Variable Pressure Application Technique

V-PAT™

For Repair of Water Leakage Through Concrete

www.avantigrout.com

Variable Pressure Application Technique Summary: Field Guide

The Check List

Resin (accelerator for hydrophobics)
Resin pump
Water pump
Injectors
Hammer drill
Drill bits (appropriate for substrate)
Extra couplers
Clean 5-gallon buckets (4-5)
Thick-mil garbage bags to line buckets
Clean stir sticks
Personal Protective Equipment (PPE)
Portable eye wash station
Optional accessories:
- Plastic sheeting
- Tape
- Oakum
- Rags
- Hand tools

This is a recommended guideline based on experience. Each job is unique and could require deviation from this guideline depending on job site conditions.

For the complete V-PAT process, refer to pages 3-7 of the V-PAT Technical Manual.

The Process: Quick Reference

Step 1: Identify and Clean

Mechanically remove dirt, loose substrate and mineral deposits. Water can be used to help clean the area.

Step 2: Locate

Injection should start from the lowest point in the crack or the narrowest side of a horizontal crack.

Step 3: Drill at a 45° Angle Toward the Crack

Start drilling the number of inches off the crack equal to half the wall thickness. If the wall is 12” thick, the hole should be drilled 6” away from the crack. Drilling on alternating sides of the joint or crack will help make certain the crack or joint is intercepted and will also help prevent spalling.

Step 4: Remove Debris

Flush hole with water to remove debris and dust.

Step 5: Install Injector

Place the port in the drilled hole so that the top of the sleeve is just below the concrete surface. Tighten by hand until snug, then tighten further with a ratchet and socket or open end wrench.

Step 6: Pump Water

Pump water through the port to flush the crack and to verify that the crack has been intercepted.

Step 7: Pump Resin

Pump on the lowest setting possible. Some resin return out of the crack is good; this is a positive indicator of grout flow and coverage. Excessive resin flow from the crack or joint can be controlled by placing oakum into the joint or crack.

Step 8: Continue

Once the joint will no longer accept material or the resin is no longer moving along the crack or joint, it is time to drill a new injection hole. The hole should be drilled parallel to the end of the resin travel in the joint or crack. Repeat steps 3-8. To view crack injection animations, visit www.AvantiGrout.com.

Step 9: Completion

Once the length of the crack has been filled with cured resin and the water leaks have stopped, injectors may be removed.

Background

Water leaking through cracks and joints in concrete is as old as concrete itself. The majority of cracks in concrete are going to be dynamic in nature as the concrete swells and shrinks with temperature. Freeze-thaw damage, corrosion of reinforcing steel, structural weakness and even total failure can all be traced to cracking and water intrusion. Water can expand nine percent in volume in its frozen state, and internal reinforcing steel can expand seven times volume when it rusts. Besides structural damage to the concrete, water infiltration has many undesirable effects from damaging assets or property to creating hazardous conditions.

In spite of the best efforts of the architect, engineer and contractor, structures will sometimes move in unanticipated places causing cracks. Resin can be injected into the concrete to accomplish one of two purposes:

1. Restore design strength
2. Stop water leakage

If the load bearing member such as walls, beams or columns are weakened, injection of high strength epoxies may be appropriate, but more often than not the concern with cracking is water infiltration. Epoxies are designed to be strong with little to no elongation and chemically bond the concrete back together, which is not appropriate for a dynamic, leaking crack. The epoxy will be stronger than the concrete and will cause the concrete to crack nearby. Additionally, the majority of epoxies are water intolerant and are therefore not suitable for waterproofing.

Concrete cracks for a reason. During curing of green concrete, shrinkage and thermal cracking can occur. This type of cracking stops when the concrete is cured and is static. Another source of static cracking can be external damage (i.e. car hitting a concrete retaining wall).

The vast majority of cracking is dynamic and can vary in width and length. Expansive soils, loading and unloading of a structure, thermal cycles, freeze-thaw cycles, and rusting of internal steel all lead to cracking of concrete.

External forces are often repetitive and cause the crack to expand and contract. Usually these cracks are not a structural concern, but water infiltration through these cracks can be a serious problem.

