A. A radon mitigation barrier shall prevent passage of radon gas and shall comply with physical requirements specified below. The radon mitigation system barrier shall consist of a geomembrane sealed at seams, penetrations, and terminations in accordance with manufacturer recommendations. The radon mitigation system barrier geomembrane shall meet the requirements for ASTM E1745 "Class A" and the following physical property specifications:

i Minimum 10-mil thickness.

ii Tensile strength of at least 45.0 lb/in.

iii Puncture resistance of at least 2,200 grams.

iv Radon diffusion coefficient of no greater than 10^{-10} m^2/sec.

B. Basis of Design: Stego® Wrap 15-Mil Vapor Barrier.

C. Accessory products recommended by the selected radon mitigation barrier manufacturer including tapes, adhesives, and mastics shall be used to seal penetrations, terminations, and seams.

PART 3 - EXECUTION

3.1 Radon Collection and Venting System

A. The gas permeable layer shall be placed with a minimum depth of four inches to form a continuous layer beneath slab-on-grade areas that are beneath an enclosed, occupiable building space. The gas permeable layer shall allow for uninterrupted flow of soil gases to the sub-slab vapor collection system. Utilities placed in the gas permeable layer may not be larger than 1 inch in diameter. Larger utilities shall be buried in the subbase.

B. The sub-slab vapor collection system shall be installed in accordance with manufacturer recommendations. Collection mats shall be placed centrally within the gravel layer. Outlet adapters shall be used at transitions from low profile mats to PVC piping.

C. PVC plastic pipe joints shall be solvent-welded in accordance with the pipe manufacturer's instructions with solvent cement conforming to ASTM D2564. The joint surfaces for PVC plastic pipe and fittings to be solvent-welded shall be prepared with a primer conforming to ASTM F656.

D. Vertical exhaust ventilation piping shall be secured to the building structure at intervals not exceeding 10 feet and horizontal exhaust ventilation piping shall be secured at intervals not exceeding 4 feet, or as per local building code.

E. Exhaust ventilation piping shall be sloped a minimum of 1% slope toward ground surface to gravity drain and avoid traps.

F. Exhaust ventilation piping shall be labeled "Radon Mitigation System" at least every 10 linear feet, including above the roof.

G. A location on the roof at each exhaust ventilation piping riser shall be identified and labeled for future installation of an active soil depressurization fan, if necessary. Electrical conductors from a dedicated, labeled, breaker shall be provided within 6 feet of each proposed fan location to supply a boxed junction installed in accordance with applicable codes. The boxed junction shall be labeled "Radon Gas Fan" and shall provide continuous service when activated and shall not be joined to mechanical or automated systems that could deactivate the breaker. Each conductor shall provide 120 volts, 60 Hz, AC power on minimum 15 amp circuit.

H. Exhaust outlets shall be at least 18 inches above flat roofs. Exhaust outlet locations shall meet the requirements of Section 9 of ANSI/AARST CC-1000 "Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings" and shall not be less than 4 feet above or 15 feet away from operable openings in structures and 10 feet away from mechanical air intakes.

3.2 Radon Mitigation Barrier

A. The radon mitigation barrier shall be applied continuously below slabs within the areas specified on the drawings. The radon mitigation barrier shall be installed in conformance with manufacturer recommendations. Where manufacturer's details conflict with details in the radon mitigation design drawings, radon mitigation design drawing details shall be used.

B. Barrier edges shall be sealed to footers to create an air-tight seal in accordance with manufacturer recommendations. Alternatively, if a monopour of slabs and footers is used, the barrier shall extend beneath footers and to the exterior edge of exterior footers.

C. Barrier seams shall be overlapped a minimum of six inches and sealed air-tight.

D. At penetrations through the radon mitigation barrier (e.g., utility conduits, plumbing pipes, etc.), the penetrations shall be sealed per radon mitigation barrier manufacturer recommendations to create an air-tight seal around the penetration (Detail 3 on Sheet V6).

E. Concrete forms, reinforcing steel, etc. shall not be driven into the membrane and shall be placed to be protective of the membrane. Hollow pipe supports penetrating the barrier shall not be used. Punctures or other damage shall be patched in accordance with manufacturer recommendations.

F. Foundation walls in contact with soil and an enclosed, occupiable space shall be damp proofed or waterproofed with methods consistent with Section 1805 of the International Building Code. The methods shall be applied on exterior surfaces of walls from the top of the footing to above ground level, to include closure of all cold joint seams below grade. If waterproofing or damp proofing is not provided, the radon mitigation barrier shall be applied to these walls (Detail 10 on Sheet V6).

G. The radon mitigation barrier components shall be installed in coordination with waterproofing products and must be reviewed and approved by the architect or waterproofing consultant.

3.3 Vacuum Monitoring Points

A. Temporary vacuum monitoring points shall be installed to allow for sub-slab vacuum measurement during pressure field extension testing (see Specification 3.4.B).

B. Temporary vacuum monitoring points shall be installed by drilling a 1/4-inch diameter hole through the concrete slab and radon mitigation barrier at approximate locations shown on the drawings. Locations of temporary vacuum monitoring points may be adjusted in the field based on access or obstructions. Alternatively, temporary vacuum monitoring points may be installed prior to closing barriers and casting slabs by securing a PVC pipe with an open end in the gas permeable layer and extending above the top of slab (Detail 4 Sheet V6).

C. Following acceptable sub-slab vacuum measurements, temporary vacuum monitoring points shall be abandoned by cutting flush with the top of slab and filling with non-shrinking cement grout.

3.4 Quality Assurance/Quality Control, Operations and Maintenance

A. The following inspections are required to be performed during system construction:

i Sub-slab system components (e.g., gas permeable layer, soil gas inlets, and piping) shall pass inspection prior to being covered with a radon mitigation barrier.

ii Placement of the radon mitigation barrier shall pass inspection prior to pouring the concrete slabs.

iii Exhaust vent piping and outlet locations shall be inspected prior to covering with drywall or other finishings.

Inspections shall be conducted in coordination with an individual who is trained and qualified for design of systems under ANSI/AARST CC-1000 "Soil Gas Control Systems in new Construction of Multifamily, School, Commercial, and Mixed-Use Buildings."

B. Pressure field extension testing shall be performed by or under direction of a Qualified Radon Professional to verify that areas below the slab can be effectively influenced by the radon collection network. Pressure field extension testing shall be performed using varying applied vacuum levels to allow for sizing of future radon fans (if required). A minimum acceptable vacuum influence of 1 Pascal at remote extents of the sub-slab shall be used.

C. System documentation shall include a written Operation, Maintenance and Monitoring Manual for the mitigation system suitable for distribution to maintenance personnel and other appropriate parties. This document shall include items specified in Section 12 of ANSI/AARST CC-1000 "Soil Gas Control Systems in new Construction of Multifamily, School, Commercial, and Mixed-Use Buildings" including a system descriptions, as-built drawings, results of pressure field extension testing, designated responsibilities, and contingency plans for system activation.

D. Radon testing shall be performed following system construction following protocols in ANSI/AARST MA-MFLB "Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily, School, Commercial and Mixed-Use Buildings".

E. Building mechanical ventilation systems shall be designed and operated to avoid excessive negative pressure locations below and to the side of the exterior foundation surfaces that adjoin soil, in accordance with Section 10 of ANSI/AARST CC-1000.

The undersigned Radon Professional is certified by the American Assoication of Radon Scientists and Technologists (AARST) National Radon Proficience Program (NRPP) as a Radon Mitigation Specialist.

David Hanley
NRPP # 113993-RMS

REVISION	DATE	DESCRIPTION	
0	08/06/25	ISSUED	DH

Hanley Environmental Engineering & Consulting
HANLEY ENVIRONMENTAL, PLLC
323 MANNING DRIVE
CHARLOTTE, NORTH CAROLINA

