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GLEEM Testing Fixture

by David Gray

ARL-TN-360 July 2009

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14. ABSTRACT

A test method was used to develop a process to emplace a refractory metal liner inside a gun tube as a part of an effort at the U.S. Army Research Laboratory to develop an autofrettage gun barrel application. The process consisted of filling the liner with an elastomeric material and then slipping this arrangement into the gun tube. The ends of the liner were plugged with plastic disks, and pressure was applied to the elastomeric material by a load frame. A test fixture was developed to facilitate containment and alignment of the gun barrel during testing. The fixture is described in this report, and preliminary data is provided to show the utility of the fixture.

15. SUBJECT TERMS

GLEEM testing fixture, tech note, autofrettage, gun liner emplacement by elastomeric material

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1. Introduction

The term GLEEM (patent pending) is derived from "Gun Liner Emplacement by Elastomeric Material" developed by Drs. Robert Carter, U.S. Army Research Laboratory, and Bill de Rosset, Dynamic Science, Inc., as a potential economic way to apply liners to and/or induce a state of autofrettage in gun barrel applications. By compressing an elastomeric material inside the tube, plastic deformation of the gun tube was produced, resulting in a compressive residual stress near the surface of the liner/gun tube interface. This strengthened the gun tube and allowed higher operating pressures and longer fatigue life.[1] In order to achieve the compressive loads required to obtain the desired bond strength, a fixture was made to constrain test coupons (see figure 1). Previously, there was no fixture available for the GLEEM process.

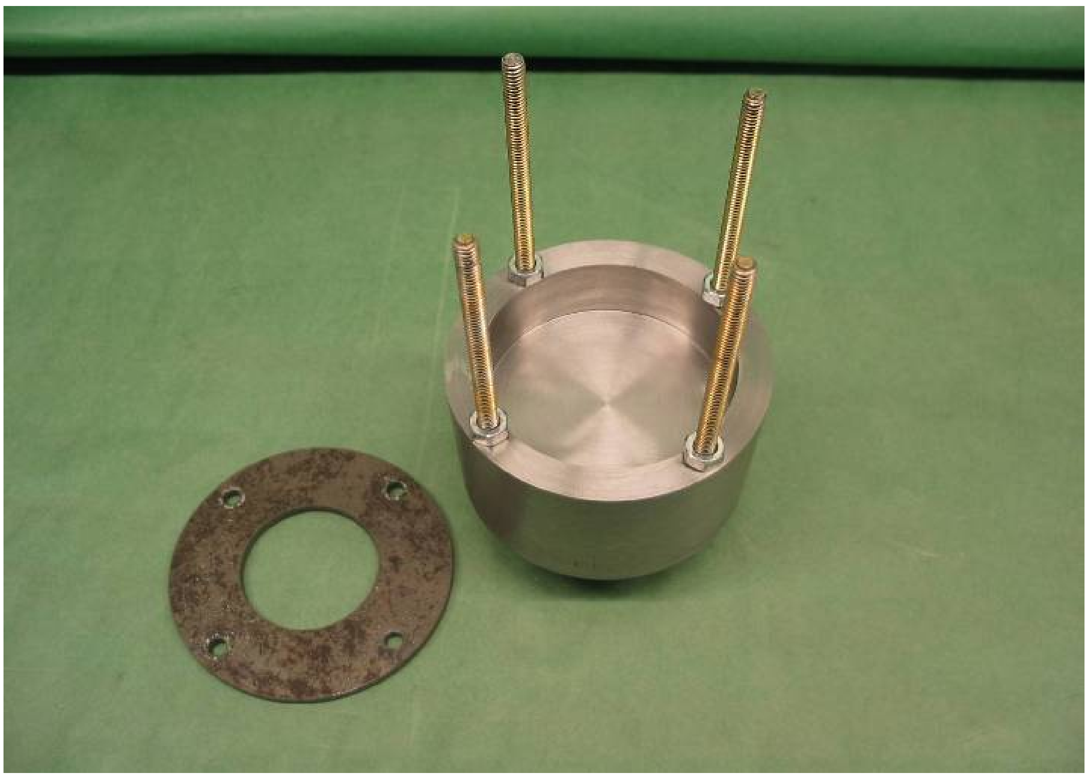

Figure 1. GLEEM 100,000-lb compression fixture.