The side of the structure where the hydrostatic load originates is called the **positive side**. In most cases, the positive side will also be the soil or substrate side. Any water control material has a much higher probability of success when placed on the positive side because it has the original structure for support.

This can be problematic as almost all access to water leakage will be from the **negative side** (i.e. inside a below-grade parking garage). Water control materials which are surface applied on the negative side have a propensity for failure. Their effectiveness depends mostly on their bond strength to the concrete and their tensile/elongation capabilities. The majority of surface applied waterproofing has limited elongation and fails just as the concrete failed amidst dynamic changes.

How can you work from the negative side and yet place a water stop material on the positive side? Here are some resin characteristics needed to effectively deal with small cracks, movements, active water flow, dampness, and debris in the crack:

1. Low viscosity
2. Adjustable gel times
3. Bond/cure wet surfaces
4. Work in and underwater
5. Flexibility after curing
6. Easy to handle
7. Inert final product
8. Tolerant of mix variations and field conditions
9. Expansive

Polyurethane resins from Avanti International are designed specifically for sealing leaks in concrete. Uncured resin grouts are liquids that have a wide range of physical properties based on their formulations. The resins are designed to create foams or gels which also have a wide array of physical properties.

V-PAT Process

V-PAT crack sealing follows this simple sequence:

1. Identify and Clean
2. Locate
3. Drill at 45° Angle Toward the Crack
4. Remove Debris
5. Install Injector
6. Pump Water
7. Pump Resin
8. Continue Injection
9. Completion

Step 1: Identify and Clean

Examination of the crack after cleaning tells the technician where the crack goes and how wide it is. This gives a firsthand impression of how the crack will behave when grout is pumped. The surface can be cleaned mechanically. Loose debris or patches should be removed to reveal the crack. To maximize results, it is best to inject an actively leaking crack.

Step 2: Drill Injection Holes

Injection should start from the lowest point of the crack or the narrowest side of a horizontal crack. The angle and depth of injection holes (ports) can be predetermined and specified using a hammer drill.

Step 3: Drill at 45° Angle Toward the Crack

The injection hole should be placed at a distance away from the crack equal to half the wall thickness. For example, if the wall is 12" thick, the hole should be drilled 6" from the crack. This forms an isosceles right triangle with the drilling depth being the hypotenuse ($H=L \times \sqrt{2}$). Drilling into the concrete more than 18" is usually not required - even if the concrete is more than 36" thick - as long as adequate pumping pressure is available. At a 45° angle, drill toward the crack.

If the concrete thickness is 6" or less, do not attempt angle drilling. Set the ports straight into the face of the crack. This procedure will help minimize spalling of the concrete. The drill bit size will correspond with the injector size. Use 1/2" drill bit if you are using a 1/2" injector.

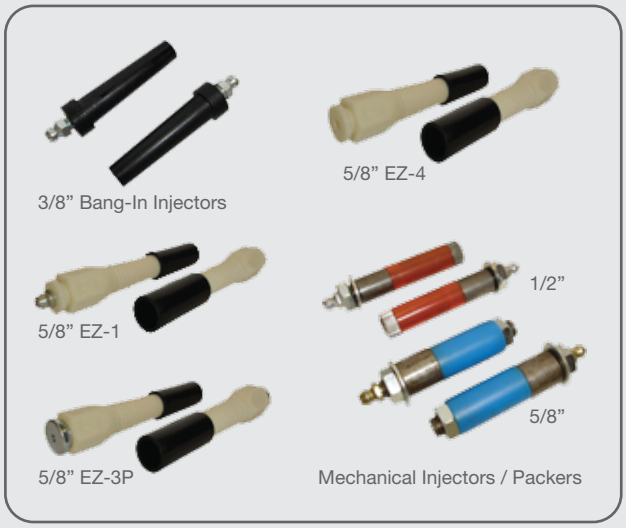
The best way to determine the distance between ports is to monitor the resin flow. The termination point of resin travel is the best location for the next port. As the crack gets wider, the space between ports can increase. Eight to twenty-four inches will be the most common spacing. Ports should always be staggered from one side of the crack to the opposite side, making a zigzag or stitch pattern. Using injection ports on alternating sides of the crack helps to prevent spalling and helps ensure interception of the crack. No two cracks behave alike. In some instances, a crack can be sealed using few injection ports. Others may require many ports.

