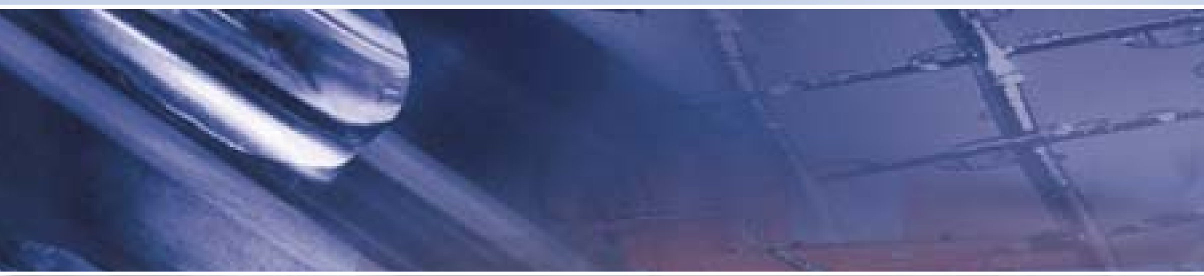
LOCTITE®

Porosity Sealing by Design



Henkel

TABLE OF CONTENTS

INTRODUCTION

Henkel brings the Loctite® Impregnation System™ (LIS) to the manufacturing world. This system has been continuously improved and enhanced for over 20 years. LIS has become the industry standard for sealing porosity in all types of manufactured parts. Manufacturers producing parts made from any casting technology, powder metal (PM) and metallic or non-metallic composite materials have made LIS an integral part of their manufacturing operations where high quality and low cost are paramount.

MODERN POROSITY SEALING FOR THE TWENTY-FIRST CENTURY

Advanced product designs and new manufacturing techniques are driving renewed interest in modern methods for sealing microporosity in metal castings, PM parts, electronic components, plastic composites, weldments and other porous substrates. A growing appreciation of the benefits of modern sealants and application methods, along with increasingly stringent quality requirements, has sparked fresh developments in manufacturing technology. Today, vacuum impregnation, as a means of reliably sealing porosity in a variety of substrates, is once again a priority. The ability to reliably and permanently seal pores in parts in a cost effective manner has elevated impregnation sealing to a new status as a trusted manufacturing operation.

In the past, some manufacturers were discouraged from using resin impregnation due to concerns for parts being impacted with sticky residues, inconsistent sealing results, long-term reliability and environmental issues associated with impregnation systems. To some, impregnation was seen as a costly salvage operation of dubious value.

Attitudes have changed in recent years with advances in modern, low-viscosity sealants and improved application equipment. Thin-walled die castings can routinely be designed into high-pressure fluid retaining applications thanks to highly effective porosity sealing. Reliability is ensured with vacuum impregnation and sophisticated sealants.

The extensive porosity inherent in PM parts can be reliably and permanently sealed so they can be used in hydraulic and even flammable gas systems without fear of leakage. Vacuum sealing pores in PM has earned acceptance as an important preparatory step for plating and other finishing operations, and is even helpful in improving the machining properties of these parts. The same application methods and sealants that have proven effective in sealing pores of metal parts also can be applied to prevent leakage due to microscopic passageways through the structures of plastic composites and other non-metallic substrates.

Demand for impregnation products and services has multiplied several times in recent years, particularly in the automotive and electronic industries.

• A DESIGNED-IN MANUFACTURING OPERATION

In the past, vacuum impregnation was thought of as a salvage operation used to “repair” castings that had been identified as “leakers” in leak test operations. Now, modern resin impregnation systems have proven so effective and economical that traditional leak testing of individual castings has been phased out in favor of 100 percent impregnation of the parts. The incidence of leaks after impregnation is so rare, castings are not leak tested until after final assembly of the manufactured product. Thus, with castings, powder metal, and other substrate materials, modern resin impregnation has advanced into the arena of the in-line manufacturing process.

• OLDER TECHNOLOGIES

Impregnation of parts to seal porosity is not new, especially in the casting industry. For decades various technologies have been used; sodium silicate, also known as “waterglass”, has been widely used as has styrene-based resin. These older sealing technologies have never earned high levels of confidence from manufacturers. Multiple trips through the impregnation process were common to seal many parts. Processing was slow and often accompanied by strong odors and tanks of hot curing oil. With a host of environmental issues and deserved concerns regarding long-term reliability, these older technologies have mostly faded away.

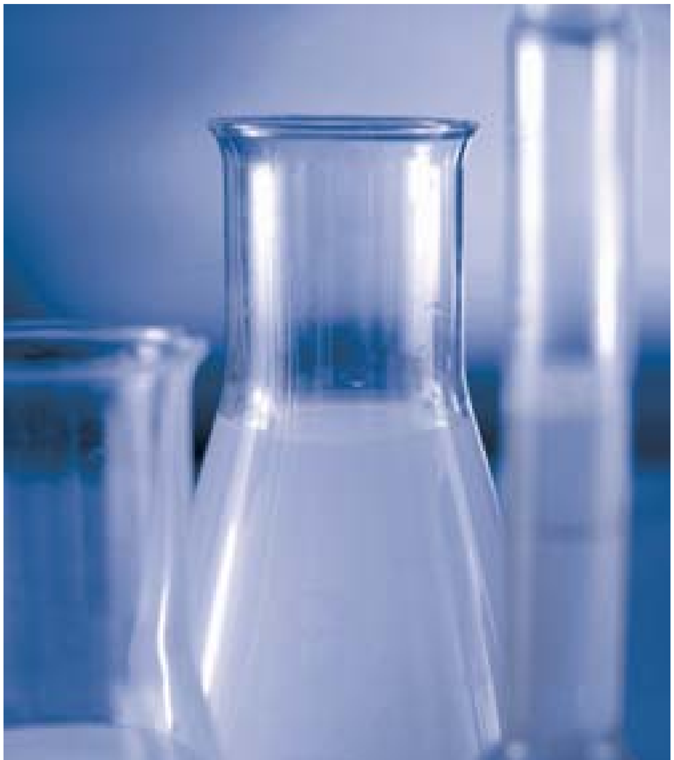
In today's manufacturing world, impregnation sealing of porous parts has become a welcome story of success with modern sealing materials and vastly improved process equipment and methods.

