



MiniSShot

Propellant Grain Structural Loading Investigation

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Draft

Introduction

This document describes the setup and test procedure for an experimental investigation into the effects of structurally loading a propellant grain subjected to internal pressure. In this test, pressure is applied hydrostatically. The specimen grain assembly, which consists of two bonded segments, is installed in a section of motor case tubing. The grain assembly is sealed at both ends to the casing wall to artificially prevent pressure equalization around the grains. This is intended to simulate the condition that could occur in an actual rocket motor during startup if combustion gases are unable to fill the space between the grain and casing wall rapidly enough.

Apparatus Setup

1. Cast the propellant grains in the same manner as was done for the MiniSShot flight, including “topping up” with propellant.
2. Perform tap test on both grains, and record any indications of possible disbond.
3. Take density measurements of both grains and record in Appendix A.
4. Bond both grains together with epoxy adhesive.
Note – it is imperative that the joint be pressure-tight. Lay a generous amount of epoxy in the female flange. Wet the male flange with epoxy. Wipe excess epoxy from outer surface once mated. Allow to fully cure.
5. Perform joint leak check as described in Appendix B.
6. Paint ends of both grains at boundary region where propellant meets the casting tube, as illustrated in Figure 1. Use a non-flexible enamel paint. Prior to painting, clean region with alcohol or paint thinner.
7. Cut a piece of Garolite liner (.005”) to size 11” x 10.25”. Wrap the piece around the grain assembly tightly and secure the butt joint with tape. The Garolite must not overlap.
8. Drill two small holes (e.g. 1/8”) approximately at mid-span of casing as shown in Fig.2. Holes should be approximately 180 degrees apart.
9. Clean the interior of the casing thoroughly. Wipe with alcohol or paint thinner to remove all traces of oil or grease.
10. Clean both ends of the grain assembly casting tubes, removing all traces of propellant. Wipe with alcohol or paint thinner to remove all traces of oil or grease.
11. Install the grain assembly into the casing approximately midspan, as illustrated in Fig.2.
12. Seal the perimeter of the casting tubes at both ends with silicone adhesive or RTV to form a pressure-tight seal. Use a generous amount of adhesive to ensure a pressure-tight seal. Allow to cure minimum 24 hours.
13. Seal the nozzle throat with a suitable “nozzle plate” as illustrated in Figure 2, using silicone adhesive or RTV. Allow to cure minimum 24 hours.
14. Remove pressure transducer from bulkhead. Install male flare fitting in its place.

- 15. Install igniter fitting in bulkhead.
- 16. Remove snap-ring which retains thrust fitting in bulkhead, then remove fitting.
- 17. Install nozzle and bulkhead, lubricating o-rings with silicone grease.
- 18. In a suitable manner, mount assembled casing upright, bulkhead end up.
- 19. Mount pump (Fig.3) securely to a suitable platform using two c-clamps. The end with the 3/4" nut should extend to the edge of the platform, to allow the wrench handle freely rotate nut during operation of the pump.
- 20. Attach the pressure gage to the pump using the short copper tube. Tighten flare nuts securely using two 9/16" open-end wrenches.
- 21. Attach one end of the long copper tube to the pump. Tighten flare nuts securely using two 9/16" open-end wrenches.
- 22. Attach other end of the long copper tube to the bulkhead flare fitting. Leave slightly loose for the time being (snug up then back off 1/2 turn).

Test Procedure

Important note: perform test out of doors and away from any open flame. Methanol has high vapour pressure and is flammable.

