Blast Tube Motor – Guidelines for Preparation and Firing

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Author R.Nakka

Purpose

The purpose of this document is to provide guidelines for the preparation, firing and post-firing inspection of the Blast Tube Motor (BTM). The BTM is an experimental rocket motor that simulates, in part, a dual-phase firing. The objective of firing the BTM is to study the effect of the high-velocity exhaust flowing over ablative insulation specimens. The goal of the study is to develop an ablative insulation that will provide adequate thermal protection of a motor casing subjected to the harsh heating associated with dual-phase motor operation.

The BTM consists of two chambers – a forward chamber that houses the propellant grains, and an aft chamber that houses the tubular ablative specimen. The aft chamber is referred to as a *blast tube*. A mid-bulkhead, which connects the two chambers, also serves to locally channel the exhaust flow in a manner representative of dual-phase operation.

The BTM has provision for four KNSB propellant grains of BATES configuration, with grain dimensions as illustrated in the Appendix. Other grain configurations such as finocyl can be used, with care taken not to exceed a maximum Kn of 420.

The BTM is illustrated in Figure 1. A dimensionally detailed drawing is provided in the Appendix.

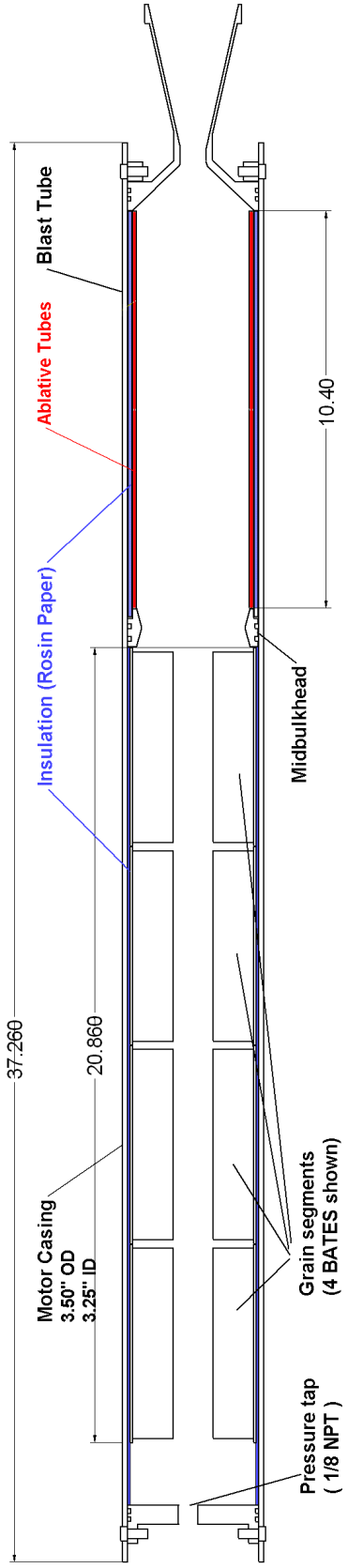


Figure 1 –BTM details

Preparation

1) The total length of the ablative tube specimen should be 10.40”, consisting of two equal sections of 5.20”, as shown in the Appendix. The two sections are to be bonded together using epoxy adhesive. A single length of 10.40” may alternatively be used.

2) Thermal labels are to be applied to outside of ablative tube specimen. Exact location of labels is not important. Figure 3 shows a suggested layout.
   340-380°F (yellow)
   450-500°F (gold)
   175-300°F (red) may be substituted for either

   Prior to applying the labels, clean the ablative tube surface with alcohol, lacquer thinner or other suitable cleaning agent.

