Silane Penetrating Waterproofing Treatments AND Changing VOC Regulations

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Penetrants

- Forms chemical bond with the walls of the pores, the pores themselves, or both
- Does not change the substrates appearance
- Better long-term effectiveness in traffic abrasive environments
- Does not plug substrate pores
- Leaves the substrate water and salt repellant, yet still permeable
- Actually improves curing time
Silane vs. Untreated Substrate

Silane Treated Substrate

Un-treated Substrate
### Recommended Laboratory Tests For Specifying Water Repellents

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Type/Length of Test</th>
<th>Acceptable Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCHRP 244</td>
<td>Series II, Reduction in Water Absorption</td>
<td>80%</td>
</tr>
<tr>
<td>NCHRP 244</td>
<td>Series II, Reduction in Chloride Ingress</td>
<td>80%</td>
</tr>
<tr>
<td>NCHRP 244</td>
<td>Series IV, Reduction in Chloride Ingress</td>
<td>95%</td>
</tr>
<tr>
<td>Alberta DOT</td>
<td>BT001, Type 1b, initial waterproofing</td>
<td>82.5%</td>
</tr>
<tr>
<td>Alberta DOT</td>
<td>BT001, Type 1b, waterproofing after abrasion</td>
<td>82.5%</td>
</tr>
<tr>
<td>ASTM C672</td>
<td>50 cycles on non-air entrained concrete</td>
<td>0 + running rate</td>
</tr>
<tr>
<td>ASTM D1653</td>
<td>Compare % breathable to untreated specimen</td>
<td>80%</td>
</tr>
<tr>
<td>ASTM E96</td>
<td>Compare % breathable to untreated specimen</td>
<td>80%</td>
</tr>
</tbody>
</table>

Source: Clear Water Repellents (Kansas City Missouri: Sealant, Waterproofing & Restoration Institute)
<table>
<thead>
<tr>
<th>Sealer</th>
<th>No Abrasion</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Abrasion (simulating 5 to 7 yrs. of traffic)</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Abrasion (simulating 10 yrs. of traffic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>84%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Epoxy</td>
<td>90%</td>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>10% Siloxane</td>
<td>90%</td>
<td>80%</td>
<td>30%</td>
</tr>
<tr>
<td>20% Silane in alcohol</td>
<td>85%</td>
<td>80%</td>
<td>40%</td>
</tr>
<tr>
<td>40% Silane in alcohol</td>
<td>87%</td>
<td>88%</td>
<td>65%</td>
</tr>
<tr>
<td>100% Silane</td>
<td>92%</td>
<td>92%</td>
<td>91%</td>
</tr>
</tbody>
</table>

Source: Paul Carter “Evaluation of Waterproofing Performance and Effective Penetration Depth of Silane Sealers in Concrete” (American Concrete Institute, Fall Convention, 1993)
Steel Corrosion

SIL-ACT™ STOPS STEEL CORROSION

73% Surface Corrosion

Control 73% Corrosion

SIL-ACT™ NO Corrosion
Silane waterproofing treatment prevents:

- Efflorescence
- Spalling
- Delamination
- Steel reinforcement bar corrosion
The Chemistry Of Silane

- The silane molecule
- The silane reaction
- Chloride repellent
- Corrosion inhibitor
- Molecular reaction with various treatments
The Silane Molecule

Silane compared to Siloxane
Silane Reaction

**1. HYDROLYSIS**

- **Alkyl Group**
  - Water Repellent
  - $R'$
  - Isobutyl, n-Octyl, etc.

- **OR²**
  - Methoxy, Ethoxy, etc.

- Alkoxy Groups (3) Reactive Sites

\[
\text{Si} - \text{OR}^2 + \text{H}_2\text{O} \rightarrow \text{R}^1\text{Si} - \text{OH} + \text{R}^2\text{OH}
\]

- **SILANOL**
  - (Intermediary molecule)
  - Formed immediately prior to chemical attachment.
  - Can also react with other silanols to form polymer.

- Alcohol evaporates

**2. CONDENSATION**

- **Site of Substrate/Silanol Chemical Bonding**

\[
\text{Si} - \text{OH} + \text{Si} - \text{OH} \rightarrow \text{Si} - \text{O} - \text{Si} - \text{OH} - \text{H}_2\text{O}
\]

- **Silicate based substrate**
  - Concrete, brick or masonry

- **Alkyl Group**
  - Water repellent chemically attached to substrate
  - (Not a coating)
alkyltrialkoxy silane

Alkyl Group

R₁

Si

OR₂

OR₂

OR₃

Alkoxy Group

methoxy
ethoxy

Isobutyltrimethoxysilane

Isobutyltriethoxysilane

Dries faster than n-Octyls

n-Octyl

isobutyl
Structures protected by Silane Products

- Bridges
- Parking Garages
- Airports (including runways)
- Nuclear Power Plants
- Office Buildings
- College campuses
- Anywhere a need to protect concrete and masonry exists
Chesapeake Bay Bridge & Tunnel
Chesapeake Bay, Virginia

- Eighteen miles of structure protected by Silane
Nuclear Power Plant
Palo Verde, Arizona