- 1. Using a funnel, fill casing full with methanol. Add dye as required. Approximately xx litres will be required. Fill completely, leaving no residual air.
- 2. Reinstall thrust fitting into bulkhead opening and secure with snap ring.
- 3. Rotate pump nut clockwise until piston screw is fully inserted.
- 4. Open fill valve (handle turned upward). Fill cup with clean water.
- 5. Purge air from the pump by rotating nut to extend screw out about an inch, then screw back in fully. Air bubbles will be seen rising in the cup emanating from the valve. Repeat this a few times to purge a majority of the air from the pump.
- 6. Rotate nut to extend screw all the way out, making sure cup does not run dry as water is drawn into the pump body. Add water to the cup as needed.
Note: screw withdraws approximately 6", after that, the nut will freely turn.
- 7. Close fill valve, then rotate nut to insert screw. The long copper line will begin to fill with water. Monitor the other end of the copper line where it connects to the bulkhead. Once water is seen to start dripping, tighten the flare nut securely using two 9/16" wrenches.
- 8. Proceed to charge the casing to a target pressure of 1000 psi. Recharge pump as needed. Record any minor sounds such as ticks. If any loud sounds such as 'crack' are heard, stop and record pressure at which sound occurs.

9. Disassemble apparatus and record any signs of damage to the casting tubes or to the propellant grain.

Recharging pump: Once the screw has been fully turned in, open the valve while placing your hand over the cup, as water may spray out due to possible residual air in the system. Refill the cup with water, then rotate the screw fully out to recharge. Close the fill valve.

Releasing pressure: To release pressure in system, simply loosen any flare nut joint. Wrap a cloth around joint while doing this to catch the water spray.

