



DoubleSShot

Boilerplate Motor

Propellant Casting & Grain Assembly

Rev. 2011/08/29

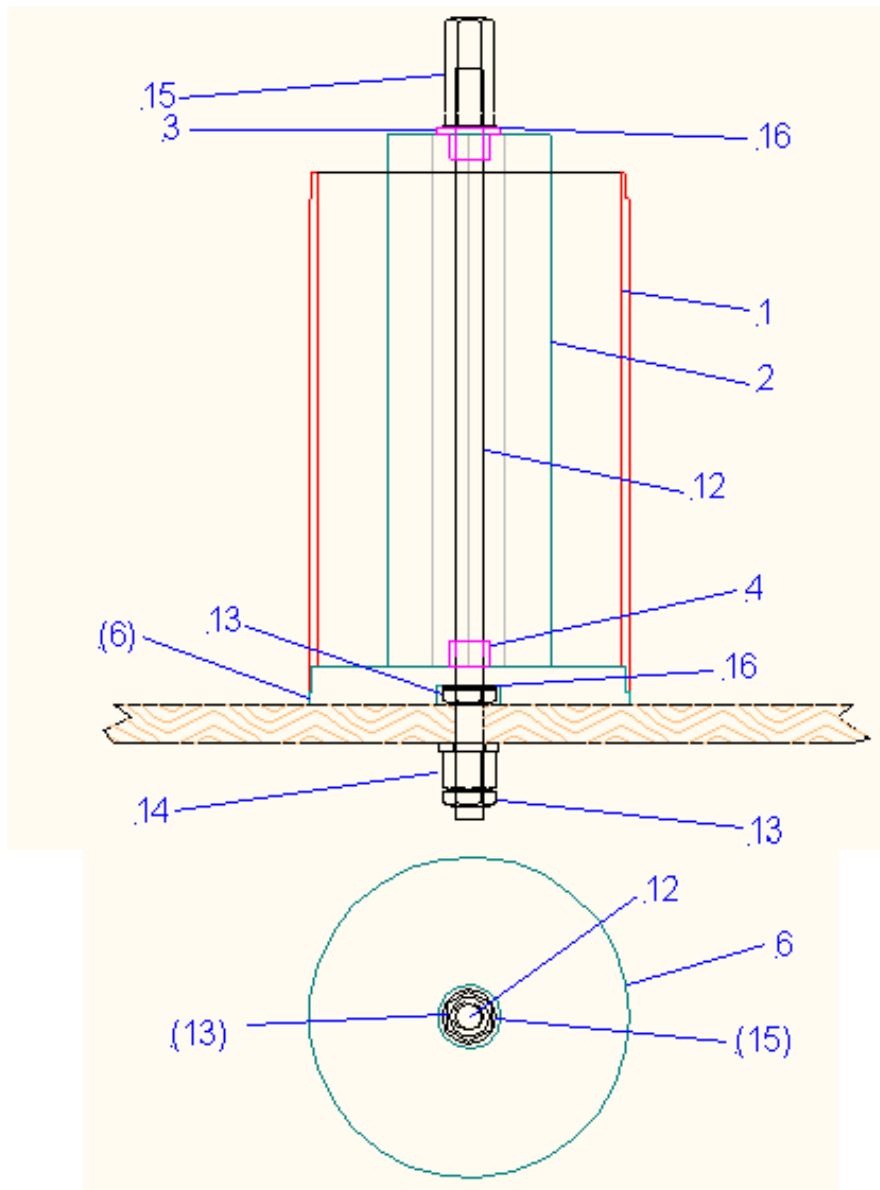
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General information

This document provides the procedure for preparing the propellant grains for the *DoubleSShot Boilerplate (DSS BP)* static test rocket motor. In particular instructions are provided for casting six individual grain segments, followed by assembly of the six segments into a single monolithic grain assembly. The propellant is standard potassium nitrate oxidizer and sorbitol fuel/binder of 65/35 O/F ratio (KNSB). Both the potassium nitrate and sorbitol must meet the suitability requirements specified in DSS WP#3a. The grain configuration is a 7-pointed star with burning restricted to the core. Assembly of the grain involves bonding the individual segments together at interfacing lap joints. The assembly process also incorporates the procedure for inhibiting both ends of each of the cast segments.

