



MiniSShot

Propulsion Team Debriefing Session relating to the
July 25th, 2009 Static Test Firing of the
ProtoSShot-M Mark III Rocket Motor

Rev. 2009/07/28

Propulsion Team Debriefing session to discuss MiniSShot static test firing of July 25th, 2009.

Date/time: July 26, 2009 5 PM - 7:30PM EDT (2PM – 4:30PM PDT)

Method: Skype conference call

Participants:

Matt Campbell
Chris King
Rick Maschek
Richard Nakka

Topics covered:

- 1) Overall observations
- 2) What went particularly well?
- 3) What did not go well?
- 4) What might be done to improve things next time?

Matt also put forth the following items for discussion:

- a) Assembly Manual/Checklist document changes and updates
- b) Thermal data acquisition system reliability
- c) Significance of Aft Casing discoloration
- d) Future flight plans / project schedule
- e) Status of the new FAR Large Horizontal Test Stand for future SS2S platforms
- f) Additional personnel resources for motor prep
- g) Establishing a photographic records directorate

1. Observations

- Overall, things went pretty smoothly.
- Matt assigned task ownership to those present which served well to organize the event.
- Motor assembly took 4-4.5 hours, which was comparable to past firing events, despite fewer assembly steps.
- Rick headed assembly of the motor and was helped by Paul Avery.
- At times, there were too many people around (non-project) which tended to be distracting.
- The intense heat at the site (est. 110°F) added difficulties to personnel and equipment. One positive consequence is that the motor has been proven under severe ambient conditions.

2. What went particularly well?

- Motor assembly went very smoothly as long as checklist was followed.
- Setup of data acquisition equipment went basically smoothly.
- Good thrust & pressure data was obtained.
- Test rig setup with metal clamps worked much better than previous arrangement.
- Despite initial misalignment of load cell bracket, rectifying the issue went smoothly.
- Lots of good video footage of test firing was obtained.

3. What did not go well?

- Missing a step in the Assembly Manual resulted in a twenty five minute effort to rectify.
- Temperature sensor did not work.
- Thermal Labels may not be sufficient to capture thermal history during firing.
- Bright ambient light made it hard to see computer screen.
- Ambient heat was hard on instruments.
- Small post-firing fire occurred at aft end of motor.
- Unclear directive with regard to post-firing directive.
- No snap ring pliers made unplanned field removal of thrust fitting difficult.
- Difficulty tightening igniter fitting.
- New load cell mount did not line up initially.
- Instrumentation calibration shifted over time, possibly from ambient heat.
- Instrumentation tent blew away.
- Forward bulkhead removal was difficult; no provision to rotate it.
- Lack of usual wind at site resulted in smoke obscuring the test firing video footage.

3. What might be done to improve things next time?

- Review the Motor Assembly Manual beforehand so ‘in field’ changes to procedure are minimized or eliminated (avoid risk associated with ad-hoc changes).
- Make sure Motor Assembly Manual is prepared sufficiently in advance of the test date to allow more time for review by team members.
- Have available a “one paragraph bullet list of test goals” available to make participants aware of priorities.
- Forward Bulkhead thrust fitting should be rotationally fixed to serve more effectively as a bulkhead removal aid.
- Determine beforehand what size spanners are needed for each motor part e.g. all items such as igniter fitting, and add notation to Assembly Manual. Also add to Checklist of Parts.
- Have greater chamfering of motor casing attachment holes to reduce risk of o-ring damage during installation of closures.
- Procedure for installation of closures with respect to aligning and installing attachment screws needs to be improved.
- Data Acquisition equipment should be housed in an air-conditioned environment.
- Increase chamfer on nozzle bell to eliminate personnel cut hazard.
- Sand bag tripods to prevent wind from tipping them.
- Revise Motor Assembly manual to replace e-match for 1st phase with high-current igniter, for enhance safety.
- Revise Motor Assembly manual procedure to have continuity check of e-match after assembly of thermite sack, then again after installation of Forward Bulkhead
- Instead of having the event begin at 9AM, consider an earlier start time to avoid high ambient temperatures at time of motor firing (motor was fired at 2:15 PM).
- The following items need to be added to the Checklist of Parts: 2” PVC x 4’ pipe with flat head for contingency disassembly of motor; small wrench (size TBD) for igniter fitting; deep socket wrench set; pair of leather gloves

Other items put forth for discussion

a. Assembly Manual/Checklist document changes and update

- Covered by above discussion

b. Thermal data acquisition system reliability

- Specifically relating to temperature sensors, a complete review of any proposed data acquisition system is recommended.
- Real-time thermal measurements of casing are very important and can serve to supplement Thermal Label readings to obtain a more precise temperature mapping and temperature history of the motor parts.

c. Significance of Aft Casing discoloration

After the firing, Matt recalled noticing a pronounced yellowing of the Aft Motor Casing. Entire Aft Casing was a different shade of white (yellowish) than Forward Casing. Rick recalled one spot the size of thumb near top of the Aft Motor Casing.

To enlighten the discussion, Rick then brought the two casing “to the table” for visual inspection and verbal description. Rick noted that discolouration began at the reinforcement just aft of the Mid-bulkhead and extended a distance of 10” toward the nozzle end. Thermal labels peaked at red maximum (300°F) but nothing registering on the yellow label (<340 °). Rick could not detect any clear yellowing of the Aft Casing under the present ambient lighting. It was agreed that Rick would photograph the two casings side by side in full daylight to obtain a more true colour comparison. Additionally, an action was assigned to both Matt and Richard to investigate the potential for any adverse permanent effects of exceeding the glass transition temperature (Tg) of epoxy such as that used for the casing.

d. Future flight plans / project schedule

It was agreed that a tentative MiniSShot launch date, assuming the motor will be deemed flight-worthy, should be arrived upon as soon as possible to maintain momentum of the project. It was suggested that this be opened up to discussion on the SS2S mailing list. The suggestion of a 3-4 month target date from today was agreed to be a viable starting point for discussion.

e. Status of the new FAR Large Horizontal Test Stand for future SS2S platforms

Matt & Richard were actioned to contact Kevin Baxter to discuss modification of the planned LHTS larger to accommodate our largest motor (est. length 20’)

f. Additional personnel resources for motor prep

Rick stated that the propellant casting and assembly went smoothly and was accomplished to high quality standards because there were minimal “hands in the pot” and as such, adherence to proper and careful procedure was possible. A key to this was having a reasonable timeframe within which to accomplish the tasks. Rick also mentioned that Paul Avery served well with regard to helping him assemble the motor and that Paul could be a value resource in the future. In particular, with propellant casting, as long as quality is emphasized and maintained.

g. Establishing a photographic records directorate

It was agreed that this topic could not be covered in satisfactory detail during this telecon, owing to the complexity of such a directorate. It was agreed that Dan Pollino could potentially be a valuable resource with regard to producing a video record of future events and that he should again be invited to participate.