DATE 08/06/25
PROJECT NO. PJ25014
DRAWN BY NAH

PREPARED FOR
CORCORAN OTA, INC.
5871 GLENRIDGE DRIVE, SUITE 200
ATLANTA, GEORGIA

PROJECT
MILL CREEK APARTMENTS - PHASE I
2600 GOVERNORS DRIVE SW
HUNTSVILLE, AL 35801

SHEET TITLE
TITLE SHEET AND SPECIFICATIONS

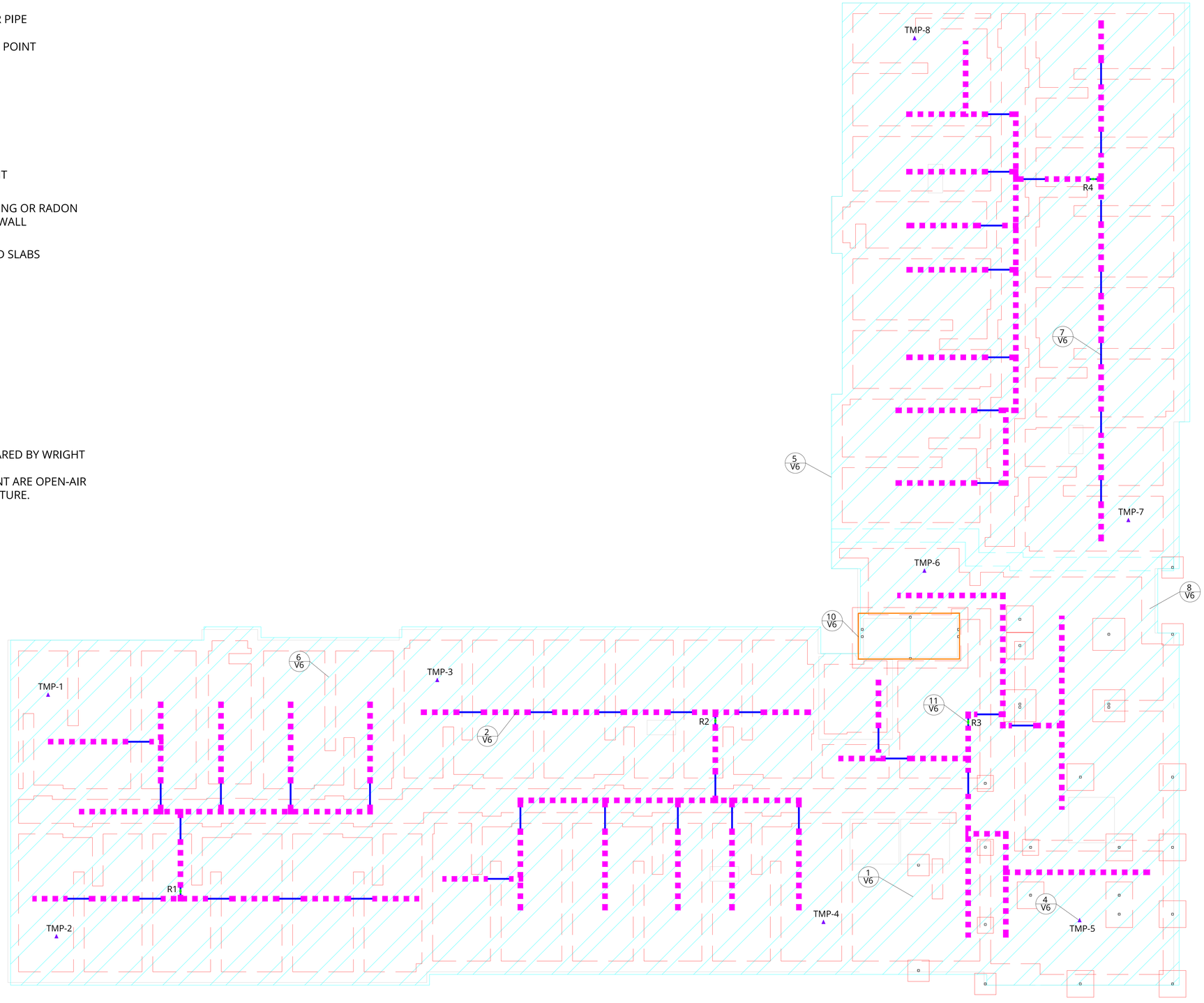
SHEET NO.
V1

LEGEND

- 4" SCH. 40 PVC EXHAUST VENT RISER PIPE
- TEMPORARY VACUUM MONITORING POINT
- VAPOR COLLECTION SYSTEM
- 4" SCH. 40 PVC PIPE
- 3" SCH. 40 PVC PIPE
- RADON MITIGATION BARRIER EXTENT
- DAMP PROOFING OR WATERPROOFING OR RADON MITIGATION BARRIER ON VERTICAL WALL
- BUILDING FOOTERS AND THICKENED SLABS
- 5 / V6 — DETAIL CALLOUT

NOTES

1. FOUNDATION PLAN BACKGROUND PREPARED BY WRIGHT ENGINEERING, PROVIDED ON 06/04/2025.
2. BUILDING AREAS OUTSIDE BARRIER EXTENT ARE OPEN-AIR AND SHALL NOT BE ENCLOSED IN THE FUTURE.



1 BUILDING 1 SUB-SLAB RADON MITIGATION LAYOUT
SCALE: 1/8" = 1'-0"

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SHEET TITLE
SUB-SLAB RADON MITIGATION LAYOUT

SHEET NO.
V2

LEGEND

- 4" SCH. 40 PVC EXHAUST VENT RISER PIPE
- TEMPORARY VACUUM MONITORING POINT
- 5 / V6 — DETAIL CALLOUT

NOTES

1. ARCHITECTURAL PLAN BACKGROUNDS PROVIDED BY CORCORAN OTA ON 04/21/2025.

1 LEVEL 1 RADON MITIGATION LAYOUT
SCALE: 1/8" = 1'-0"

The undersigned Radon Professional is certified by the American Assoication of Radon Scientists and Technologists (AARST) National Radon Proficience Program (NRPP) as a Radon Mitigation Specialist.

David Hanley
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SHEET TITLE
LEVEL 1 RADON MITIGATION LAYOUT

SHEET NO.
V3

LEGEND

- 4" SCH. 40 PVC EXHAUST VENT RISER PIPE
- 5 / V6 — DETAIL CALLOUT

NOTES

1. ARCHITECTURAL PLAN BACKGROUNDS PROVIDED BY CORCORAN OTA ON 04/21/2025.

1 LEVELS 2-4 RADON MITIGATION LAYOUT
SCALE: 1/8" = 1'-0"

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SHEET TITLE
LEVELS 2-4 RADON MITIGATION LAYOUT

SHEET NO.
V4

LEGEND

- 4" SCH. 40 PVC EXHAUST VENT RISER PIPE
- 5/V6 DETAIL CALLOUT

NOTES

1. ARCHITECTURAL PLAN BACKGROUNDS PROVIDED BY CORCORAN OTA ON 04/21/2025.

1 LEVELS 2-4 RADON MITIGATION LAYOUT
SCALE: 1/8" = 1'-0"

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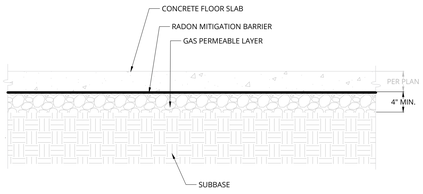
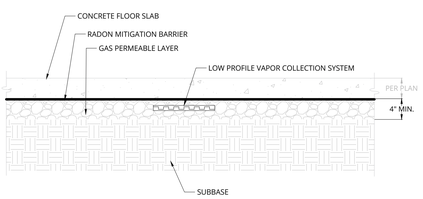
HUNTSVILLE, AL 35801

SHEET TITLE
ROOF RADON MITIGATION LAYOUT

SHEET NO.
V5



1 TYP. RADON MITIGATION BARRIER AND GAS PERMEABLE LAYER
SCALE: 1" = 1'-0"



2 TYP. SUB-SLAB COLLECTION SYSTEM
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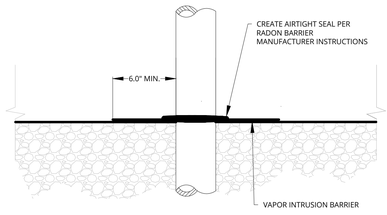
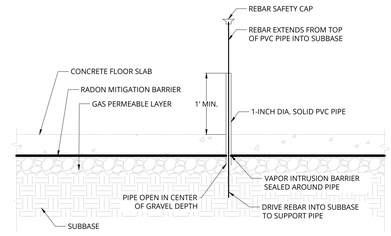
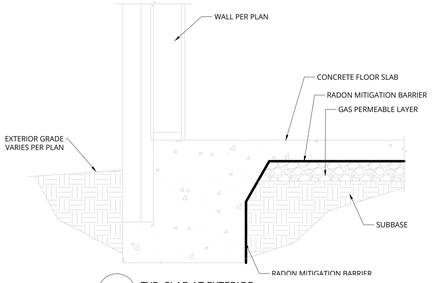


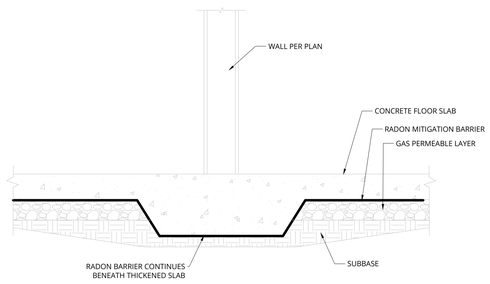
3 TYP. RADON MITIGATION BARRIER PENETRATION
NOT TO SCALE



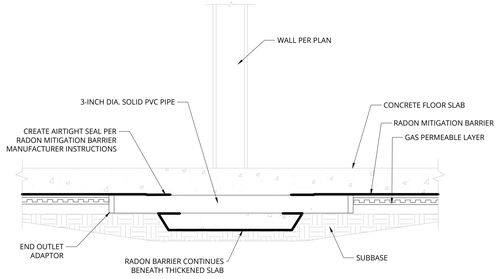
4 TYP. TEMPORARY VACUUM MONITORING POINT
SCALE: 1" = 1'-0"



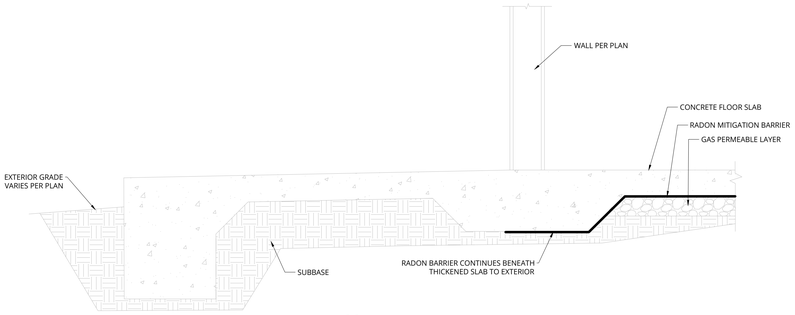
5 TYP. SLAB AT EXTERIOR
SCALE: 1" = 1'-0"



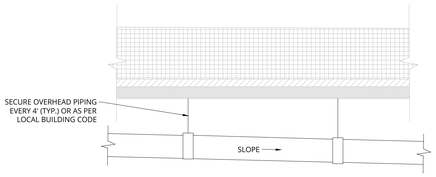
6 TYP. SECTION AT INTERIOR FOOTING
SCALE: 1"=1'-0"



7 TYP. SUB-SLAB COLLECTION SYSTEM AT INTERIOR FOOTING
SCALE: 1" = 1'-0"

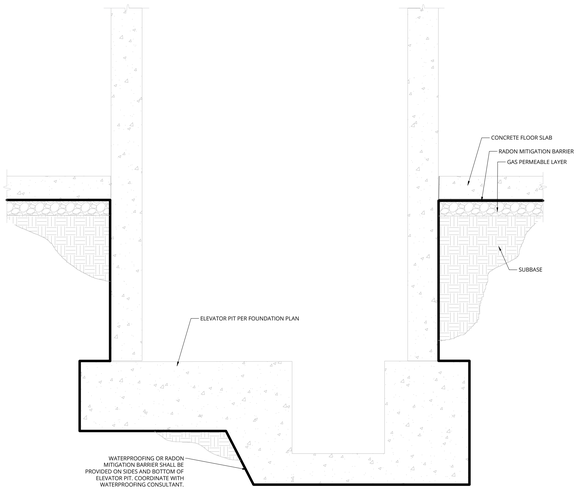


8 TYP. SECTION AT PORCH SLAB
SCALE: 1"=1'-0"

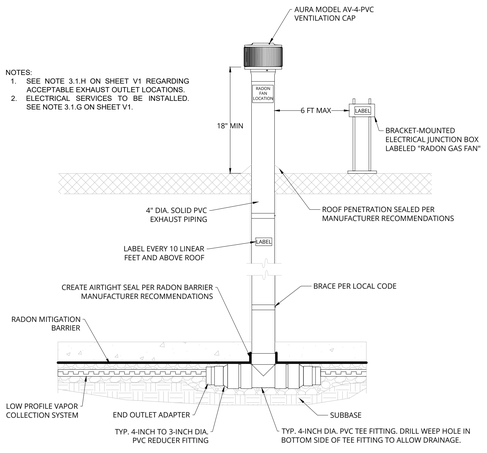


NOTES:
1. MAINTAIN AT LEAST 1/8" PER FOOT SLOPE TOWARD GROUND AND AVOID TRAPS.