Pre-casting setup & assembly of mould

1. Pre-blend KN/sorbitol to 65/35 oxidizer/fuel ratio.
2. Accurately weigh all casting tubes individually and use Table 1 to record masses.
3. Apply PVC electrical tape around top end of casting tubes to protect flange lip from contamination.
4. Condition the Mandrel, Top Cap Assembly and Bottom Cap with a coat of suitable mould release.
5. Cut out several mylar donut-discs that have a diameter slightly less than the inner diameter of the casting tube. Cut a hole of 1" (approximately).
6. Assemble casting apparatus for propellant loading shown in Figure 1.
Notes:
 - a. Mylar discs should be held in place on Bottom Cap using a small amount of glue-stick adhesive.
 - b. After assembly of the components, secure the casting tube to the Bottom Cap using 3/4" polyester tape, one layer only. Overlap should be 1" maximum. Clean bonding surfaces beforehand with lacquer thinner or similar degreaser.
 - c. Verify the Top Cap slides freely in the casting tube top end.



Parts list		
No.	Item	Qty per assy
1	Casting tube	1
2	Mandrel	1
3	Upper bushing	1
4	Lower bushing	1
6	Bottom Cap	1
12	Threaded rod	9/16-18 NF x 14.75'
13	Hex jam nut	9/16-18 NF
14	Hex heavy nut	9/16-18 NF
15	Hex coupling nut	9/16-18 NF
16	Shim	4

Figure 1 – Setup for propellant loading operation.

7. Set up the steel reinforcing tube for the casting tube as follows (reference Figure 2):
- a. Place the PVC spacer into the steel reinforcing tube
 - b. Place the two band clamps into position and tighten up to remove slack in the clamps
 - c. Insert casting tube.
 - d. Slide one of the two plywood Formers onto the reinforcing tube, tapered side first. Snug up the band clamps, as needed, to fit the plywood Former.
 - e. Likewise, slide the second wooden Former into position
 - f. Place Top Cap into top of casting tube and verify it slides freely. If tight, loosen upper band clamp slightly until Top Cap is a sliding fit

