Evaluation of Chemical Grout Performance for Concrete Repair at Reclamation

Research and Development Office
Science and Technology Program
Mission Statements

Protecting America's Great Outdoors and Powering Our Future

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Evaluation of Chemical Grout Performance for Concrete Repair at Reclamation

Prepared by/Technical Approval: Shannon Harrell, P.E.
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Acronyms and Abbreviations

<table>
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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>CGSL</td>
<td>Concrete, Geotechnical, and Structural Laboratory</td>
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<tr>
<td>ft</td>
<td>foot (feet)</td>
</tr>
<tr>
<td>ID</td>
<td>inside diameter</td>
</tr>
<tr>
<td>min</td>
<td>minutes</td>
</tr>
<tr>
<td>oz</td>
<td>ounce</td>
</tr>
<tr>
<td>psi</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>sec</td>
<td>seconds</td>
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Executive Summary

Reclamation’s concrete infrastructure is aging and with that aging comes a host of problems like leaking cracks and joints. Reclamation’s Concrete, Geotechnical, and Structural Laboratory group (CGSL) specifies and performs repairs on leaking concrete joints and cracks. However, there are a countless number of products on the market all claiming to be the best product for the job. This study tested six different chemical grouts, three hydrophilic and three hydrophobic polyurethane grouts. These tests were conducted to determine which product bonded the best with concrete and which product traveled the furthest both before and after the product had reacted with water. The information from this study will help CGSL specify the most appropriate product depending on field conditions.

There were two laboratory phases to this investigation. The first phase consisted of testing all six products using a modified bond tester to determine the bond strength of the chemical grout to concrete. Each product was tested at 4 hours and 24 hours after the specimens were made.

The second laboratory phase investigated the travel distance of the chemical grouts both before and after the grout reacted with water. The test was conducted by first injecting the grout into a dry polyurethane tube at 120 psi and recording the time and distance the grout traveled. The second test was the same except the polyurethane tube was filled with water prior to grout injection, with the intent to simulate a leaking concrete crack. The distance the grout traveled before and after the product reacted with the water was recorded.

Alchemy/Spetec PU F400 hydrophobic chemical grout and Strata-Tech ST-504 hydrophilic chemical grout had the highest bond strengths in their respective categories. The hydrophilic grouts had better bond strengths than the hydrophobic grouts. Four out of the six products tested had lower bond strengths at 24 hours than at 4 hours.

Alchemy/Spetec PU F400 hydrophobic grout and Alchemy/Spetec AP Seal 500 hydrophilic grout had the longest travel distance in a line filled with water. Viscosity was not always an indicator of how far the grout would travel once it reacted with water. Test results indicate a higher viscosity grout traveled further than the lowest viscosity product in the wet line testing.

The results obtained from this study will aid CGSL staff in specifying and selecting the most appropriate product for field conditions. Further investigations should be considered including the following:

- Testing of more products.
- Heating the grout to determine if it accelerates the reaction and the effects it may have on the results.
- Vary the percentage of catalyst used with each product to determine if it influences bond or travel.
- Investigate larger crack widths (1/4 to 1/2-inch).
- Develop a test method that can test the travel of the grout in a repeatable concrete crack.
Contents

Executive Summary ........................................................................................................... vi
Background ..........................................................................................................................9
Literature Review .................................................................................................................9
Research Objective ............................................................................................................10
Conclusions ........................................................................................................................10
Bond Testing ......................................................................................................................11
  Bond Test Equipment ....................................................................................................11
  Bond Test Methods ........................................................................................................16
  Bond Test Results and Discussion .................................................................................18
    Hydrophilic Grout Results .......................................................................................... 18
    Hydrophobic Grout Results ........................................................................................ 20
Travel Testing ....................................................................................................................22
  Travel Test Equipment ...................................................................................................22
    Hydrophobic Test Setup ...............................................................................................22
    Hydrophilic Test Setup ...............................................................................................25
  Travel Test Methods .......................................................................................................28
    Hydrophobic Grout Testing .........................................................................................28
    Hydrophilic Grout Testing ...........................................................................................30
  Travel Test Results and Discussion ...............................................................................30
    Hydrophobic Grout Results .........................................................................................31
    Hydrophilic Grout Results ...........................................................................................34
Recommendations for Next Steps ......................................................................................36
References ..........................................................................................................................38
  Appendix A – Bond Testing Photos ............................................................................. A–1
  Appendix B – Grout Travel Photos ............................................................................... B–1
  Appendix C – Manufacturer Technical Data Sheets ....................................................... C–1
  Appendix D – Bond Test Raw Data ............................................................................... D–1

Tables

Table 1. Summary of Product Performance for Hydrophobic and Hydrophilic Grouts ....10
Table 2. Product viscosity listed from lowest to highest for hydrophobic and hydrophilic grouts. ............................................................................................................................................31
Table 3. Hydrophobic grout travel testing summary- listed from furthest travel distance to shortest. ..............................................................................................................................31
Table 4. Total distance and the time for hydrophobic grouts in a dry line. .......................32
Table 5. Hydrophilic Grout Summary- Listed from furthest travel distance to shortest. ..34
Table 6. Total distance and time for hydrophilic grouts in a dry line..............................35

Figures

Figure 1. Rubber mold for bond test..................................................................................12
Background

The Bureau of Reclamation’s Concrete, Geotechnical, and Structural Laboratory (CGSL) group performs concrete repairs that often consist of sealing leaking cracks and joints in Reclamation structures. Chemical grouts are injected into the leaking cracks and joints, which then react with water to form an expansive foam that mechanically locks into the crack. There are two types of polyurethane chemical grouts, hydrophobic and hydrophilic. Hydrophobic grouts require a catalyst and use only a small percentage of water to react. Hydrophilic grouts typically require a 1:1 ratio of water to grout, so they are normally injected with water. Hydrophilic grouts do not perform as well as hydrophobic grouts in wet/dry cycle environments because they shrink when they dry out. This shrinking can either cause the grout to tear or lose its mechanical lock on the concrete.

The conditions that require sealing of leaking joints and cracks range from large cracks with large flows to very small cracks that make injection challenging. If the crack is large, the flow of water needs to be shut down quickly. In these cases, a product that has a very quick reaction time and good bond to hold back the water once it is stopped would be most advantageous. However, if the crack is small, a lower viscosity product might be better so that it can travel further into the crack to achieve an effective seal.

Many of the manufacturers publish the tensile strength of the cured product, but don’t publish the bond strength between the grout and concrete or other materials. The manufacturers also publish reaction times, but don’t provide a correlation between reaction time and travel distance.

Literature Review

A document developed by Magill and Berry gave an extensive overview of the different types of chemical grouts and when/where they should be used. Magill and Berry described hydrophilic expansive foam grouts as “chasing and absorbing water in the crack and in all the fractures that branch off from the main crack.” [1] This characteristic was noticed by the researcher during the wet line testing of the hydrophilic products. As the expansive foam would flow along the tubing, occasionally, a small bead of the grout foam would break off and “chase” the water in the line.

Magill and Berry also noted that a lower viscosity product would be better suited for further travel applications [1]. This is one of the parameters that was investigated in this study.

Hydrophilic expansive foams should be used in locations where the foam will remain wet. Otherwise, dry environments may cause the foam to shrink [1]. Hydrophobic grouts, on the other hand, are water active and can use as little as 4% water to start the reaction. Because they have a very low water content, they are not prone to the same shrinkage issues as the hydrophilic foams [1].

Naudts noted that CO₂ is formed during the reaction of hydrophobic grouts with water. The formation of CO₂ decreases the viscosity of the product just prior to initial set. The generation of CO₂ in a confined space (such as a crack in concrete) will create extra pressure that will push the grout into the crack [2]. This increase in CO₂ and decrease in viscosity could explain why in this
study, a higher viscosity resin had a longer travel distance after the resin reacted with water as compared to injection without water.

**Research Objective**

There are many manufacturers on the market with numerous chemical grout products. This investigation will look at the hydrophilic and hydrophobic grouts that the CGSL group use frequently to seal leaking cracks and joints. The objective of this study is to determine the bond strength and travel distances of those products. The bond strength was tested using a modified version of the pull-off test per ASTM C1583 [3]. The travel distance of the grout was tested by injecting the grouts into small diameter polyurethane tubing which was used to simulate a small, tight crack.

**Conclusions**

Table 1 summarizes each of the products and their performance in the two categories tested, bond strength and travel. Blank cells are not an indication of poor performance, but rather there was nothing of interest to note.

**Table 1. Summary of Product Performance for Hydrophobic and Hydrophilic Grouts**

<table>
<thead>
<tr>
<th>Product</th>
<th>Average Bond Strength (psi)</th>
<th>Average Travel Distance (ft)</th>
<th>Dry Line</th>
<th>Wet Line</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Before Reaction</td>
<td>After Reaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hr</td>
<td>24 hr</td>
</tr>
<tr>
<td><strong>Hydrophobic</strong></td>
<td></td>
<td></td>
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<td>0.11</td>
<td>0.14</td>
<td>30</td>
<td>11.9</td>
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<td>Alchemy/Spetec PU F400</td>
<td><strong>3.89</strong></td>
<td><strong>1.73</strong></td>
<td>27</td>
<td>11.1</td>
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<tr>
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<td>0.89</td>
<td>0.48</td>
<td>18</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Hydrophilic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alchemy/Spetec AP Seal 500</td>
<td>0.82</td>
<td>0.91</td>
<td><strong>10</strong></td>
<td><strong>5.3</strong></td>
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<tr>
<td>Strata-Tech ST-504</td>
<td><strong>5.52</strong></td>
<td><strong>5.55</strong></td>
<td>9</td>
<td>0.0</td>
</tr>
<tr>
<td>Avanti AV-202</td>
<td>2.10</td>
<td>1.68</td>
<td>5</td>
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• Bond Testing
  o Hydrophilic chemical grouts had better bond strength than hydrophobic chemical grouts.
  o Three of the six products tested had lower bond strength at 24 hours than at 4 hours. The products that did not have a lower bond strength at 24 hours either had similar bond strengths to the 4-hour tests, or they were only slightly higher.
  o Avanti AV-202 and AV-248 had very consistent bond test results with a standard deviation at 4 hours of 0.04 and 0.06, respectively.
• Travel Testing
  o For hydrophobic grouts, viscosity is not always an indicator of how far the grout will travel once it reacts with water. Conversely, viscosity is an indicator of travel distance for hydrophilic grouts, both before and after they have reacted with water.
  o Hydrophobic Grouts: Alchemy/Spetec PU F400 travels further than Avanti AV-248 or AV-248-LV after reacting with water.
  o Hydrophilic Grouts: Both Avanti AV-202 and Strata-Tech ST-504 reacted in the grout injection assembly just before the point of injection, therefore their travel distance prior to reaction with water is not reported for these products.

Bond Testing

Bond Test Equipment

The bond strength of chemical grout was tested by modifying a pull-off test apparatus that is normally used for testing the bond strength of concrete overlays over existing concrete substrates. The bond testing in this study tested the bond of cured chemical grout to a concrete substrate (concrete pavers). A new gauge was used which had a lower range of values to consider the anticipated weaker bond. Custom steel angles were fabricated to retain the concrete pavers. Custom steel plates were required to accommodate the concrete pavers. Figure 1 through Figure 5 show the test specimens and the test setup. The Bond Test Methods section provides further detail about specimen preparation and testing.