9 TYP. HORIZONTAL OVERHEAD PIPE, IF NECESSARY
SCALE: 1"=1'-0"



10 TYP. ELEVATOR PIT
NOT TO SCALE



11 TYP. EXHAUST RISER
SCALE: 1"=1'-0"

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SHEET TITLE
RADON MITIGATION SYSTEM DETAILS

SHEET NO.
V6

Hanley Environmental, PLLC
323 Manning Drive
Charlotte, North Carolina 28209
T: (704) 317-8044
www.hanleyenvironmental.com

August 6, 2025

Judy Warner-Babb
Associate Principal
Corcoran Ota, Inc.
5871 Glenridge Drive, Suite 200
Atlanta, GA 30328
babb@corcoran-ota.com

Re: Basis of Design - Radon Mitigation System
Mill Creek Apartments – Phase I
2600 Governors Drive SW
Huntsville, Alabama 35805
Project No. PJ25014

Dear Judy Warner-Babb:

Hanley Environmental, PLLC is providing this Basis of Design to Corcoran Ota, Inc. (the Client) for a radon mitigation system for the multifamily residential building at the proposed Mill Creek Multifamily Building development, a planned mixed-use apartment development located in Huntsville, Alabama, (the site). The purpose of this Basis of Design is to document the key design considerations, criteria, and assumptions used in development of the radon mitigation system design. This report also describes requirements for quality assurance/quality control (QA/QC) during system construction, requirements for post-construction performance monitoring/testing, and reporting/documentation requirements.

Proposed Development Overview

The proposed multifamily residential development includes one four-story apartment building with residential amenity space (i.e. fitness room, mail room, work room, etc.) on the ground floor. The building includes approximately 21,750 square feet in contact with the ground surface.

The building will be constructed on 5-inch-thick slabs on grade with grade beam/thickened slab foundations and column footings. Wall footers/grade beams inside the slab perimeter will serve as obstructions to vapor transport below the slab. The building will include two elevators within a single elevator pit that extends below grade.

Radon Mitigation System Overview and Objectives

The objective of the proposed radon mitigation system is to reduce occupant exposure to radon, a colorless, odorless, naturally occurring, radioactive, inert gaseous element. Madison County, Alabama, the location of the proposed development, is classified by the United States (US) Environmental Protection Agency (EPA) as radon Zone 1, which indicates the highest potential for radon occurrence. The US EPA recommends an action level of 4 picocuries per liter (pCi/L) of radon in indoor air to take action to address radon. There is no known safe level of exposure to radon, and the action level of 4 pCi/L is a recommendation rather than a regulatory standard. Based on this recommendation, the objective of the proposed radon mitigation system design is to reduce radon concentrations to below 4 pCi/L in the indoor air of occupied spaces in portions of the building where radon mitigation will be provided. This will be achieved by providing a pathway for venting soil gas from below the building floor slab to above the building roof, reducing the likelihood of soil gas containing radon entering the occupied building spaces.

Based on the uncertainty of radon conditions at the site (testing has not been performed) and the complexities of radon transport mechanisms, compliance with the specifications in this design with passive venting does not guarantee reduction of soil gas entry to the degree needed to achieve action levels for radon gas. Testing should be performed following system construction to evaluate radon concentrations in the buildings. If warranted, additional actions may be required such as implementing active mitigation with electric fans, sealing cracks or conduits, or other measures. The systems were designed to reduce radon intrusion originating from subsurface soil gas. The systems will not address hazards from other

potential radon sources, such as airborne radon that results from radon in water, building materials, or other less common radon sources.

The radon mitigation system design was prepared under the direction of an NRPP-certified Radon Mitigation Specialist (RMS #113993). Use of specific guidance documents and standards in development of this Basis of Design Report is described below. This Basis of Design requires implementation of the specified QA/QC procedures, effectiveness testing requirements, contingency activation requirements, and reporting procedures. Failure to implement these procedures and requirements may limit the system's effectiveness.

Design Basis

The radon mitigation system design, as presented in the design drawings and specifications prepared by Hanley Environmental, was developed in general accordance with *Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings* (ANSI/AARST CC-1000 revised 2023), and in consideration of other applicable guidance and relevant professional experience. The radon mitigation system design meets requirements of Section 512 – Subslab Soil Exhaust Systems of the 2018 International Mechanical Code as required by the Madison County Building Inspection Department.

The scope of radon mitigation at the proposed development includes one four-story multifamily apartment building. The radon mitigation system will provide soil gas control for portions of the foundation where there is enclosed space immediately above the slab-on-grade. Apartment patios are not enclosed and will not receive mitigation. Patios should not be enclosed in the future.

The radon mitigation system design in each building generally includes the following components:

- A soil gas retarder membrane beneath the concrete slab. The membrane shall consist of polyethylene sheeting, or other barrier meeting specifications in the drawings, of

not less than 10 mils in thickness. The membrane shall be continuously sealed airtight at terminations, penetrations, and seams.

- A gas permeable layer beneath the soil gas retarder membrane consisting of at least 4 inches in depth of washed gravel or crushed stone.
- A soil gas vent system within the gas permeable layer providing collection of soil gas and routing soil gas to exhaust vent riser pipes.
- Four soil gas exhaust vent pipes consisting of solid PVC piping extending from the gas permeable layer beneath the building slab to exhaust outlets above the building roof.
- Exhaust outlets at the terminations of exhaust vent riser pipes above the building roof, initially consisting of passive ventilator caps. A location above the roof at each exhaust ventilation piping riser shall be identified and labeled, and an electrical outlet shall be installed for future installation of an active soil depressurization fan, if necessary.
- Temporary vacuum monitoring points consisting of temporary drilled holes or PVC pipes installed through the slab to allow for measurement of pressure field extension in the gas permeable layer following slab installation.

Heating, ventilation, and air conditioning (HVAC) evaluations are a required component of *Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings* (ANSI/AARST CC-1000 revised 2023) for enclosed areas located below or to the side of exterior foundation surfaces. HVAC evaluations are outside the scope of Hanley Environmental's design, and it is assumed that building HVAC systems are designed and will be operated to avoid excessive negative pressure locations below and to the side of the exterior foundation surfaces that adjoin soil.

Quality Assurance/Quality Control

In accordance with *Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings* (ANSI/AARST CC-1000 revised 2023), inspections for compliance during construction are required for each component of the system and will include the following:

- Inspection of sub-slab system components (e.g., gas permeable layer, soil gas inlets and piping) prior to being covered with a radon mitigation barrier.
- Inspection of placement of the radon mitigation barrier prior to pouring the concrete slabs.
- Inspection of exhaust riser piping prior to covering with drywall or other finishings.

Inspections shall be conducted in coordination with an individual who is trained and qualified for design of systems under ANSI/AARST CC-1000. Findings that do not meet specifications will be re-inspected following correction.

Pressure Field Extension Testing

Pressure field extension testing is required to be performed prior to building occupancy to verify that areas below the slab can be effectively influenced by the piping network. Pressure field extension testing will occur after slabs have been cast. The evaluation will include connecting a fan to exhaust vent piping and measuring the resulting vacuum within the gas permeable layer at strategic locations. This testing will verify that no changes are needed for the design of exhaust vent piping assemblies. Temporary vacuum monitoring points (VMPs) will consist of approximately 1/4-inch diameter holes drilled through the slab at strategic locations remotely distant from the exhaust vent pipe risers to evaluate effectiveness and consistency of soil gas transport beneath the building slab. Alternatively, temporary VMPs may be installed prior to closing membranes and casting slabs by securing a PVC pipe with an open end in the gas permeable layer which extends above the top of slab elevation.

Testing may be performed before pipes are extended to the building roof. A fan will be connected to riser pipes one at a time to apply a vacuum to the gas permeable layer and the pressure differential in nearby VMPs will be measured and recorded. Pressure field extension testing will be performed using varying applied vacuum levels to allow for sizing of future radon fans (if required). The vacuum measurements will be evaluated for evidence of poor effectiveness and inconsistencies, and consideration of system modifications will be

taken if such evidence is identified. A minimum acceptable vacuum influence of 1 pascal at remote extents of the sub-slab will be used to evaluate effectiveness.

Operation, Maintenance, and Monitoring Requirements

System documentation shall include a written Operation, Maintenance and Monitoring Manual for the mitigation systems suitable for distribution to maintenance personnel and other appropriate parties. This document shall include items specified in Section 12 of ANSI/AARST CC-1000 revised 2023 "*Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings*" including a system description, as-built drawings, results of pressure field extension testing, designated responsibilities, and contingency plans for system activation.

If testing results indicate radon concentrations exceeding the action level of 4 pCi/L, the system shall be activated and retested to verify radon concentrations are below the action level of 4pCi/L. If retesting results indicate continued exceedance of the action level of 4 pCi/L, additional diagnostics and mitigation shall be conducted by a qualified mitigation professional.

Closing

Please do not hesitate to contact David Hanley at (704) 317-6970 if you would like to discuss this Basis of Design.

Sincerely,

Nick Hotzelt
Project Engineer

David Hanley
Principal Engineer
NRPP Radon Mitigation Specialist

Appendix B Stego Drago Wrap Data Sheet

DRAGO® WRAP
VAPOR INTRUSION BARRIER

A STEGO INDUSTRIES, LLC INNOVATION | VAPOR RETARDERS 07 26 00, 03 30 00 | VERSION: FEB 4, 2025

1. PRODUCT NAME

DRAGO WRAP VAPOR INTRUSION BARRIER

2. MANUFACTURER

Stego Industries, LLC
216 Avenida Fabricante, Suite 101
San Clemente, CA 92672
Sales, Technical Assistance
Ph: (877) 464-7834
contact@stegoindustries.com
stegoindustries.com

3. PRODUCT DESCRIPTION

USES: Drago Wrap Vapor Intrusion Barrier is specifically engineered to attenuate volatile organic compounds (VOCs) and serve as a below-slab moisture vapor barrier.

COMPOSITION: Drago Wrap Vapor Intrusion Barrier is a multi-layered plastic extrusion that combines uniquely designed materials with only high grade, prime, virgin resins.

ENVIRONMENTAL FACTORS: Drago Wrap Vapor Intrusion Barrier can be used in systems for the control of various VOCs including hydrocarbons, chlorinated solvents, radon, methane, soil poisons, and sulfates.