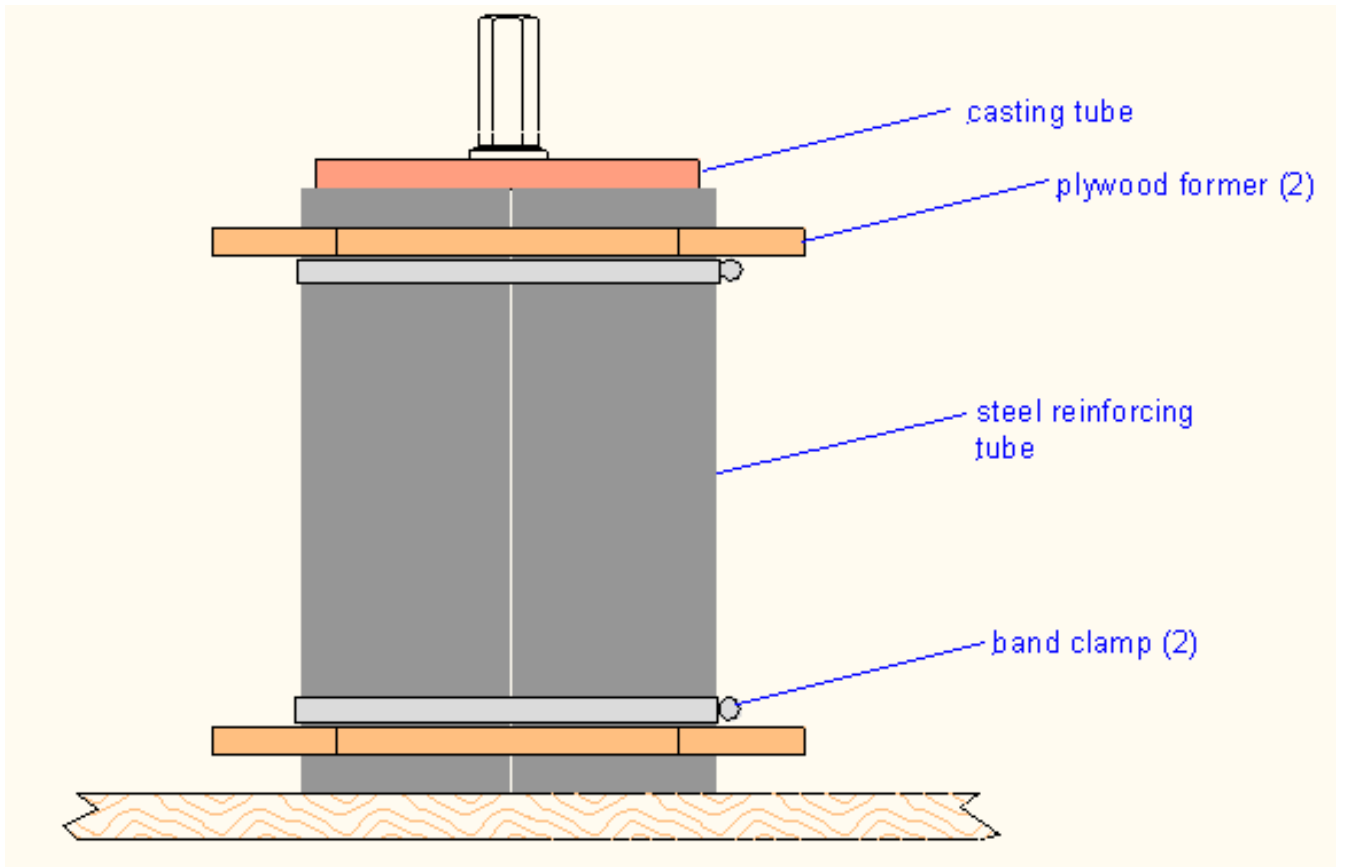


Figure 2 – Reinforcing tube setup

Casting procedure

8. Preheat heating vessel to temperature range of 250°F (120°C) to 285°F (135°C).
9. Weigh out enough powdered mixture for one segment (Table 2).
10. Incrementally add powdered mixture to the heating vessel. Allow melted slurry to reach target casting temperature 265°F (130°C) to 275°F (135°C). Do not allow temperature of propellant to exceed 285°F (140°C) for extended duration.
11. When heating vessel is full of melted slurry at the target temperature, transfer contents, into casting tube. Vibrate for at least five minutes after the last propellant is poured in. If several pours are required per grain, it should be vibrated during each pour
12. Repeat steps 9-10 until casting tube is completely full.
13. Slide Top Cap into place over mandrel and press down gently until it is slightly submerged (approximately 1/16").
14. As illustrated in Figure 3, install upper threaded rod into coupling nut and secure with jam nut.
15. Place compression tube, lower plate, spring, upper plate, two round shims, heavy hex nut and jam nut in place over the threaded rod. Snug up heavy hex nut until spring just begins to compress. Adjust jam nut until it makes contact with the heavy hex nut (do not tighten jam nut).
16. Slowly turn heavy hex nut and apply light compression until slurry begins to ooze out.
17. Allow propellant to cool until it reaches approximately 100°F (38°C).
18. Slowly turn heavy hex nut to apply compression. Continue turning until the heavy hex nut has moved one inch down (using jam nut as datum). Stop if propellant begins to ooze, and allow to further cure. Repeat, until heavy hex nut has been moved down one inch.
19. Allow propellant to cool completely.