CURRENT TECHNOLOGIES

The term "polymerization" refers to the chemical reaction that results in solidification of the sealant material. The term is used here interchangeably with "curing." The resulting solid material is known as a polymer. Loctite® brand impregnation products are available in two basic technologies. The two technologies are defined by how this polymerization takes place – either by the application of heat (hot water curing) or at room temperature, by removing air from the sealant (anaerobic).

• RESIN IMPREGNATION — HOT WATER CURING

This system is a modern approach to porosity sealing that uses various forms of methacrylate or polyester resins that can be cured at temperatures below the boiling point of water. Sealants in this category are generally lower in viscosity than the older styrene resins and often can be applied with much simpler impregnation equipment using the wet vacuum method.



• RESIN IMPREGNATION — ANAEROBIC

This process involves methacrylate sealants with more sophisticated curing systems. Once impregnated into the porosity of the parts, anaerobic sealants will automatically self-cure to a fully polymerized state. The principal cause of the polymerization is the absence of air. Sealant remaining on outside part surfaces is exposed to air and will remain in liquid form until it is washed off. Curing of the resin can be accelerated or retarded by various chemical influences, through the reactivity of the substrate material, or by heating.

LOCTITE® IMPREGNATION PRODUCTS

The "System" of Henkel's LIS refers to the process equipment, the sealant material and the know-how to effectively seal porous parts. Henkel's Loctite® brand system is built around either of two sealant technologies: hot water curing or anaerobic curing.

• HOT WATER CURING

Impregnation systems that utilize heat curing to polymerize the sealant within the parts offer advantages in terms of simpler equipment requirements and moderately reduced maintenance needs. These characteristics make heat-curing systems attractive in instances where the impregnation process is used intermittently and may stand idle for periods of time. Several methods may be used to impregnate the sealant into the pores of the parts, followed by heating to cure the sealant within. The heating of the parts is most often accomplished by soaking them in a tank of hot water in the impregnation process line.

With hot water curing, some "bleedout" of the sealant may occur. Bleedout is a weeping of sealant from the pores of the parts as they get hot. The sealant cures as it bleeds out, often appearing as tiny balls of cured sealant on part surfaces. The pores enlarge, sealant viscosity declines, and thermal expansion takes place. The result is some reduction in sealing success and possible fouling of part surfaces. Agitation of the parts during hot water immersion can reduce fouling of the parts with bleedout, although it may persist inside screw holes and other small cavities. Bleedout can increase if there are any deficiencies in the vacuum impregnation process that allow residual air to remain in the pores.

The final stage of a heat cure system is the tank of hot water where the parts are soaked for curing. Caution must be exercised because the water is near the boiling point. Steam will come off the water tank any time it is open, so operators must use care and venting may be desirable.

Heaters for the hot water tank must be of sufficient capacity to maintain the specified water temperature for proper curing of the sealant. The operation must be controlled to ensure parts remain in the hot water long enough to reach proper temperature and completely cure the sealant. Failure to meet time and temperature requirements can result in parts leaving the sealing operation with incomplete curing. If this occurs, the polymer will not fully cross-link and performance characteristics of the sealant within the parts can be diminished.

Heat cure impregnation often is used in applications where parts are leak tested and leakers are set aside for impregnation or in situations where parts can be conveniently leak tested after treatment. Relatively simple maintenance requirements and ease of use are attractive features of heat-curing impregnation processes.

There are three Loctite® brand products for use in heat cure impregnation systems — Loctite® Resinol 90C™, Loctite® Resinol® 88C™, and Loctite® Resinol® 90R™.

• SELF-CURING ANAEROBIC

Anaerobic impregnation sealant was pioneered more than 30 years ago as the unique chemistry of Loctite® brand anaerobic machinery adhesives was applied to the requirements of vacuum impregnation application methods. The term "anaerobic" is borrowed from the field of biology. Webster defines "anaerobic" as "able to live and grow where there is no air or free oxygen, as certain bacteria." In Loctite® products, "anaerobic" describes a chemical product that reacts chemically and cures in the absence of air. Thus, anaerobic impregnation sealant cures in the absence of air. Anaerobic sealant is impregnated into the pores of the parts with the same methods as other impregnation sealants. Inside the pores, the sealant is no longer exposed to air and will cure. The key to curing is the absence of air. Curing can be accelerated by the presence of metal ions (always present in pores of a casting or PM), certain chemical activators or heat, although none of those is essential to cure.

The ability to use a chemical activator to augment anaerobic sealant curing provides another dimension to the sealing capability. When porosity is large and wall sections are thin, an activator rinse can be used in the process line to accelerate curing of the sealant and successfully seal larger pores. The activator rinse only works with the anaerobic sealant.

Anaerobic impregnation has consistently proven to be the most effective porosity sealing system available. The ability of these materials to self-cure at room temperature, and therefore eliminate the need for a hot water cure, prevents bleedout of the sealant and resulting loss of sealing effectiveness and eliminates the need to rework parts.

Anaerobic impregnation is generally recommended for high-volume manufacturing situations where extremely high success rates are desired in sealing the parts. This process often is employed as an in-line manufacturing process, with every part being treated rather than only isolating leakers. Many manufacturers rely on the excellent sealing capability of anaerobic impregnation to help ensure all parts reaching the assembly line are leak free, with no leak testing performed on individual parts, before or after impregnation.

Anaerobic impregnation products are always recommended for impregnation of PM parts. The extensive porosity that is typical of PM leads to bleedout problems when heat-curing sealants are used. The room temperature curing anaerobics with no bleedout are unmatched in producing quality results in PM.

