



MiniSShot

ProtoSShot-M Mark II Rocket Motor

Assembly & Propellant Loading Manual

Rev. 2008/11/17

Introduction

This document describes the procedures required to assemble the *ProtoSShot-M Mark II* rocket motor and to load the propellant charges and igniter systems. The *ProtoSShot-M Mark II* motor incorporates design improvements over the *Mark I* version of the motor which was test-fired in April 2008.

The *ProtoSShot-M Mark II* motor is illustrated in Figure 1.

Instructions -- Check off the box on the left side upon completion of each step.

Parts listing

<u>P/N</u>	<u>Qty.</u>	<u>Description</u>
P0	1	Aft motor casing
P1	1	Forward motor casing/thermal insulation assembly
P2	1	Phenolic thermal casing liner (pre-cut to 32.25" in length)
P3	1	Nozzle assembly
P4	1	Mid-bulkhead/Delay Plug/Burst Diaphragm assembly
P5	1	Forward bulkhead
P6A	6	Propellant grain segment, aft chamber (titanium liner)
P6B	6	Propellant grain segment, forward chamber (phenolic liner)
P7A	1	0.060" cork sheet, cut to size as grain insulation (41.5 cm x 24.4 cm)
P7B	1	0.060" cork sheet, cut to size as grain insulation (42 cm x 24.4 cm)
P8	a/r	White carpenters glue
P9	5	Coupler Rings
P10	1	Head-end Ring
P11	a/r	Intumescent paint
P12	a/r	Aluminum foil tape, 1.8" width or similar
P13	a/r	Stainless steel foil tape, 2" width
P14	8	O-ring, -234, nitrile (Buna-N)
P15	96	#8-32x1/4 custom shoulder screw
P16	a/r	Silicone grease, Dow Corning 111 or equivalent
P17	a/r	Silicone rubber sealant (type I) or RTV
P18	a/r	Lacquer thinner or acetone
P19	2	Pyrotechnic igniter ("electric match")
P20	a/r	Ignition Primer Slurry. Prepare by mixing 70% IPA with a blend of finely pulverized mixture of potassium nitrate and charcoal, to the mass ratio of 80/20. Slurry consistency should be that of thick paint.
P21	2	Primary Igniter charge containing 10 grams of CuO/Mg or CuO/Al thermite
P22	1	Wooden dowel, 1/4" diameter x 3' (min.)
P23	1	Aft-end Ring
P24	a/r	Roll of 5" stretch wrap plastic film.
P25	a/r	Kwik J-B Weld

Tools required

T1	Allen (hex) key, 9/64"
T2	Centre punch, tapered
T3	Wooden craft sticks
T4	Small paint brush
T5	Grain alignment tool (angle or channel section, minimum length 3')
T6	Medium paint brush

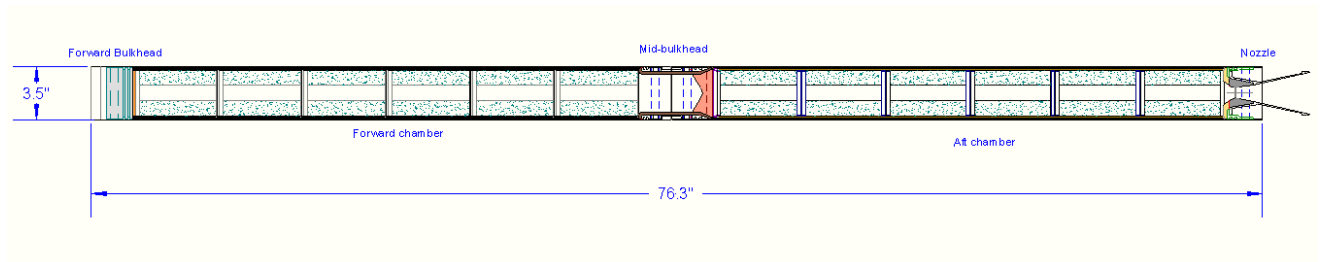


Figure 1 – Basic dimensions and components of the Mark II motor assembly

NOTE: STEP I SHOULD BE COMPLETED A MINIMUM OF 24 HOURS PRIOR TO ASSEMBLY OF MOTOR . STEPS II THROUGH IV SHOULD BE DONE AT LEAST 4 HOURS PRIOR.

I. Priming of Propellant Segments

1. Prepare Ignition Primer slurry (P20) and paint onto both ends of all 12 propellant grain segments (P6A, P6B), as shown in Figure 2, using small paint brush (T4).
Optional: paint core to within 1" of each end.