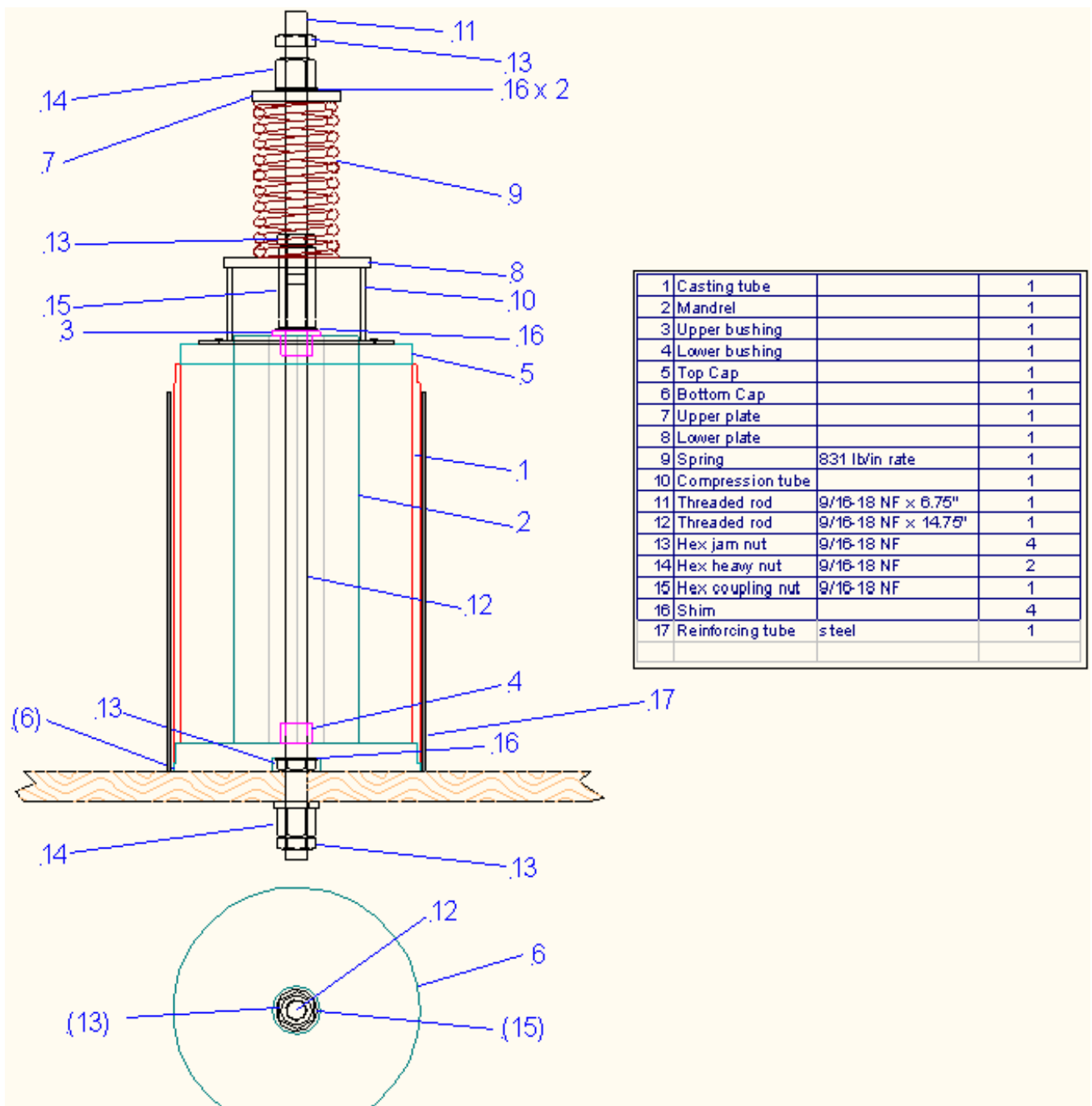


Figure 3 – Casting mould arrangement.