There are four Loctite® anaerobic impregnation sealants — Loctite® PMS-50E™, Loctite® Resinol® RTC™, Loctite® Resinol® AT™, and Loctite® PM 5120™.

How They Compare

	Loctite® Anaerobic Cure	Loctite® Heat Cure
Filling[1]	Excellent	Excellent
Retention[1]	Excellent	Good
Curing System[2]	Excellent	Good
Polymer[3]	Excellent	Excellent
Process Cost	Excellent	Good
Cycle Time	Excellent	Good
Clean-Up	Excellent	Excellent

[1] 'Filling' and 'Retention' refer to how well the pores are filled with sealant and how well the sealant is retained in the part after processing — the heat cure process generally loses some sealant to bleedout during curing.

[2] 'Curing System' refers to the certainty that the sealant will cure properly — anaerobic is self curing, heat cure depends on time and temperature.

[3] 'Polymer' refers to the performance of the cured sealant.

The Anaerobic Advantage

The unique self-curing capability of anaerobic sealants, along with the ability to regulate the cure rate, has made this the most reliable family of materials for sealing porosity in metallic and non-metallic parts. The liquid sealant polymerizes naturally, but is prevented from doing so by lightly aerating it in the process tank and holding it at a constant temperature. When it is impregnated into a part, it no longer has a source of stabilizing air and will begin to chemically solidify. The contact with metal helps promote curing, as will the application of heat and certain chemical catalysts. However, heat, metals and catalysts are not essential to the cure process. These factors can be used to regulate the speed of the cure reaction. By controlling the speed of cure or reactivity, the sealant system can be "tuned" for optimal results in each application. The sealing process also can use an optional "activator" rinse to help quickly "set" the sealant in larger pores.

The ability to cure without heating the parts, combined with use of the activator rinse, gives the anaerobic sealants much greater flexibility in sealing a wide range of pore sizes, especially larger pores.

Bleedout of sealant does not happen with anaerobic sealants, so fouling of parts does not occur and sealing performance is consistently high.

The certainty of self curing of the anaerobic sealant assures that impregnated parts will be properly sealed. The process is not dependent on operator control of the hot water cure station for proper curing of the sealant as is the case with heat-cured systems.

SELECTION OF LOCTITE® IMPREGNATION PRODUCTS

• RESINOL® 90C™ (HOT WATER CURING)

This product is recommended for salvage type impregnation use and for low- to medium-volume production impregnating. Loctite® Resinol® 90C™ is intended for any impregnation service where simplicity and ease of maintenance are priorities, and where the impregnation system is to be used occasionally or intermittently. Loctite® Resinol® 90C™ is excellent for replacing older impregnating products in existing process equipment without extensive equipment modifications. Loctite® Resinol® 90C™ impregnation was specifically developed to be the simplest, lowest maintenance, most trouble-free impregnation process available.

• LOCTITE® RESINOL® 88C™ SEALANT (HOT WATER CURING)

The latest generation of Loctite® impregnation products, Loctite® Resinol® 88C™ is a proven, reliable and thoroughly modern sealant developed to surpass the performance of any heat-cured impregnation sealant on the market. Laboratory testing has confirmed Loctite® Resinol® 88C™ outperforms all comparable products in the critical metrics of sealing effectiveness and washing. It also carries out less sealant to rinse away and offers the potential for cost savings through lower consumption per part. Loctite® Resinol® 88C™ can be used in any impregnation system configured for a heat-cured sealant.

• LOCTITE® RESINOL® 90R™ (HOT WATER CURING, RECYCLABLE)

This new generation of sealant combines all the virtues of Loctite® Resinol® 88C™ with the ability to separate the sealant from the rinse water after processing and reclaim both the waste sealant and waste water. Loctite® Resinol® 90R™ offers state-of-the-art technology that enables better performance and lower overall costs than any comparable recyclable product. This material can be used in any impregnation system configured for heat-cured impregnation. The recycling process requires additional equipment.

• LOCTITE® PMS-50E™ (ANAEROBIC)

Loctite® PMS-50E™ is a premium sealant and is slightly higher in viscosity. It has significantly enhanced solvent resistance capabilities and the upper temperature limit is approximately 50°F (28°C) higher than any other impregnation sealant. Loctite® PMS-50E™ is ideal for sealing parts that will be used in extreme environments and is especially recommended for impregnating advanced magnetic parts made from rare-earth metal powders.

- **LOCTITE® RESINOL® RTC™ (ANAEROBIC)**

An evolutionary development, this product incorporates 100 percent reactive advanced proprietary washing agents that provide excellent washing in plain water (no detergent required) with a constant overflow of water to rinse away waste sealant. This is the most widely used impregnation product in the world.

- **LOCTITE® RESINOL® AT™ SEALANT (ANAEROBIC)**

This Advanced Technology (AT) product incorporates patent-pending technology to raise porosity sealing to a whole new level. It was developed specifically to be the most effective impregnation product available anywhere. Laboratory tests confirmed its best-in-class performance in sealing effectiveness and washing – the two most critical elements of impregnation porosity sealing.

- **LOCTITE® 5120™ SEALANT (ANAEROBIC)**

This sealant was specially developed for use in high-volume impregnating of PM parts to prepare for plating operations and machining enhancement. Loctite® PM 5120™ is used for shallow "picture frame" impregnating to seal out plating solutions. This product is not for pressure sealing use.

- **LOCTITE® 990™ SPRAY SEALANT (ANAEROBIC)**

This material is designed for localized application to leak areas of castings. It readily penetrates into pores and self-cures. Excess material can be washed with water or wiped off. The process is suitable for large castings where location of porosity is known. The sealant can be applied using a spray or brush. This sealant is not for use in vacuum impregnation systems and is generally not recommended for high volume use.

- **SPECIAL PRODUCTS**

Henkel's Loctite® product laboratories can modify existing products or create custom formulas to suit unique requirements if necessary for specialized applications.

