

# Testing Vacuum Impregnation Sealant Compatibility vs Impregnation Process Effectiveness

**Andrew Marin**, Marketing Coordinator  
Godfrey & Wing Inc.  
Aurora, Ohio

There exists a misconception on testing requirements for vacuum impregnation sealants and vacuum impregnation processes. Testing impregnation sealants for application compatibility and testing the impregnation process effectiveness are grossly different.

**Impregnation sealants** are tested through Military Standard MIL-I-17563C. MIL-I-17563C demonstrates a sealant is compatible with the application and that the sealant will not degrade or fail over the life of the part.

**Impregnation processes** are governed by Military Standard MIL-STD-276A. MIL-STD-276A provides the standards for processing to seal parts and testing process effectiveness.

The misconception comes to light as operators or engineers use test methods designed to demonstrate **impregnation sealant** compatibility as an indication of **impregnation process** effectiveness. The outcome of this mis-application of testing methods will lead to false positive results. Meaning the impregnation process will appear capable of sealing parts when it is not. This can create a field failure leading to significant unforeseen costs and quality issues.

This paper clarifies the difference between the two specifications, MIL-I-17563C and MIL-STD-276A, and the testing required for each standard.

## What is a Military Standard?

In the late 18<sup>th</sup> century and throughout the 19<sup>th</sup> century, the American and French militaries were early sponsors and advocates of interchangeability and standardization. Today, the United States Military Standards (often called Mil Specs or MIL-STD), are used to standardize processes and products for the United States Department of Defense. For decades these MIL-STDs have served as the basis for specifications used by global manufacturers to ensure products are manufactured to the same quality standards regardless of their country or point of origin.

## Impregnation Sealants: MIL-I-17563C

MIL-I-17563C governs the testing and approval process for vacuum impregnation sealants. Sealants tested must pass this standard to gain acceptance onto the Qualified Product List (QPL).

The specification places impregnation sealants into one of three classes:

- **Class 1** - Suitable for service temperatures up to 300°F (149°C)
- **Class 1a** - Suitable for use on mortar shell castings up to 300°F (149°C)
- **Class 2** - Suitable for service temperatures up to 500°F (260°C)
- **Class 3** - Suitable for use where air pollution requirements apply and compatible with acrylic-nitrocellulose lacquer paint system up to 300°F (149°C)

## MIL-I-17563C Testing

MIL-I-17563C testing is done using a certified test ring. The test ring is used as a 'carrier' or 'standard coupon' for the sealant testing. The ring has an excessive amount of porosity compared to an actual part. In other words, the sealant in the test ring will be exposed to the maximum amount of cured sealant to the change in fluids, gases, and/or temperatures.

MIL-I-17563C states that the configuration of the test ring should be 1 inch (25.4mm) long with a nominal ¾ inch (19.0mm) inside diameter, and 1 inch (25.4mm) outside diameter (Figure 1).



**Figure 1** - The test ring shall be 1 inch (25.4mm) long with a nominal ¾ inch (19.0mm) inside diameter and 1 inch (25.4mm) outside diameter.

Test rings shall not have the surface altered by operations such as burnishing, coining or sizing. The interconnected porosity should be 15%-25%. The exact amount is determined by the method specified in ASTM B 328. The alloy composition of the test specimens shall conform to one of the three types as specified in MIL-I-17563C (Table 1).

**Table 1 - Excerpt from MIL-I-17563C.**

Element	Composition Percent		
	Type I	Type II	Type III
Copper	82.0-90.0	-	-
Iron	1.0 (max)	95.0 (min)	-
Tin	9.5-10.5	-	-
Lead, maximum	4.0	-	-
Zinc, maximum	1.0	-	-
Aluminum, maximum	-	-	99
Carbon, maximum <sup>1</sup>	1.75	-	-
Total other elements by diff., maximum percent	0.5	4	1
Combined carbon <sup>2</sup> (on basis of iron only)	-	.60-1.00	-

1. Commonly graphite. A maximum of 1-1/2 percent of another type of solid lubricant may be substituted when authorized.
2. The combined carbon may be a metallographic estimate of the carbon in the iron.

The test follows five simple steps:

1. **Pressure Test** - Test ring is pressure tested for leakage at 50 lbs./in<sup>2</sup> to verify leak paths are present.
2. **Impregnation** - The test ring is impregnated with an approved impregnation process, as discussed below in the “Impregnation Process: MIL-STD-276A” section.