[1]Carter, R. H.; Gray, D. M.; de Rosset, W. GLEEM – A New Composite Gun Tube Processing Technology. ASC paper; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, 2008.

2. Testing Assembly and Load Frame Installation

The fixture was designed to restrain only the steel barrel while allowing the insert material to plastically deform unhindered, via the expansion of the elastomeric plug, as loads increased. A schematic of a GLEEM process is shown in figure 2. Without the restraints, the liner and gun tube move, causing the sealing discs to fail and allowing the elastomeric plug to blow out of the bottom. A typical coupon assembled in fixture is shown in figures 3 and 4.

The fixture threads into the lower ram actuator of a Material Test Systems (MTS)/Instron load frame. The upper load cell has a threaded platen to drive the piston down into the sealing caps of the test coupon. The MTS load frame control software is used to compress at an inch/minute rate and hold at a final predetermined load set by Drs. Robert Carter and Bill de Rosset. The MTS 100,000-lb hydraulic model load frame installation is shown in figure 5. By changing length of the restraining rods, the GLEEM fixture is also capable of testing a longer steel tube sample, as can be seen in figures 6 and 7.

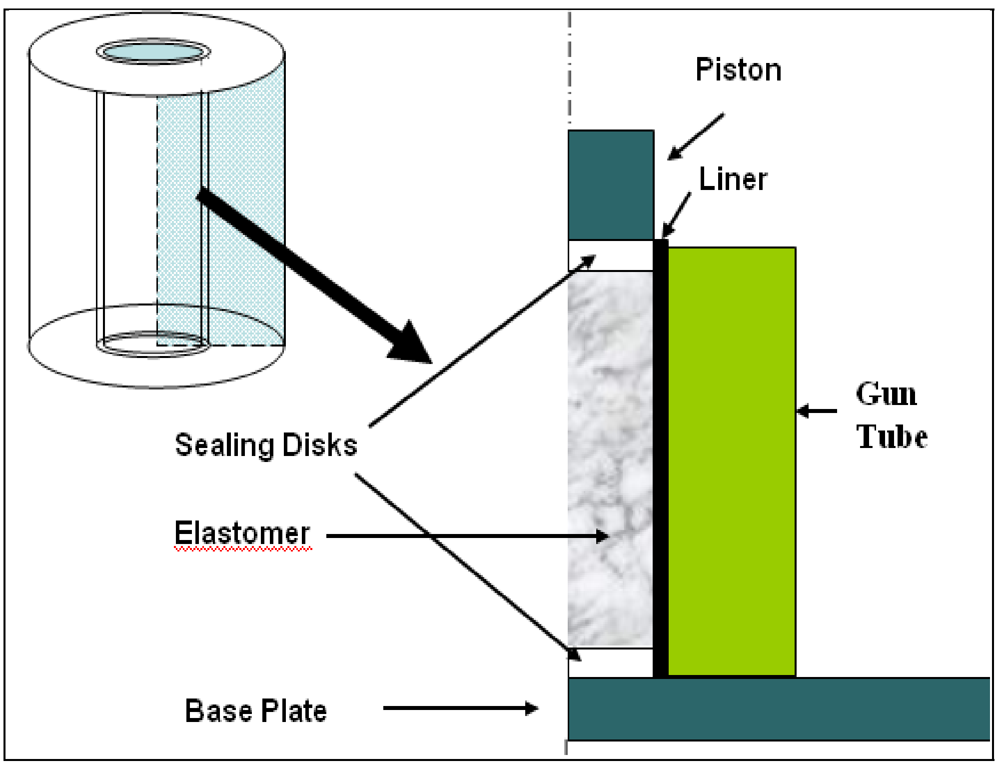

Figure 2. Schematic of GLEEM application setup.[1]