VACUUM IMPREGNATION METHODS

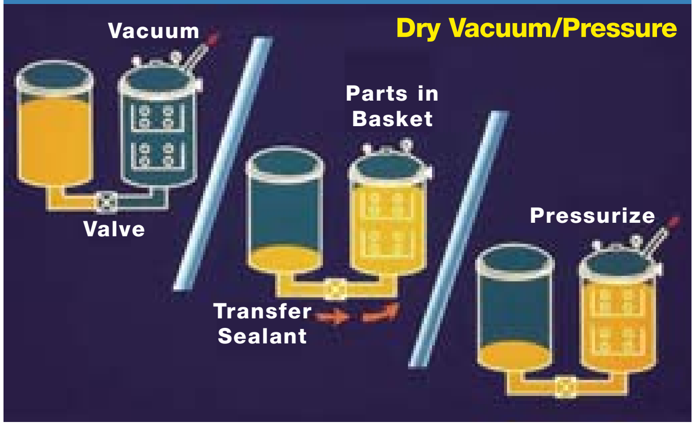
A variety of processing methods may be used to impregnate parts. The method selected depends on the sealant and the requirements of the parts.

Fundamentally, vacuum impregnation sealing of porosity addresses a pair of fluid mechanics problems. The laws of fluid mechanics govern the flow problem of removing the air from the pores and the flow problem of filling the pores with liquid sealant. The entire process can be reduced to four basic steps:

Process Steps:

1. Remove the air from the pores.
2. Fill the pores with liquid sealant.
3. Wash excess sealant from outer surfaces of the parts (without removing sealant from the pores).
4. Cure the sealant within the pores.

Each of the following impregnation process methods accomplishes these steps, but in slightly different ways.



• DRY VACUUM/PRESSURE (DVP)

This is the most complex vacuum impregnation method. The cycle requires two tanks, one which holds the sealant, and one in which the parts are processed.

Process Steps:

1. Place parts in process basket and load into process tank.
2. Draw vacuum in process tank to remove air from pores of parts. (Dry vacuum)
3. Transfer sealant from storage tank to process tank and submerge parts, still under vacuum.
4. Release vacuum and pressurize process tank with compressed air. Pressure helps to drive the sealant into the pores.
5. Release pressure and transfer sealant back to storage tank.
6. Remove parts. Wash and complete other process steps.

DVP processing was traditionally used with old-tech high-viscosity sealants. The DVP method is now sometimes specified with modern sealants where porosity is very small and sealing requirements are unusually rigid. The advantage of the dry vacuum is that there is no liquid present to interfere with degassing the pores. In a typical impregnation tank with a liquid level of 30 inches, the presence of the liquid column of sealant can reduce effective vacuum at the bottom of the tank by almost 8 percent. Use of dry vacuum eliminates that small variable. The pressure step is helpful in forcing the sealant into the pores. This is most important where the porosity is extremely small.

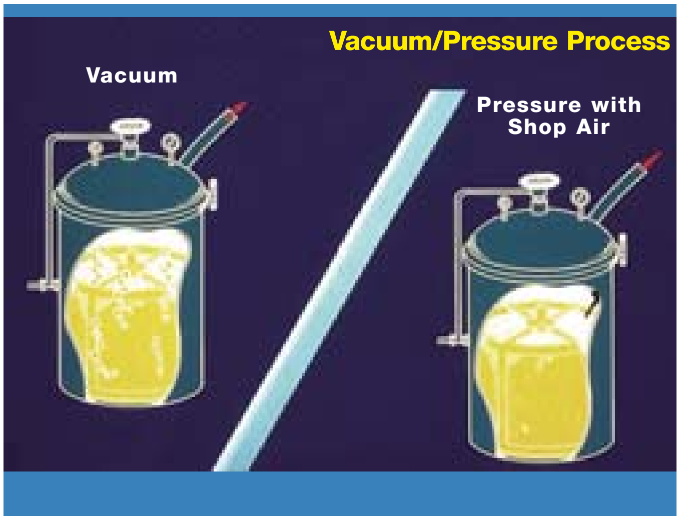
• WET VACUUM/PRESSURE (VP)

This process method requires only one tank. Parts are submerged in the sealant, which remains in the process tank at all times. The vacuum is applied to parts and sealant together, followed by pressurization with air. This process retains the pressure step, but does not use the dry vacuum. This is often an effective compromise, as the dry vacuum is less beneficial than the pressure step. The equipment is greatly simplified and the process will run faster.

Process Steps:

1. Place parts in process basket and load into process tank.
2. Draw vacuum in process tank to remove air from pores of parts.
3. Release vacuum and pressurize tank with air.
4. Release pressure.
5. Remove parts. Wash and complete other process steps.

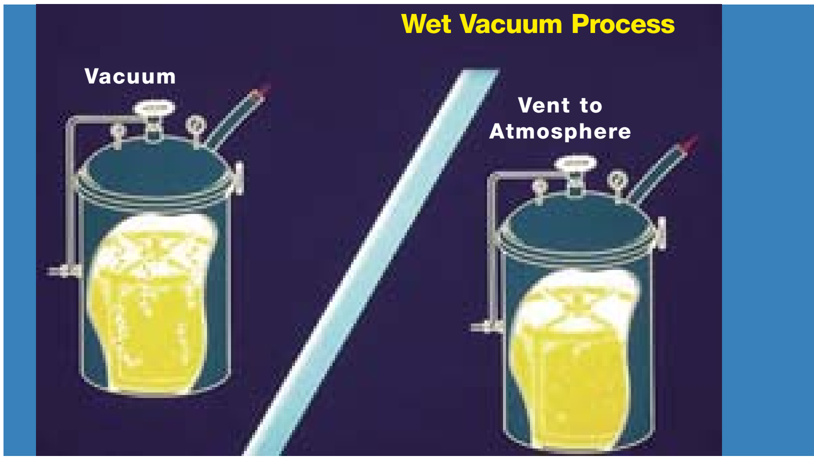
VP processing is more common for production processing of castings with very fine porosity and for high density PM parts.