**Table 2 - Excerpt from MIL-I-17563C.**

Impregnant Class	Specimen Type	Material	Median Specification	Time	Temperature
1, 1a, 2, 3	All	Water	-	14 days	212°F (100°C) (Boiling)
	All	Oil	MIL-H-17672	14 days	210 +/- 5°F (99 +/-2.8°C)
	All	Hydrocarbon fluid	TT-S-735	14 days	73.4 +/- 3.6°F (23 +/-2°C)
	All	Carbon Removal	P-C-111	30 min.	73.4 +/- 3.6°F (23 +/-2°C)
	All	Lubricating oil	MIL-L-7808	48 hours	255 +/- 5°F (121 +/-2.8°C)(1)
	All	Turbine fuel	MIL-T-5624	48 hours	73.4 +/- 3.6°F (23 +/-2°C)
	All	Ethylene glycol	MIL-E-9500	14 days	C1 1-300 +/- 5°F (149 +/-2.8°C) (2) C1 2-397 +/- 5°F (197 +/-2.8°C) (2)
1, 1a, 2, 3	All	Hydraulic fluid	MIL-F-17111	14 days	210 +/- 5°F (99 +/-2.8°C)
	All	Fuel	ASTM D 910	48 hours	73.4 +/- 3.6°F (23 +/-2°C)
	All	Diester grease	MIL-G-23827	48 hours	73.4 +/- 3.6°F (23 +/-2°C)
	All	18 percent sulfuric acid	O-S-809	2 hours	73.4 +/- 3.6°F (23 +/-2°C)
	All	Stoddard solvent	P-D-680	48 hours	73.4 +/- 3.6°F (23 +/-2°C)
	All	Ethyl alcohol	MIL-E-463	48 hours	73.4 +/- 3.6°F (23 +/-2°C)
1, 1a, 2, 3	All	Thermal resistance	-	14 days	300 +/- 5°F (149 +/-2°C) (2)
	All	Thermal resistance	-	14 days	500 +/- 5°F (260 +/-2°C) (2)

Notes:

- (1) Specimens shall be cleaned in a suitable degreaser after exposure.
- (2) Specimens shall be cleaned in a suitable degreaser for not less than 30 minutes prior to exposure to the stated conditions.

3. **Pressure Test** - After impregnation, the test ring is tested for leakage at 50 lbs./in<sup>2</sup>. If there is no leakage, then the part is sealed. MIL-I-17563C acknowledges that not all test specimens will pass the leak test after impregnation.
4. **Environmental Conditioning Test** - The test ring is tested as specified on Table 2. This is done to evaluate the sealant’s resistance to fluids, gases, temperatures and time.
5. **Pressure Test** - The test ring is tested again after impregnation. The ring must exhibit zero leakage.

## Impregnation Process: MIL-STD-276A

MIL-STD-276A is the military approval that governs the impregnation process of porous metal castings and powder metal components. MIL-STD-276A states that there are three viable vacuum impregnation processes: Internal Pressure, Dry Vacuum and Pressure, and Wet Vacuum and Pressure.

## Use Parts, Not Test Rings

MIL-STD-276A states that the parts being impregnated are to be used for the process verification. There is no mention of test rings in MIL-STD-276A. As the test rings have little to no similarity to most parts, they are only used to ‘carry’ the sealant, and not test the process. Using the actual part is the only way to measure

the process effectiveness, as a pressure test of the part demonstrates the leak path is sealed.

A common misconception is that if one can seal a 15,000 ccm leak rate, then one can seal a <100 ccm leak rate. This is incorrect because each leak path is different. The material, wall thickness, porosity, and size will vary between parts. Process parameters, such as cycle time, pressure, wash cycle, and sealant viscosity, will be different to seal a 15,000 ccm leak rate than what is required to seal a <100 ccm leak rate.

## Common Misconception on Sealing Powdered Metal Rings

Many operators or engineers assume that if they can seal a powder metal test ring, then the impregnation process is effective. They assume that if they can seal the large porosity in a powder metal test ring, then they can seal porosity of any size. This is not the case. This misconception can be explained by comparing the properties of a powder metal test ring to an engine block (Table 3).

**Table 3** - Comparing the properties of a powder metal test ring and an engine block.

Property	Powder Metal Test Ring	Engine Block
Material	95% iron powdered metal	300 series cast alloy
Porosity Type	Through	Blind, Enclosed, Through
Relative Porosity	15-25%	4%
Initial Leak Rate	>10,000 cc/min	<100 cc/min
Pass Leak Rate	Visual, few bubbles	<2 cc/min
Effective Surface Area Subject to Test	>3 square inches	>1,000 square inches
Machined Features (Blind taps, Passages, Mounts, etc.)	0	>30
Wall Thickness	Consistent @ .25 inches	Variable 0.125 to >0.75 inches
Mass	1.2 ounces (38 grams)	70 lbs (32 kg)

Most impregnation vessels can impregnate sealant into a test ring that is 15%-25% porous and leaks 10,000 cc/min. A test ring can be impregnated at atmospheric pressure because of the large porosity. Keeping it in requires a passive wash and cure so the sealant does not emulsify out from the leak paths.

Conversely, the engine block requires pressure in the impregnation vessel to penetrate the porosity. This is because the engine block porosity is smaller when compared to the powder metal test ring. Unlike the test ring, the sealant will never wash from the engine block porosity due to the small size of the porosity. However, the sealant must still be removed from small machined features in the block which requires an aggressive wash and cure.

## In Summary

Properly understanding the difference between military standards is the first step to identify the best means to seal a leak path. Using the correct sealant and process will ensure that parts are properly sealed and eliminate the possibility of a field failure.



### About the Author

*Andy Marin is the Marketing Coordinator for Godfrey & Wing. He received a B.S. in marketing from John Carroll University and an MBA from Cleveland State University. He joined Godfrey & Wing in 2016, and manages the company's marketing operations and communication.*

## NADCA MARKETPLACE

### What is the Marketplace?

The Marketplace is NADCA's new online store. You can purchase the items below. Trying to register for someone else? No problem! This is also an option in the new Marketplace.

- Purchase Publications
- Register for Conferences
- Register for Courses
- Register for Webinars
- Sign Up & Renew Membership
- Purchase Online Course Access

### How to Buy?

Simply add the item or items to your shopping cart and proceed to checkout! To view more details on items available in the Marketplace visit: [www.diecasting.org/store](http://www.diecasting.org/store).