Disassembly, Topping-up & Storage.

- 20. Allow propellant to fully harden prior to releasing spring (minimum of 24 hours).
- 21. Disassemble compression hardware (jam nut, heavy hex nut, upper plate, spring, lower plate & compression tube).
- 22. Remove Top Cap using the Cap Removal Tool, as illustrated in Figure 4.
- 23. Use a circular level, make sure that the casting tube is completely level.
- 24. Measure out enough propellant powdered mixture to “top up”. Refer to Table 3.
- 25. Preheat heating vessel to temperature range of 250°F (120°C) to 285°F (135°C).
- 26. Add the powdered mixture to the heating vessel. Allow melted slurry to reach target casting temperature 265°F (130°C) to 275°F (135°C). Do not allow temperature of propellant to exceed 285°F (140°C) for extended duration.
- 27. Transfer contents into mould until casting tube is completely full.
- 28. Allow to fully cool.
- 29. Clean the exterior surface of each casting tube to remove all traces of propellant. Use hot water to aid removal if necessary (water is not harmful to the casting tube ablator).
- 30. Remove Bottom Cap. A wooden dowel may be used to aid removal. After inserting dowel into core, use a mallet to gently tap on top end of the dowel.
- 31. Weigh each grain segment and record individual weights using Table 1. Measure and record depths of each recessed end, and casting tube lengths.
- 32. Store grain in a deep freeze.