• WET VACUUM (V)

This is the simplest and fastest of the vacuum impregnation methods. It is similar to the VP method, except that the tank is not pressurized. Instead, the tank is simply vented to atmosphere after establishing the vacuum. Penetration of the resin into the parts takes place at atmospheric pressure. The resin flows in to fill the vacuum created inside the porosity of the parts.

Wet vacuum impregnation is the most widely used application method by far. The simplicity and rapid processing, along with lower equipment cost, make this the method of choice in many impregnation system installations.



Process Steps:

1. Place parts in baskets and load into process tank.
2. Draw vacuum in process tank to remove air from pores of parts.
3. Release vacuum and vent tank to atmospheric pressure.
4. Allow parts to soak briefly while sealant penetrates.
5. Remove parts. Wash and complete other process steps.

- **PRESSURE IMPREGNATION**

This specialized method of applying impregnating sealants generally is used to treat parts individually and can be a very effective way to seal porosity in some situations. Typically, the parts are not placed inside a tank. Instead, each part is fixtured so it can be filled internally with the liquid sealant. The sealant is then pressurized, usually with compressed air, to force it to flow through any porosity leaks. The part is then drained, washed and processed further as in a tank method.

Process Steps:

1. Position part in fixture and close all open ports.
2. Fill part with liquid sealant.
3. Pressurize to force sealant through any leaking pores.
4. Release pressure and drain liquid sealant from part.
5. Remove part from fixture. Wash and complete other process steps.

Pressure impregnation in a highly automated system requires only seconds to process each part. Specially assembled set-ups can be useful when the part is too large to fit into a vacuum process tank, or when there are a large number of large parts where vacuum impregnation in a tank system would be costly.

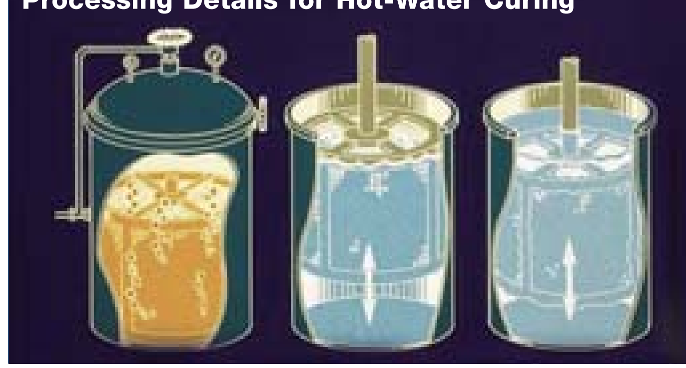
PROCESSING DETAILS FOR HOT WATER CURING

Processing is similar for Loctite® Resinol® 90C™, Loctite® Resinol® 88C™, or Loctite® Resinol® 90R™.

Process Steps:

1. Impregnate parts using any of the process methods described in section titled "Vacuum Impregnation Methods".
2. Use the Loctite® centrifuge to spin the basket of parts before removal from the impregnation tank. This removes most of the surface resin from the parts, returning that resin to the original bath. This step is very important for part clean-up. The sealant removed by the spinner returns to the bath, minimizing sealant usage. This is the most effective method available for removing excess sealant with no risk of damage to the parts. Since this is done inside the impregnation tank, very little time is required.
3. Using the Loctite® oscillator, lower the basket into the wash tank to clean the parts. Washing takes place in plain water with constant overflow, using the oscillator to agitate the parts in the water.
4. Place the basket of parts into the hot water cure tank and allow sufficient soaking time for the sealant to cure within the parts. The sealant will cure in four to 10 minutes at 90˚C (194˚F), but time must be allowed for the parts to reach that temperature throughout. Twenty minutes of soak time in the hot water tank is usually sufficient. Note: Parts must be allowed to cool after removal from the hot water. They can be leak tested as soon as they are cool. A corrosion inhibitor can be added to the hot water tank to provide protection for parts that might rust or corrode easily.

Processing Details for Hot-Water Curing



PROCESSING DETAILS FOR SELF-CURING ANAEROBIC SEALANTS

Processing is similar for Loctite® PMS-50E™, Loctite® Resinol® RTC™, Loctite® Resinol® AT™ and Loctite® 5120™.

Process Steps:

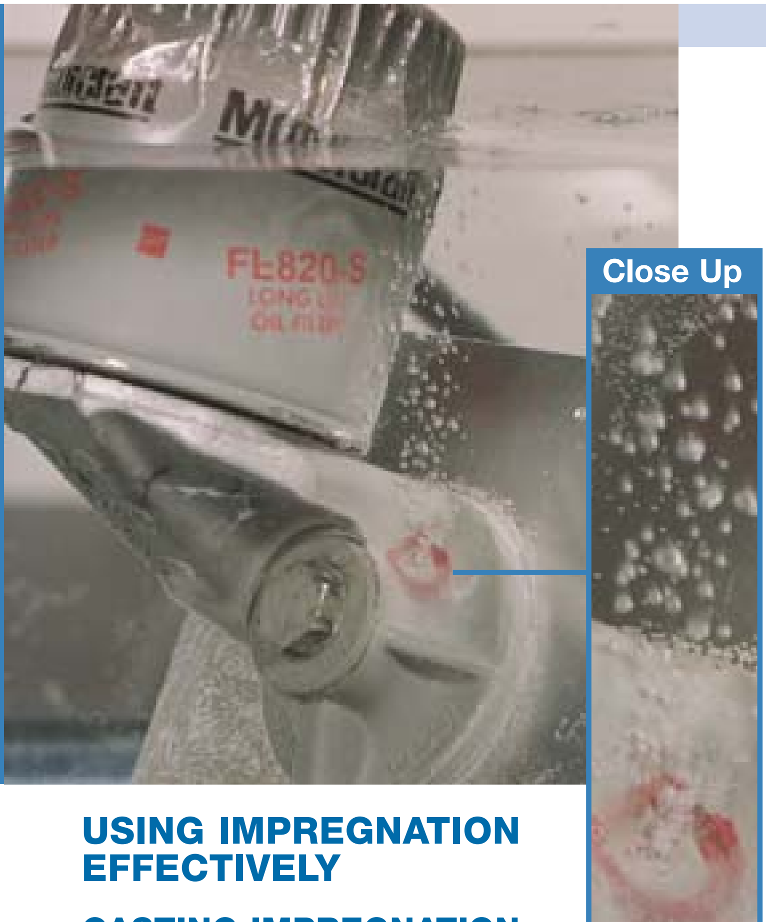
1. Impregnate parts using any of the process methods described in sectioned titled “Vacuum Impregnation Methods”.
2. Use the Loctite® centrifuge to spin the basket of parts before removal from the impregnation tank.
3. Using the Loctite® oscillator, lower the basket into the wash tank to clean the parts. The oscillator is used to agitate the parts during washing. Compressed air agitation in the water also may be used. Washing takes place in plain water with constant overflow with Loctite® Resinol® RTC™, Loctite® Resinol® AT™ and Loctite® 5120™. With Loctite® PMS-50E™, a mild detergent is added to the water.
4. Place the basket into the activator rinse tank and soak. The activator solution is a safe, mild water solution that has a catalytic effect on the anaerobic sealant. When exposed to the activator rinse, sealant at the pore entrances will cure quickly, creating a “plug” that prevents remaining liquid sealant from escaping while it continues to cure slowly by the anaerobic system. (The activator rinse may not be necessary in all applications.)
5. Parts are soaked in a final rinse tank of water at 110˚F (43˚C). The final rinse removes the activator solution from the basket, which will begin a new cycle in the resin tank, and provides one more rinse to clean the parts. If needed, a corrosion inhibitor can be added to the final rinse. At 110˚F (43˚C), the rinse water will dry quickly from the parts when they are removed. Usual soak time is about five minutes, although soaking for 25 to 30 minutes can expedite curing of the sealant in the parts. If desired, the Loctite® centrifuge also can be used after the final rinse to quickly remove excess water from the parts. Parts impregnated with an anaerobic sealant can be handled and processed in subsequent operations as soon as they are removed from the final rinse tank. The interval for full curing is normally about three hours at room temperature, or the sealant can be fully cured by extending the soak time in the final rinse to 25 minutes at 110˚F (43˚C). Parts will pass a typical leak test within about 30 minutes with room temperature curing.

The anaerobic impregnation system will cycle three to 15 loads per hour, depending on application requirements.

Wet Vacuum | Wash (Water) | Catalyst Activator | Warm Water Rinse (110ºF)

• SPRAY SEALING

Spray sealing is a porosity sealing technique that may be a practical substitute for impregnating in some instances. It is most often utilized in larger castings that may be awkward to handle or too costly to impregnate in a conventional tank system. The location of the porosity must be known so that the sealant can be applied directly to the area where the pores open onto the surface. The very low viscosity sealant then penetrates into the pores by capillary action. Loctite® spray sealants are self-curing anaerobics that will cure inside the part in two to three hours, permanently sealing the porosity. The sealant can be applied directly from the original container, by paint brush or by spray methods. Spraying is the most common application method and may be accomplished by a hand held pump sprayer, a tank sprayer, or a completely automated on-line robotic sprayer. The product used for spray sealing is Loctite® 990™ Spray Sealant.



USING IMPREGNATION EFFECTIVELY

CASTING IMPREGNATION

Castings sometimes have visible surface defects that may be described as “porosity.” These defects usually are not improved by impregnation sealing. The sealant washes out of surface defects during processing, leaving them unchanged. The target for impregnation sealing is the internal porosity that occurs on a smaller, microscopic scale. This porosity may be due to gas inclusions or shrinkage from the casting process.

In general terms, most applications for casting impregnation involve porosity that is so small it is not visible to the naked eye. The presence of the porosity can usually be demonstrated by leak testing the parts. The most basic leak test method consists of pressurizing the part with compressed air or other gases and submerging it under water to observe air bubbles emerging from the metal. Even where there is no visible blemish on the part, leaks observed in this way may range from a steady stream of large air bubbles to a barely visible stream of “champagne” bubbles.

Leak testing in manufacturing environments often is preformed with automated systems. Pressurizing the casting with air and measuring the rate of decay of the pressure (or leakdown rate) is common and is known as “pressure decay” testing. More sophisticated leak testing is becoming common, using helium to pressurize the parts and detecting leaks with a mass spectrometer. This type of leak test can detect very small leaks that may not be found with pressure decay tests. Loctite® impregnation is a perfect companion to any of these leak test methods and is especially capable of sealing the smaller leaks that concern modern manufacturers.

Questions often arise about the size of pores that can be sealed consistently. A number of variables are involved, so a general guideline regarding the specific leak sizes that can be sealed would not be realistic for every case. For example, a pore size that might be easily sealed in a part with thick wall sections might be very difficult to seal in a part with very thin wall sections. This is because the washing action in the impregnation rinse line might be more inclined to remove the sealant from the pore in the thin wall section. The only useful way to determine the capability of the sealing process for a given part configuration is to impregnate samples of parts with known leak rates and test the results.

• FLUID SEALING

The most common reason for impregnation of castings is to prevent leaks through porosity. Examples are:

- automotive cylinder blocks and heads;
- transmission cases and related components;
- steering gear housings retaining hydraulic oil up to several thousand psi;
- fuel system pumps, regulators, and filters with gasoline, diesel and hybrid fuels under pressure;
- coolant pumps retaining various coolants;
- hydraulic pump and motor parts, refrigerant compressor parts, gear cases, pressure-tight aircraft instrument housings, airbrake components, and gas meters.

Properly impregnated, these parts are permanently sealed and can hold pressures up to the burst strength of the casting.

