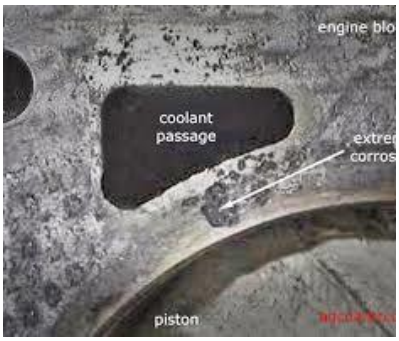
600 N Ellsworth Road Box Elder, South Dakota 57719 · (605) 716-0061

VRC Engine & Engine part Remanufacturing Application Sheet

VRC the world leader in cold spray thermal repair and remanufacturing technology have successfully completed several types of metal repair on engines and engine parts:

1) **Cold spray Babbitt onto Babbitt**
2) **Cold Spray of cast iron using 50/50 410SS/CrC-410-1**

Material or Part	Description	Repair Details
1. Babbitt to repair bearings	 Bearings for rotating components in an enormous number of machines. Piston engines, compressors, turbines	Babbitt on Babbitt is quite common for the larger rotating equipment. Current process is done by GTAW welding. Also a big issue in Steam turbines. Example in Indonesia approximately 1000 kg per year is sold for this application. All maintenance and repair. VRC can cold spray deposit Babbitt, we have done demo sprays developed by our senior engineer. The repair can be done by hand and by robot using Nitrogen sprays.
2. 410SS/CrC to repair cast iron castings	 Cast iron parts with small defects  Cylinder liner OD	VRC has achieved **25ksi <u>shear</u> adhesion strength** (3-lug shear, see Appendix A) with 50/50 410SS/CrC onto cast iron, using <u>nitrogen</u>. Porosities are low, <2%. Typically inexpensive to perform. 410SS and CrC-410-1 both are relatively inexpensive materials and readily available, and we get excellent results with nitrogen. Can be done with hand spray; We have experience with hand-spray repair of castings when it comes to aluminum. 410SS/CrC-410-1 with nitrogen has been used for cast iron repair. Should work for other iron and cast steel parts as well.

	 Engine block deck  Cylinder Head – Flat Erosion Sites away from Fire Surface  Cast iron cylinder blocks (not what is pictured): Not entire cylinder, but worn areas in upper bore, to avoid putting stainless steel ring in that area. This was developed for a major, global construction equipment and engine OEM.	Is being used by global OEM of construction equipment and engines for cast iron V8 engine block repair, to eliminate “insertion of SS ring in upper cylinder”. The blend machines nicely, major US reman company has even been able to hone our 410SS/CrC-410-1 deposits.

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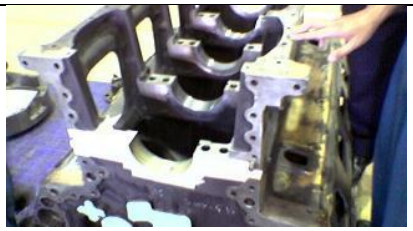
3. Bearing seats we can use 410SS/CrC-410-1 or an aluminum bronze.	 **Bearing seats**	These hold the bearings themselves. In job shops they use NiAl Bond, top coat AlBz. Materials in CAT they use NiAl Bond and top coat Fe Based, often 410” **If the bearing seat is cast iron then we can directly spray 410SS/CrC-410-1 with nitrogen and get good adhesion.** We have sprayed tin bronze with nitrogen and get good results. If Al-Bronze specifically is required then some development work will be needed. This likely can be done with nitrogen. Might well add CrC-410-1 for improved adhesion and lower porosity.
4. Ship-size piston ring grooves	**Piston Ring Grooves**  	For **ship** size pistons of 10,000 Kw or higher this works. Ship size pistons grooves are 0.5in wide and 0.5in. deep which cold spray can reach. Handling parts of that size would be the responsibility of the customer. Wartsila-Sulzer RTA 96-C engine, 1810 liter, 102,000 Hp crankshaft-example of marine type engine

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APPENDIX A
Shear adhesion tests: Known as "Three-lug shear test" or "Triple lug shear test" (both terms used).