4. TECHNICAL DATA

TABLE 4.1: PHYSICAL PROPERTIES OF DRAGO WRAP VAPOR INTRUSION BARRIER

PROPERTY	TEST	RESULTS
Under Slab Vapor Retarders	ASTM E1745 – Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs	ASTM E1745 Compliant
Water Vapor Permeance	ASTM F1249 – Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor	0.0069 perms
Push-Through Puncture	ASTM D4833 – Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products	183.9 Newtons
Tensile Strength	ASTM D882 – Test Method for Tensile Properties of Thin Plastic Sheeting	53.5 lbf/in
Permeance After Conditioning (ASTM E1745 Sections 7.1.2 - 7.1.5)	ASTM E154 Section 8, F1249 – Permeance after wetting, drying, and soaking ASTM E154 Section 11, F1249 – Permeance after heat conditioning ASTM E154 Section 12, F1249 – Permeance after low temperature conditioning ASTM E154 Section 13, F1249 – Permeance after soil organism exposure	0.0073 perms 0.0070 perms 0.0062 perms 0.0081 perms
Benzene Permeation Coefficient	Aqueous Phase Film Permeation Testing	4.5×10^{-13} m^2/s
Toluene Permeation Coefficient	Aqueous Phase Film Permeation Testing	5.1×10^{-13} m^2/s
Ethylbenzene Permeation Coefficient	Aqueous Phase Film Permeation Testing	3.1×10^{-13} m^2/s
M&P-Xylenes Permeation Coefficient	Aqueous Phase Film Permeation Testing	2.9×10^{-13} m^2/s
O-Xylene Permeation Coefficient	Aqueous Phase Film Permeation Testing	2.7×10^{-13} m^2/s
TCE Permeation Coefficient	Aqueous Phase Film Permeation Testing	9.8×10^{-13} m^2/s
PCE Permeation Coefficient	Aqueous Phase Film Permeation Testing	6.6×10^{-13} m^2/s
MTBE Permeation Coefficient	Aqueous Phase Film Permeation Testing	1.0×10^{-15} m^2/s
DCM Permeation Coefficient	Aqueous Phase Film Permeation Testing	4.5×10^{-13} m^2/s
Naphthalene Permeation Coefficient	Aqueous Phase Film Permeation Testing	2.5×10^{-14} m^2/s
1,4-DCB Permeation Coefficient	Aqueous Phase Film Permeation Testing	7.1×10^{-13} m^2/s
Methane Transmission Rate	ASTM D1434 – Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting	7.0 GTR** (mL(STP)/m^2*day)
Radon Diffusion Coefficient	K124/02/95	9.8×10^{-14} m^2/second
Thickness		20 mil
Roll Dimensions		14' x 105' or 1,470 ft^2
Roll Weight		150 lb

Note: perm unit = grains/(ft^2*hr*in-Hg) **GTR = Gas Transmission Rate

Continued...
Note – legal notice on page 2.

DRAGO® WRAP
VAPOR INTRUSION BARRIER

5. INSTALLATION

UNDER SLAB: Unroll Drago Wrap Vapor Intrusion Barrer over a tamped aggregate, sand, or earth base. Overlap all seams a minimum of 12 inches and tape using DragoSeal® Tape. All penetrations must be sealed using a combination of Drago Wrap Vapor Intrusion Barrer and Drago Accessories.

Drago Wrap should be installed below 110°F. Do not exceed 7 days between Drago Wrap installation and concrete placement or full protection from UV and weather exposure. Please review technical data sheets for Drago accessory products for installation/application temperature ranges.

Review Drago Wrap Vapor Intrusion Barrer's complete installation instructions prior to installation.

6. AVAILABILITY & COST

Drago Wrap Vapor Intrusion Barrier is available nationally through our network of building supply distributors. For current cost information, contact your local Drago distributor or Stego® Sales Representative.

7. WARRANTY

Stego believes to the best of its knowledge, that specifications and recommendations herein are accurate and reliable. However, since site conditions are not within its control, Stego does not guarantee results from the use of the information provided herein. Stego does offer a limited warranty on Drago Wrap Vapor Intrusion Barrier. Please see **stegoindustries.com/legal**

8. MAINTENANCE AND STORAGE

Maintenance: None required.
Storage and Handling: Store between 40°F and 100°F. Do not allow to freeze.

Please refer to the Safety Data Sheet (SDS) for detailed safety, storage, and handling procedures.

9. TECHNICAL SERVICES

Technical advice, custom CAD drawings, and additional information can be obtained by contacting Stego or by visiting the website.

Email: contact@stegoindustries.com
Contact Number: (877) 464-7834
Website: **stegoindustries.com**

10. FILING SYSTEMS: stegoindustries.com

DRAGO® WRAP VAPOR INTRUSION BARRIER
SUMMARY OF PERMEATION AND ATTENUATION TESTING

BACKGROUND

From October 2015 through August 2018, Drago Wrap Vapor Intrusion Barrier was subjected to a series of diffusion and sorption tests to obtain the film's diffusion, partitioning, and permeation characteristics. This testing was designed and overseen by an expert in the permeation of volatile organic compounds (VOCs) at a prominent university. The results of this testing, combined with further modeling and analysis, have been used to empirically determine the attenuation efficacy of Drago Wrap against various hydrocarbons and chlorinated solvents. The purpose of this document is to briefly discuss the theory behind diffusive vapor intrusion (VI); summarize and explain the robust testing protocol utilized; and relay the results of the testing and analysis.

CHEMICALS TESTED

Drago Wrap has been tested with regard to permeation of the following chemicals: Trichloroethylene (TCE); Perchloroethylene (PCE); the BTEX family: Benzene, Toluene, Ethylbenzene, Xylene; Dichloromethane; 1,4 Dichlorobenzene; Methyl tert-butyl ether (MTBE) and Naphthalene. This list was chosen based on a survey of the most often found chemicals on brownfield projects.

THEORY

The practical purpose behind obtaining permeation, diffusion, and partitioning coefficients is to apply them to the equations governing mass flux per Fick's laws during design of VI mitigation systems. The following briefly explains the theory and physics behind Fick's First Law.

The diffusion coefficient, D_g (units expressed in [m^2/s]), is the parameter defining the membrane's resistance to the diffusive mass flux [g/m^2s] transported within the membrane as governed by Fick's First Law:

$$f = -D_g \frac{dc_g}{d_z} \qquad \text{(Eq. 1)}$$

due to a concentration gradient dc_g/d_z [g/m^4] in the membrane layer. If the contaminant source is an aqueous solution adjacent to the membrane, the concentration of the contaminant in the membrane can be related to that in the fluid (at equilibrium) by the partitioning coefficient, S_{gf} (where S_{gf} is analogous to a Henry's coefficient). It is given by Equation 2 and depends on the solubility of the contaminant in the material:

$$S_{gf} = \frac{c_g}{c_f} \qquad \text{(Eq. 2)}$$

where c_f is the concentration of the contaminant in the fluid, adjacent to and in equilibrium with, the concentration, c_g, in the membrane.

Thus, the mass flux (f) from the fluid on one side of the membrane to the fluid on the other side (at steady state) is given by:

$$f = S_{gf} D_g \frac{dc_g}{d_z} = \frac{P_g}{l} \Delta C \qquad \text{(Eq. 3)}$$

where l is the thickness of the film/membrane, and ΔC is the difference in concentration between the two sides of the film/membrane at steady state, and the product of the two parameters (S_{gf} D_g) is called the permeation coefficient, P_g (m^2/s):

$$P_g = S_{gf} D_g \quad \text{(Eq. 4)}$$

It can be gleaned from Equations 1-4 that the diffusion coefficient, D_g, is not enough to characterize the film's mass transfer properties for contaminants moving from below the membrane to above it. Diffusive mass transfer through an intact geomembrane is a 3-step process: partitioning into the geomembrane; diffusion through the geomembrane; and partitioning out of the geomembrane. Both D_g and S_{gf} (or simply P_g) must be known in order to effectively utilize Fick's steady state mass transfer equations. Therefore, to allow for full and complete analysis, Drago Wrap's permeation was fully characterized with all three values (permeation, diffusion, and partitioning coefficients) for each chemical tested. Those values are contained in Tables 2 and 3. It is also imperative to understand the differences in methodologies between lab and site-specific field-testing setups. If such differences exist, the addition of the phase transition coefficient between water and air, Henry's coefficient (H), may also be required in the analysis. Both aqueous and air coefficients are provided in Tables 2 and 3, respectively. A deeper discussion on accounting for these differences is beyond the scope of this summary. Please contact the Stego Industries' Technical Department for additional assistance.

TESTING METHODOLOGY

Two types of tests and subsequent modeling have been employed in characterizing Drago Wrap's relevant characteristics: diffusion testing, sorption testing, and the finite layer modeling and analysis program, POLLUTE v7 (Rowe and Booker 2004).

The diffusion testing setup used stainless steel double-compartment cells (Figure 1), such that source and receptor volumes were separated by the Drago Wrap membrane. The cell was screwed together, with the membrane secured using two Viton rings (Figure 2) to prevent the loss of contaminant at the connection between each compartment and the membrane. Both the source and receptor were filled with double deionized (DDI) water, and a septum was inserted into the sampling ports to prevent losses. A stock solution of contaminants was added to the source compartment to form a dilute aqueous solution with a known concentration. Before assembly, and after disassembly, the mass of the membrane was recorded.

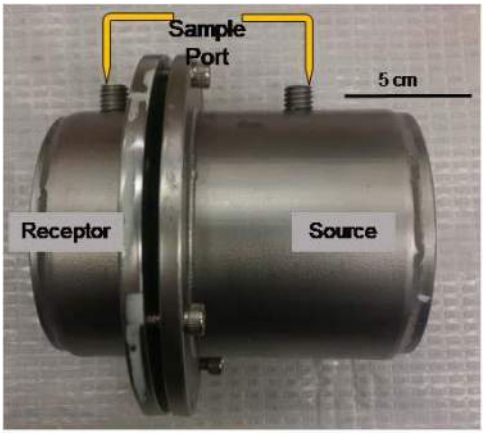

Figure 1: Double Compartment Cell

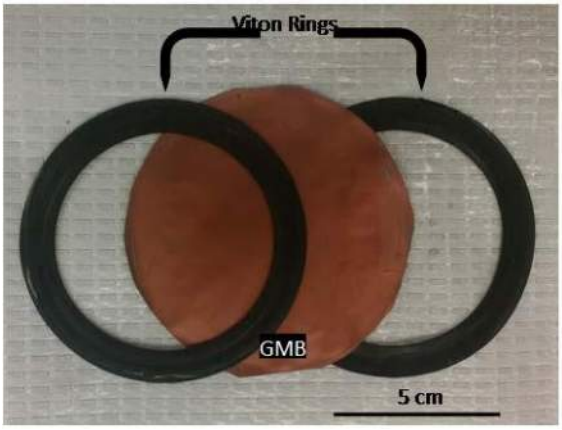

Figure 2: Membrane and Viton Rings

Sorption testing was also performed to directly measure the partitioning coefficients for each chemical. The sorption testing was conducted using 20-ml vials where a specimen was placed in double deionized water. The mass of the specimen was recorded beforehand. The vials were filled with double deionized water so that there was no airspace in the vial. Known masses of contaminants were added and 50 µl samples were taken daily from the vials for analysis and replaced with double deionized water until equilibrium was reached. The chemical analysis of these specimens was performed in the same manner as chemical analysis of the diffusion tests. This analysis is described in Appendix B.