Step 4: Remove Debris

Flush hole with water to remove any debris and dust.

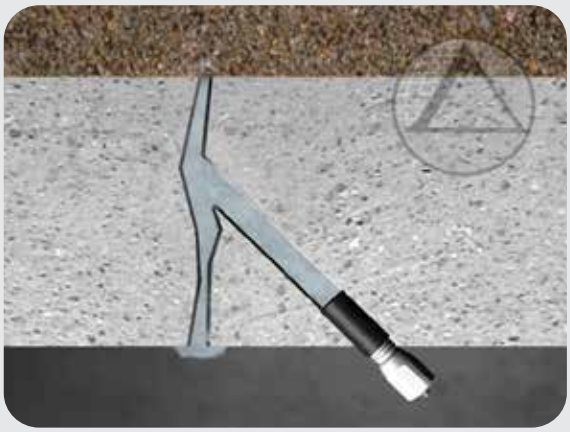
Step 5: Install Injectors

Place the port in the drilled hole so that the top of the sleeve is just below the concrete surface. Tighten by hand until snug, then tighten further with a ratchet and socket or open end wrench.



Step 6: Pump Water

Use the **water pump** to flush the port and crack. Flushing the crack with water prior to resin injection is very important. The water flush removes debris and drilling dust, and improves subsequent penetration of the resin. Water left in the concrete pores will aid in curing the resin. The flushing operation also helps the technician determine how the crack will behave during resin injection. Flush water should flow from the crack face.



The same kind of pump used for resin injection can also be used to flush the crack. However, special caution is required if the same pump is used for flushing as well as resin injection. All water must be completely removed from the pump before charging with resin. Failure to remove all the water will cause resin to cure in the pump. The pump may not be permanently damaged, but can lead to extended down time. Avanti recommends a separate pump to be used for each operation so that clean-up and the possibility of mistakes is minimized.

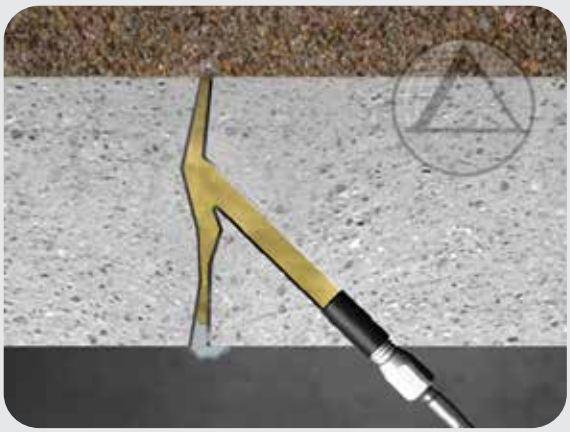
The flow of flush water into the crack is critical. If water does not travel under pressure from the injection hole through the crack, then there is no connectivity and no need to inject resin into that port. The injector should be removed from such locations and the hole plugged with quick-setting cement. Do not try and pump a “blind” or non-connective hole.

You will need to raise pressure and volume levels slowly. Flush the crack with the highest flow volume that is practical without exceeding permissible pressure. For cold weather applications (50° F and below), please contact Avanti. Epoxy resin injection sometimes calls for the use of muriatic or hydrochloric acid as flushing agents. Do not use these materials when working with urethane resins. Such agents are difficult to completely remove from the crack and are not needed by the resin system.

Step 7: Pump Resin

Flush the pump with solvent to remove moisture that might be in the pump or hose. When all preparation work is completed, charge the pump, hose, and gun. Pull the trigger on the gun to allow all solvent to pass into a trash bucket while watching for the resin to appear. Keep the resin covered in wet environments, especially if water is dripping from overhead - a cover that you can see through is best. Begin the injection of resin at the lowest point on a vertical crack or at the narrowest side of the horizontal crack.

Patience is important in resin injection work - slow is better. Always start injecting with the pump set at the lowest setting.



Hold pressure constant for several minutes. If flow still does not occur, raise the pressure slowly. An extra minute or two can make the difference between 95% and 100% crack filling. Sudden applications of high pressure may help unintentionally open the crack. If in doubt, **slower is better**. As soon as flow is established, decrease pressure as much as possible consistent with desired flow rate.