Figure 1 shows the rubber molds that were used to contain the chemical grout between the two concrete pavers for bond testing. The 3-inch diameter hole in the center of the mold is the same diameter as the steel puck used in the testing. The mold was cut in half, so the mold could be easily removed from between the two concrete pavers with minimal disturbance to the chemical grout sample. Electrical tape was used to hold the two sides of the mold together because of its ease of removal.
Figure 1. Rubber mold for bond test

Figure 2 shows the specimens immediately after they were made. The steel clamps on each side were used to confine the expansion of the chemical grouts. The clamps remained until testing of each specimen was conducted. The chemical grout was molded such that it was sandwiched between the top and bottom concrete paver.
Figure 2. Bond testing specimens prior to testing.

Figure 3 shows the location of the steel puck on the top concrete paver. The ball and rod at the top of the steel puck is used to connect the steel puck to the bond tester. The steel puck was epoxied to the concrete paver using a fast setting two-part epoxy.
Figure 3. Steel puck for bond test located in center of top paver.

Figure 4 shows the bond testing setup for this study. The bottom paver is locked between 2 steel angles with set screws so that when the top paver is lifted, the bond between the chemical grout and the pavers is put into tension. The wheel at the top of the apparatus is turned to apply a hydraulic load which pulls the steel puck and the top paver. The pressure applied to the puck is displayed on a pressure gauge which helps determine how much force was applied to fail the bond between the chemical grout specimen and the concrete paver. A load test was performed on the gage prior to testing which determined one psi reading on the gauge equals one pound of force.
Figure 4. Bond test setup.

Figure 5 shows a close-up of how the bottom paver was locked into position. The set screws were tightened on all four corners to keep the bottom paver from moving during testing.
Bond Test Methods

1) Concrete pavers were kept in 100% humidity room until the day before they were used to make the specimens. The pavers were moved to a water bath where they remained overnight, so they were saturated before testing. Only the bottom half of the pavers were submerged so that the top of the paver was dry for attaching the steel puck.

2) A 3/8-inch thick mold was made from rubber which had a 3-inch diameter hole in the center as shown in Figure 1. The mold was approximately 3/8-inch wider than the pavers on all four sides. The mold was cut in half and then taped together with electrical tape so that the mold could be easily removed before testing. The mold was greased on both sides so that any spillover of the grout did not stick to the rubber mold or the concrete pavers.

3) The steel pull-off test pucks were epoxied to the top paver and the paver placed back into the water bath with the steel puck and epoxy out of the water.

4) The bottom paver was removed from the water bath and the rubber mold was placed on top of the paver.

5) The hydrophilic grouts were mixed in a 16 oz. plastic cup. The cup was filled to about 1/3 volume of grout and water was added to a 1:1 ratio. The mixture was thoroughly mixed and was poured immediately into the mold once it appeared the grout was close to initial set. The top paver was quickly placed on top of the mold. The pavers were clamped together using steel clamps to keep the expansion of the product from...
moving the pavers and to maintain a confined condition. The *hydrophobic* grouts were all mixed with 10% catalyst in a 10%. The accelerated grout was then mixed with 10% water to activate the grout. The same process of pouring the mixture into the mold and clamping the top and bottom pavers together was used.

6) Once all the specimens were made (10 specimens per product), the specimens were moved to a 50% humidity room where they remained until testing.

7) Five tests were conducted at each age on each product:
   a. (5) tests at 4 hours
   b. (5) tests at 24 hours

8) Prior to testing each sample, the clamps were removed from the specimen. The electrical tape and mold were removed. The pull-off test apparatus was connected to the steel puck and the bottom paver was locked into place between the steel angles of the test apparatus. Connecting the pull-off test apparatus to the steel puck and locking the bottom paver into place had to be performed simultaneously and with care using two people to avoid prematurely breaking the bond.

9) The wheel on the bond tester apparatus was turned at a slow, steady pace until either the bond broke or the apparatus reached the maximum distance it could move. The maximum load when the bond broke was recorded. In the case where the apparatus reached its maximum distance of 7/8-inch without breaking the bond, the distance between pavers was recorded.

10) Tensile bond strength was recorded as well as the location of rupture (bond to substrate or in the material itself). Refer to Appendix A for photographs of each test and Appendix D for notes on failure location.
Bond Test Results and Discussion

The results of the bond testing have been separated into hydrophilic vs. hydrophobic grouts. Figure 6 shows the average bond strength of each hydrophilic material at 4 hours and 24 hours after molding. Five tests were performed on each product at each age, so an average could be calculated from the results. Strata-Tech ST-504 had the highest bond strength, which was over double the bond strength of the next closest product.

Hydrophilic Grout Results

![Average Bond Strength Chart](chart)

Figure 6. Average bond strength of hydrophilic grouts.

Figure 7 and Figure 8 show the individual bond strengths of hydrophilic grout specimens tested at 4 and 24 hours, respectively. Bond strength results for two of the Avanti AV-202 specimens were not available because the maximum reading on the pressure gauge was reached before the bond broke. Although the results were higher, there was more variability in the strengths for Stata-Tech ST-504 than the Avanti AV-202 or the Alchemy/Spetec AP Seal 500.
Figure 7. Individual bond strengths of hydrophilic grouts at 4 hours.

Figure 8. Individual bond strengths of hydrophilic grouts at 24 hours.
Hydrophobic Grout Results

Figure 9 shows the average bond strength of the three hydrophobic products tested at 4 and 24 hours after the samples were made. Alchemy/Spetec PU F400 had the highest bond strength of the three hydrophobic products. The average bond strength of PU F400 is over four times the bond strength of the next highest bond strengths. The average for the Avanti AV-248-LV at 4 hours was calculated using only the two readings that were recorded. Note that because only one reading was achieved at 24 hours for AV-248-LV, the average reported is of a single test.

![Average Bond Strength Chart]

**Figure 9. Average bond strengths of hydrophobic grouts.**

Figure 10 and Figure 11 show the individual bond strengths of each product at 4 and 24 hours, respectively. The loading of Avanti AV-248-LV was too low and did not register on the pressure gauge. Although the strengths are higher in the PU F400 product, there is more variability in the results than there were for the AV-248 product.
Figure 10. Individual bond strengths of hydrophobic grouts at 4 hours.

Figure 11. Individual bond strengths of hydrophobic grouts at 24 hours.
Travel Testing

Travel Test Equipment

The travel test of the chemical grouts was conducted on both hydrophobic and hydrophilic grouts. The tests were conducted by injecting the grouts into small diameter (1/16” ID) clear polyurethane tube. The hydrophobic grouts were catalyzed at 10% by volume prior to injection. A shutoff valve and pressure gauge at the point of injection were used to set the injection pressure at 120 psi initial pressure so that all grouts were injected under the same conditions.

Hydrophobic Test Setup

Figure 12 shows the initial setup of the hydrophobic chemical grout travel testing. A single component grout pump was used to inject the hydrophobic grout, which had already been catalyzed. Two tests were run on the hydrophobic chemical grouts. The first test was conducted by injecting the catalyzed chemical grout into a dry line. The second test was conducted by injecting the catalyzed chemical grout into a line that was filled with water. The same test setup was used for both tests. The Travel Test Methods section of this report describes the test procedure in further detail.
Figure 12. Single component grout pump used to inject hydrophobic chemical grouts.

The end of the grout line from the pump was configured with the connection shown in Figure 13. The grout hose was connected to the pressure gauge, so the pressure could be read at the point of injection. A valve was installed immediately downstream of the pressure gauge. The test was ready to commence once the pressure gauge read 120 psi, at which point the valve was opened.
Figure 13. Hydrophobic grout line configuration.

Figure 14 shows the water hose configuration used to fill the polyurethane tubing for the second test. A fitting was used to convert a water hose attachment to a polyurethane tube attachment. The other three valves were shut off so that all the water in the hose traveled into the polyurethane tubing. Water was run through the tubing until it reached the other end of the tubing.
Figure 14. Water hose used to fill the polyurethane tubing with water prior to grout injection.

Hydrophilic Test Setup
Figure 15 shows the initial setup of the hydrophilic chemical grout travel test. The dual component grout pump delivers water and resin at a 1:1 ratio. Hydrophilic grouts typically require a 1:1 ratio of water to resin to react and form an expansive foam. There are separate hoses and material containers for water and chemical grout.
Figure 15. Dual component grout pump used to inject hydrophilic chemical grouts.

Figure 16 shows the configuration of the mixing assembly just prior to the point of injection. Both the water line and the chemical grout line had pressure gauges installed to ensure the water and chemical grout lines were both pressured to 120 psi prior to injection. Once both lines reached 120 psi, the valve shown in Figure 16 was opened and the chemical grout and water were mixed prior to the valve due to turbulence in the assembly, and the mixed components were sent through the single injection line. The water line and pressure gauge (not shown in Figure 16) was identical to the chemical grout line and pressure gauge.
Figure 16. Chemical grout and water line assembly.

Figure 17 shows the overall test setup for the travel testing. The polyurethane tubing was taped to the concrete floor and a tape measure placed adjacent to the tubing so the travel distances could be easily read. Video footage was achieved by mounting a GoPro camera to the bottom of a cart and having the cart roll over the top of the tubing and tape measure during testing. The tubing was centered under the cart and the cart was manually pushed as the grout flowed through the tubing. Figure 17 shows the test setup for the hydrophilic chemical grouts, but the same setup was used for the hydrophobic chemical grouts.
Travel Test Methods

Hydrophobic Grout Testing

Dry Line Procedure
The dry tubing tests for the hydrophobic testing consisted of the following steps:

1. Lay out 50-ft long tape measure and tape to the concrete floor with the end of the tape measure secured at the point of injection on the injection nozzle.
2. Lay out 50-ft long polyurethane tubing flat and tape to the concrete floor adjacent to the tape measure so that the travel distances of the chemical grout can be easily read.
3. Place a plastic sheet at the end of 50-ft tubing to collect chemical grout material if it travels over 50 ft.
4. Prime the pump and ensure there is a steady flow of grout traveling through the grout line.
5. Close the valve between the grout line and the tubing.
6. Attach the grout line to the tubing.
7. Turn on the pump until the pressure on the gauge at the end of the grout line reads 120 psi (bleed off pressure in excess of 120 psi at the pump).
8. Once the pressure is at 120 psi, open the valve at the end of the grout line and simultaneously start the timer.
9. The first reading is taken at 5 ft (because some of the grouts move quickly, it is impossible to manually take a reading in the first 4 ft).
10. The lap function is used to take a reading at each foot after the initial 5 ft reading. The laps indicate how long it took the grout to travel 1 ft.
11. The test is stopped once the grout travel stops which was defined as when it takes over 1 min 30 seconds to travel 1 ft.
12. The final distance when the test was stopped (in feet) and the total time it took to travel to that point is recorded. Refer to Appendix B for photographs of the travel testing.

