Vacuum vs. Pressure

How Vacuum Out Performs Pressure Injection

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Vacuum technology has been proving its merit in the repair of concrete, masonry and stone since the processes were patented the early 1970's. We at Tecvac, Inc. have been performing a variety of vacuum processes since 1991. Many years prior to our conversion to vacuum, I would guess that we pressure injected as much epoxy as any of the other injection contractors in the area. We know the difference vacuum makes in the permanence of repairs and there is no question about its unprecedented qualities, especially when coupled with the right repair resin. We have vacuum applied epoxies and urethanes, but when performing structural repairs, methyl methacrylate is our product of choice; and for good reasons. Oh, I don’t suppose I blame the pressure advocates, especially those pump manufacturer's who's lively hood could be jeopardized with any notion that vacuum could un-do the prevalence of conventional pressure injection superiority. Howbeit, it sort of reminds me of the buggy builder though, talking about Henry Ford. No doubt, the guy had been building buggies for 100 years and knew a thing or two about buggy's…but he knew little about automobiles or Ford Motor Company.

Let’s start with the basics and the propagation of vacuum's total superiority to conventional pressure injection. As you might know, everything is porous. A typical crack has fissures, voids and interconnecting cracks located in the side walls of the fracture. These fissures, voids and interconnecting cracks continue on a microscopic level. Imagine sealing and pressurizing one of these little voids with air…like a concrete balloon. Is it hard to see how air and/or moisture can be trapped in the tiny fissures of the matrix? Imagine filling the concrete balloon with a pressurized liquid. How full do you think you would get it? Yet, using only a modest 10in of vacuum would reduce the pressure inside the cavity by half. But, let’s just say we can only lower the pressure in the fracture area to 14psi from 14.7psi…and apply Boyle's Law. One cubic inch, one cubic foot or 1 cubic meter of air will evacuate! But vacuum, stand alone or assisted, employs the application of the most basic physics law…You can’t put two things in the same place at once. Despite assertions otherwise, this is a very important law to be mindful of when considering vacuum vs. pressure.

With that said, it has long been touted within the realm of pressure injection, and continues to be touted with numerous methods and apparatus to accommodate the purpose, that low pressure is better than high pressure. Now, if vacuum will eliminate ALL pressure, how can it be said that vacuum cannot reasonably be considered useful? That vacuum will contribute little, or be rarely useful to the pressure injection processes? Doesn't it make sense that this lower pressure zone, induced by vacuum, would be more receptive to resin installation? Try the Boyle's Law thing.

The installation and penetration of the repair resin is hence, two different animals. While pressure injection continuously labors against atmospheric pressure, vacuum injection flows **because of atmospheric pressure.** Think about it…injecting at a very modest 25psi is only serving its purpose by overcoming 14.7psi atmospheric (1bar). Why would it take 100, 200 or 1000psi to move material in a fracture zone? Porosity? Fluid resistance? Why would a vacuum applied to the same set-up, the same fracture zone, pull the material right out of an open bucket?...well, it does. Vacuum injection is starkly adverse to pressure injection; the vacuum process actually de-pressurizes the repair resin and, naturally de-pressurizes the entire fracture zone.

Yes, all concrete is porous. The example of splashing a cup of water on a wall is evidence of that fact. However, while this porosity is remarkably useful when installing low-viscosity repair resins, it is not very useful when attempting to pressurize an enclosed fracture and then expecting the porosity of the concrete to dissipate entrapped air. What is air entrained concrete? More to the point, its not that concrete is good or bad at trapping air, it will tenaciously resist air moving through it. Pick up a piece of the roughest open-surface concrete you can find, so thin it's fragile to the touch, and try to blow air through it. How much pressure do you think it would take to force air through a piece of solid concrete? Our vacuum processes can seal a piece of plastic to a concrete surface so tight it is impossible to remove with out destroying it. How do we do that if air is moving through the concrete? There is a profound difference in air and moisture vapor moving through a concrete matrix and the dissipation of pressurized air during an injection process. I would pose this question to a competent and conscientious pressure technician…or pump manufacturer.

Let's think about the little concrete balloon again; and let's say you have a respectable pressurized fill level of 85% at the point of refusal. Good luck trying to get that concrete balloon 85% full without some exhaust. Anyway, how would one propose to achieve 90% fill level? Stay on the crack longer? Lower the pressure? No! It would require you to jack up the pressure. Only makes sense doesn't it? Is it so hard for the pressure tout's to understand that increasing the pressure could, and will with enough force applied, extend the crack? Why? Because the entrapped air, the unvented void, will pressurize and exceed the strength of the matrix. At what pressure the extension would transpire is directly related to the design strength and condition of the matrix. Apply 3000psi pressure to a crack in a 2500psi matrix and it will give. If the greatest advantage of high pressures is production, what is the greatest disadvantage? And why do pressure injection specifications restrict the amount of pressure that may be applied during the injection process?