• FINISHING OPERATIONS

Castings also are impregnated to seal porosity in preparation for metal finishing operations, such as painting or plating. If the pores are not sealed, foreign fluids may be absorbed that remain in the pores through the finishing operations. These trapped fluids may emerge later, attacking the finish coating from within and causing pits, blisters or other blemishes in the finish. "Blowouts" that occur in paint curing ovens often are caused by gases or liquids emerging from pores. Some effects of porosity may not appear on the surface finish until well after all processing has been completed, perhaps into the useful life of the product. Impregnating of castings performed before finishing operations will seal the pores so that unwanted fluids cannot be absorbed.

• CORROSION PREVENTION

In some instances, it may be desirable to seal pores in a casting so that corrosive fluids cannot enter. This prevents corrosion that may originate within the porosity. If corrosion does occur within the pores, stains may appear on the surface of the part from the internal corrosion, even though the surface of the part has been treated to prevent corrosion. Impregnating such a part will help to seal out corrosion that might otherwise occur inside the pores.

POWDER METAL PARTS IMPREGNATION

Uniform interconnected porosity is a natural result of PM parts manufacturing in which metal parts are formed by compacting metal powder and sintering the compacted powder in high-temperature furnaces. Resin impregnation is a perfect companion for this unique manufacturing technology. Vacuum impregnation with Loctite® anaerobic resins is widely utilized for sealing the pores in PM parts. In fact, porosity is so extensive in this type of part that Loctite® anaerobics are the method of choice for PM sealing needs. Heat-curing sealants usually are not satisfactory in PM because of problems related to the inevitable bleedout in extensive porosity.

• FLUID SEALING

Many successful PM manufacturing programs would not be possible without the high reliability provided by Loctite® impregnation. Millions of PM parts are produced each year for use in critical components of hydraulic systems where high pressure hydraulic oil would easily pass through even very high density PM parts. PM parts are successfully used in this environment because of the highly successful and cost effective application of Loctite® impregnation resins. The porosity in these parts is permanently sealed with virtually 100 percent success with one pass through Loctite® impregnation processes.

• PLATING

PM parts also are commonly impregnated for other reasons. Platers and other metal finishers know that the extensive porosity in PM parts will absorb cleaning agents and acids that are used in painting, plating and other metal finishing operations. These absorbed solutions can cause problems in the finishing operations or premature failure of the finish itself in the form of pits or blisters. Impregnation of the parts prior to finishing operations will effectively seal the pores so that foreign solutions cannot be absorbed. Loctite® resin impregnation is now a standard process step for platers and metal finishers who work with PM parts. Loctite® 5120™ Powder Metal Plating Grade Sealant has been specially developed for metal finishing and machining enhancement in PM, although any Loctite® anaerobic impregnation sealant can be used.

- **MACHINING**

A rapidly growing purpose for resin impregnation of PM parts is to enhance machining properties. Parts that are drilled, tapped, bored, milled or otherwise machined with cutting tools are much more easily machined after resin impregnation.

Controlled tests have shown that tool life can be extended several hundred times and machining can be done at much higher speeds just by impregnating the PM parts. Dimensional accuracy of the machined parts improves substantially so that Statistical Process Control (SPC) methods become more effective. Many PM parts are impregnated today solely for the benefits in machining.

- **CORROSION PREVENTION**

Corrosion of PM parts may originate within the porosity of the sintered part. Moisture, chemicals from other processes and atmospheric conditions can combine to create corrosion within the pores. Resin impregnation applied soon after sintering can avoid penetration of other fluids and gasses, helping to prevent internal corrosion.

- **SEAL PORES FOR ADHESIVE BONDING**

Adhesive bonding of PM parts is sometimes difficult to accomplish. Many adhesives will migrate into the pores of the part before the adhesive cures. When this happens, there may be insufficient adhesive remaining at the surface to adequately bond the PM part to another surface. Resin impregnation of the PM part fills the pores so that adhesives will bond reliably without migrating into the pores.

WHEN TO IMPREGNATE: COMPATIBILITY WITH OTHER OPERATIONS

Technical Specialists for Loctite® impregnation recommend that castings be fully machined, cleaned and dried before impregnation. As castings are machined, more internal porosity may be exposed and only after all machining is completed is it possible for the impregnation sealant to reach all areas that need to be sealed. It is important for the parts to be clean and dry so that the pores are not blocked with foreign materials that might prevent thorough penetration by the impregnation sealant. Parts should be at room temperature when they are impregnated.

Powder metal (PM) parts should be impregnated after sintering and before any secondary operations. The porosity is normally completely open at that point and can be entirely filled by the impregnation sealant. Impregnating of PM parts before subsequent machining or finishing operations will improve those operations as well. Plating, painting, or other finishing operations for either castings or powder metal parts should be done after the impregnation is complete and the sealant has been allowed to fully cure. The cured sealant in the impregnated parts will not be affected by the various cleaning and etching steps normally seen in finishing operations. Even where strong acid solutions are used in finishing, the exposure times are brief and the sealant will not be affected.

If parts must be heat treated after impregnation, it is likely that the temperatures reached may cause some reduction of properties in the sealant. Consult a Loctite® impregnation specialist for advice in such cases.

IMPREGNATION OF NON-METALLIC PARTS

Non-metallic materials, such as wood, ceramics and fiber-reinforced plastic composites, may have internal porosity that requires sealing in certain situations. Typical are electrical connectors made with conductive metal pins molded into plastic bodies. Loctite® impregnation specialists have experimented extensively with this type of sealing application and have experience with long-running production operations sealing non-metal substrates with processes and sealants similar to those used for PM and castings.

SEALANT PERFORMANCE PROPERTIES

Service temperature data for Loctite® impregnation sealants are listed on product data sheets. In general terms, the cured sealants are suitable for continuous service up to 400˚F (204˚C). Brief exposure to higher temperatures, as might occur in paint ovens, will not normally cause any difficulty. These sealants are used successfully in such high-temperature environments as automotive engine blocks, cylinder heads, and coolant pumps. Cured sealant is a thermoset plastic which will not melt, liquefy or run out of the parts at elevated temperatures. If operated beyond listed temperature limits, cured sealant will slowly lose weight and turn to ash.