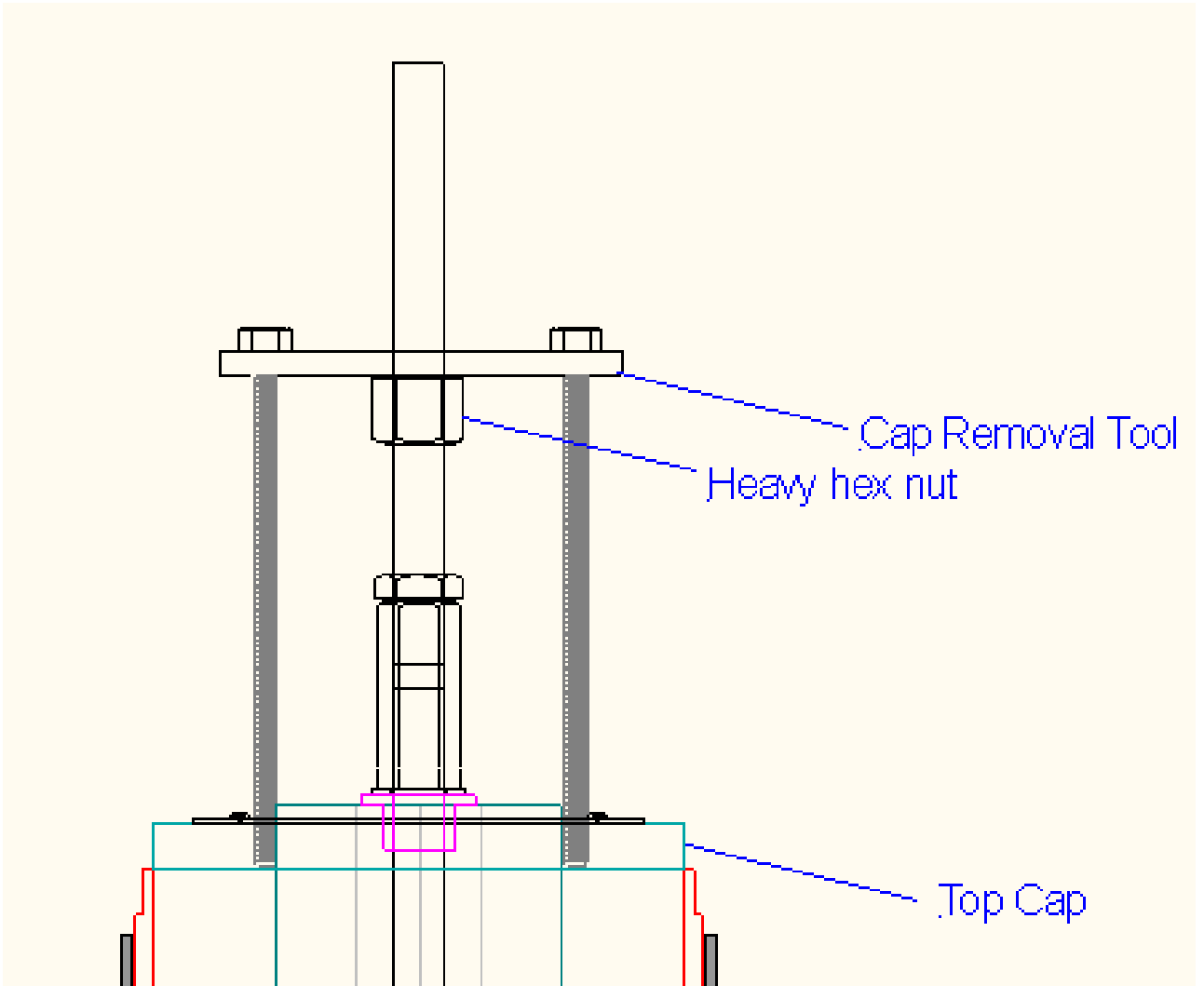


Figure 4 – Removal of Top Cap

Assembly of Grain Segments

| Note: Grain Assembly Jig must be used during assembly to prevent toppling

- 33. Remove grains from deep freeze 24 hours prior to assembly.
- 34. Prior to assembling, trial fit each individual grain separately in a Motor Chamber to verify that the fit is free without binding or excessive friction.
- 35. Clean end faces of mating propellant grains to remove mandrel release agent.
- 36. Clean mating surfaces (flanges) of all casting tubes with lacquer thinner.
- 37. Prior to bonding, do a trial assembly of two mating segments to ensure a good fit.
- 38. Apply silicone adhesive over the entire end surfaces of both mating grains, making sure to leave no gaps in coverage. The surface of the adhesive should be at, or slightly above, the level of the flange lip, as illustrated in Figure 5.
Note: Use GE Silicone Type I or equivalent
- 39. Replace Bottom Cap into lower casting tube for support.
Note: Bottom Cap should be modified by enlargening the hole to accept 1" Schedule 40 pipe.
- 40. Prepare a batch of well-blended, quality epoxy adhesive.
- 41. Apply a light coat of epoxy over both male and female flange surfaces of mating tubes.
- 42. With lower tube to be joined lying upright on a firm, flat surface, fully press mating tube in place.
- 43. Wipe off excess adhesive on outside surface of joint.
- 44. Repeat process (steps 38-42) for remaining tubes. Figure 6 illustrates assembled grain joint.
- 45. Slide motor casing over assembled grains.
- 46. Allow adhesive to fully cure before laying grain assembly horizontal

Note: Grain assembly must not be removed from casing without providing suitable support over its entire length, else fracture could occur.