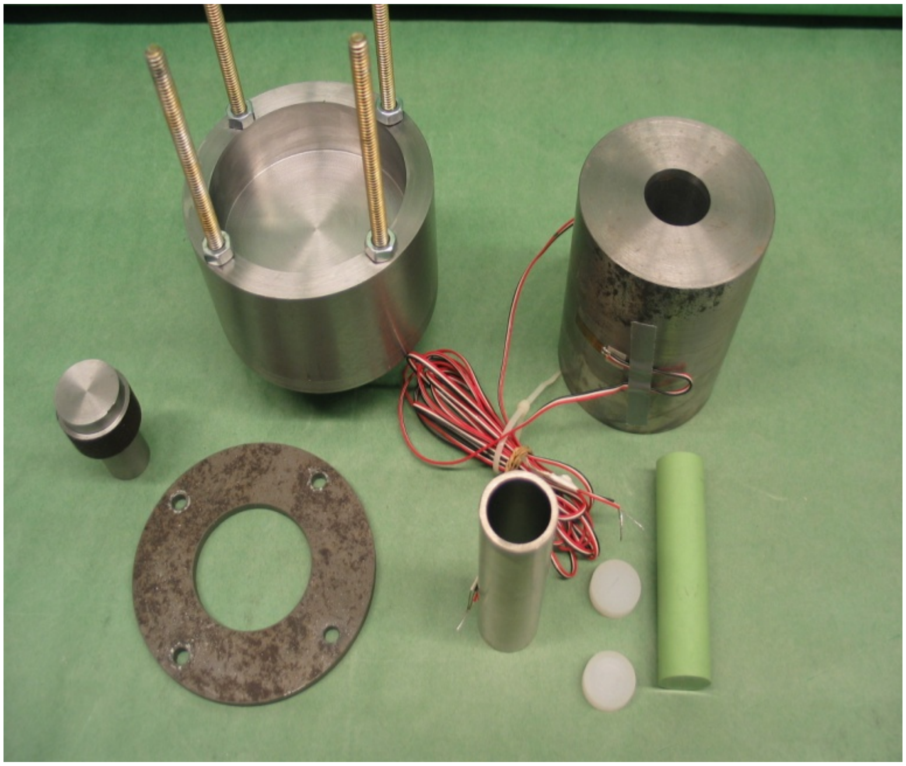

Figure 3. Four-inch test coupon assembly.

