Brownfield Vapor Barriers:

Chemical Compatibility, Testing and Advancements in Material Science

Todd Herrington
VAPOR INTRUSION

Penetrations
Concrete Slab
Cracks
Subsurface VOC Contamination

Land Science Technologies
Sub-Slab

Contaminant Vapor Barrier
Contaminant Vapor Barrier Materials

Over the past five years two materials have generally been considered:

- High Density Polyethylene (HDPE)
- Spray Applied Asphalt/ Latex
High Density Polyethylene (HDPE)

- Excellent Chemical Resistance
- Very Low Permeance To VOCs
- Excellent Durability
- Excellent Constructability
- Cost Effective
Spray Applied Asphalt/Latex Membranes

- Excellent Constructability
- Excellent Durability (w/geofabric)
- Cost Effective
- Excellent Chemical Resistance
- Very Low Permeance To VOCs
Asphalt/Latex Membranes

Common Composition:

- Asphalt/ Latex Emulsions (bitumen/polystyrene) with clay or carbonate “builders”
- Spray Applied with CaCl$_2$ Solution

All of these Compositions are Lipophilic

- Tend to Adsorb VOC Vapors
VOC Transport Across Membranes

EARLY ADSORPTION (Partitioning)

Partitioning of VOCs

Indoor Environment

Membrane

Subsurface Environment
VOC Transport Across Membranes

NEAR SATURATION

Partitioning of VOCs

Indoor Environment

Membrane

Subsurface Environment
VOC Transport Across Membranes

POST SATURATION

Increased Permeance

Indoor Environment

Membrane

Subsurface Environment
Permeance of VOCs Across Membranes

Cumulative VOC Permeance

Phase I: Pre-Saturation Membrane Permeance

Phase II: Post-Saturation Membrane Permeance

Breakthrough

Time
# 7-day Hexane Weight Gain Vapor Test (ASTM D 543)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen</td>
<td>72.2</td>
</tr>
<tr>
<td>PSL</td>
<td>18.1</td>
</tr>
<tr>
<td>CaCl2</td>
<td>0.7</td>
</tr>
<tr>
<td>CaCO3</td>
<td>9.0</td>
</tr>
<tr>
<td>Bentonite</td>
<td>0.0</td>
</tr>
</tbody>
</table>

% Weight Gain  

|          | 15.0 | 12.5 | 14.1 | 10.9 |
Q: How to improve chemical resistance of spray applied asphalt/latex?

A: Use HDPE to Encapsulate the asphalt/latex in a Composite Membrane!
Development of Geo-Seal™

Composite membrane\(^1\) was best of both worlds:

- Chemical Resistance & Low Permeance of HDPE
- Constructability and low cost of Spray Applied Membrane

\(^1\)Patents Pending (US and international)
Geo-Seal™
Advanced Vapor Management Technology

Geo-Seal CORE
Spray Applied
Copolymer Modified
Bitumen/polystyrene
Geo-Seal BOND
HDPE/Polyolefin
Hybrid 2
Geo-Seal BOND
HDPE/Polyolefin
Hybrid 2

Geo-Seal CORE
Spray Applied
Copolymer Modified
Bitumen/polystyrene

Geo-Seal BASE
HDPE/Polyolefin
Hybrid 1
Geo-Seal™
Advanced Vapor Management Technology

Geo-Seal BOND
HDPE/Polyolefin Hybrid 2

Geo-Seal CORE
Spray Applied Copolymer Modified Bitumen/polystyrene

Geo-Seal BASE
HDPE/Polyolefin Hybrid 1

Geo-Seal Vapor Vent
HDPE Vent System

Land Science™ Technologies
Serum Exposure Testing

- PCE Saturated Vapors on One Side of Membrane
- 7 Day Test

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test Weight (g)</th>
<th>Post-Test Weight (g)</th>
<th>Weight Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt/Latex</td>
<td>4.24</td>
<td>4.7</td>
<td><strong>10.80%</strong></td>
</tr>
<tr>
<td>Geo-Seal™</td>
<td>3.87</td>
<td>3.95</td>
<td><strong>2.10%</strong></td>
</tr>
</tbody>
</table>

*Intertek Laboratories, Foxboro Mass. 2008
Solvent Exposure Testing

Results Indicate:

- Geo-Seal is 5X more resistant to VOC partitioning than simple asphalt/Latex membranes

- This is a result of HDPE encapsulation
Permeation/Diffusion Testing

Q: How to Accomplish Permeability Testing?

Others have reported Permeance/Diffusion Rates without considering VOC partitioning.....

- Very suspect methodology
- Overtime these rates may increase as membrane becomes saturated
Estimating the permeation rate solely on the amount of VOC that passes through a geomembrane surface area per unit time is incorrect for it does not account for partitioning...

Permeation Testing

Q: How to accomplish Permeability Testing?

A: *Saturate the membrane Prior to Testing.*

- Removes concern about partitioning impacting permeance
- Represents *Long Term* resistance requirement
Permeation Testing

ASTM F 739: Standard Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact
Permeation Testing

Test Cell Set Up

- Glass Stopper
- Glass Housing
- Open vial of PCE liquid
- Clamp
- Membrane
- Nitrogen Tank
- Detector
- Carbon Trap

Permeation Testing

- 24 hour saturation period
- 8 hour permeation period w/ Gas VOC
- Double compartment apparatus

<table>
<thead>
<tr>
<th>Barrier Material</th>
<th>VOC Contaminant</th>
<th>Breakthrough Time (minutes)</th>
<th>Steady-State Perm Rate (ug/cm²/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt/ Latex</td>
<td>PCE</td>
<td>450</td>
<td>5</td>
</tr>
<tr>
<td>Geo-Seal</td>
<td>PCE</td>
<td>No Breakthrough</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

*Intertek Laboratories, Foxboro Mass. 2008
Permeation Testing

Results of Gaseous Challenge Indicate:

**Geo-Seal:**
- Resisted Permeance Breakthrough
- Asphalt/Latex did breakthrough with significant VOC permeance
Application and Sealing of BASE Layer
Application of CORE
BOND Layer Under Steel
VaporVent Low Profile Gas Collection and Vent System

- Active
- Passive
- Material Options
  - Polystyrene
  - HDPE
QA/QC Measures

- Manufacturer and 3rd party inspection
- Coupon sampling
- Depth Gauge testing
- Applicator network
- Smoke testing
- Other factors:
  - Color of the membrane
  - Multiple layers of redundancy
  - Competitive Warranty
635 S. Hobart Street. Los Angeles, CA
√ Excellent Chemical Resistance
√ Very Low Permeance To VOCs
√ Excellent Constructability
√ Excellent Durability
√ Cost Effective

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