**Wet Line Procedure**

The wet tubing tests for the hydrophobic testing consisted of the following steps:

1. Lay out 50-ft long tape measure and tape to the concrete floor with the end of the tape measure secured at the point of injection on the injection nozzle.
2. Lay out 50-ft long polyurethane tubing flat and tape to the concrete floor adjacent to the tape measure so that the travel distances of the chemical grout can be easily read.
3. Place a plastic sheet at the end of 50-ft tubing to collect chemical grout material if it travels over 50 ft.
4. Attach a garden hose to the tubing and fill the line with water. Once a steady stream of water flows from the end, turn off the water hose.
5. Prime the pump and ensure there is a steady flow of grout traveling through the grout line.
6. Close the valve between the grout line and the tubing.
7. Attach the grout line to the tubing.
8. Turn on the pump until the pressure on the gauge at the end of the grout line reads 120 psi (bleed off pressure in excess of 120 psi at the pump).
9. Once the pressure is at 120 psi, open the valve at the end of the grout line and track the leading edge of the grout.
10. The test is stopped once the grout stops moving and there is no water being pushed out of the end of the line.
11. Record the furthest distance the grout traveled and the distance where the grout begins to leave reacted material in the line (there will be unreacted material from zero to the location where reacted material in the line begins). Refer to Appendix B for photographs of the travel testing.
Hydrophilic Grout Testing

Dry Line Procedure
The dry tubing tests for the hydrophilic testing followed the same test procedure as the dry tubing test for the hydrophobic testing.

Wet Line Procedure
The wet tubing tests for the hydrophilic testing consisted of the following steps: Note: the water was introduced at the point of injection rather than in a pre-filled line.

1. Lay out 50-ft long tape measure and tape to the concrete floor with the end of the tape measure secured at the point of injection on the injection nozzle.
2. Lay out 50-ft long polyurethane tubing flat and tape to the concrete floor adjacent to the tape measure so that the travel distances of the chemical grout can be easily read.
3. Place a plastic sheet at the end of 50-ft tubing to collect chemical grout material if it travels over 50 ft.
4. Prime the pump and ensure there is a steady flow of grout traveling through the grout line.
5. Close the valve between the grout line and the tubing.
6. Attach the grout line to the tubing.
7. Turn on the pump until the pressure on the gauge at the end of the grout line reads 120 psi (bleed off pressure in excess of 120 psi).
8. Turn on the pump until the pressure on the gauge at the end of the water line reads 120 psi (bleed off pressure in excess of 120 psi).
9. Verify that the pressure at the grout line still reads 120 psi and adjust as required.
10. Once the pressure is at 120 psi on both the grout and water lines, open the valve at the end of the assembly and follow the leading edge of the grout.
11. The test is stopped once the grout stops moving.
12. Record the furthest distance that the grout traveled and the distance where the grout begins to leave reacted material in the line (there will be unreacted material from zero to the location where reacted material in the line begins. In some cases, the grout reacted so quickly that there was no unreacted material in the line). Refer to Appendix B for photographs of the travel testing.
13. The grouting “F” assembly was replaced with a new one for each product tested to prevent product mixing.

Travel Test Results and Discussion

A travel test was conducted on each of the six selected products to determine how far the products would travel both before and after they had reacted. Grout travel in a crack is an important parameter when selecting the appropriate product for the job. Many cracks are deep, so the product needs to travel a significant distance to fully seal the leak. Another reason for assessing grout travel is to optimize injection port spacing. Port spacing has a direct impact on the amount of labor required to drill and install injection ports.
Table 2. Product viscosity listed from lowest to highest for hydrophobic and hydrophilic grouts.

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrophobic Grouts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avanti</td>
<td>AV-248-LV</td>
<td>150-250 [cP]</td>
</tr>
<tr>
<td>Alchemy/Spetec</td>
<td>PU F400</td>
<td>340 [cP]</td>
</tr>
<tr>
<td>Avanti</td>
<td>AV-248</td>
<td>550-830 [cP]</td>
</tr>
<tr>
<td><strong>Hydrophilic Grouts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alchemy/Spetec</td>
<td>AP Seal 500</td>
<td>250-350[cP]</td>
</tr>
<tr>
<td>Strata-Tech</td>
<td>ST-504</td>
<td>700 [cP]</td>
</tr>
<tr>
<td>Avanti</td>
<td>AV-202</td>
<td>3,200-6,000[cP]</td>
</tr>
</tbody>
</table>

Looking at the viscosity of each of the products, one would assume that the lowest viscosity product would be most likely to travel the furthest. The travel testing was conducted looking first at the travel distance and time in a dry line (i.e. unreacted). Secondly, the products were tested to see how far they would travel once water was introduced (i.e. reacted).

**Hydrophobic Grout Results**

Table 3. Hydrophobic grout travel testing summary- listed from furthest travel distance to shortest.

<table>
<thead>
<tr>
<th>Line Condition</th>
<th>Company</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Line</td>
<td>Avanti</td>
<td>AV-248-LV</td>
</tr>
<tr>
<td></td>
<td>Alchemy/Spetec</td>
<td>PU F400</td>
</tr>
<tr>
<td></td>
<td>Avanti</td>
<td>AV-248</td>
</tr>
<tr>
<td>Wet Line</td>
<td>Alchemy/Spetec</td>
<td>PU F400</td>
</tr>
<tr>
<td></td>
<td>Avanti</td>
<td>AV-248-LV</td>
</tr>
<tr>
<td></td>
<td>Avanti</td>
<td>AV-248</td>
</tr>
</tbody>
</table>

As was expected, the product with the lowest viscosity, Avanti AV-248-LV, had the furthest travel distance in the dry line. However, once water was introduced to the system, Alchemy/Spetec PU F400 had the furthest travel distance.
Dry Line

Figure 18. Total travel distances for hydrophobic grouts in a dry line.

Table 4. Total distance and the time for hydrophobic grouts in a dry line.

<table>
<thead>
<tr>
<th>Material</th>
<th>Test Number</th>
<th>Total Distance (ft)</th>
<th>Total Time (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU F400</td>
<td>Test 1</td>
<td>27</td>
<td>12:53.2</td>
</tr>
<tr>
<td></td>
<td>Test 2</td>
<td>27</td>
<td>13:03.9</td>
</tr>
<tr>
<td></td>
<td>Test 3</td>
<td>27</td>
<td>13:12.1</td>
</tr>
<tr>
<td>AV-248-LV</td>
<td>Test 1</td>
<td>31</td>
<td>15:23.1</td>
</tr>
<tr>
<td></td>
<td>Test 2</td>
<td>30</td>
<td>14:16.6</td>
</tr>
<tr>
<td></td>
<td>Test 3</td>
<td>30</td>
<td>14:52.4</td>
</tr>
<tr>
<td>AV-248</td>
<td>Test 1</td>
<td>18</td>
<td>10:00.1</td>
</tr>
<tr>
<td></td>
<td>Test 2</td>
<td>17</td>
<td>10:13.0</td>
</tr>
<tr>
<td></td>
<td>Test 3</td>
<td>18</td>
<td>10:39.3</td>
</tr>
</tbody>
</table>
Wet Line

Figure 19 shows the unreacted and reacted distances traveled by each product. As can be seen from the figure, Alchmey/Spetec PU F400 had significant travel distances even after the product had reacted with water to form a foam. Comparing the low viscosity AV-248-LV and normal viscosity AV-248, there were not significant differences in travel distances between them once they had reacted with water. The lower viscosity version will ultimately travel better in tighter cracks than products with higher viscosity, but the product will not travel significantly further if there is water in the crack.

Figure 19. Travel distances for hydrophobic grouts in a wet line.
Hydrophilic Grout Results

Table 5. Hydrophilic Grout Summary- Listed from furthest travel distance to shortest.

<table>
<thead>
<tr>
<th>Line Condition</th>
<th>Company</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Line</td>
<td>Alchemy/Spetec</td>
<td>AP Seal 500</td>
</tr>
<tr>
<td></td>
<td>Strata-Tech</td>
<td>ST-504</td>
</tr>
<tr>
<td></td>
<td>Avanti</td>
<td>AV-202</td>
</tr>
<tr>
<td>Wet Line</td>
<td>Alchemy/Spetec</td>
<td>AP Seal 500</td>
</tr>
<tr>
<td></td>
<td>Strata-Tech</td>
<td>ST-504</td>
</tr>
<tr>
<td></td>
<td>Avanti</td>
<td>AV-202</td>
</tr>
</tbody>
</table>

The hydrophilic grouts were tested in the same manner as the hydrophobic grouts. However, unlike the hydrophobic grouts, the product with the lowest viscosity traveled the furthest both before and after it had reacted.
Dry Line

Figure 20. Total travel distances for hydrophilic grouts in a dry line.

Table 6. Total distance and time for hydrophilic grouts in a dry line.

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Total Distance (ft)</th>
<th>Total time (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>6</td>
<td>06:13.1</td>
</tr>
<tr>
<td>Test 2</td>
<td>5</td>
<td>05:41.3</td>
</tr>
<tr>
<td>Test 3</td>
<td>5</td>
<td>05:19.7</td>
</tr>
</tbody>
</table>

AV-202

| Test 1      | 11                  | 05:30.0              |
| Test 2      | 11                  | 05:41.5              |
| Test 3      | 7                   | 03:24.8              |

AP SEAL 500

| Test 1      | 9                   | 06:12.5              |
| Test 2      | 9                   | 05:52.9              |
| Test 3      | 9                   | 05:33.3              |

ST-504
**Wet Line**

Figure 21 shows the distance each product traveled before and after it reacted with water. There is no travel distance shown for the unreacted material for Avanti AV-202 or Strata-Tech ST-504 because the products reacted so quickly there was no sign of unreacted material in the polyurethane line. The advantage of the AP Seal 500 product is that it will travel a fair distance before it reacts, giving the installer more working time. However, this could be a disadvantage if the leaking is significant and needs to be shut down immediately. If the unreacted travel distance was removed from the chart on AP Seal 500, the average travel distance of AP Seal 500 and ST-504 would be approximately the same, with average travel distances of 6.90 feet and 6.74 feet, respectively.

![Figure 21. Total travel distances for hydrophilic grouts in a wet line.](image)

**Recommendations for Next Steps**

- Test more products. The results for both the bond testing and the travel testing varied significantly between the tested products.
- Heating the grout prior to injection often speeds up the reaction time. Future studies should consider heating the grout to different temperatures to determine the effect of...
grout temperature on the results. Heating the grout can also have effects on the travel distance.

- **Bond Testing:**
  - There is potential for eccentricity in the pull-off test apparatus when the bottom paver is being placed between the angles. One person is sliding the bottom pavers between the support angles while another person is simultaneously sliding the apparatus onto the pull-off test steel puck. If this task is not performed together, there is potential to prematurely break the bond. Future studies should investigate other test procedures that do not require excessive handling of the specimens prior to testing.
  - Future tests should consider using a load cell instead of the pressure apparatus.
  - Obtain a pressure gauge with higher resolution and retest Avanti AV-248-LV. Seven of the 10 tests resulted in a 0 psi reading. A higher resolution gauge could provide more data.
  - All the hydrophobic grouts incorporated 10% catalyst by volume. Future studies should vary the amount of catalyst to determine if there is an optimum amount of catalyst for each product with respect to bond values.