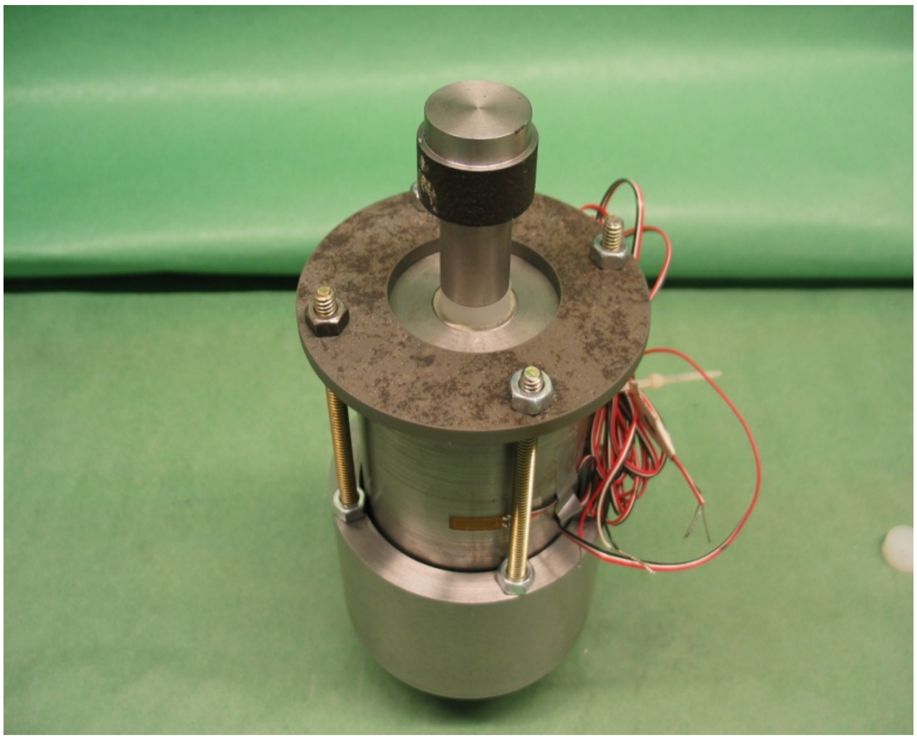

Figure 4. Assembled 4-inch test coupon.

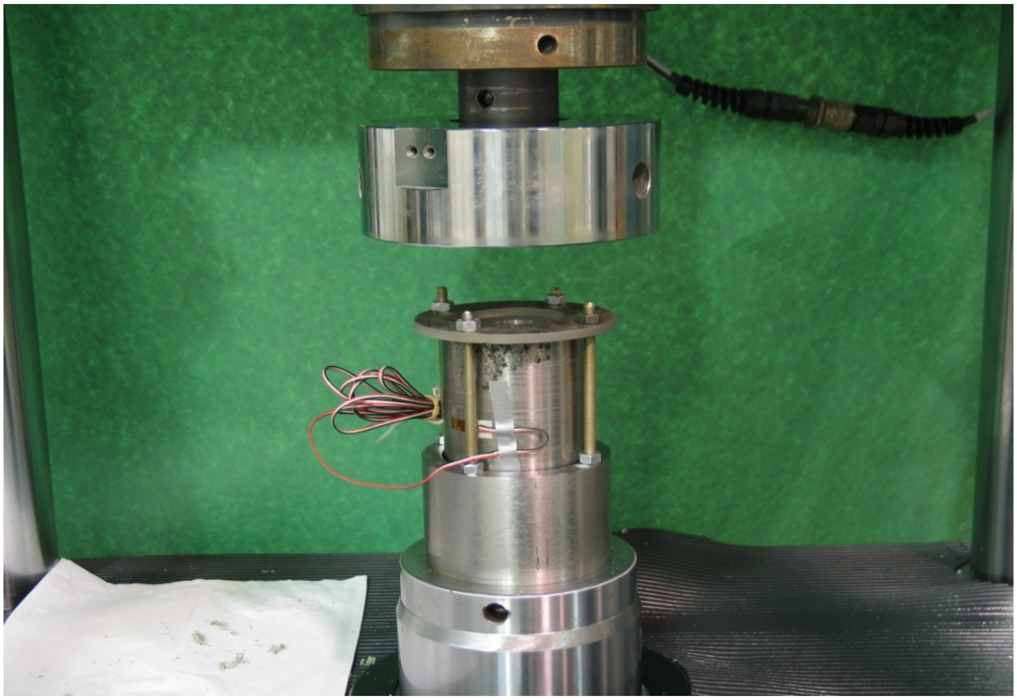

Figure 5. MTS 100,000-lb load frame with single top compression platen.