- Millions Of Square Feet Protected By Silane
Changing VOC Regulation

- Volatile Organic Compounds
- Environmental Protection Agency
- Ozone transport Commission
Air Pollution Transport and How It Affects New Hampshire

White Mountains, New Hampshire

May 2004
Volatile Organic Compounds

- Have a high vapor pressure and low water solubility.
- Many VOCs are human-made chemicals used in the manufacture of paints, pharmaceuticals, and refrigerants.
- VOCs typically are industrial solvents, such as trichloroethylene; fuel oxygenates, such as methyl tert-butyl ether (MTBE); or by-products produced by chlorination in water treatment, such as chloroform.
- VOCs are often components of petroleum fuels, hydraulic fluids, paint thinners, and dry cleaning agents. VOCs are common ground-water contaminants.
Unlike many other pollutants, ground-level ozone is not directly emitted into the atmosphere from a specific source. Instead, ground-level ozone is formed when nitrogen oxides (NOx) chemically react with volatile organic compounds (VOCs) through a series of complicated chemical reactions in the presence of strong sunshine (ultraviolet light). The sources of NOx and VOCs—called ozone precursors—are many and varied. Almost all NOx emissions originate from human activities related to fossil fuel combustion (see Figure 2.3). Conversely, over 90 percent of VOC emissions in New Hampshire result primarily from natural (biogenic) sources, mainly forests and urban vegetation (see Figure 2.4).

**Figure 2.3 - National Nitrogen Oxide (NOx) Emissions by Sector, 1996**

![Pie chart showing NOx emissions by sector.]

*Data Source: EPA 1996 National Emissions Inventory (NEI)*

**Figure 2.4 - Volatile Organic Compound (VOC) Emissions in New Hampshire by Sector on a Hot Summer Day (when emissions are greatest), 1996**

![Pie chart showing VOC emissions by sector.]

*Data Source: NHDES and EPA*
The US Environmental Protection Agency

- Has long recognized the negative effects of VOC’s on air quality
- Enacted the National VOC Emission Standards for Architectural and Industrial Maintenance Coatings
- Established VOC limits on Construction Products
Ozone Transport Commission

- A multi-state Organization
- Represents the Northeastern and Mid-Atlantic States
- Established VOC Limits Lower Than The EPA
## VOC Limits By Product Area

<table>
<thead>
<tr>
<th>Product Area</th>
<th>Current Federal VOC Limit Grams Per Liter</th>
<th>OTC Limits Gram Per Liter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Coatings</td>
<td>450</td>
<td>340</td>
</tr>
<tr>
<td>Penetrating Water Repellents</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>Curing and Sealing Compounds</td>
<td>700</td>
<td>350</td>
</tr>
<tr>
<td>Form Release Agents</td>
<td>450</td>
<td>250</td>
</tr>
</tbody>
</table>
Current states status: Delaware, Maryland, New York, New Jersey, Pennsylvania, Virginia (specifically the Northern Virginia Air District) and the District of Columbia have adopted the OTC model effective January 1, 2005.

Maine adopted the OTC model effective January 1, 2006.

New Hampshire is currently drafting rules with an expected compliance date of January 1, 2007.

Vermont, Massachusetts, Rhode Island and Connecticut have not begun drafting regulations and have not set a compliance date.
California

- Divided Into Air Pollution Control Districts And Air Quality Management Districts
- These Are County Or Regional Governing Authorities
- Most have adopted 400g/l VOC Limits For AIM Coatings
- The Tehama and South Coast Air Districts Have Adopted 100g/l VOC Limits For AIM Coatings
Available Options

- **Use old technologies.** Silicone emulsions, silicates and methyl siliconates have been making a comeback. Marketing techniques to label these products as “new and improved” are in fact misleading. The marketplace rejected these products years ago because of their poor performance. They usually have low active contents (<15%) and high alkalinity (pH > 10). On masonry particularly, they may exhibit characteristics of discoloration, reduced water vapor transmission and minimal penetration.

- **Move to water-borne products.** The benefits of solvent borne water repellents is that they allow wider application conditions (temperature and substrate moisture content) and material stability (longer shelf life). Solvent borne products also have better penetration in most cases. With water borne products, you will still achieve most of the same performance characteristics, with some reduction of the former items.

- **Use existing products with exempt solvents.** There are several exempt solvents that have little or no effect on ground level ozone. However, changing solvent may alter the chemical characteristics of the final formula. Some exempt solvent have negative health effects. For instance, methyl chloroform is considered a primary ground water pollutant.

- **Pay exceedance fees.** The EPA implemented a system whereby the manufacturer pays a fee in lieu of meeting the VOC limits, based upon the amount of VOC over the proscribed limits. However, this option is to be phased out over time.

- **Use products with higher solids.** Some types of products such as acrylics and silicones may darken the substrate if the concentration is too high, however, for most silane products this method is the best solution. With silane products formulated at a higher solid content you usually will obtain better performance, especially regarding penetration and longer shelf life.
In Conclusion, Silane Waterproofing Treatments Are:

- Cost Effective
- Proven water and salt repellents
  - Wiss, Janney, Elstner Associates, Inc.
  - U.S. Department of Transportation
  - Various State DOTs and University Studies
- Protects Both Substrate and Re-Bar
- Easy to apply
Effectiveness Of Silane

QUESTIONS?