- **Travel Testing:**
  - The testing performed in this investigation assessed travel in a small, tight crack (1/16-inch). Future studies should focus on travel in larger cracks (1/4 to 1/2-inch).
  - All the hydrophobic grouts incorporated 10% catalyst by volume. Future studies should vary the amount of catalyst to determine if there is an optimum amount for each product with respect to travel distance.
  - Develop a test apparatus that could measure the travel in an actual concrete crack. The testing in this study used polyurethane tubing so that the substrate was relatively frictionless and repeatable between tests. It would be more representative of field conditions to determine if there a possibility that some of the products can overcome the friction within concrete cracks better than others?
References


Appendix A – Bond Testing Photos

- Hydrophilic chemical grouts
  - Alchemy/Spetec AP Seal 500
  - Avanti AV-202 Multigrout
  - Strata-Tech ST-504
- Hydrophobic chemical grouts
  - Avanti AV-248-LV Flexseal LV
  - Avanti AV-248 Flexseal
  - Alchemy/Spetec PU F400
Hydrophilic Adhesion Testing

Alchemy/Spetec - AP Seal 500

Test 1 - 4 Hours

Figure 1. AP Seal 500 - Test 1 - 4 Hours (left) side view (right) top view

Figure 2. AP Seal 500 - Test 1 - 4 Hours - Material stuck to top and bottom brick
Figure 3. AP Seal 500 - Test 1 - 4 Hours (left) top and bottom brick after testing (right) material after testing

Test 2 - 4 Hours

Figure 4. AP Seal 500 - Test 2 - 4 Hours (left) side view (right) top view
Figure 5. AP Seal 500 – Test 2 – 4 Hours (left) top and bottom brick after testing (right) material after testing

Test 3 - 4 Hours

Figure 6. AP Seal 500 - Test 3 - 4 Hours (left) side view (right) top view
Figure 7. AP Seal 500 - Test 3 - 4 Hours (left) top and bottom brick after testing (right) material after testing

Test 4 - 4 Hours

Figure 8. AP Seal 500 - Test 4 - 4 Hours (left) side view (right) top view
Figure 9. AP Seal 500 - Test 4 - 4 Hours - Material stuck to top and bottom brick

Figure 10. AP Seal 500 - Test 4 - 4 Hours (left) top and bottom brick after testing (right) material after testing
Test 5 - 4 Hours

Figure 11. AP Seal 500 - Test 5 - 4 Hours (left) side view (right) top view

Figure 12. AP Seal 500 - Test 5 - 4 Hours - Material stuck to top and bottom brick (left) side view (right) front view
Figure 13. AP Seal 500 - Test 5 - 4 Hours (left) top and bottom brick after testing (right) material after testing

Test 1 - 24 Hours

Figure 14. AP Seal 500 - Test 1 - 24 Hours (left) side view (right) top view
Figure 15. AP Seal 500 - Test 1 - 24 Hours - Material stuck to top and bottom brick

Figure 16. AP Seal 500 - Test 1 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Test 2 - 24 Hours

Figure 17. AP Seal 500 - Test 2 - 24 Hours (left) side view (right) top view

Figure 18. AP Seal 500 - Test 2 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Test 3 - 24 Hours

Figure 19. AP Seal 500 - Test 3 - 24 Hours (left) side view (right) top view

Figure 20. AP Seal 500 - Test 3 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Test 4 - 24 Hours

Figure 21. AP Seal 500 - Test 4 - 24 Hours (left) side view (right) top view

Figure 22. AP Seal 500 - Test 4 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Test 5 - 24 Hours

Figure 23. AP Seal 500 - Test 5 - 24 Hours (left) side view (right) top view

Figure 24. AP Seal 500 - Test 5 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Avanti - AV-202 Multigrunut

Test 1 - 4 Hours

Figure 25. AV202 - Test 1 - 4 Hours (left) side view (right) top view

Figure 26. AV202 - Test 1 - 4 Hours (left) top and bottom brick after testing (right) material after testing
Test 2 - 4 Hours

Figure 27. AV202 - Test 2 - 4 Hours (left) side view (right) top view

Test 3 - 4 Hours

Figure 28. AV202 - Test 3 - 4 Hours (left) side view (right) top view
Figure 29. AV202 - Test 3 - 4 Hours - top and bottom brick after testing

Figure 30. AV202 - Test 3 - 4 Hours - material on bricks after testing
Test 4 - 4 Hours

Figure 31. AV202 - Test 4 - 4 Hours (left) side view (right) top view

Figure 32. AV202 - Test 4 - 4 Hours - top and bottom brick after testing
Figure 33. AV202 - Test 4 - 4 Hours - material on bricks after testing

Test 5 - 4 Hours

Figure 34. AV202 - Test 5 - 4 Hours (left) side view (right) top view
Figure 35. AV202 - Test 5 - 4 Hours - top and bottom brick after testing

Figure 36. AV202 - Test 5 - 4 Hours - material on bricks after testing
Test 1 - 24 Hours

Figure 37. AV202 - Test 1- 24 Hours (left) side view (right) top view

Figure 38. AV202 - Test 1 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Test 2 - 24 Hours

Figure 39. AV202 - Test 2 - 24 Hours (left) side view (right) top view

Figure 40. AV202 - Test 2 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Test 3 - 24 Hours

Figure 41. AV202 - Test 3- 24 Hours (left) side view (right) top view

Figure 42. AV202 - Test 3 - 24 Hours - top and bottom brick after testing

Figure 43. AV202 - Test 3 - 24 Hours - material on bricks after testing
Test 4 - 24 Hours

Figure 44. AV202 - Test 4 - 24 Hours (left) side view (right) top view

Figure 45. AV202 - Test 4 - 24 Hours - top and bottom brick after testing

Figure 46. AV202 - Test 4 - 24 Hours - material on bricks after testing
Test 5 - 24 Hours

Figure 47. AV202 - Test 5 - 24 Hours (left) side view (right) top view

Figure 48. AV202 - Test 5 - 24 Hours - top and bottom brick after testing

Figure 49. AV202 - Test 5 - 24 Hours - material on bricks after testing
Strata-Tech, Inc. - ST-504

Test 1 - 4 Hours

Figure 50. ST504 - Test 1 - 4 Hours - side view

Figure 51. ST504 - Test 1 - 4 Hours - Material stuck to top and bottom brick (left) side view (right) front view

Figure 52. ST504 - Test 1 - 4 Hours - top and bottom brick after testing
Figure 53. ST504 - Test 1 - 4 Hours - material on bricks after testing

Test 2 - 4 Hours

Figure 54. ST504 - Test 2 - 4 Hours (left) side view (right) top view
Figure 55. ST504 - Test 2 - 4 Hours - top and bottom brick after testing

Figure 56. ST504 - Test 2 - 4 Hours - material on bricks after testing
Test 3 - 4 Hours

Figure 57. ST504 - Test 3 - 4 Hours (left) side view (right) top view

Figure 58. ST504 - Test 3 - 4 Hours - top and bottom brick after testing

Figure 59. ST504 - Test 3 - 4 Hours - material on bricks after testing
Test 4 - 4 Hours

Figure 60. ST504 - Test 4 - 4 Hours (left) side view (right) top view

Figure 61. ST504 - Test 4 - 4 Hours - top and bottom brick after testing

Figure 62. ST504 - Test 4 - 4 Hours - material on bricks after testing
Test 5 - 4 Hours

Figure 63. ST504 - Test 5 - 4 Hours (left) side view (right) top view

Figure 64. ST504 - Test 5 - 4 Hours - top and bottom brick after testing

Figure 65. ST504 - Test 5 - 4 Hours - material on bricks after testing
Test 1 - 24 Hours

Figure 66. ST504 - Test 1 - 24 Hours (left) side view (right) top view

Figure 67. ST504 - Test 1 - 24 Hours - top and bottom brick after testing

Figure 68. ST504 - Test 1 - 24 Hours - material on bricks after testing
Test 2 - 24 Hours

Figure 69. ST504 - Test 2 - 24 Hours (left) side view (right) top view

Figure 70. ST504 - Test 2 - 24 Hours - top and bottom brick after testing

Figure 71. ST504 - Test 2 - 24 Hours - material on bricks after testing
Test 3 - 24 Hours

Figure 72. ST504 - Test 3 - 24 Hours (left) side view (right) top view

Figure 73. ST504 - Test 3 - 24 Hours - top and bottom brick after testing

Figure 74. ST504 - Test 3 - 24 Hours - material on bricks after testing
Test 4 - 24 Hours

Figure 75. ST504 - Test 4 - 24 Hours (left) side view (right) top view

Figure 76. ST504 - Test 4 - 24 Hours - Material stuck to top and bottom brick (left) side view (right) front view
Figure 77. ST504 - Test 4 - 24 Hours - top and bottom brick after testing

Figure 78. ST504 - Test 4 - 24 Hours - material on bricks after testing
Test 5 - 24 Hours

Figure 79. ST504 - Test 5 - 24 Hours (left) side view (right) top view

Figure 80. ST504 - Test 5 - 24 Hours - top and bottom brick after testing

Figure 81. ST504 - Test 5 - 24 Hours - material on bricks after testing
Hydrophobic Adhesion Testing

Avanti - AV-248-LV Flexseal LV

Test 1 - 4 Hours

Figure 82. AV-248-LV - Test 1 - 4 Hours (left) side view (right) top view

Figure 83. AV-248-LV - Test 1 - 4 Hours - top and bottom brick after testing
Figure 84. AV-248-LV - Test 1 - 4 Hours - material on bricks after testing

Test 2 - 4 Hours

Figure 85. AV-248-LV - Test 2 - 4 Hours (left) side view (right) top view

Figure 86. AV-248-LV - Test 2 - 4 Hours - top and bottom brick after testing
Test 3 - 4 Hours

Figure 87. AV-248-LV - Test 2 - 4 Hours - material on bricks after testing

Figure 88. AV-248-LV - Test 3 - 4 Hours (left) side view (right) top view

Figure 89. AV-248-LV - Test 3 - 4 Hours - top and bottom brick after testing
Figure 90. AV-248-LV - Test 3 - 4 Hours - material on bricks after testing

Test 4 - 4 Hours

Figure 91. AV-248-LV - Test 4 - 4 Hours (left) side view (right) top view

Figure 92. AV-248-LV - Test 4 - 4 Hours - top and bottom brick after testing
Test 5 - 4 Hours

Figure 93. AV-248-LV - Test 4 - 4 Hours - material on bricks after testing

Figure 94. AV-248-LV - Test 5 - 4 Hours (left) side view (right) top view

Figure 95. AV-248-LV - Test 5 - 4 Hours - top and bottom brick after testing
Test 1 - 24 Hours

Figure 96. AV-248-LV - Test 5 - 4 Hours - material on bricks after testing

Figure 97. AV-248-LV - Test 1 - 24 Hours (left) side view (right) top view

Figure 98. AV-248-LV - Test 1 - 24 Hours - top and bottom brick after testing
Figure 99. AV-248-LV - Test 1 - 24 Hours - material on bricks after testing

Test 2 - 24 Hours

Figure 100. AV-248-LV - Test 2 - 24 Hours (left) side view (right) top view

Figure 101. AV-248-LV - Test 2 - 24 Hours - top and bottom brick after testing
Test 3 - 24 Hours

Figure 102. AV-248-LV - Test 2 - 24 Hours - material on bricks after testing

Figure 103. AV-248-LV - Test 3 - 24 Hours (left) side view (right) top view

Figure 104. AV-248-LV - Test 3 - 24 Hours - top and bottom brick after testing
Test 4 - 24 Hours