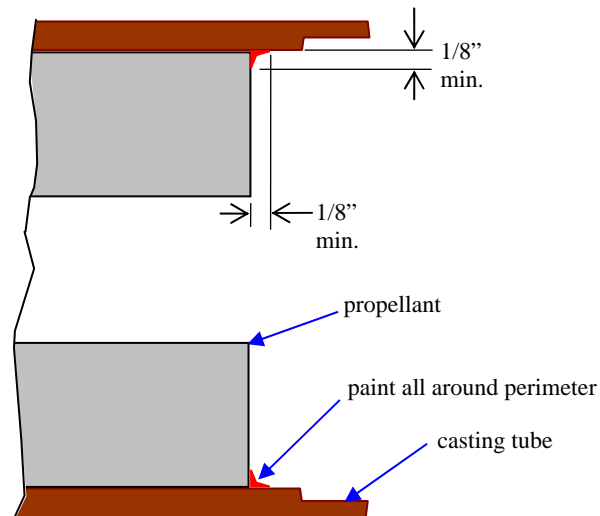


Figure 1

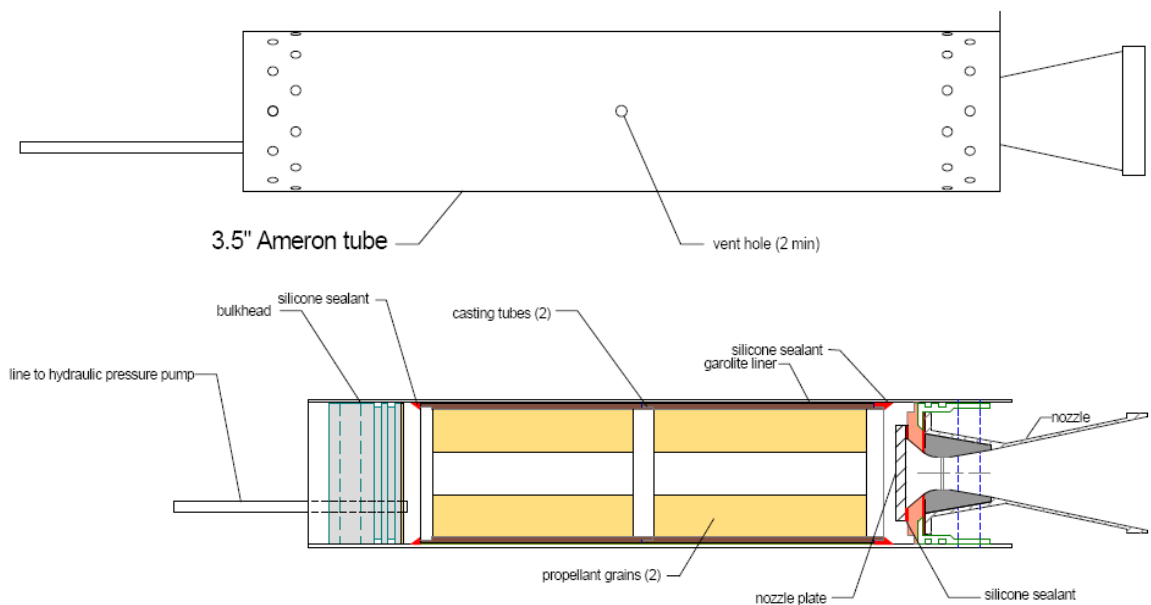


Figure 2

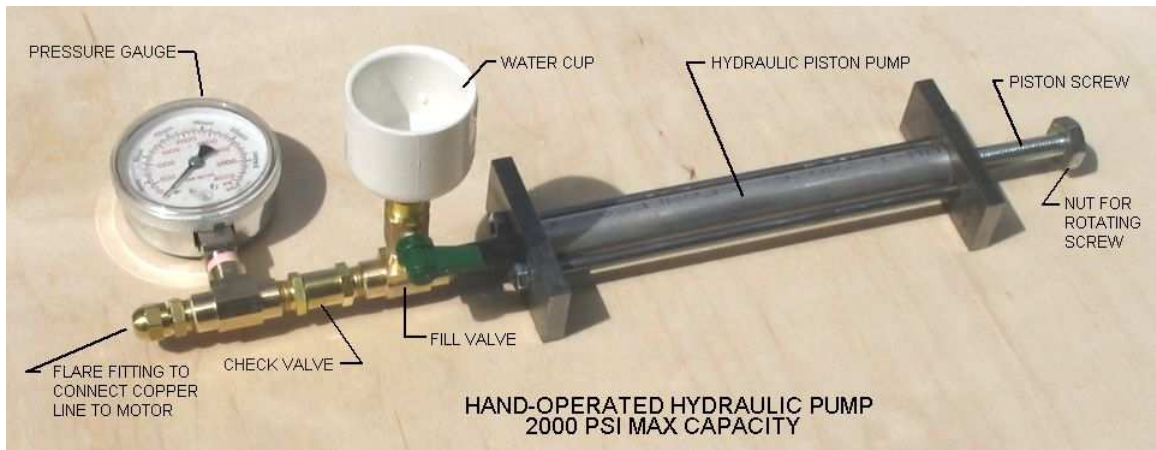


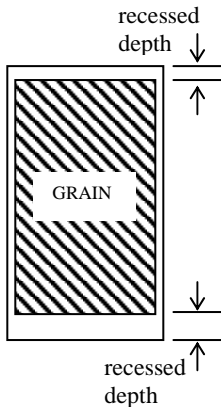
Figure 3

Appendix A

Casting tube inner diameter = 76.32 mm
 Core diameter = 25.45 mm

Grain ideal density = 1.841 gram/cc

Grain s/n	Mass of casting tube (grams)	Mass of casting tube + propellant (grams)	Length of casting tube (mm)	Recessed depth Top (mm)	Recessed depth Bottom (mm)	Grain length (mm)	Mass of propellant (grams)	Grain density ratio (actual/ideal)
13								
14								



Appendix B

Grain Joint Leak Check and Repair

This is a simple check that is meant to detect imperfections in the epoxied grain assembly joint that would result in a non pressure-tight seal. Although this check does not guarantee that joint is completely leak proof under high pressure, it will detect flaws in the joint that can be corrected prior to installing the grain assembly in the casing.

Set grain assembly horizontal on a table. Using a baster or other suitable syringe, carefully insert approximately 5 ml alcohol in the space between grains. Slowly rotate the grain assembly about its long axis. This will serve to wet the entire joint. Rotate several times, and observe for any signs of alcohol leaking to the exterior of the joint.

If a leak(s) is found, mark the location(s). Drain and allow to dry. Seal with epoxy using a similar technique, but do not rotate, instead allowing the epoxy to pool over the fault.