The results from the diffusion and sorption tests were transduced and analyzed using the finite layer modeling and analysis program, POLLUTE v7, to create the results seen in Tables 2 and 3.

In addition to whole-film testing, the discrete layers that make up Drago Wrap were tested to determine their respective permeation, diffusion and partitioning coefficients. The results obtained from the mathematical modeling of these tests do not necessarily equate to the values obtained from whole-film permeation testing. In other words, the full membrane benefits from a synergistic effect: the whole is greater than the sum of its parts. Due to its unique design, the testing demonstrated a very important feature to Drago Wrap: its ability to degrade chlorinated solvents like TCE. The results show about a 50-day half-life for TCE when the membrane is installed in its intended orientation. The results in Tables 2 and 3 come from the most conservative approach to analyzing the results and do not consider these synergies.

RESULTS

As described earlier, the values displayed in Tables 2 and 3 result from a conservative approach to the analysis of data generated from several phases and years of testing, and subsequent numerical modeling. The preferred methodology for obtaining accurate results requires an aqueous-to-aqueous testing scenario. Table 2 depicts these results. Table 3 utilizes Henry's coefficients, per chemical, to obtain the air-to-air partitioning and permeation coefficient adjustments. There exist scenarios where mass flux design with Drago Wrap requires additional consideration of phase-change analysis beyond what is offered in Tables 2 and 3. Please contact the Stego Industries' Technical Department for assistance should the need arise.

Table 1 – Descriptions of the Tested Chemicals

Chemical	Abbreviation	Family	Use
Benzene	Btex	Aromatic Hydrocarbon	Gasoline byproduct
Toluene	bTex	Aromatic Hydrocarbon	Gasoline byproduct
Ethylbenzene	btEx	Aromatic Hydrocarbon	Gasoline byproduct
M&P-Xylenes	bteX	Aromatic Hydrocarbon	Gasoline byproduct
O-Xylene	bteX	Aromatic Hydrocarbon	Gasoline byproduct
Trichloroethylene	TCE	Chlorinated Hydrocarbon	Dry Cleaning and Solvent
Tetrachloroethylene	PCE	Chlorinated Hydrocarbon	Dry Cleaning and Solvent
Methyl tert-butyl ether	MTBE	Oxygenate	Octane-increasing additive to fuel
Dichloromethane	DCM	Chlorinated Hydrocarbon	Paint Stripper, Decaffeinate, Aerosol propellant
Naphthalene	Naphthalene	Polycyclic Aromatic Hydrocarbon	Fumigant, Pyrotechnics, Wetting Agent
1,4-Dichlorobenzne	1,4-DCB	Chlorinated Hydrocarbon	Pesticide, Disinfectant, Deodorant

Table 2 – Aqueous Coefficients

Chemical	Diffusion, D_g [x 10^{-15} m^2/s]	Partitioning, S_{gf} [-]	Permeation, P_g [x 10^{-13} m^2/s]
Benzene	2.6	171	4.5
Toluene	1.5	339	5.1
Ethylbenzene	0.41	764	3.1
M&P-Xylenes	0.4	743	2.9
O-Xylene	0.4	670	2.7
TCE	3.9	251	9.8
PCE	1.1	610	6.6
MTBE	1	1	0.01
DCM	0.95	475	4.5
Naphthalene	0.014	1710	0.25
1,4-DCB	0.94	760	7.1

Table 3 – Conversion to Air Coefficients

Chemical	Diffusion*, D_g [x 10^{-15} m^2/s]	Aqueous		Henry's**	Air	
		Partitioning, S_{gw} [-]	Permeation, P_g [x 10^{-13} m^2/s]		Partitioning, S_{ga} [-]	Permeation, P_g [x 10^{-13} m^2/s]
Benzene	2.6	171	4.5	0.22	38	0.98
Toluene	1.5	339	5.1	0.27	92	1.4
Ethylbenzene	0.41	764	3.1	0.35	267	1.1
M&P-Xylenes	0.4	743	2.9	0.26	193	0.75
O-Xylene	0.4	670	2.7	0.22	147	0.60
TCE	3.9	251	9.8	0.48	120	4.7
PCE	1.1	610	6.6	1.16	708	7.7
MTBE	1	1	0.01	0.024	0.02	0.00024
DCM	0.95	475	4.5	0.13	62	0.59
Naphthalene	0.014	1,710	0.25	0.015	26	0.0038
1,4 DCB	0.94	760	7.1	0.18	137	1.3

*The conversion does not affect Diffusion D_g

**Henry's coefficients are temperature dependent. Room temperature (23°C) assumed.

CONCLUSION

Drago Wrap has proven to be a superior barrier to standard geomembranes like HDPE (by a factor of about 10 to 200 – See Appendix A) for all contaminants where comparisons could be made to HDPE and has remarkably low values for BTEX, TCE; PCE; MTBE; Naphthalene; DCM; and 1,4 DCB with permeation coefficients of the order of magnitude of 10^{-13} – 10^{-14} m^2/s. In addition, the testing has shown that chlorinated solvents experience degradation while permeating through the membrane with a half-life of 50 days for TCE when the film is correctly oriented relative to the contaminant source.

APPENDIX A – COMPARISON TO HDPE (WHERE AVAILABLE)

	Permeation Coefficients- 20-mil Drago Wrap			Permeation Coefficients – 80-mil HDPE[1]			
	D_g (m^2/s)	S_{gf} (-)	P_g (m^2/s)	D_g (m^2/s)	S_{gf} (-)	P_g (m^2/s)	Ratio (P_{gDrago}/P_{gHDPE})
Benzene	$2.6x10^{-15}$	171	$4.5x10^{-13}$	$3.5x10^{-13}$	30	$1.05 x10^{-11}$	23
Toluene	$1.5x10^{-15}$	339	$5.1x10^{-13}$	$3.0 x10^{-13}$	100	$3.0 x10^{-11}$	60
Ethylbenzene	$4.1x10^{-16}$	764	$3.0x10^{-13}$	$1.8 x10^{-13}$	285	$5.1 x10^{-11}$	170
m&p-Xylenes	$4.0x10^{-16}$	743	$2.9x10^{-13}$	$1.7 x10^{-13}$	347	$5.9 x10^{-11}$	200
o-Xylene	$4.0x10^{-16}$	670	$2.7x10^{-13}$	$1.5 x10^{-13}$	240	$3.6 x10^{-11}$	130
TCE	$3.9x10^{-15}$	251	$9.8x10^{-13}$	$4.0 x10^{-13}$	85	$3.4 x10^{-11}$	35
PCE	$1.1x10^{-15}$	610	$6.6x10^{-13}$	-	-	-	-
MTBE	$1.0x10^{-15}$	1	$1.0x10^{-15}$	-	-	-	-
DCM	$9.5x10^{-16}$	475	$4.5x10^{-13}$	$6.5 x10^{-13}$	6	$3.9 x10^{-12}$	9
Naphthalene	$1.4x10^{-17}$	1710	$2.5x10^{-14}$	-	-	-	-
1,4-DCB	$9.4 x10^{-16}$	760	$7.1x10^{-13}$	-	-	-	-

[1]Sangam & Rowe (2001)

APPENDIX B– CHEMICAL ANALYSIS

The cells were sampled at regular time intervals. During each sampling event, 10 ul to 100 ul was removed from the cell, and that volume was replaced with DDI water so there was no airspace in the cell.

The samples were added to a vial containing 0.4 ml of methanol, 0.01 ml internal standard, and water was added so the total fluid volume in the vial was 1.6 ml. A Solid Phase Micro Extraction (SPME) fiber was inserted into vial headspace and the volatile compounds sorbed onto the fiber. This fiber was analyzed using gas chromatography (GC), and results compared to a certified laboratory standard calibration curve for the contaminant in question. Two types of detectors were used (depending on the cell in question); namely, a mass selective detector and a flame ionization detector. A quality assurance certified lab standard (from a different source to the calibration standards) was assessed during each sampling event.

All laboratory testing was conducted in a Canadian Association for Laboratory Accreditation (CALA) lab and followed CALA methods. This means that rigorous quality assurance practices were followed during chemical analysis. CALA frequently reviews the methods used and the accreditation is renewed every two years.

REFERENCES

Rowe, R. K., and Booker, J. R. (2004). "POLLUTE V.7 - 1D Pollutant Migration through a Non-homogenous Soil." GAEA Environmental Engineering Ltd.

Sangam, H. P., and Rowe, R. K. (2001). "Migration of dilute aqueous organic pollutants through HDPE geomembranes." Geotextiles and Geomembranes, 19(6), 329–357.