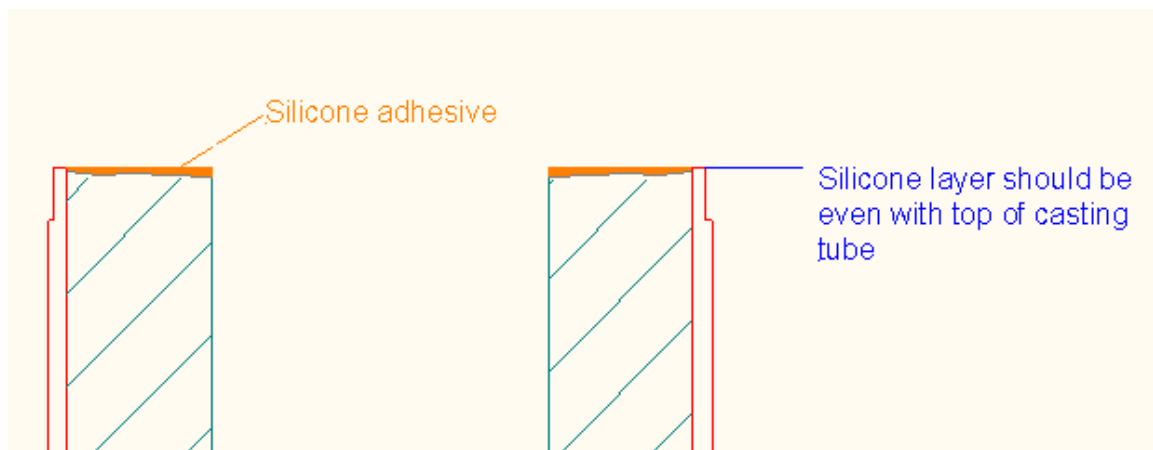


Figure 5 – Application of silicone adhesive

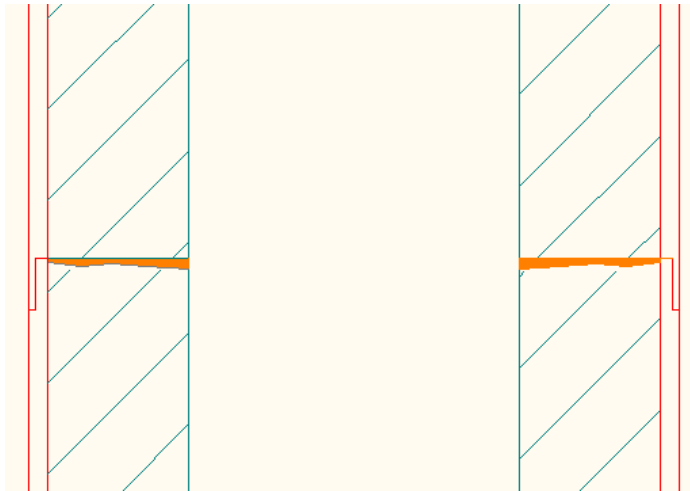
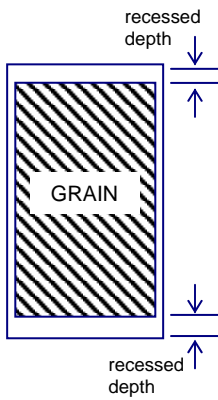


Figure 6 – Joint detail of two assembled grains

IMPORTANT NOTE: The scope of this document does not include complete information on safety precautions that must be followed. Refer to other sources for such information. Recommended safety wear, as a minimum, are protective glasses, clear faceshield, leather gloves, and leather or heavy jacket (long sleeves).



Grain s/n	Mass of casting tube (grams)	Mass of casting tube + propellant (grams)	Length of casting tube (mm)	Recessed depth	
				Top (mm)	Bottom (mm)
1	423				
2	463				
3	486.5				
4	502				
5	486				
6	519				
1F	224				
2F	224				
3F	211				
4F	216				
5F	209				
6F	216				

* S/N 1 is nearest nozzle

Table 1 – Recording sheet for grain masses and dimensions.

	Aft chamber	Forward chamber
	grams	grams
KNO3	4609	4561
sorbitol	2482	2456
Total	7091	7017
<i>Includes 5% extra for wastage</i>		

Table 2 – Propellant masses required per grain segment.

Topping-up Depth	Mass propellant required
cm.	grams
0.5	137
1.0	274
1.5	411
2.0	548
2.5	685
3.0	822
<i>Wastage not accounted for</i>	

Table 3 – Guide to “Topping up” propellant masses required per grain segment.