Figure 105. AV-248-LV - Test 3 - 24 Hours - material on bricks after testing

Figure 106. AV-248-LV - Test 4 - 24 Hours (left) side view (right) top view

Figure 107. AV-248-LV - Test 4 - 24 Hours - top and bottom brick after testing
Test 5 - 24 Hours

Figure 108. AV-248-LV - Test 4 - 24 Hours - material on bricks after testing

Figure 109. AV-248-LV - Test 5 - 24 Hours (left) side view (right) top view

Figure 110. AV-248-LV - Test 5 - 24 Hours - top and bottom brick after testing
Figure 111. AV-248-LV - Test 5 - 24 Hours - material on bricks after testing

Avanti - AV-248 Flexseal

Test 1 - 4 Hours

Figure 112. AV-248 - Test 1 - 4 Hours (left) side view (right) top view

Figure 113. AV-248 - Test 1 - 4 Hours - material on bricks after testing
Test 2 - 4 Hours

Figure 114. AV-248 - Test 2 - 4 Hours (left) side view (right) top view

Figure 115. AV-248 - Test 2 - 4 Hours - Material stuck to top and bottom brick

Figure 116. AV-248 - Test 2 - 4 Hours - top and bottom brick after testing
Test 3 - 4 Hours
Test 4 - 4 Hours

Figure 120. AV-248 - Test 4 - 4 Hours (left) side view (right) top view

Figure 121. Av-248 - Test 4 - 4 Hours - Material stuck to top and bottom brick (left) side view (right) front view
Figure 122. AV-248 - Test 4 - 4 Hours - top and bottom brick after testing

Figure 123. AV-248 - Test 4 - 4 Hours - material on bricks after testing
Test 5 - 4 Hours

Figure 124. AV-248 - Test 5 - 4 Hours (left) side view (right) top view

Figure 125. Av-248 - Test 5 - 4 Hours - Material stuck to top and bottom brick (left) side view (right) front view

Figure 126. AV-248 - Test 5 - 4 Hours - material on bricks after testing
Test 1 - 24 Hours

Figure 127. AV-248 - Test 1 - 24 Hours (left) side view (right) top view

Figure 128. AV-248 - Test 1 - 24 Hours - material on bricks after testing
Test 2 - 24 Hours

Figure 129. AV-248 - Test 2 - 24 Hours (left) side view (right) top view

Figure 130. AV-248 - Test 2 - 24 Hours - top and bottom brick after testing

Figure 131. AV-248 - Test 2 - 24 Hours - material on bricks after testing
Test 3 - 24 Hours

Figure 132. AV-248 - Test 3 - 24 Hours (left) side view (right) top view

Figure 133. AV-248 - Test 3 - 24 Hours - top and bottom brick after testing

Figure 134. AV-248 - Test 3 - 24 Hours - material on bricks after testing
Test 4 - 24 Hours

Figure 135. AV-248 - Test 4 - 24 Hours (left) side view (right) top view

Figure 136. AV-248 - Test 4 - 24 Hours - top and bottom brick after testing

Figure 137. AV-248 - Test 4 - 24 Hours - material on bricks after testing
Test 5 - 24 Hours

Figure 138. AV-248 - Test 5 - 24 Hours (left) side view (right) top view

Figure 139. AV-248 - Test 5 - 24 Hours (left) top and bottom brick after testing (right) material after testing
Spetec - PU F400

Test 1 - 4 Hours

Figure 140. PU F400 - Test 1 - 4 Hours (left) side view (right) top view

Figure 141. PU F400 - Test 1 - 4 Hours - top and bottom brick after testing
Figure 142. PU F400 - Test 1 - 4 Hours - material on bricks after testing

Test 2 - 4 Hours

Figure 143. PU F400 - Test 2 - 4 Hours (left) side view (right) top view

Figure 144. PU F400 - Test 2 - 4 Hours - Material stuck to top and bottom brick (left) side view (right) front view
Figure 145. PU F400 - Test 2 - 4 Hours - top and bottom brick after testing

Figure 146. PU F400 - Test 2 - 4 Hours - material on bricks after testing
Test 3 - 4 Hours

Figure 147. PU F400 - Test 3 - 4 Hours (left) side view (right) top view

Figure 148. PU F400 - Test 3 - 4 Hours - top and bottom brick after testing
Figure 149. PU F400 - Test 3 - 4 Hours - material on bricks after testing

Test 4 - 4 Hours

Figure 150. PU F400 - Test 4 - 4 Hours (left) side view (right) top view

Figure 151. PU F400 - Test 4 - 4 Hours - Material stuck to top and bottom brick (left) side view (right) front view
Figure 152. PU F400 - Test 4 - 4 Hours - top and bottom brick after testing

Figure 153. PU F400 - Test 4 - 4 Hours - material on bricks after testing
Test 5 - 4 Hours

Figure 154. PU F400 - Test 5 - 4 Hours (left) side view (right) top view

Figure 155. PU F400 - Test 5 - 4 Hours - top and bottom brick after testing

Figure 156. PU F400 - Test 5 - 4 Hours - material on bricks after testing

Test 1 – 24 Hours
Test 2 - 24 Hours

Figure 157. PU F400 - Test 2 - 24 Hours (left) side view (right) top view

Figure 158. PU F400 - Test 2 - 24 Hours - top and bottom brick after testing

Figure 159. PU F400 - Test 2 - 24 Hours - material on bricks after testing
Test 3 - 24 Hours

Figure 160. PU F400 - Test 3 - 24 Hours (left) side view (right) top view

Figure 161. PU F400 - Test 3 - 24 Hours - top and bottom brick after testing
Figure 162. PU F400 - Test 3 - 24 Hours - material on bricks after testing

Test 4 - 24 Hours

Figure 163. PU F400 - Test 4 - 24 Hours (left) side view (right) top view

Figure 164. PU F400 - Test 4 - 24 Hours - Material stuck to top and bottom brick (left) side view (right) front view
Test 5 - 24 Hours

Figure 166. PU F400 - Test 5 - 24 Hours (left) side view (right) top view
Figure 167. PU F400 - Test 5 - 24 Hours - top and bottom brick after testing

Figure 168. PU F400 - Test 5 - 24 Hours - material on bricks after testing
Appendix B – Grout Travel Photos

- **Hydrophobic chemical grouts**
  - Alchemy/Spetec PUF400
  - Avanti AV-248-LV Flexseal LV
  - Avanti AV-248 Flexseal

- **Hydrophilic chemical grouts**
  - Alchemy/Spetec AP Seal 500
  - Avanti AV-202 Multigrout
  - Strata-Tech ST-504
Spetec - PU F400
Test 1 - Clear Line with Water

Figure 1. Spetec PU-F400 - Test 1 - Start of reacted material in line filled with water. (9'-2'"

Figure 2. Spetec PU-F400 - Test 1 - End of reacted material in line filled with water. (37'-4'"

START OF REACTED MATERIAL

END OF REACTED MATERIAL
Test 2 - Clear Line with Water

Figure 3. Spetec PU-F400 - Test 2 - Start of reacted material in line filled with water. (12'-8")

Figure 4. Spetec PU-F400 - Test 2 - End of reacted material in line filled with water. (31'-7 ½")
Test 3 - Clear Line with Water

Figure 5. Spetec PU-F400 - Test 3 - Start of reacted material in line filled with water. (11'-6")

Figure 6. Spetec PU-F400 - Test 3 - End of reacted material in line filled with water. (28'-6 ¼")
Avanti - AV-248-LV FLEXSEAL LV

Test 1 - Clear Line with Water

Figure 7. Avanti AV-248LV - Test 1 - Start of reacted material in line filled with water. (10’-3”)

Figure 8. Avanti AV-248LV - Test 1 - End of reacted material in line filled with water. (16’-8”)

START OF REACTED MATERIAL

END OF REACTED MATERIAL
Test 2 - Clear Line with Water

Figure 9. Avanti AV-248LV - Test 2 - Start of reacted material in line filled with water. (12'-3 ½")

Figure 10. Avanti AV-248LV - Test 2 - End of reacted material in line filled with water. (15'-9 ½")
Test 3 - Clear Line with Water

Figure 11. Avanti AV-248LV - Test 3 - Start of reacted material in line filled with water. (13’-1”)

Figure 12. Avanti AV-248LV - Test 3 - End of reacted material in line filled with water. (19’-2 ¼”)

B-7
Avanti - AV-248 FLEXSEAL

Test 1 - Clear Line with Water

Figure 13. Avanti AV-248 - Test 1 - Start of reacted material in line filled with water. (13'-3")

Figure 14. Avanti AV-248 - Test 1 - End of reacted material in line filled with water. (16'-10")
Test 2 - Clear Line with Water

Figure 15. Avanti AV-248 - Test 2 - Start of reacted material in line filled with water. (12'-11")

Figure 16. Avanti AV-248 - Test 2 - End of reacted material in line filled with water. (15'-5 ½")
Test 3 - Clear Line with Water

Figure 17. Avanti AV-248 - Test 3 - Start of reacted material in line filled with water. (9’-2 ½”)

Figure 18. Avanti AV-248 - Test 3 - End of reacted material in line filled with water. (12’-7 ½”)

Figure 19. Alchemy/Spetec AP Seal 500 - Test 1 - Start of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (8'-2")
Test 2 - Clear Line

![Start of reacted material](image1)

Figure 20. Alchemy/Spetec AP Seal 500 - Test 2 - Start of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (3'-6 1/2")

![End of reacted material](image2)

Figure 21. Alchemy/Spetec AP Seal 500 - Test 2 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (9'-5")
Test 3 - Clear Line

Figure 22. Alchemy/Spetec AP Seal 500 - Test 3 - Start of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (4'-1 1/2")

Figure 23. Alchemy/Spetec AP Seal 500 - Test 3 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (12'-1 1/4")
Avanti - AV-202 Multigrout

Test 1 - Clear Line

No Pictures

Test 2 - Clear Line

Figure 24. Avanti AV-202 -Test 2 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (5'-6")
Test 3 - Clear Line

Figure 25. Avanti AV-202 - Test 3 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (3'-3")
Test 1 - Clear Line

Figure 26. ST-504 - Test 1 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (8'-2")

Test 2 - Clear Line

Figure 27. ST-504 - Test 2 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (6'-4 1/2")
Test 3 - Clear Line

Figure 28. ST-504 - Test 3 - End of reacted material in line. Water and grout were injected simultaneously and the grout line was dry. (5’-8 ¼")
Appendix C – Manufacturer Technical Data Sheets
**PU F400**

**DESCRIPTION**

Solvent and phthalate free, water reactive, hydrophobic, closed cell, low viscosity, shrink-free, flexible, one-component polyurethane injection resin designed to shut off water leaks.

**APPLICATIONS**

- Shut off water leaks in concrete, brickwork and sewers where movement and settlement may occur.
- Water cut-off of water leaks in foundations such as diaphragm walls, piling sheets and secant piles.
- Sealing water-carrying cracks and joints in tunnel segments.
- Curtain grouting behind tunnel, concrete, brickwork and sewer walls.
- Injection of water cut-off membranes and liners in tunnels.