DRAGO WRAP VAPOR INTRUSION BARRIER
MILL CREEK PHASE I
HUNTSVILLE, AL 35805

	Tested Coefficients			Modeled Attenuation			
Chemical	Diffusion Coefficient[1], D_g	Partitioning Coefficient[1], S_{ga}	Permeation Coefficient[2], P_g	Starting Concentration[3]	AER[4]	Attenuation Factor[5]	Est. Indoor Air Concentration[6]
	m^2/s	--	m^2/s	$\mu g/m^3$	/hr	--	$\mu g/m^3$
Benzene	2.6E-15	38	9.8E-14	10.8	0.25	8.05E-05	8.69E-04
M&P-Xylenes	4.0E-16	193	7.5E-14	53.8	0.25	4.78E-05	2.57E-03
O-Xylene	4.0E-16	147	6.0E-14	53.8	0.25	5.40E-05	2.90E-03
PCE	1.1E-15	708	7.7E-13	32	0.25	6.24E-05	2.00E-03

Note 1 - Diffusion and Partitioning/Sorption Coefficients calculated in the testing lab. See Drago Wrap Vapor Intrusion Barrier - Summary of Permeation Testing.
Note 2 - Diffusion Coefficient * Partitioning Coefficient = Permeation Coefficient
Note 3 - Starting Concentration - Soil Vapor Data Provided by Slosky & Company, Inc.
Note 4 - Assumed Air Exchange Rate of the building
Note 5 - Drago Attenuation Factors - determined by the testing lab through finite layer modeling and analysis program, POLLUTE v 7. The Drago AF's are based on the permeation coefficients and some assumptions/parameters in the model, including: non-depleting source, source concentration is equal to the maximum concentration in soils report, source concentration is located directly below Drago Wrap, no attenuation from concrete, no contribution from other sources or sorption into other materials, etc.
Note 6 - Estimated indoor air concentration = C_{sv} * AF

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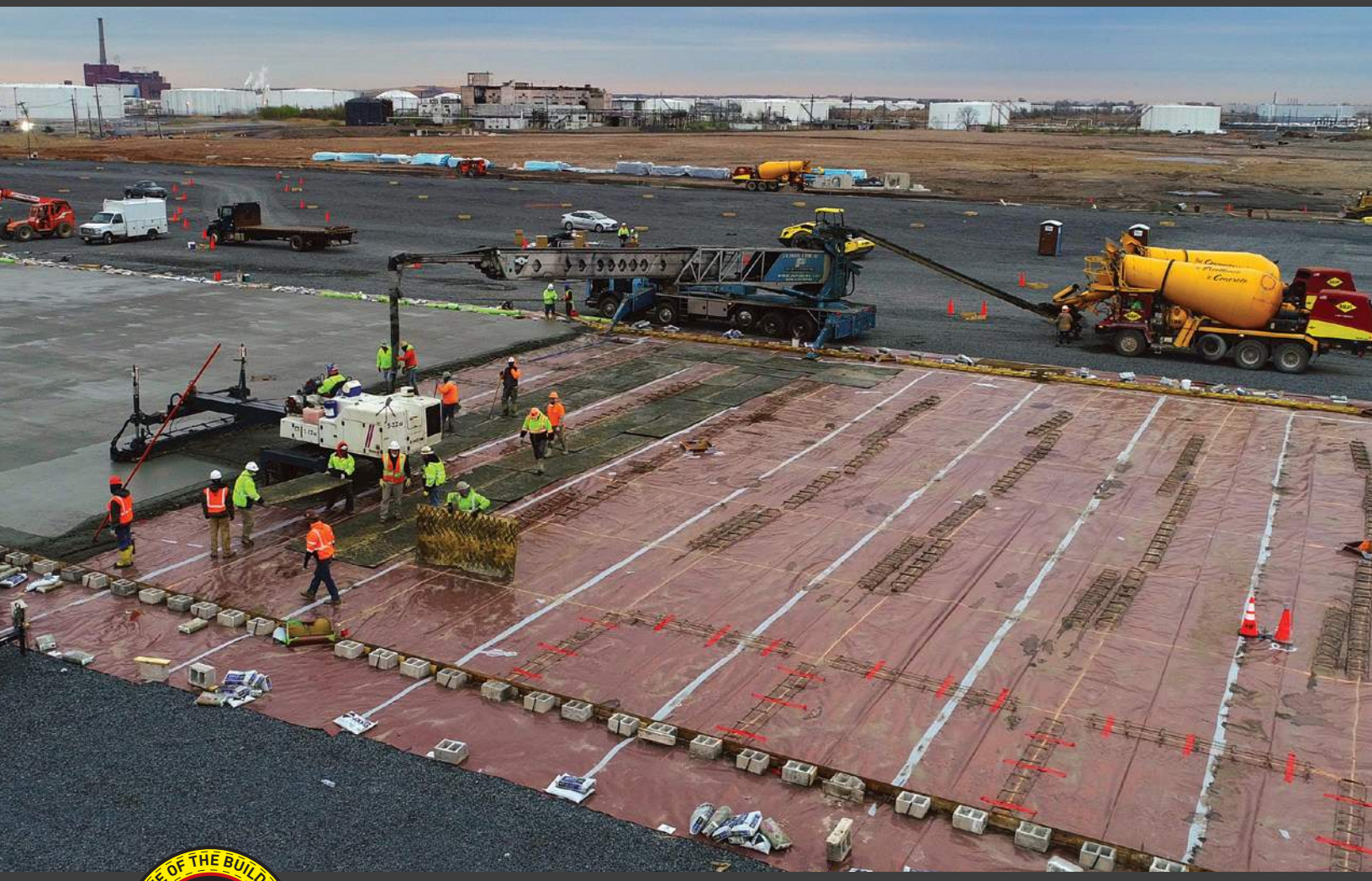
Appendix C Stego Drago Wrap Installation Instructions

DRAGO® WRAP
INSTALLATION INSTRUCTIONS



ENGINEERED PERFORMANCE
LIFE OF THE BUILDING™ PROTECTION

Additional Drago Wrap installation resources and videos are available on our website at:

stegoindustries.com/resources

CONTENTS

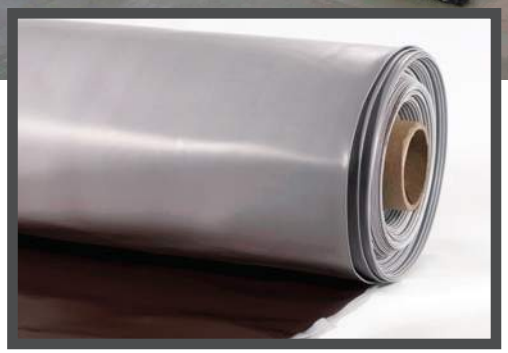
NOTE: While the photos in this guide show Drago® Wrap Vapor Intrusion Barrier, these installation instructions are also applicable to Drago® Wrap Soil Gas Barrier and Drago® Wrap Soil Gas Retarder, as all Drago Wrap membranes are installed using the same accessories and installation methodology.

The installation recommendations set forth in these instructions are generally based on ASTM E1643 and specific applications of Drago products. Each section provides explanations and options for the varying conditions.

Stego Installation Support - A Free Service

When you choose **Stego® Barrier Solutions** and products, you gain access to a large nationwide network of full-time technical sales representatives providing unmatched local support and service. If you ever have a question or concern regarding the following installation scenarios please contact us and take advantage of our free Stego Installation Support.

Drago Wrap Barriers & Retarders



DRAGO WRAP
VAPOR INTRUSION BARRIER
A multi-layered plastic extrusion that combines uniquely designed materials with only high grade, prime, virgin resins. This patent pending barrier technology provides high performance and longevity, allowing for the redevelopment of contaminated sites, creating a healthy built environment.

DRAGO WRAP
SOIL GAS BARRIER
A multi-layered plastic extrusion that combines gas barrier technology with only high-grade, prime, virgin resins. Drago Wrap Soil Gas Barrier can be used in systems for the control of VOCs, methane, radon, soil poisons, and sulfates.

DRAGO WRAP
SOIL GAS RETARDER
A multi-layered plastic extrusion manufactured with only high-grade, prime, virgin resins. Drago Wrap Soil Gas Retarder is a pre-emptive solution for contaminated sites with trace amounts of VOCs.

Drago Accessories

At Stego, we know every project has its own unique challenges. To make a Drago Wrap installation easy and flexible, we offer an extensive line of accessory items that gives you options to create a monolithic membrane between all interior intrusion pathways and vapor sources below the slab as well as at the slab perimeter. **Consult the project architect, owner's representative, and design engineer of record before proceeding with any of these options.**

DragoSeal® Tape
Combines Drago Wrap technology with a powerful adhesive for a barrier solution to seal seams, patches, and other details, defending against vapor intrusion.

DragoTack® Tape
A solvent-resistant, double-sided adhesive strip used to bond and seal Drago Wrap to concrete, masonry, wood, metal, and other surfaces.

Drago® Sealant
A two-component, high-performance epoxy, designed to be used with Drago Wrap for sealing utility and pipe penetrations.

Drago® Mastic
A polymer-modified anionic asphalt emulsion, designed to be used with Drago Wrap, for sealing utility, pipe penetrations, and terminating edges.

Drago® Sealant Form
A low-density, cross-linked, closed-cell polyethylene foam designed to be used as a detailing piece with Drago Sealant.

Creating a Monolithic Membrane

The key to an effective Drago Wrap installation is to create a monolithic layer of protection between the building foundation and vapor sources below. While Drago Wrap installation instructions are generally based on ASTM E1643 - *Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs*, these instructions are meant to be used as a guide, and do not take into account specific job site situations. Consult local building codes and regulations along with the building owner or owner's representative before proceeding.

ASTM E1643 discusses the selection of the vapor retarder and preparation of the subbase to minimize potential damage during installation and concrete placement.

ASTM E1643, Section 5.3.4.1 - *Select a vapor retarder material capable of withstanding potential construction site damage.*

ASTM E1643, Section 5.3.5.1 - *Select vapor retarder material capable of withstanding tear or puncture damage due to the type, gradation, and texture of the base material to be installed below the material. Prepare base material to minimize risk of puncture, for example, by rolling or compacting.*

ASTM E1643, Section 6.1 - *Level and compact base material.*

ASTM E1643 then states to create a monolithic membrane to protect the slab from adjacent moisture sources.

ASTM E1643, Section 6.4 - *. . . create a monolithic membrane between the surface of the slab and vapor sources below the slab as well as at the slab perimeter.*

ASTM E1643, Section 6.5 - *Lap joints as instructed by the manufacturer and seal laps in accordance with the manufacturer's recommendations.*

Drago Wrap can be installed over an aggregate, sand, or tamped earth base. If installing on a design approved aggregate base, it is recommended to use a non-woven geotextile below Drago Wrap. Consult the design team for project-specific recommendations.

1 Unroll Drago Wrap over the area where the slab is to be placed.

Note: Grey color side of membrane is face-down, copper color side is face-up.

2 Unless otherwise indicated by the design professional(s) of record, unfold Drago Wrap to completely cover the placement area.

3 All joints/seams should be overlapped a minimum of 12 inches.

4 Ensure Drago Wrap is clean and dry when applying DragoSeal Tape.

Tip: Use a cloth or other means to remove dust, debris, and excess moisture from Drago Wrap prior to applying DragoSeal Tape.

5 Seal the seams with DragoSeal Tape.

Note: Remove the release liner of DragoSeal Tape prior to application. After applying DragoSeal Tape, use consistent, firm pressure along the 4" width of DragoSeal Tape to ensure continuous adhesion. Optional ~4" steel roller is ideal.

OPTIONAL SEALING METHOD: Hot air wedge welding equipment is ideal for heat welding seams of Drago Wrap.

Where to Terminate the Drago Wrap

Always consult the project design team for where to terminate the vapor barrier to strike a balance between the location of the vapor barrier on or around foundation constructions and any structural concerns before proceeding.