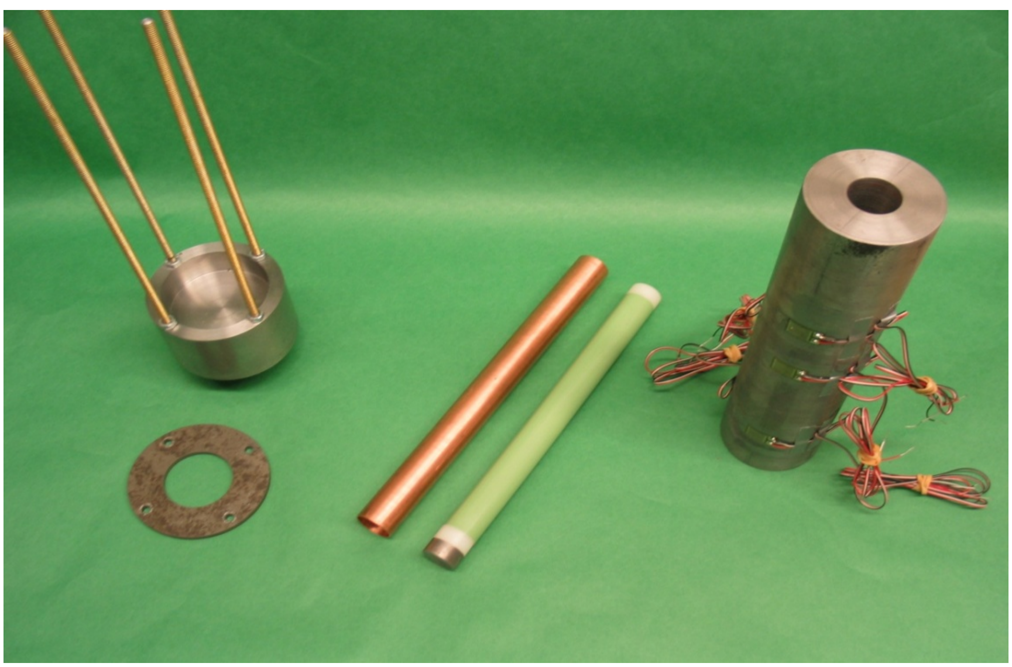

Figure 6. GLEEM fixture 12-inch test sample adaptation.

Figure 7. GLEEM fixture with 12-inch test sample.

3.   Fixture Description

Figures 8 and 9 describe the components of the GLEEM fixture and their purposes.

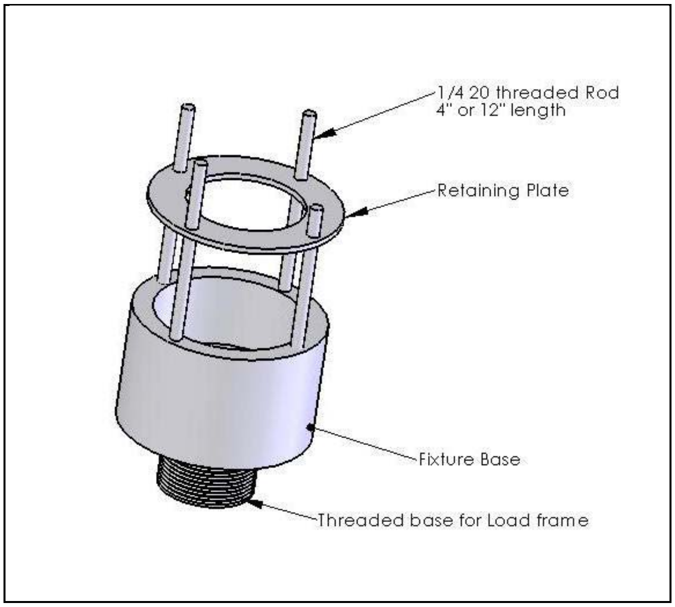

Figure 8. GLEEM fixture drawing.

Figure 9. Complete assembly prior to testing.

4. Test Procedure

The load frame used was the MTS 100,000-lb maximum load with a cross head rate of 0.1 in/min. To allow internal pressure equalization, the software was configured to ramp to 90,000 lb and hold. The specimen was placed in the fixture according to the procedure described in the fixture description in section 3.