**ADVANTAGES**

- One component
- Different reaction times are possible by adjusting the percentage of F400 ACC.
- The closed-cell structure of cured polyurethane ensures permanent flexible sealing of cracks and joints.
- Cured polyurethane is flexible, shrink-free and exhibits good chemical resistance (contact our Technical Service for chemical resistance).
- Cured polyurethane is harmless for the environment and resistant to biological attacks.
- WQA drinking water certificate.

**PROCEDURE**

Read the technical and safety data sheets prior to commencement of the injection works.

Vigorously shake the F400 ACC before use and pour the required quantity (2-10%) into the PU F400 resin. Mix the accelerator homogeneously into the resin and protect against moisture and rain to prevent premature reaction.

Depending on the application, injection can be carried out using a hand pump, pneumatic pump or electric pump. Preferably use a separate pump for injection of water and PU resin. Prior to injection, the pump must be flushed with Spetec PU Pump Flush and be completely free of water to prevent pump blockage.

**PACKAGING AND STORAGE**

PU F400 is moisture sensitive and should be stored in a dry area between 41°F and 86°F.

Shelf life: 24 months in original packaging. Once opened, containers should be used as soon as possible.

Resin: Packaged in 45 gallon drums and 5 gallon pails. Accelerator: Packaged in 0.5 gallon polyethylene bottles.

**SAFETY INSTRUCTIONS**

Avoid contact with eyes and skin, always use personal protective equipment in compliance with local regulations. Read the relevant safety data sheets before use. When in doubt contact Resiplast Technical Service.

**PROPERTIES**

<table>
<thead>
<tr>
<th>PU F400, uncured (appearance: white liquid)</th>
<th>PU F400 ACC, Accelerator for PU F400 (appearance: blue liquid)</th>
<th>PU F400 + Accelerator cured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity at 77°F ASTM D4878-98</td>
<td>Viscosity at 77°F ASTM D4878-98 ±15cps</td>
<td>Tensile strength ASTM D3574-03 290psi</td>
</tr>
<tr>
<td>Flash point ASTM D1310-86 &gt;302°F</td>
<td>Flash point ASTM D1310-86 ±302°F</td>
<td>Elongation at break ±100%</td>
</tr>
<tr>
<td>Density ASTM D5505-96 (2000) 1.067 ± 0.005</td>
<td>Density ASTM D5505-96 (2000) 0.995 ± 0.003</td>
<td>Density ±62.43lb/ft³</td>
</tr>
</tbody>
</table>

**REACTION RATE**

<table>
<thead>
<tr>
<th>F400 ACC</th>
<th>41°F</th>
<th>59°F</th>
<th>77°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Start</td>
<td>End</td>
<td>Start</td>
</tr>
<tr>
<td>2</td>
<td>145&quot;</td>
<td>320&quot;</td>
<td>120&quot;</td>
</tr>
<tr>
<td>6</td>
<td>65&quot;</td>
<td>110&quot;</td>
<td>50&quot;</td>
</tr>
<tr>
<td>10</td>
<td>45&quot;</td>
<td>70&quot;</td>
<td>30&quot;</td>
</tr>
</tbody>
</table>

This information is provided in good faith, but without guarantee. The application, use and processing of the products are beyond our control and therefore your entire responsibility. Should Resiplast US nevertheless be held liable for any damage, such liability will be limited to the value of the goods delivered by us. We are committed to providing high-quality goods at all times. This version supersedes all previous versions.

Version 1.0 Date: 12 May 2016 3:04 PM

Resiplast US • P.O. Box 308 • Cypress, TX 77410 • info@resiplastus.com • www.resiplastus.com
Local: 281-758-1800 • Toll-Free: 855-909-1800

Spetec PU F400 when combined with the ACC F400 accelerator is certified by WQA to NSF/ANSI 61 and CSA-B483.1 for materials safety only, as verified and substantiated by test data. Please refer to WQA website (www.wqa.org) for more information.
AVANTI

TECHNICAL DATA SHEET

AV-248-LV FLEXSEAL LV™

HYDROPHOBIC POLYURETHANE FOAM

DESCRIPTION
AV-248-LV Flexseal LV is the low viscosity version of the original AV-248. Injected as a single component, catalyzed AV-248-LV Flexseal LV is a moisture activated MDI-based polyurethane resin. The chemical reaction is catalyzed by using AV-248-LV Cat-LV, using moisture as an initiator. AV-248-LV Flexseal LV withstands wet/dry cycles and reacts with moisture; but unlike all other hydrophobics, it forms a resilient, impermeable flexible foam. This high quality resin is designed to seal active and potential water leaks in various cracks and annular spaces where flexibility is needed but is susceptible to wet/dry cycles. Avanti’s AV-248-LV is one of the most versatile products on the market.

APPLICATION
• Fine cracks above or below grade in humid or arid atmospheres
• Fills various voids and pipe penetrations
• Stops leaks in concrete structures
• Designed for tunnels, mines, dams, reservoirs, block walls, and structures that may shift

FEATURES AND BENEFITS
• Very low viscosity
• Expands 400% – 600%
• No VOC
• Controllable reaction time by adjusting AV-249-LV Cat-LV volume
• Withstands wet/dry cycles
• Unique hydrophobic that cures into a flexible, closed-cell foam

GROUTING TECHNIQUES
• Expanded Gasket Placement Technique (EGP)
• Variable Pressure Application Technique (V-PAT) – Crack Injection

HOW IT WORKS
AV-248-LV is a water-activated reaction that forms a resilient, flexible seal accomplished by three mechanisms: the resin seeks out water in the space and adheres to the surface, then begins to expand forming a tight seal while the network of compressed grout material within all the cracks forms a mechanical lock.

CATALYSTS
• AV-249-LV Cat-LV – catalyst, 32 oz. (0.95 L)

PACKAGING
Product packaged by weight based on specific gravity.
• Drum = Net Wt. 484 lbs.
• Pail = Net Wt. 44 lbs.
• Gallon = Net Wt. 8 lbs.

SHIPPING
• Motor Class 55
• Non-Hazardous
• Air freight available

CLEANING PRODUCTS
• AV-208 Acetone, Technical Grade (CAS# 67-64-1) – removes moisture from equipment
• AV-284 Pump Wash (Proprietary Blend) – removes uncurled resin from pump and hose
• AV-222 Cleaner (Proprietary Blend) – removes cured resin from equipment

STORAGE
Store between 45°F – 95°F (7°C – 35°C) in a dry atmosphere. Keep lid tightly closed when not in use. Packaged under dry nitrogen to keep moisture out and extend shelf life.

AV-248-LV Flexseal LV is tested and certified by WQA against NSF/ANSI 61 Drinking Water System Components. For product use restrictions visit www.wqa.org

AV-248-LV – UNCURED*

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Milky white to clear liquid</td>
</tr>
<tr>
<td>Viscosity</td>
<td>150 – 250 cP @ 77°F (25°C) ASTM D-4889</td>
</tr>
<tr>
<td>Flash Point</td>
<td>&gt;200°F (&gt;93°C)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.034 @ 72°F (22°C) ± 3%</td>
</tr>
<tr>
<td>Density</td>
<td>1.034 kg/m³ ± 3%</td>
</tr>
<tr>
<td>Specific Weight</td>
<td>64.6 lb./ft³ (0.6 lb./gal) ± 3%</td>
</tr>
</tbody>
</table>

AV-248-LV – CURED**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Milky white flexible foam ASTM D-3574</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>150 psi</td>
</tr>
<tr>
<td>Elongation</td>
<td>250%</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Non-toxic</td>
</tr>
</tbody>
</table>

**Cured properties vary depending on application and field conditions.

AV-249 Cat-LV*

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Light yellow to white, clear liquid</td>
</tr>
<tr>
<td>Viscosity</td>
<td>5 cP @ 72°F (22°C)</td>
</tr>
<tr>
<td>Flash Point</td>
<td>&gt;200°F (&gt;93°C)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.894 @ 72°F (22°C) ±3%</td>
</tr>
<tr>
<td>Density</td>
<td>894 kg/m³ ±3%</td>
</tr>
<tr>
<td>Specific Weight</td>
<td>55.8 lb./ft³ (7.4 lbs./gal) ±3%</td>
</tr>
</tbody>
</table>

*Laboratory Results

MIX PROCEDURE
Typically, one container of AV-249-LV Cat-LV is used per 5-gallon container of AV-248-LV Flexseal LV. Depending on the desired reaction time, AV-248-LV may be doubled. Mix thoroughly, but slowly, to avoid creating bubbles in the solution. Perform the standard cup test with site water to determine the desired reaction time.

PERFORMANCE
Flush equipment with AV-208 before and after use to remove moisture and clean equipment. Performance will be influenced by site conditions. If site temperatures are low, heat the product to recommended operating temperatures of 45°F – 95°F (7°C – 35°C) and/or increase catalyst amount by 1% – 2%. Do not exceed 78 oz. (2.3 L) of AV-249-LV Cat-LV per 5-gallon container of AV-248-LV Flexseal LV resin. Do not use open flame as a heat source. Excess amounts of AV-248-LV may adversely affect performance. Because catalyzed resin will react to moisture from the air, use product soon after mixing for best results.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at www.AvantiGrout.com.

NOTICE
The data, information and statements contained herein are believed to be reliable, but are not construed as a warranty or representation for which Avanti International assumes any legal responsibility. Since field conditions vary widely, users must undertake sufficient verification and testing to determine the suitability of any product or process mentioned in this or any other written material from Avanti for their own particular use. NO WARRANTY OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE. In no case shall Avanti International be liable for consequential, special, or indirect damages resulting from the use or handling of this product.

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Gel (Cure) Time for AV-248-LV Flexseal LV (Min:Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50°F</td>
<td>7:42</td>
</tr>
<tr>
<td>60°F</td>
<td>6:52</td>
</tr>
<tr>
<td>70°F</td>
<td>5:00</td>
</tr>
</tbody>
</table>
DESCRIPTION
Injected as a single component, catalyzed AV-248 Flexseal is a moisture activated MDI-based polyurethane resin. The chemical reaction is catalyzed by using AV-249 Flexseal AC and uses moisture as an initiator. Like other hydrophobics, AV-248 Flexseal withstands wet/dry cycles and reacts with moisture; but unlike other hydrophobics, it forms a resilient, impermeable flexible foam. This high quality resin is designed for sealing active and potential water leaks in various cracks, and annular spaces where flexibility is needed but is susceptible to wet/dry cycles. Avanti’s AV-248 is one of the most versatile products on the market.

APPLICATION
• For use above or below grade in humid or arid atmospheres
• Fills various cracks and pipe penetrations
• Stops leaks in concrete structures
• Designed for tunnels, mines, dams, reservoirs, block walls and structures that may shift

FEATURES AND BENEFITS
• Expands 400% – 600%
• Solvent-free system
• Controllable reaction time by adjusting AV-249 Flexseal AC volume
• Withstands wet/dry cycles
• Unique hydrophobic that cures into a flexible, closed-cell foam

GROUTING TECHNIQUES
• Expanded Gasket Placement Technique (EGP)
• Variable Pressure Application Technique (V-PAT) – Crack Injection

HOW IT WORKS
AV-248 is a moisture-activated resin. When injected into a concrete structure, the low viscosity resin will react with moisture and begin to expand. The final product is a very dense, closed cell foam impermeable to water yet flexible in nature.