ASTM E1643 provides direction on where to terminate the vapor barrier as follows:

ASTM E1643, Section 6.4 - *Extend vapor retarder over footings and seal to foundation wall, grade beam, or slab at an elevation consistent with the top of the slab or terminate at impediments such as waterstops or dowels...*

ASTM E1643, Section 6.6 - *Extend vapor retarder over the tops of pile caps and grade beams to a distance acceptable to the structural engineer.*

In accordance with ASTM E1643, terminate the Drago Wrap as follows:

At an elevation (height) consistent with the top of the slab;

Note: Turn Drago Wrap up foundation walls or forms. Ensure Drago Wrap is flush against the corner to avoid tenting.

At Impediments; OR

Note: Impediments may include rebar, dowels, water stops, etc. and may be located at interior grade beams in addition to perimeter walls and footings.

At a location of termination designated by the project design team.

Note: The distance to which the vapor barrier is extended adjacent to, onto, or completely over a footing or grade beam should be determined by the project design team.

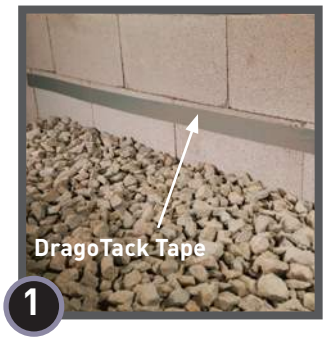
If the location of vapor barrier termination has not been clearly addressed in the construction documents, then clarification should be requested from the project design team. Should no direction be given, Stego recommends the project team follow, at minimum, the guidelines of ASTM E1643.

Regardless of where the vapor barrier is determined to be terminated, ASTM E1643 requires the terminating edges to be sealed.

Sealing the Terminating Edges of Drago Wrap Up Foundation Walls & Vertical Surfaces **Using DragoTack Tape *or* DragoSeal Tape**

DragoTack Tape or DragoSeal Tape can be used to seal Drago Wrap to foundation walls, grade beams or other adjacent concrete constructions.

IMPORTANT: **Make sure the area of adhesion is free of dust, dirt, debris, moisture, and frost to allow maximum adhesion.**

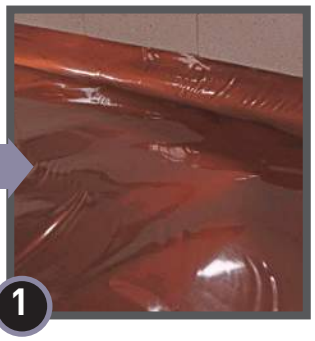


1 Remove the release liner on one side of **DragoTack Tape** and adhere to foundation wall at the height of the slab or at impediments.

2 When ready to apply Drago Wrap, remove the exposed release liner from **DragoTack Tape**.

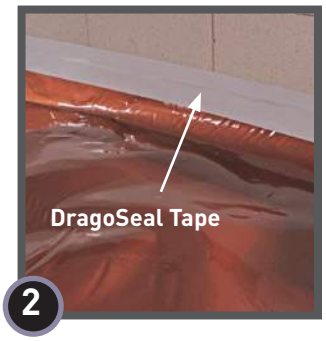
3 Press Drago Wrap firmly against **DragoTack Tape** to secure.

OR



1 Extend Drago Wrap up the vertical surface, likely to the height of the slab.

Note: See Where to Terminate the Drago Wrap, page 5.



2 Apply **DragoSeal Tape** on the perimeter edge so that 2" is on the Drago Wrap and 2" is on the wall/vertical surface. Press firmly to secure.

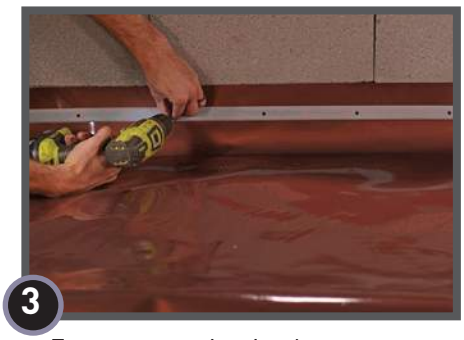
MECHANICAL SEAL OPTION:
If a mechanical seal is needed, fasten a termination bar over the top of the Drago Wrap inline with the **DragoTack Tape** (as shown in image) **or DragoSeal Tape.**

Using Drago Mastic

IMPORTANT: **Make sure the area of adhesion is free of dust, dirt, debris, moisture, and frost to allow maximum adhesion.**

1 Apply Drago Mastic to the foundation wall at the anticipated edge of the subsequently applied Drago Wrap at the height of the slab or impediments.

2 Press Drago Wrap firmly against the applied Drago Mastic on the foundation wall.



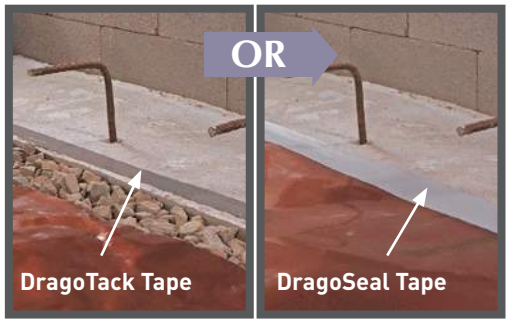
3 Fasten a termination bar over the top of the Drago Wrap inline with the Drago Mastic.

Sealing the Terminating Edges of Drago Wrap on a Horizontal Plane

Always consult the project design team for where to terminate the vapor barrier to strike a balance between the location of the vapor barrier on or around foundation constructions and any structural concerns before proceeding.

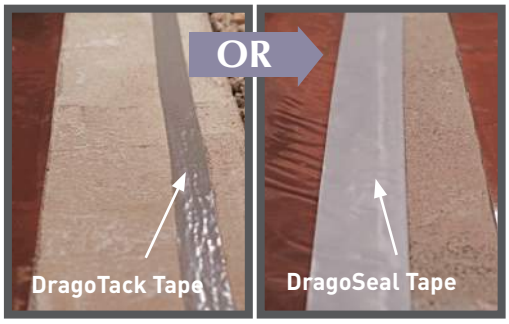
After the location of where to terminate the vapor barrier has been determined, seal Drago Wrap along all terminating edges as indicated by the project team.

Using DragoTack Tape *or* DragoSeal Tape



Onto a Perimeter Footing at Impediments: Seal Drago Wrap to concrete with **DragoTack Tape or DragoSeal Tape**.

Onto Interior Grade Beams at Impediments: Seal Drago Wrap to concrete with **DragoTack Tape or DragoSeal Tape**.



At a Location Designated by the Design Team: Seal Drago Wrap to concrete with **DragoTack Tape or DragoSeal Tape**.

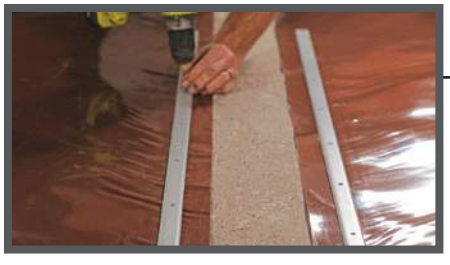
MECHANICAL SEAL OPTION:
If a mechanical seal is needed, fasten a termination bar over the top of the Drago Wrap inline with the **DragoTack Tape** (as shown in image); **or** fasten a termination bar over the 2" of **DragoSeal Tape** that is on top of Drago Wrap (not shown).

Using Drago Mastic

Onto a Perimeter Footing at Impediments: Seal Drago Wrap to concrete with Drago Mastic.

Onto Interior Grade Beams at Impediments: Seal Drago Wrap to concrete with Drago Mastic.

At a Location Designated by the Design Team: Seal Drago Wrap to concrete with Drago Mastic.



MECHANICAL SEAL OPTION:
If a mechanical seal is needed, fasten a termination bar over the top of the Drago Wrap inline with the Drago Mastic.

See "Where to Terminate the Vapor Barrier" on page 5 prior to choosing your terminating edge sealing accessory.

Sealing Damaged Areas: **Small Hole or Slice**

In the event that Drago Wrap is damaged during or after installation, repairs must be made. For smaller holes or slices in Drago Wrap, DragoSeal Tape can be used as noted below.

Small hole or slice in Drago Wrap.

Clean area of adhesion.

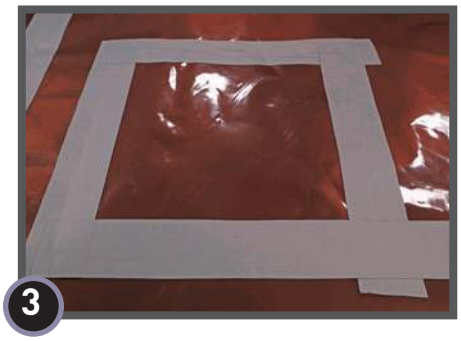
Center DragoSeal Tape over small hole or slice in Drago Wrap. Apply pressure to DragoSeal Tape after application.

Larger Hole

In the event that Drago Wrap is damaged during or after installation, repairs must be made. For larger holes, cut a piece of Drago Wrap to a size and shape that covers any damage by a minimum overlap of 6" in all directions. Clean all adhesion areas of dust, dirt, moisture, and frost. Tape down all edges using DragoSeal Tape.

Occasionally there are larger holes in the vapor barrier that require a patch.

Measure and cut a piece of Drago Wrap to cover damaged area 6" in all directions. Clean area of adhesion.



Seal the patch with DragoSeal Tape.

Sealing Single Pipe Penetration: **Minimal Void Space**

All penetrations must be sealed. All pipe, ducting, rebar, wire penetrations and block outs should be sealed using Drago Wrap and either DragoSeal Tape, Drago Mastic, or Drago Sealant and Drago Sealant Form. If penetrations are encased in other materials, such as expansive materials like foam, unless otherwise specified, Drago Wrap should be sealed directly to the underlying penetration.

1

Install Drago Wrap around pipe penetrations by slitting/cutting material as needed. Try to minimize the void space created.

2

Pull material over and flatten. Clean area of adhesion where the Drago accessory will be applied.

3

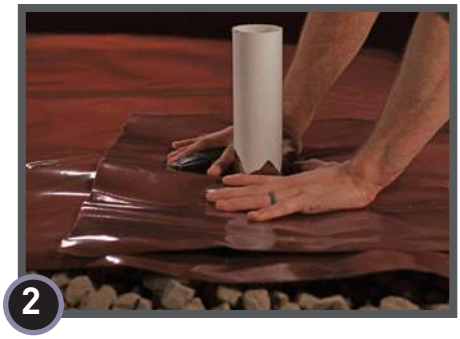
If Drago Wrap is close to pipe and void space is minimized then seal around pipe penetration with either DragoSeal Tape (as shown), Drago Mastic or Drago Sealant and Drago Sealant Form.

Larger Void Space Requires Detail Patch

To minimize void space around a larger penetration, a detail patch may be required.