As resin begins to flow, the technician should carefully watch:

1. The crack - to measure resin flow along the crack
2. The whip line - pump pulsations indicate resin flow
3. The gauge - to monitor actual pressure in the crack

Holding the whip line allows the operator to feel the pump pulsations. A common pump for polyurethane resin applications is an airless paint sprayer. As resistance increases against the fluctuating diaphragm in the pump head, the rate of pumping will decrease proportionately. Thus, the technician can use hose vibration and the sound of the pump to determine how well material is flowing into the crack. If the crack surface exhibits immediate free flow of resin, use Oakum to stop the free flow. The resin will react with the water and expand rapidly. The resulting foam in the confinement of the crack will be a dense, rubber product. A small amount of leakage is beneficial because it shows the extent of resin travel and is good insurance that the crack is well filled. Under proper pumping conditions, the following signs will be observed in the order listed:

1. Water displaced from the crack by the resin
2. Water and resin mix (foamy) appearing at the crack
3. Pure resin from the crack

Step 8: Continue Injection

When the resin is no longer traveling along the crack, drill a new port (Step 2).

Step 9: Completion

Once the crack is completely sealed with cured resin, injectors can be removed and clean-up started.

V-PAT and Expansion Joints

Polyurethane resin is an excellent repair material for failed waterstops and leaking expansion joints. In the past, repairing leaking expansion joints has been difficult because, by definition, an expansion joint is designed to move. However, many products used for stopping water are rigid and hard-setting; such materials either break up and fall out over time, or they bond solidly and kill the designed movement within the joint - thereby defeating its purpose.

On the other hand, most flexible sealants require a clean, dry surface (or special surface preparation) to obtain a bond. These materials can stretch, but often fail to stick because of imperfect conditions during their installation.

Expansion joints must be allowed to expand, but clean, dry surfaces are hard to find below the water table.

Expansion joint repair with polyurethane resin takes full advantage of the resin's ability to expand in confined spaces. The concrete surfaces of the joint provide confinement on two sides. The back confinement surface may be soil, but in most cases will be either the waterstop or oakum rope. Containment on the outer surface is provided temporarily by hydraulic cement. If desired, this temporary surface may be removed after resin injection.

Although the repair technique for expansion joints using polyurethane resin follows the same basic sequence as crack, a few extra steps are required:

1. Remove Debris from Joint Surface
2. Drill Injection Holes and Set Injectors
3. Flush Injection Holes and Joint
4. Apply Joint Seal Backing (if required)
5. Apply Temporary Outer Joint Surface Seal
6. Inject Resin

Step 1: Remove Debris From Joint Surface

Clean away surface deposits and debris as you would for crack sealing work. Old cement patches in expansion joints defeat the purpose of the joint and should be removed. Complete removal is usually difficult and may not be practical. All loose mortar must be removed to allow enough room in the joint for the polyurethane resin to be placed in sufficient quantity. Expansion joints are designed to move. At 50% elongation, 0.10” can only become 0.15" while 0.50” can become 0.75". Loose beads of polysulfide or polyurethane sealants should be completely removed. Fiber or cork fillers may not require complete removal, but should usually be cleaned out to a depth of 6”. If a waterstop is present and its depth is less than 8”, remove everything down to it.

Step 2: Drill Injection Holes and Set Injectors

Injection holes for expansion joints should be drilled in the same manner as they would for a crack. However, if a waterstop is present, best results are usually obtained by incorporating what is left into the new seal. Thus, injection ports should not pierce the waterstop if full-depth penetration is not required; each hole should be angled to end just short of the waterstop material. When water is already flowing from the joint, removal of the failed joint filler material will sometimes allow the flow to increase. Small seepages or light flows can be ignored because they will be overcome by reaction and combination with the polyurethane resin.