This test is described in detail in MIL-J-24445A Joint, Bimetallic Bonded, Aluminum to Steel, including procedures, specimen dimensions, and test apparatus and jigs to be used. This test is used to determine the shear strength of the bond between a deposit and a substrate. The procedures are applied to other material combinations as well, such as aluminum on aluminum, and any other material combination for which shear adhesion strength data is sought. Typically, one specimen is used for this test, as one specimen provides three data points. Additionally, there are fewer concerns regarding test or specimen failures than with tensile testing, where grips can slip, or specimens can break outside the gage section.

Fig. A1 illustrates how the triple lug shear test is performed, where a finish-machined specimen is pushed down through a fixture in to impart shear load upon the "lugs":

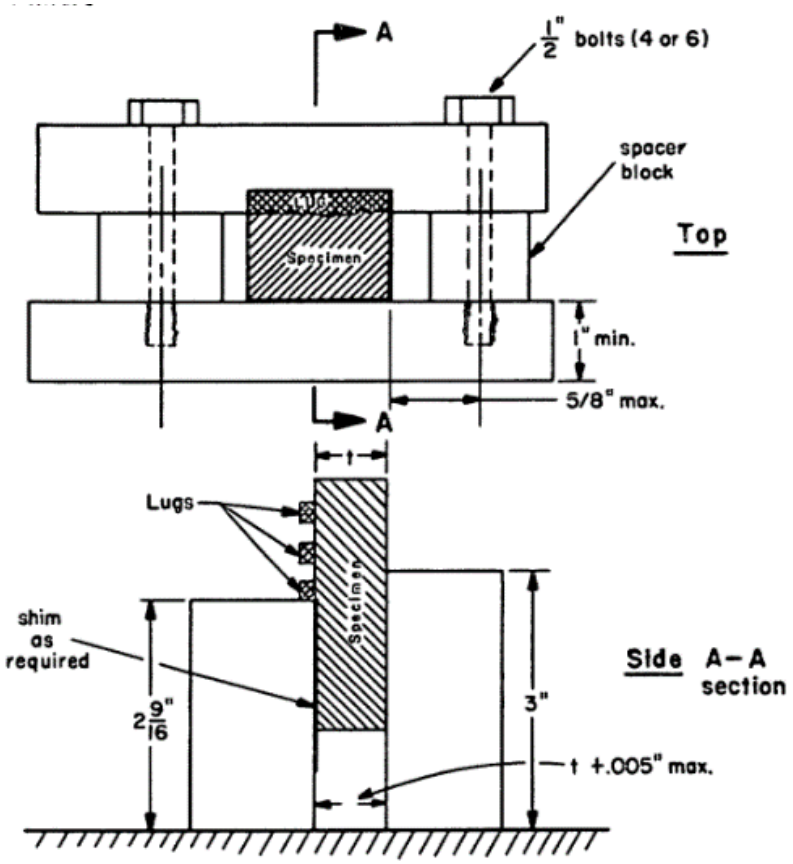