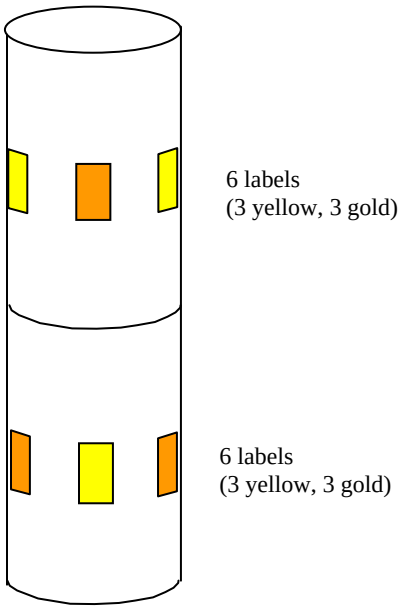


Figure 3 – Application of thermal labels on ablative tube specimen

3) Weigh and record the mass of the ablative specimen, with thermal labels attached.

   initial mass = _____ grams.

4) Measure and record the thickness of the ablative tube at a number of locations at each end.

5) Rosin paper is used for thermal insulation of <u>both</u> the motor casing and blast tube. The insulation for the both sections needs to be cut to the appropriate length, and the number of wraps needs to be determined based on the casting tube OD and the ablative tube OD. Use sufficient wraps to allow for a sliding fit without too much looseness.

   If grain segment ODs are not all the same, extra wraps of rosin paper should be wrapped around the smaller grains to bring them to them to the same OD as the larger grains.

   Place the grain segments with the extra wraps of insulation at the fore end of the casing, as the fore end receives greater heating.

   Rosin paper should be a heavier grade of thickness 9 mil. For reference, this is approximately the thickness of two sheets of standard bond paper (#20).

   For insulating the ablative tube (only), the rosin paper should be bonded at both fore and aft ends, as illustrated in Figure 2. The intention is to seal out hot exhaust gases from impinging directly on the thermal labels. Adhesive should be white (carpenter's) glue, diluted with water to allow easy application with a brush. Apply thermal labels prior to wrapping with insulation.

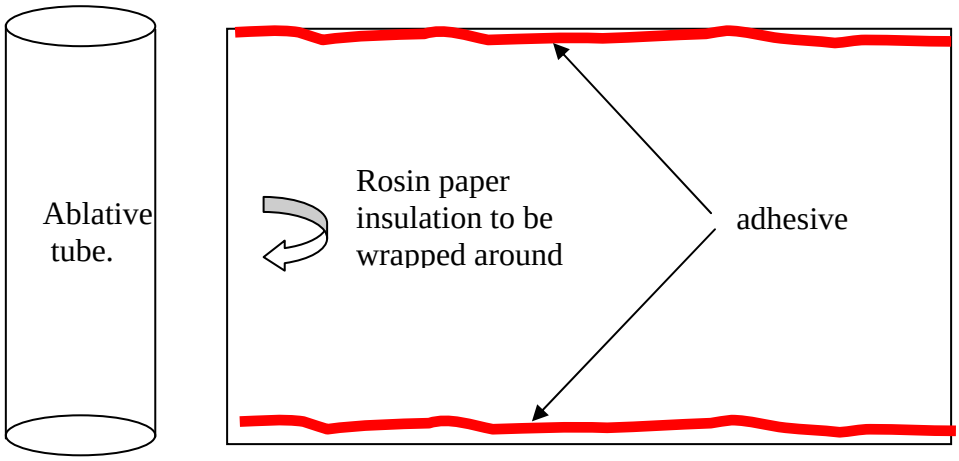


Figure 2 – Sealing rosin paper to ablative tube

6) If chamber pressure is not being measured, close off bulkhead pressure tap hole with 1/8 NPT plug sealed with teflon tape.

7) Bulkhead interior surface is to be thermally protected with one layer of 1/16" cork per expected firing. For example, if 3 firings are expected, 3 layers of cork can be applied without need to refurbish between firings. Bond cork using any suitable adhesive such as silicone.

Firing

1) Igniter composition is optional; 10 grams of copper thermite is recommended.

2) If chamber pressure is being measured, pressure gage reading is to be video recorded.

3) Make sure all piping connections from the bulkhead to the gage are fully tightened & properly sealed to prevent any leakage. Even small leakage can result is significant errors in pressure readings.

Post-firing

To preserve the thermal label readings, it is important to minimize the effect of post-firing heat soak. As such, the following steps should be taken:

I. If practical, the blast tube should be doused externally with water immediately after firing, while taking care to avoid wetting the rocket nozzle.