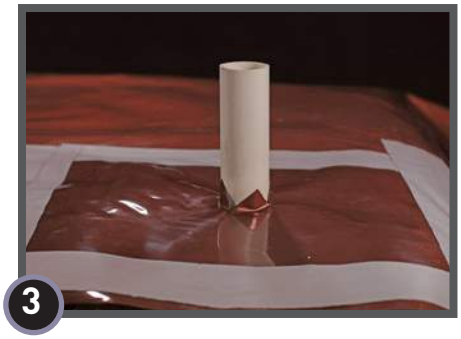
1

Cut a detail patch to a size and shape that creates a 6" overlap on all edges around the void space at the base of the pipe.



2

Cut an "X" the size of the pipe diameter in the center of the detail patch and slide tightly over pipe.



3

Seal all sides of the detail patch with DragoSeal Tape.

4a

Seal around the base of the pipe using DragoSeal Tape.

OR

4b

Seal around the base of the pipe with Drago Mastic.

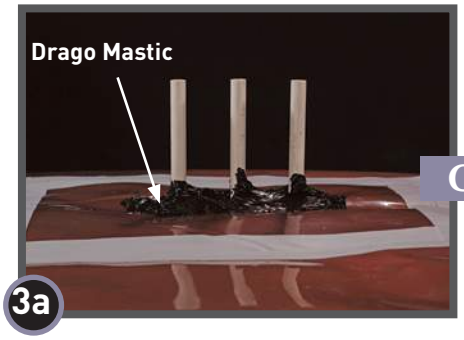
Note: apply using disposable glove, paint brush, or similar.

Sealing Multiple Pipe Penetrations:
Using Drago Mastic *or*
Using Drago Sealant and Drago Sealant Form

Multiple pipe penetrations in close proximity and very small pipes may be most efficiently sealed using Drago Wrap and Drago Mastic, or Drago Wrap, Drago Sealant, and Drago Sealant Form.

Cut a slit the size to accommodate the width of the multiple pipes. Try to minimize the void space created.

Place a detail patch over and around the base of the pipe penetrations as closely as possible, ensuring that it is flush with the base of the penetrations. Seal all sides of the detail patch with DragoSeal Tape.

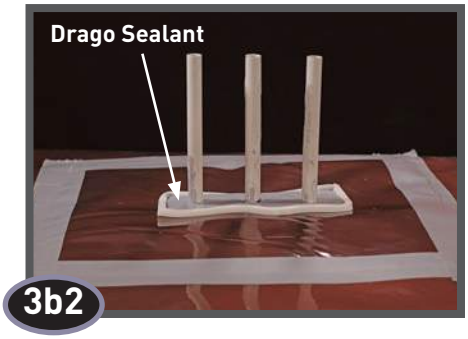


Apply Drago Mastic around the entire perimeter of the group of penetrations and between the penetrations to fill any void spaces present.

Note: apply using disposable glove, paint brush, or similar.

OR

Install Drago Sealant Form continuously to Drago Wrap and around the entire perimeter of the group of penetrations and at least 1 inch beyond the terminating edge of Drago Wrap.



Pour Drago Sealant inside of Drago Sealant Form to create a seal around the penetrations.

Note: If the void space between Drago Wrap and the penetrations is not minimized and/or the base course allows for too much drainage of sealant, a second coat of Drago Sealant may need to be poured after the first application has cured.

Drago Sealant pot/working life is roughly 30-45 minutes.

Avoid Punctures with Beast® Concrete Accessories

To help eliminate the use of non-permanent penetrations in Drago Wrap installation, Stego recommends the use of Beast vapor barrier-safe concrete accessories.

IMPORTANT: Avoid puncturing Drago Wrap with stakes while forming, bracing, and screeding.

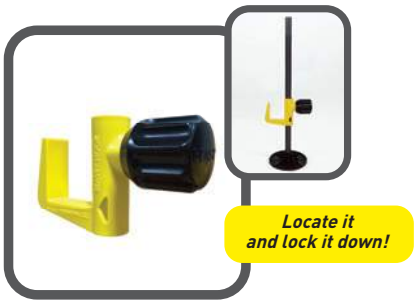
BEAST® FORM STAKE can be used with **BEAST® FOOT** as part of the Stego vapor barrier-safe forming system which meets ASTM E1643 requirements.

This concrete form stake takes the place of traditional nail stakes for interior forming applications, utilizing SpeedTrack™ Fastening Grooves for unlimited fastener placement.

Note: Refer to Beast Form Stake Installation Guide for detailed usage instructions.

Beast Form Stake is strong enough to withstand a beating during concrete placement while holding its shape. It is easy to remove and reusable for the next job.

Note: Beast Form Stake can be removed once concrete has set sufficiently to hold its shape. Fill and repair any voids in the concrete as necessary once the Beast Form Stake has been removed and strike Beast Form Stake against a hard surface to loosen the concrete buildup.



BEAST® HOOK is a **faster**, **easier** way to set 2x4 overhead screeds. Use Beast Foot and Beast Form Stake and make it a vapor barrier-safe screed system.

No tools are required, just grip the knob to loosen or tighten. Fast, easy, efficient.

BEAST® SCREED is a fixed-elevation, point-to-point guide screed system designed to replace common wet-screed methods.

Improve efficiency and maintain concrete floor levelness with the BEAST SCREED SYSTEM!

Set it and forget it. Beast Screed eliminates the need to frequently re-establish grade to ensure floor elevation has not changed during the screeding operation as is typical with traditional wet-screed methods.

Note: Refer to Beast Screed System Installation Instructions for detailed usage instructions.

NOTE: Stego Industries, LLC's ("Stego") installation instructions are based on ASTM E1643 - *Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.* These instructions are meant to be used as a guide, and do not take into account specific job site situations. Consult local building codes and regulations along with the building owner or owner's representative before proceeding. If you have any questions regarding the above mentioned installation instructions or Stego products, please call us at 877-464-7834 for technical assistance. While Stego employees and representatives may provide technical assistance regarding the utility of a specific installation practice or Stego product, they are not authorized to make final design decisions.

When it comes to building construction, ***don't take the vapor intrusion barrier installation lightly***. After all, it is there to protect the building's vital foundation from the threats lurking below the slab.

Stego's industry-leading barriers and unrivaled support equip you with the confidence to create resilient foundations for buildings where people work, learn, and gather.

We help keep you up to speed on the latest installation methods.

DISCUSS YOUR PROJECT NEEDS

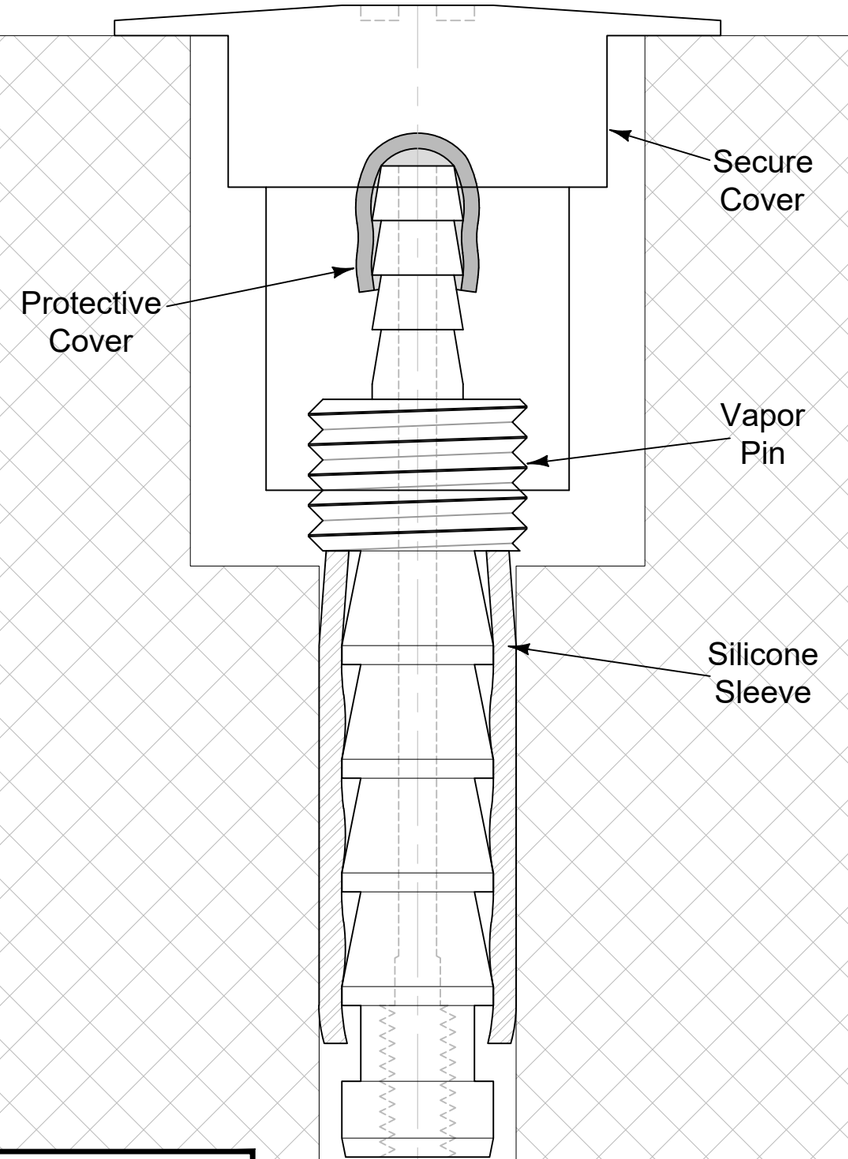
Have questions? Give us a call.

877-464-7834

stegoindustries.com

Appendix D Vapor Pin® Schematic

VP0001.02



Notes: Dimension Tolerance
0.00 = +/- 0.01
0.000 = +/- 0.005
Dimensions in inches

Materials:
Brass
Stainless Steel (303)

VaporPin®

Vapor Pin Enterprises, Inc.
7750 Corporate Blvd.
Plain City, Ohio 43064
VaporPin.com

Name: VAPOR PIN® with Secure Cover

Drawing No.: VP0001.02

Date: November 17, 2023

(A) Hole through device is used to transmit air.

(B) This thread must engage with Secure Cover (Item A - Drawing No. VP0004.##) and Installation/Extraction Tool Coupler (Item A - Drawing No. VP0009.##).

(C) This thread must engage with VAPOR PIN® Extension 1.5" (Item B - Drawing No. VP0005.##); VAPOR PIN® Sieve (Item B - Drawing No. VP0006.##); and VAPOR PIN® Barb Extension (Item B - Drawing No. VP0007.##).