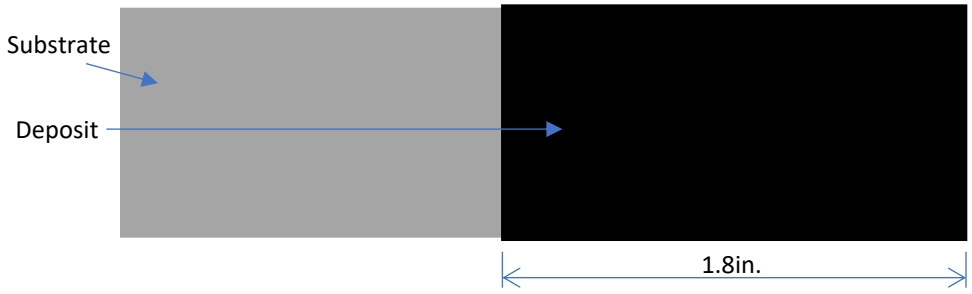
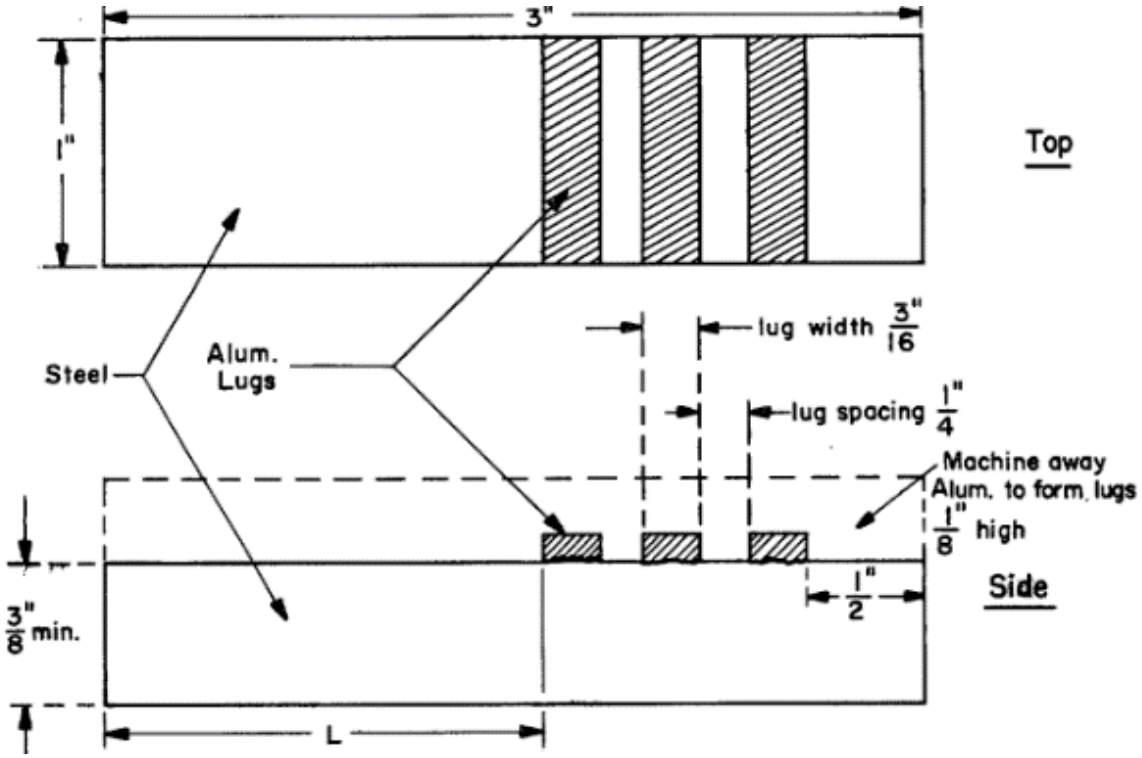


Figure A1: Sketch of experimental setup for triple lug shear testing. Taken from MIL-J-24445A.

As illustrated in Fig. A2, the substrate shall have dimensions of 1in. width, 3in. length, and at least 3/8in. thickness. The height of the "lugs" after machining shall be 0.125in., and so it is recommended to make the deposit at least 0.140in. thick. The deposit start at one end and go 1.8in. across the substrate, while fully covering the width.



(a)



(b)

Figure A2 a) Illustration of deposit coverage prior to machining, b) Final deposit dimensions.

The finished specimen shall be tested in accordance with MIL-J-24445A, and the peak load shall be recorded for each lug. The resulting shear stress on each lug shall be calculated based on the base dimensions of the lug, which per the standard are nominally 1in. by 3/16in.

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