II. The motor should be opened up as soon as possible after firing in order to cool the ablative tubing specimen. To facilitate this, a power screwdriver with the appropriate hex key bit should be used

III. Once the ablative tube specimen has been extracted and the insulation removed, photos should be taken, paying particular attention to the thermal labels.

Post-firing Inspection

The following inspections may be done at any time post-firing.

1) Thermal label readings are to be recorded.

2) Ablative tube specimen is to be washed in hot water & soap to remove all exhaust residue and loose charred particles. The specimen should again be photographed.

3) Weigh and record the mass of the cleaned ablative specimen, with thermal labels still attached.

   clean post-firing mass = _____ grams.

4) The ablative specimen is to be cut lengthwise into two halves, in order to allow for more thorough inspection of the interior. The interior should then be photographed.

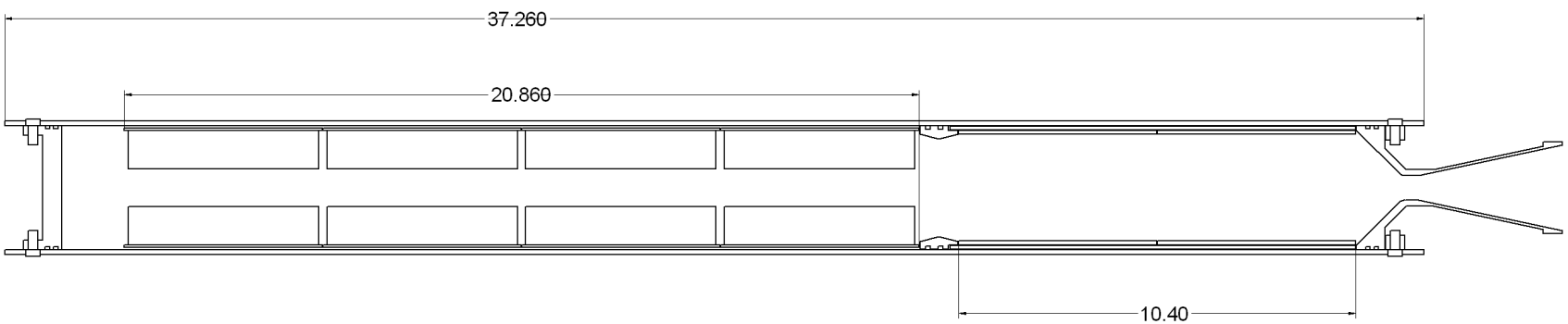
5) All the char should be scraped off the interior, leaving virgin ablative material.

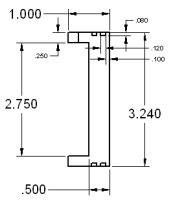
6) Weigh and record the mass of the de-charred ablative specimen (both halves), with thermal labels still attached.

post-firing mass of virgin material = _____ grams.

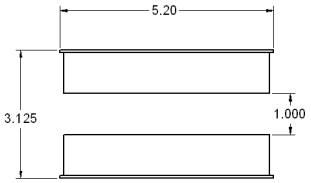
7) Measure and record the remaining thickness at several locations, at each end and along the cut length.

Appendix

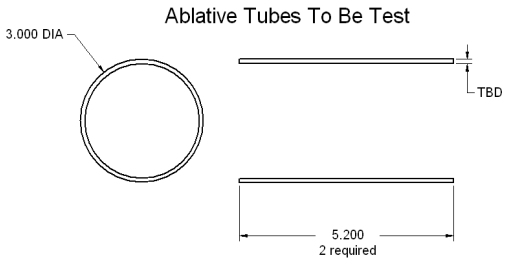


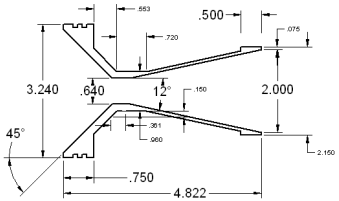


Bulkhead



Propellant Segment





Nozzle