Step 3: Flush Injection Holes and Joints

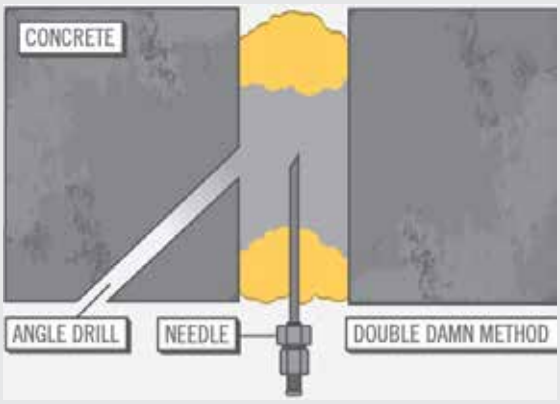
Joint flush procedures for expansion joints are the same as outlined previously for cracks.

Step 4: Apply Joint Seal Backing

Large volumes or heavy flows of water must be controlled during resin injection and cure. One of several materials and methods to control such flows may be selected. Some of the common choices are:

1. AV-219 Fibrotite (Oakum)
2. Expanded Gasket Placement (EGP)
3. Diversion Nipples
4. AV-215 Resin Rod

A thin layer of AV-219 Fibrotite, also known as oakum, placed over the waterstop will temporarily cut off flowing water. Strips of dry, oil-free oakum may be soaked in resin and packed into the joint recess. AV-215 Resin Rod or strips of other absorbent materials may also be soaked in resin and used for packing. Such strips of materials are sometimes called "expanding gaskets," and the process is called the Expanded Gasket Placement Technique (EGP). The resin combines with water to expand and cure rapidly, thus forming a quick "molded-in-place" gasket seal. For more information on the step-by-step process of the EGP Technique, please visit www.AvantiGrout.com.



If leak flows are high, one or more pieces of small diameter pipe can be embedded in the packing material. These nipples serve to relieve pressure and divert flow while the packing seal solidifies. Once the seal has cured, a small amount of resin injected through the nipples will rapidly complete the seal. The pipe nipples can then be removed.

Step 5: Apply Outer Joint Seal

With the inner seal in place, and flow temporarily controlled, proceed to installation of the temporary outer seal. Several materials may be used, but hydraulic cement has been used successfully and economically. Remember that resin develops expansion pressures as it cures. If the outer seal is not secure, you may spring a leak during injection. Such a leak is inconvenient at best, and wastes time and resin while you clean up and start over.

Step 6: Resin Injection

Resin injection for expansion joints proceeds as outlined for crack sealing. However, any pressures above the minimums required to open injector ports will seldom be needed. Special care should be taken as not to rupture the outer seal. Begin at the lowest injector and work your way up. Once pumping starts, best results are obtained by methodically proceeding to the end of the joint without stopping. Continuity helps assure uniform density of the cured foam, thus material containment and compression, as rapidly as practical.

Continue to pump each injector until relatively pure resin flows from the next port before moving up. When the last injector has been pumped, go back to the first port and work through the series again - adding a small amount of resin at each. Watch your outer seal carefully. A little resin is usually enough. After curing overnight, the expansion joint is "better than new" and is ready for service.

NOTE: Stainless steel needles are available from Avanti for re-injection of any EGP, resin rod, or double-dam method seals which may need additional resin.

Basic Equipment for Sealing Fine Cracks

1. Resin

2. Accelerator (for hydrophobics)

3. Pneumatic or electric hammer drill with appropriate drill bit

4. Injectors (plastic or mechanical)

5. High pressure pump capable of a pressure ranges of 200-3,000 PSI (preferably a positive displacement design). The pump must have a capacity of 0.50 to 2.0 gpm. It can be powered by either electric, air or hydraulics. All internal seals must be resistant to solvents such as acetone. There are a wide variety of pumps from which to choose. Call Avanti for assistance in choosing the pump to fit your application.

6. Hoses used in conjunction with pump must be moisture resistant.

7. Injection gun should be capable of 3,000 PSI and have the capability of metering the resin through the injectors to achieve variable rates (not just on or off). However, normal injection pressures are between 800 and 1,200 PSI. Pressures above 1,500 PSI significantly increase the chance of hydraulic fracturing of the concrete structure.

Safety Procedures

For safety procedures, please refer to the MSDS. Product MSDS can be found online 24/7 at www.AvantiGrout.com.

Recommended Products for the V-PAT Technique

* Certified for use with potable water

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REV. 12/14

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