ADDITIVES
• AV-249 Flexseal AC – catalyst, 16 oz. (0.5 L) container

PACKAGING
Product packaged by weight based on specific gravity.
• Drum = Net Wt. 435 lbs. / Volume 48 – 49.36 gal.
• Pail = Net Wt. 44 lbs. / Volume 4.85 – 5 gal.
• Gallon = Net Wt. 8 lbs. / Volume ~1 gal.

SHIPPING
• Motor Class 55
• Non-Hazardous
• Air freight available

CLEANING PRODUCTS
• AV-208 Acetone, Technical Grade (CAS# 67-64-1) – removes moisture from equipment
• AV-204 Pump Wash (Proprietary Blend) – removes un cured resin from pump and hose
• AV-222 Cleaner (Proprietary Blend) – removes cured resin from equipment

STORAGE
Store in temperatures within or near 60°F – 100°F (16°C – 38°C) in a dry atmosphere.

HYDROPHOBIC POLYURETHANE FOAM

PROPERTIES*

<table>
<thead>
<tr>
<th></th>
<th>AV-248 – UNCURED</th>
<th>AV-248 – CURED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Milky white to clear liquid</td>
<td>Milky white flexible foam</td>
</tr>
<tr>
<td>Viscosity</td>
<td>550 – 830 cP @ 72°F (22°C)</td>
<td>5 cP @ 72°F (22°C)</td>
</tr>
<tr>
<td>Flash Point</td>
<td>&gt;200°F (&gt;93°C)</td>
<td>&gt;200°F (&gt;93°C)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.056 @ 72°F (22°C) ±3%</td>
<td>1.02 @ 72°F (22°C) ±3%</td>
</tr>
<tr>
<td>Weight</td>
<td>8.8 lbs/gal ± 3% (1.054 kg/L ± 3%)</td>
<td>8.5 lbs/gal ± 3% (1.018 kg/L ± 3%)</td>
</tr>
</tbody>
</table>

*Laboratory Results

MIX PROCEDURE
Typically, one container of AV-249 Flexseal AC is used per 5-gallon container of AV-248 Flexseal. Depending on the desired reaction time, AV-249 may be doubled. Mix thoroughly, but slowly, to avoid creating bubbles in the solution. Perform the standard cup test with site water to determine the desired reaction time.

PERFORMANCE
Flush equipment with AV-208 before and after use to remove moisture and clean equipment. Performance will be influenced by site conditions. If site temperatures are low, heat the product to recommended operating temperatures of 60°F – 90°F (16°C – 32°C) and/or increase catalyst amount by 1% – 2%. Do not exceed more than 32 oz. (1 L) of AV-249 Flexseal AC per 5-gallon container of the AV-248 Flexseal resin. Do not use open flame as a heat source. Excess amounts of AV-249 may adversely affect performance. Because catalyzed resin will react to moisture from the air, use product soon after mixing for best results.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at www.AvantiGrout.com.

NOTICE
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<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Gel (Cure) Times for AV-248 Flexseal (Min:Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Half Catalyst</td>
</tr>
<tr>
<td>40°F</td>
<td>14:30</td>
</tr>
<tr>
<td>50°F</td>
<td>12:10</td>
</tr>
<tr>
<td>60°F</td>
<td>10:54</td>
</tr>
<tr>
<td>70°F</td>
<td>9:04</td>
</tr>
</tbody>
</table>

1100 Hercules Ave. Suite 320, Houston, TX 77058 • 800-877-2570 • Fax 281-486-7300 • www.AvantiGrout.com
DESCRIPTION
AV-202 Multigout is a single component, moisture activated MDI/TDI blended polyurethane injection resin. Designed for sealing active water leaks in large cracks or joints in concrete structures, it can absorb up to 12 times its volume in water creating a tough, impermeable foam or gel with superb adhesive qualities. Certified for use in potable water.

APPLICATION
- Large cracks or joints in concrete, or used in conjunction with AV-215 Resin Rod or AV-219 Oakum systems
- Designed for applications where high volume water flow is an active or potential problem and a high viscosity chemistry is required
- Used successfully in manhole sealing and pipe penetrations
- Excellent choice for moving cracks and joints

FEATURES AND BENEFITS
- ANSI/NSF 61 Drinking Water Systems Component – WQA Certified
- 100% solids
- Expands 400% – 600%
- Solvent-free and non-corrosive
- Forms a resilient, flexible foam with superb adhesive properties
- Can accept up to 12X its volume in water
- Thickest resin on the market
- May be used in underwater applications

GROUTING TECHNIQUES
- Expanded Gasket Placement Technique (EGP)
- Variable Pressure Application Technique (V-PAT) – Crack Injection

HOW IT WORKS
AV-202 can be applied via two techniques: EGP or V-PAT. The resin reacts to moisture to form a resilient, flexible seal accomplished by three mechanisms: the resin seeks out water in the space and adheres to the surface, then begins to expand forming a tight compressive seal, while the network of compressed grout material within all the cracks forms a mechanical lock.

RATIOS*
Preferred ratio is 1:1 (water to resin), however no pre-mixing is required. Pumped as a single component and is effective at ratios up to 12:1 with water.

PACKAGING
Product packaged by weight based on specific gravity.
- Drum = Net Wt. 484#s.
- Pail = Net Wt. 44 lbs.
- Gallon = Net Wt. 8 lbs.
- Cartridge = 10.114 fl. oz. / Volume ~ 300 ml.

SHIPPING
- Motor class 55
- Non-hazardous
- Air freight available

CLEANING PRODUCTS
- AV-208 Acetone, Technical Grade (CAS# 67-64-1) – removes moisture from equipment (see Performance section).
- AV-284 Pump Wash (Proprietary Blend) – removes uncured resin from pump hose
- AV-222 Cleaner (Proprietary Blend) – removes cured resin from equipment

PROPERTIES*
UNCURED
- Appearance: Brown resin
- Viscosity: 3,200 – 6,000 cP @ 72°F (22°C) ASTM D-4889
- Flash Point: >200°F (>93°C)
- Specific Gravity: 1.147 @ 72°F (22°C) ± 3%
- Density: 1.147 kg/m³ ± 3%
- Specific Weight: 71.7 lb./ft.³ (9.6 lb./gal.) ± 3%

CURED
- Appearance: Milky colored flexible foam
- Tensile Strength: TBD
- Elongation: TBD

PERFORMANCE
Flush equipment with AV-208 before and after use to remove moisture and clean equipment. For best results, use between 45°F – 95°F (7°C – 35°C). Performance will be influenced by site conditions. If site temperatures are low, use a heat source to warm to ~72°F (22°C) and apply. Do not use open flame as a heat source.

STORAGE
Store in temperatures within or near 45°F – 95°F (7°C – 35°C) in a dry atmosphere.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at www.AvantiGrout.com.

NOTICE
The data, information and statements contained herein are believed to be reliable, but are not construed as a warranty or representation for which Avanti International assumes any legal responsibility. Since field conditions vary widely, users must undertake sufficient verification and testing to determine the suitability of any product or process mentioned in this or any other written material from Avanti for their own particular use. NO WARRANTY OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE. In no case shall Avanti International be liable for consequential, special, or indirect damages resulting from the use or handling of this product.

AV-202 Multigout is tested and certified by WQA against NSF/ANSI 61 Drinking Water System Components

TECHNICAL DATA SHEET
AV-202 MULTIGROUT®
HYDROPHILIC POLYURETHANE FOAM
## AP Seal 500

Hydrophilic closed cell polyurethane foam injection resin.

<table>
<thead>
<tr>
<th>Description</th>
<th>Single component, low viscosity, flexible hydrophilic polyurethane foam injection resin.</th>
</tr>
</thead>
</table>
| Applications | • Sealing cracks in concrete structures through pressure injection.  
  • Sealing hairline cracks, expansion joints, wide cracks, pipe joints, pipe penetrations.  
  • Saturating dry oakum to create a flexible gasket for sealing pipe penetrations, joints and larger defects in concrete structures. |
| Advantages | • No catalyst required.  
  • Tenacious bond to wet concrete.  
  • High elongation.  
  • Thin enough to penetrate tight cracks.  
  • Moderately hydrophilic.  
  • Phthalate free (more environmentally friendly).  
  • Certified to NSF 61-5 (Approved for contact with drinking water). |
| Packaging | 5 Gallon Pails |

### Physical Properties 77º F (25º C) - Liquid
Viscosity 250-350 Centipoise.

### Physical Properties - Cured

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>(ASTM D-3574) 450 p.s.i.</td>
</tr>
<tr>
<td>Tensile Elongation</td>
<td>(ASTM D-3574) 350%</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>(ASTM D-1042/D-756) Less than 2%</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>(ASTM D-3574) 21 lbs / inch</td>
</tr>
</tbody>
</table>

These properties were based on foam cured under pressure to simulate conditions inside a confined crack. Properties will vary depending on application conditions.

### Reaction Times

<table>
<thead>
<tr>
<th>Type</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Reaction</td>
<td>30 seconds</td>
</tr>
<tr>
<td>Full Rise</td>
<td>1 minute, 50 seconds</td>
</tr>
<tr>
<td>Full Cure</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

### Material Prep
Condition overnight to 70º - 80º F (21º - 26º C). Heat bands or hot water bath may be used to warm containers. Do not heat above 80 degrees F.

### Mixing
None required. Keep lid tightly sealed when not in use and avoid splashing water into pails.

### Equipment
Single component airless sprayer recommended.

### Accessories
AP Flush 121, AP Oakum, AP Mechanical Ports, AP Soak 130
Personal Protection
Safety goggles, face shield, impermeable gloves, long sleeves and pants. Use in well ventilated areas. Open doors and windows. In confined areas use mechanical ventilation to keep vapor concentrations low. Prevent direct contact with skin and eyes. See MSDS.

Clean Up
Flush injection equipment with AP Flush 121 when necessary. Remove cured material from metal components by soaking in AP Soak 130. Clean off of skin with soap and water.

Environmental Protection
Cured material is chemically inert and safe to dispose of in landfill. Cleanup any spilled liquid resin and place in a suitable sealed container. Dispose of in accordance to applicable environmental regulations.

First Aid
- **Eye Contact:** Immediately flush with large amounts of water. Seek medical attention. **Inhalation:** Move to fresh air if symptoms occur. If breathing is difficult, seek medical attention. **Ingestion:** Seek medical attention immediately. **Skin Contact:** Wipe off contaminated area and wash with soap and water.

Limitations
Low temperatures will increase viscosity making product more difficult to pump. Low temperatures or cold water will slow down the reaction time. pH of reaction water should be between 3 and 10 for optimum foam. Keep lid tightly closed.

Storage
Store between 50º - 80º F (10º - 26º C).

Handling
Keep lids on tightly to prevent moisture from entering containers. Avoid direct contact with product. Be careful when opening as pressure may build up inside containers.

Limited Warranty
Alchemy-Spetec warrants this product to be free from manufacturer’s defects and to meet all published properties on current Technical Data Sheet for a period of one year if used according to published instructions and within the shelf life. The user is responsible for determining suitability for intended use and assumes all risk. No other warranties expressed or implied shall apply including any warranty of merchantability or fitness for a particular purpose. Purchaser’s sole remedy is limited to the purchase price or product replacement exclusive of cost of labor or other materials.