Tests were considered complete when the controls detected a 40% load drop from peak compressive load or 1 hr of static state. Load ram was returned to 0 after the test was completed. Figure 10 is a typical test graph showing calculated internal pressure vs. measured hoop strain on the outer surface of the jacket while constrained in the GLEEM fixture. The steel yield strength was 160 ksi. The pressure was calculated by dividing the load by the surface area of the piston. The gage used was in the center of a 4-in cylinder, minimizing the frictional effects affecting the pressure.

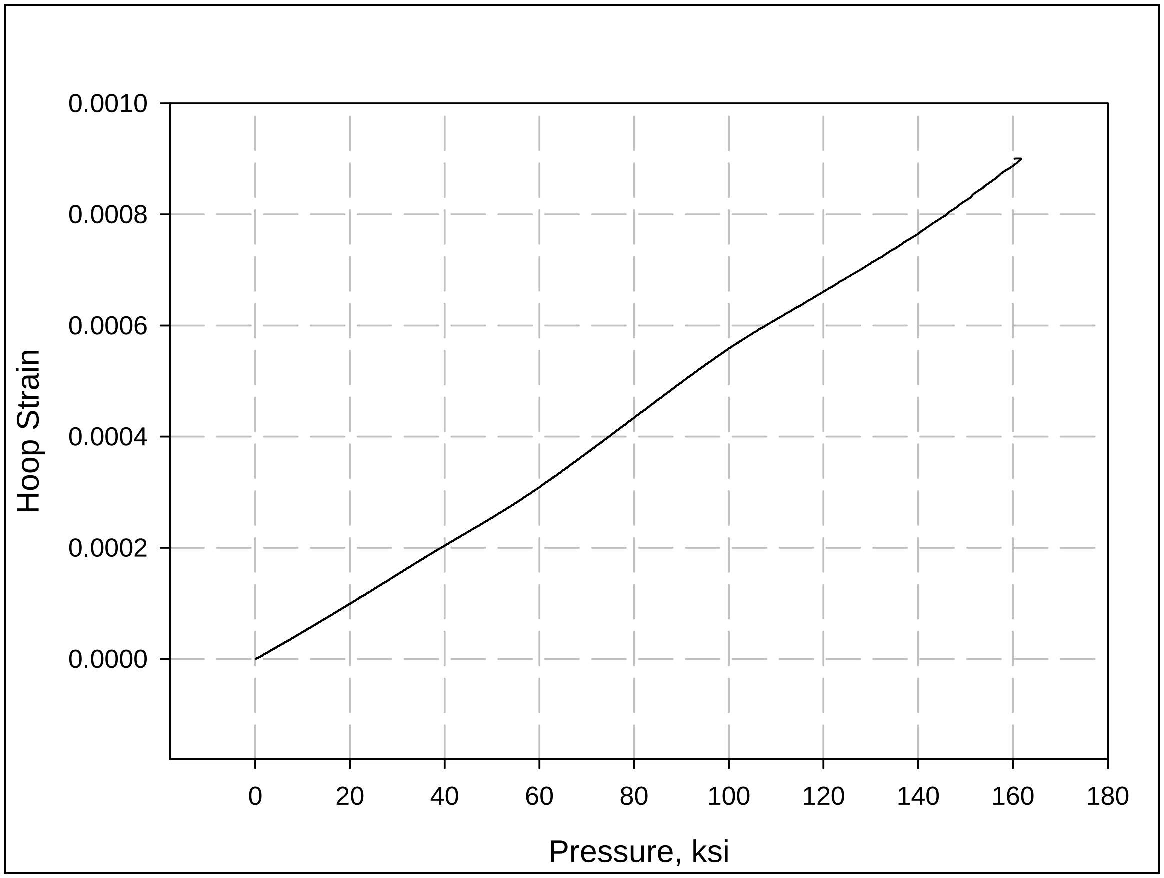

Figure 10. Hoop strain vs. internal pressure.

5. Conclusions and Recommendations

A functional test fixture was designed and fabricated to hold and align GLEEM specimens, providing desired test data and bond strength results consistently between the various experimental liner materials.

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