Loctite® impregnation sealants have been tested extensively with a wide variety of chemical agents to determine suitability for use in parts that are exposed to fuels, lubricants, coolants, cleaners and other chemicals that may be encountered in automotive, aerospace, defense and general industry environments. It is not possible to list every test result. Consult a Loctite® impregnation specialist regarding the recommended product selection for the needs of your application.

Comparison testing has shown that Loctite® impregnation products will significantly outperform competitive products at elevated temperatures and in solvent resistance capabilities.

CUSTOMER SPECIFICATIONS

Loctite® impregnation products meet automakers' and suppliers' global specifications.

Loctite® products meet the requirements of the most current military impregnation standards, as well as the individually developed specifications of a number of major military and aerospace hardware suppliers. Loctite® impregnation products also meet numerous specifications required by general industry organizations, such as Underwriter's Laboratories, Inc., for impregnation of castings used in fuel dispensing equipment and NSF for water system components.

A Loctite® impregnation specialist can assist you in finding or developing a suitable specification for your product application needs. Appropriate specifications can help assure consistent quality results whether your impregnation work is done in-house or by an outside source.

AUTHORIZED JOB SHOP IMPREGNATION CENTERS

Many manufacturers prefer to have processes like impregnation provided by outside suppliers. For those whose needs can best be served by an outside source, there is a nationwide network of authorized job shop impregnation centers equipped to provide impregnation processing on a service basis. These are independent businesses who use Loctite® impregnation products and processes. They receive technical support from Henkel's Loctite® Products Tech Service labs as needed and offer a valuable service to those companies that do not wish to bring the impregnation operation into their own plants.

HEALTH AND SAFETY: WASTE-WATER

Loctite® impregnation processes and materials are not hazardous to workers or to the environment. Special safety provisions or ventilation are not required. Material Safety Data Sheets are available on request.

Waste-water generated by Loctite® impregnation processing is not hazardous and is biodegradable. It is usually drained into public sewer systems. Each local government entity that may receive waste-water creates standards for the water coming into its respective treatment system. Waste-water specialists are available through Henkel's Loctite® Products Tech Service to consult on the nature of the waste stream. If required, Loctite® equipment specialists can provide technology and equipment to treat waste-water from the impregnation system.

QUALITY

As the creator and manufacturer of Loctite® brand impregnation sealants, Henkel Corporation has complete control over quality of these products. Loctite® impregnation products are produced in Henkel facilities certified to ISO-9002 standards. These facilities have been visited by audit teams from many major agencies and companies who have evaluated the facilities and quality systems in use. As a result of these audits, Henkel and its Loctite® products have been recognized as quality leaders with several quality supplier awards, including TS 16949.

Loctite® products are produced with state-of-the-art facilities and quality systems to ensure customers receive the finest products possible. This quality capability is unmatched in this industry.

This quality manufacturing capability is especially valuable for a supplier of chemical products, such as adhesives and sealants, as defects in this type product may not be apparent to the user.


CERTIFICATE

DQS GmbH

Henkel Cleveland Manufacturing and Distribution

Quality Management System.

ISO/TS 16949:2002

DOING BUSINESS WITH HENKEL

Henkel is the only complete supplier of impregnation products, offering turnkey impregnation systems for in-house installation or fully-supported job shop operations nationwide. Henkel is dedicated to its customers' success with a complete team of knowledgeable, experienced professionals including field representatives, chemists, equipment specialists and process engineers as well as a fully equipped process lab.

Loctite® impregnation products are packaged in convenient four-gallon containers. This allows the user to purchase in quantities that closely match needs and consumption rates, an important feature in an age of "just-in-time" inventory control. The small packaging permits easy operator handling and simple disposal of the compacted empty containers.

Loctite® impregnation equipment is designed and built to the standards of heavy industry using the finest components. Start up of systems in customer plants is supported by capable Henkel personnel, who provide assistance with the equipment start up and sealant use, as well as operator training. Henkel field representatives provide ongoing, in-plant support for the impregnation system.

The Impregnation Process Engineering Lab, located in Henkel facilities in Metropolitan Detroit, applies state-of-the-art methods and facilities to impregnation. Here, customer parts are evaluated to provide process solutions to sealing problems. These evaluations are frequently done with new parts from prospective impregnation users who wish to evaluate the capability of the process. Customer evaluation parts also can be run in these systems to compare results with a customer's in-house system or to allow Loctite® Impregnation Process Engineers to fine tune the process for maximum results.

Everyone involved in bringing you the Loctite® impregnation product line is dedicated to producing the results you need to assure your satisfaction with Loctite® Impregnation Systems.

Henkel

a global market leader

Henkel – Your Worldwide Partner

USA

Henkel Corporation
32100 Stephenson Highway
Madison Heights, Michigan 48071
Tel. (248) 583.9300
Fax (248) 583.2976

Europe

Henkel KGaA
Henkelstraße 67
40191 Düsseldorf, Germany
Tel. +49.211.797.0
Fax +49.211.798.2358
www.henkel-technologies.com

Canada

Henkel Canada Corporation
165 Rexdale Blvd.
Etobicoke, Ontario, M9W 1P7 Canada
Tel. (416) 743.8817
Fax (416) 745.8085

Henkel Canada Corporation
2225 Meadowpine Blvd.
Mississauga, Ontario, L5N 7P2 Canada
Tel. (905) 814.6511

Mexico

Henkel Capital
S.A. de C.V., Calz. De la Viga s/n,
Fracc. Los Laureles 55090
Ecatepec, Edo. de México
Tel. +52 (55) 5836.1338
Fax +52 (55) 5787.9004

Asia

Henkel Singapore Pte Ltd
19 Jurong Port Road
Singapore 619093
Tel. +65.6266.0100
Fax +65.6266.1161

Henkel Corporation
Madison Heights, MI
U.S.A.
www.henkel.us