Latest Information
Before each use read latest Technical Data Sheets, Safety Data Sheets, and instructions available at www.alchemypolymers.com. Nothing contained in any Alchemy-Spetec materials or verbal instruction relieves the user of the obligation to read and follow all usage instructions and warnings for each product contained in the latest Technical Data Sheets and Safety Data Sheets. All information given by Alchemy-Spetec about Alchemy-Spetec products and procedures is given in good faith based on our current experience level and knowledge when materials are properly stored, handled, and applied. Jobsite conditions always vary, and for this reason Alchemy-Spetec assumes no liability for the provision of such information or instructions. Neither shall any legal relationship be created by the provision of such information.

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FOR INDUSTRIAL USE ONLY. KEEP OUT OF REACH OF CHILDREN. NOT FOR INTERNAL CONSUMPTION. READ MATERIAL SAFETY DATA SHEET PRIOR TO EVERY USE.
INTRODUCTION

Stratathane ST-504 Vari-Gel Injection Resin is a solvent-free, MDI-based water control and soil stabilization system. ST-504 is hydrophilic and reacts with water to form either a flexible gel or an elastomeric foam depending on the amount of reaction water added to the mix.

Stratathane ST-504 contains no measurable amount of TDI as performed by the Modified Analysis for Diisocyanates. ST-504 is non-flammable, non-carcinogenic, and non-corrosive as defined by 40 CFR and as described in the NIOSH Pocket Guide for Hazardous Materials.

ST-504 has NSF 61 approval for potable water contact and carries the Underwriters Laboratories UL seal.

Stratathane ST-504 is mixed with water at the work site to form a single injection material. The inert end product forms a water barrier which is essentially unaffected by acids, gasses, and organisms usually found in soil. A minimum of water (around 5% by volume) is needed for a reaction to occur, but large amounts can be accommodated through reaction or displacement.

Stratathane ST-504 is useful for a wide range of water control and soil stabilization applications, including grout curtains, stabilizing water-bearing soils, and sealing cracks or joints in concrete walls, buildings, dams and utility vaults.

Stratathane ST-504 may be placed by hand pumps or multi-ratio power pumps. Stainless steel fittings are recommended but not strictly required because ST-504 is no more corrosive than water. Cleanup of solidified material in the system, however, is often accomplished with caustic cleaning compounds, making stainless steel advisable.

The low viscosity of ST-504 makes it easy to inject. Once cured, its impermeability makes it an effective water shut-off system. The permeability of soil grouted with ST-504 depends on how well its voids are filled with grout. Values in the 10-7 cm/sec range should be obtained using ASTM Constant Head Permeability Test Method D-2434.

A three stage reaction takes place when ST-504 mixes with an equal volume of water and foams. The mixture first thickens and becomes creamy. Then, carbon dioxide gas evolves rapidly and the mixture expands as it cures. The expanded ST-504 volume then sets into a strong impermeable water barrier. Unrestrained ST-504 foam may expand up to 10 times its starting volume depending upon the degree of confinement applied to the expanding mass.

When ST-504 mixes with a large volume of water (i.e. 10:1 or greater), the three stages of the foam reaction cycle are not visible in the reacting mass. Instead, a marked viscosity increase will be seen just before the mass solidifies.

The reaction sequence with water takes place continuously during injection as product exits the packer. Initial penetration of the ST-504 grout mixture is facilitated by its low viscosity. After setting (in the case of the foam sequence), the expansive mixture pressure induces further filling of the grout zone. An ST-504 seal will tolerate freeze-thaw, wet-dry cycling, extrusion, and compression to a substantial degree.

DESCRIPTION

Uncured ST-504 is a dark brown liquid with a viscosity of about 700 cps at 25°C (77°F). This low viscosity is reduced even further after water is added. ST-504 contains non-volatile materials making up almost 100% of its total weight. Cured ST-504 is very firm and flexible. Its solid is a three dimensional cross-linked molecular structure which is insoluble in water.

PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Dark brown</td>
<td></td>
</tr>
<tr>
<td>Viscosity</td>
<td>700 cps at 25°C</td>
<td>ASTM D1838</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.1 g/cc</td>
<td>9.25 lbs/gal</td>
</tr>
<tr>
<td>Flash Point</td>
<td>&gt;220 F</td>
<td>ASTM D-93</td>
</tr>
<tr>
<td>Solids Content</td>
<td>&gt;85%</td>
<td>ASTM D2832</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>&gt;250 psi</td>
<td>ASTM 3574</td>
</tr>
<tr>
<td>Elongation</td>
<td>&gt;400%</td>
<td>ASTM 3574</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>&lt;11%</td>
<td>ASTM D-1042</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>0.0000002 psi</td>
<td></td>
</tr>
<tr>
<td>Vapor Density</td>
<td>8.5 (Air = 1.0)</td>
<td></td>
</tr>
<tr>
<td>Solubility</td>
<td>Insoluble; Reacts with water</td>
<td></td>
</tr>
</tbody>
</table>

3601 104th Street Des Moines, Iowa 50322 PHONE 515/251.7770 FAX 515/251.7705
WEB SITE www.strata-tech.com EMAIL Info@strata-tech.com

CHEMICAL SEALANTS • WATER CONTROL MATERIALS • GROUTING EQUIPMENT
Set time is the period from first contact of ST-504 with water to the point where the mix becomes too thick for gravity flow. The set time (sometimes called foam time) is influenced primarily by the mix temperature and the ratio of ST-504 to water. Set times are longest at low temperatures and ST-504 ratios, and vary a little with the age of the resin and mineral content of the water. The viscosity of mixed ST-504 is lowest for the first 40% to 50% of the set time and increases rapidly as the mix approaches set.

**SET TIME**

<table>
<thead>
<tr>
<th>WATER : RESIN</th>
<th>GEL</th>
<th>RISE</th>
<th>FREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:1</td>
<td>150</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4:1</td>
<td>95</td>
<td>-</td>
<td>110</td>
</tr>
<tr>
<td>2:1</td>
<td>85</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>1:1</td>
<td>95</td>
<td>110</td>
<td>160</td>
</tr>
<tr>
<td>1:2</td>
<td>100</td>
<td>120</td>
<td>170</td>
</tr>
<tr>
<td>1:3</td>
<td>100</td>
<td>120</td>
<td>180</td>
</tr>
</tbody>
</table>

**CLEANUP**

ST-504 should not stand in equipment more than 12 hours without precautions because the possibility of moisture contamination is high. Flush equipment with ST-590 purging fluid and ST-522 Cleaner soon after use. The most common solvent for removal of liquid ST-504 is methylene chloride. Check solvents for water content prior to use.

When using solvents during cleanup, extinguish all ignition sources and observe proper precautions for handling such materials. For cleanup of cured ST-504, soak in a 100% solution of ST-522 Veri-Kleen Grout Cleaner using a covered polyethylene container. Grout spills on clothing are permanent, so disposable coveralls are recommended.

**HANDLING AND STORAGE**

Use reasonable care in handling and storing ST-504. The material is moderately sensitive to high storage temperatures. Under optimum storage of 40 - 60 F in dry conditions, the material should have a useful shelf life of one year. Storage temperature should not exceed 80 F. Once a container has been opened, the life of the material is reduced. Let container stand and adjust to ambient temperature before opening to prevent contamination by condensation. Test a resealed container to assure that moisture contamination has not occurred. Before handling this product, read and understand the Material Safety Data Sheet (MSDS). Instruction in sound safety practices is beyond the scope of this publication.

Direct contact of ST-504 liquid may cause skin and eye irritation. If ST-504 comes in contact with skin, wash with soap and water. For eye contact, flush immediately with water and consult a physician. ST-504 must not be ingested. Before eating, smoking or drinking, remove protective clothing, wash with soap and water, and stand away from the immediate work site. Do not smoke while working with ST-504. If respiratory difficulties occur, seek medical attention. Avoid exposure to vapors created from this product when it is heated. Gloves, goggles, respirator and protective clothing are recommended. Ventilate the work area as a matter of good practice, although hazardous levels of toxic vapors are not generally given off of the bulk product below 90 degrees F. Small amounts of MDI may be present and some users may be sensitive to MDI.

**Summary of Handling Precautions:**

1. Wear goggles and rubber gloves.
2. Wash any body contact area thoroughly with water.
3. In case of eye contact, wash immediately with water and seek medical attention.
4. Keep material away from heat and flame.
5. Ventilate and use respirator in hot or closed spaces.

**STATEMENT**

Strata Tech believes that the information herein is an accurate description of the general properties and characteristics of the product(s), but the user is responsible for obtaining current information because the body of knowledge on these subjects is constantly enlarged. Information herein is subject to change without notice. Field conditions also vary widely, so users must undertake sufficient verification and testing of the product or process herein to determine performance, safety, usefulness, and suitability for their own particular use.

Strata Tech warrants only that the product will meet Strata Tech's then-current specification. NO WARRANTY OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE. Users should not assume that all safety requirements for their particular application(s) have been indicated herein and that other or additional actions and precautions are not necessary. Users are responsible for always reading and understanding the Material Safety Data Sheet, the product technical literature, and the product label before using any product or process mentioned herein and for following the instructions contained therein.

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Appendix D – Bond Test Raw Data

Contact Shannon Harrell for more information at 303-445-2370.
<table>
<thead>
<tr>
<th>Date</th>
<th>Specimen ID</th>
<th>Diameter (in)</th>
<th>Specimen Area (in²)</th>
<th>Initial Load (lb)</th>
<th>Final Load (lb)</th>
<th>Average Load (lb)</th>
<th>Standard Deviation (psi)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
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<td>8/16/2017</td>
<td>AP500-4-4H</td>
<td>4</td>
<td>9</td>
<td>7.1</td>
<td>7</td>
<td>14.5</td>
<td>1.06</td>
<td>stuck to bottom brick bond</td>
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<tr>
<td>8/17/2017</td>
<td>AP500-2-4H</td>
<td>4</td>
<td>3</td>
<td>7.1</td>
<td>12</td>
<td>21.9</td>
<td>0.99</td>
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<td>8/18/2017</td>
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<td>20.1</td>
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<td>24.5</td>
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<td>9/1/2017</td>
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<td>3</td>
<td>7.1</td>
<td>11</td>
<td>20.1</td>
<td>1.95</td>
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<td>22.0</td>
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<td>broke in the material bond</td>
</tr>
<tr>
<td>Date</td>
<td>Product</td>
<td>Specimen ID</td>
<td>Cure Time (hour)</td>
<td>Diameter (in)</td>
<td>Specimen Area (in²)</td>
<td>Initial Load (lb)</td>
<td>Final Load (lb)</td>
<td>PSI</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>----------------</td>
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Data Sets that Support the Final Report

If there are any data sets with your research, please note:

- Share Drive folder name and path where data are stored:
  \bor\do\Team\ENGRLAB\MERL\Science and Technology\FY17\Harrell\Continuing_Evaluation of Grout Performance for Concrete Repair
  \bor\do\Team\ENGRLAB\MERL\Science and Technology\FY18\Harrell\Chemical Grout

- Shannon Harrell, sharrell@usbr.gov, 303-445-2370

- Short description of the data: Excel spreadsheets of the test results. Video and photos.

- Keywords: Test data, travel test data, chemical grout

- Approximate total size of all files: FY17 folder : 945 MB
  FY18 folder: 54.8 GB