We have used vacuum injection on just about all configurations of concrete, masonry and stone. In addition to individual crack repairs, vacuum can repair spider cracking by the square foot instead of the conventional lineal foot basis. Our vacuum processes can have an entire area repaired and back in service before a pressure application could be set up; and at a fraction of the cost. Unlike pressure injection, vacuum injection can be safely used for the repair of an unrestrained element. Topping slabs, mosaic tiles, delaminations, etc., can actually be simultaneously held together using the same vacuum forces used to perform the repair. This notion that high pressure cannot "blow out" a crack is nonsense. It is generally believed that any pressure in excess of 40psi has the potential to further damage concrete. REMR Technical Note CS-MR-3.9 states, "The pressure used for injection must be carefully selected. Increased pressure often does little to accelerate the rate of injection. In fact, the use of excessive pressure can propagate the existing cracks, causing additional damage." And what of ACI 301-05? "…pressure can propagate the existing cracks, causing additional damage." Despite hollow preaching claims otherwise, the perils are real and well accepted. The chance of further damage, propagation of the crack condition, is significantly greater by following conventional pressure injection methods.

Moreover, the matrix contains, at minimum, very nearly the same amount of moisture as the relative humidity of the atmosphere. Oh I know about the water insensitive epoxies used for pressure injection. But, it's back to that basic physics law when it comes to material penetrations, you cant put two things in the same place at once. If there is moisture in the pore structure, there is moisture in the pore structure. Nothing will get in unless the moisture is displaced. Pressure applied to the crack will not do it. The flow and roll of the repair resin along the interior walls of the fracture may pull some of it out but what happens to the moisture? We have found that because a manufacturer says so, does not necessarily make it so. Water insensitive epoxies will not bond when mixed with water. The failure to bond issue that this causes has been explained by the pressure injection folks. It doesn't need to bond it's been said. They go on to explain the mere fact that the member has cracked indicates it has relieved the pressures exerted in the first place. So, all one needs to do is fill the dormant void. But what if the pressure is not relieved, and even if it is, what is the need to get the material so deep into the fracture? Is 90% fill better than 70%? Sure it is. Consider a crack only filled 80% full. At the leading edge of the repair resin is a weakness. Apply pressure and the crack will radiate from this line and form a new fracture. That is, if the fracture is totally bonded the entire 80%. Of course, if it's not bonded, the fracture will just open up again when/if it comes out of compression. Many times my pressure injected crack looked fine, but six inches over, a new crack developed. Coring of the existing repaired crack could reveal the new crack emanates from, and because of, the partially filled fracture. The more complete the fill, the more permanent the repair.

Tecvac, Inc. routinely fills cracks as narrow as .001". Moreover, there are petrographic reports from CTL Labs that indicate cracks as narrow as 5 microns wide being filled using vacuum technology. We sometimes use pressure assist, but our success is directly attributable to our combination of vacuum and ultra-low viscosity repair materials, not pressure. True, the technology and the repair resins are a bit more complicated, but it's not brain surgery and, for the injection of typical in-depth cracks in concrete members, our prices are quite competitive. Our repair resin of choice is low molecular weight methylmethacrylate (MMA). This material shares all of the physical properties of epoxy, yet is just about as thin as water. It has the ability to migrate into places epoxies will never see. MMA has some drawbacks of course, but this material will outperform epoxy in every instance when it comes to injection. It smells nasty, tends to bubble when put under pressure and is not easily metered. So, there is obviously not a lot of enthusiasm from epoxy manufacturers or epoxy pump manufacturers. But let's take the splash of water example again; splash a cup of water on a concrete wall or sidewalk. See how the capillary action sucks the water deep into the matrix? Now splash a cup of honey right next to it. Very thin epoxies are claimed to be 40 centipoise, but most used for pressure injection approach 100 or better. MMA is 5-7 centipoise. See the difference? Imagine the same two materials trying to get into that .001" wide fracture. Pressure honey or vacuum water. Oh, you have a crack that is 6" wide? We can thicken MMA to paste, and apply it at 20 degrees below zero. We can drill into your pressure injected crack, where the material only penetrated 1"2", pull our MMA up against and bond to the shallow epoxy filler. We can remove our set up without grinding or marring the surface of the concrete. Vacuum injection benefits and superiority over pressure injection go on and on.

Witnessing these benefits, it’s not hard to understand why we, those of us in the vacuum injection industry, marvel at the natural wonder and the overwhelming power of vacuum. We don’t expect pressure injection folks and those with beneficial interest in that part of the concrete repair industry to embrace or even understand this technology. However, we do understand pressure injection. Tecvac technicians have performed 100's of gallons of pressure injection and know what it has to offer. We are ready for any challenge and hopeful that the results would bring the pressure injection folks into the present…the days of wooden wheels and buggy whips are a thing of the past.

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