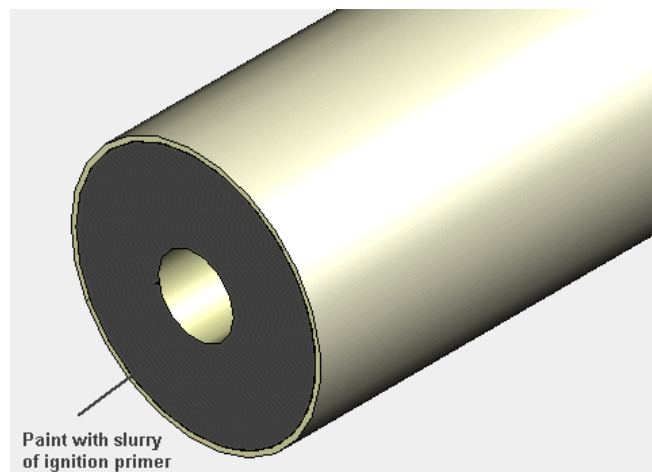


Figure 2 – Priming of propellant segments

II. Assembling Propellant Grain for Aft Chamber (titanium casting tubes)

1. Using lacquer thinner (P18), clean outer surface of all 6 “aft” propellant segments (P6A).
2. Place two grain segments onto Grain Alignment Tool (T5), per Figure 3.
3. Apply a light film of silicone adhesive (P17) onto one Coupler Ring (P9).
4. Apply a light film of silicone adhesive (P17) onto the interior of both casting tubes in the region that mate with the Coupler Ring
5. Butt the grain segments fully together with the Coupler Ring between. Use finger to smooth the silicone at joints and to remove any excess.
6. Cut a length of 2” stainless steel foil tape (P13) 10” in length, and carefully wrap around joint, centering tape over joint. Using a suitable tool, press the tape firmly all around to ensure good adhesion.
7. Repeat step 6 to install a second layer of foil tape over the first layer.
8. Repeat steps 3-7 for mating the remaining 4 segments, per Figure 3
Note: do NOT install a Coupler Ring at aft end of grain assembly.
9. Install the Head-end Ring (P10) at the forward end of grain assembly, using silicone adhesive (P17) to retain the Ring.
10. Measure overall length of grain assembly (ref. Fig.3). Maximum permissible length is 33.188”. If length is greater than this, trim tubing off of aft end.
11. Install the Aft-end Ring (P23) into the aft end of grain assembly, using silicone adhesive (P17) to retain the Ring. Ring should be submerged flush with the end of the tube.
12. Cut 2 pieces of aluminum foil tape (P12) of length 16.5 inches.
13. Prepare approximately 2 oz. of adhesive mixture for bonding cork grain insulator to grain assembly. This is prepared by mixing 2 parts carpenter glue (P8) to 1 part water.
14. Using medium brush (T6) coat one-side surface of cork sheet (P7A) with adhesive mixture.
15. Roll cork insulator around grain assembly. Lengthwise edges should form a butt joint.
16. Position piece of aluminum foil tape (step 10) lengthwise over the joint and press firmly into place, making certain the cork sheet remains snug in contact with the grain over the full surface.
17. Repeat steps 12 to 14 for second cork sheet (P7B).
18. Trim excess cork (if any) from end of grain assembly.
19. Using roll of stretch wrap (P24), tightly wrap the entire grain assembly in a “candy-cane” manner. Start at one end and work toward the other end.
20. Place the grain assembly in the Grain Alignment Tool and allow adhesives to cure.

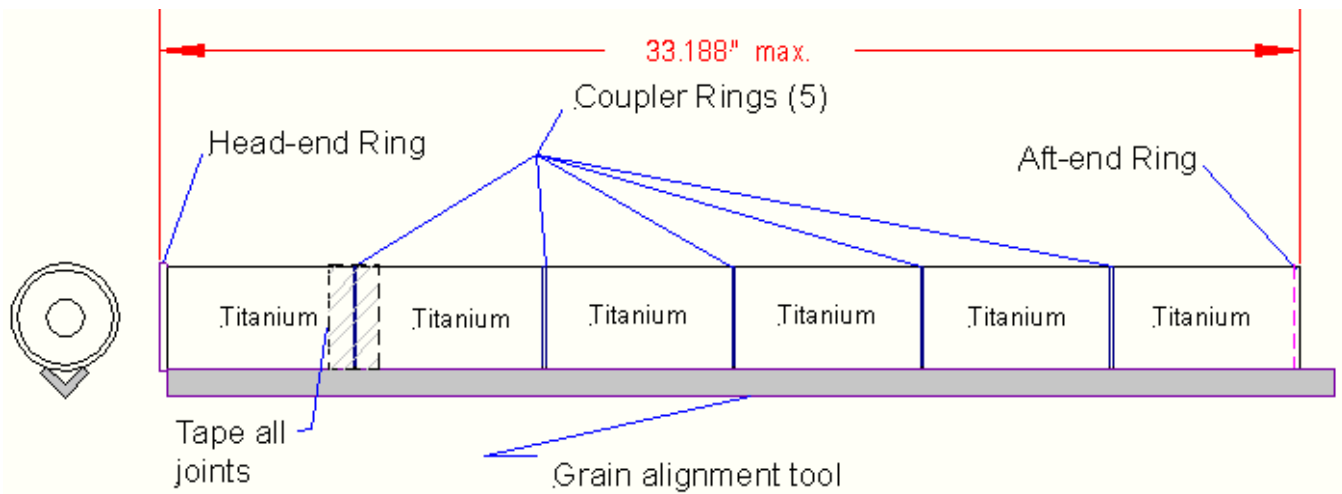


Figure 3 – Assembling grains for Aft Chamber

III. Assembling Propellant Grain for Forward Chamber (phenolic casting tubes)

1. Using lacquer thinner (P18), clean outer surface of all 6 propellant grains (P6B).
2. Place two grain segments onto Grain Alignment Tool (T5), per Figure 4.
3. Apply a light film of silicone adhesive (P17) onto ends of both casting tubes.
4. Butt the grain segments fully together. Use finger to smooth the silicone at joints and to remove any excess.
5. Cut a length of 2” stainless steel foil tape (P13) 10” in length, and carefully wrap around joint, centering tape over joint. Using a suitable tool, press the tape firmly all around to ensure good adhesion.
6. Repeat steps 3-5 for mating each of the remaining 4 segments, per Figure 4.
7. Measure overall length of grain assembly (ref. Fig.4). Maximum permissible length is 32.875”. If length is greater than this, trim tubing off of aft end

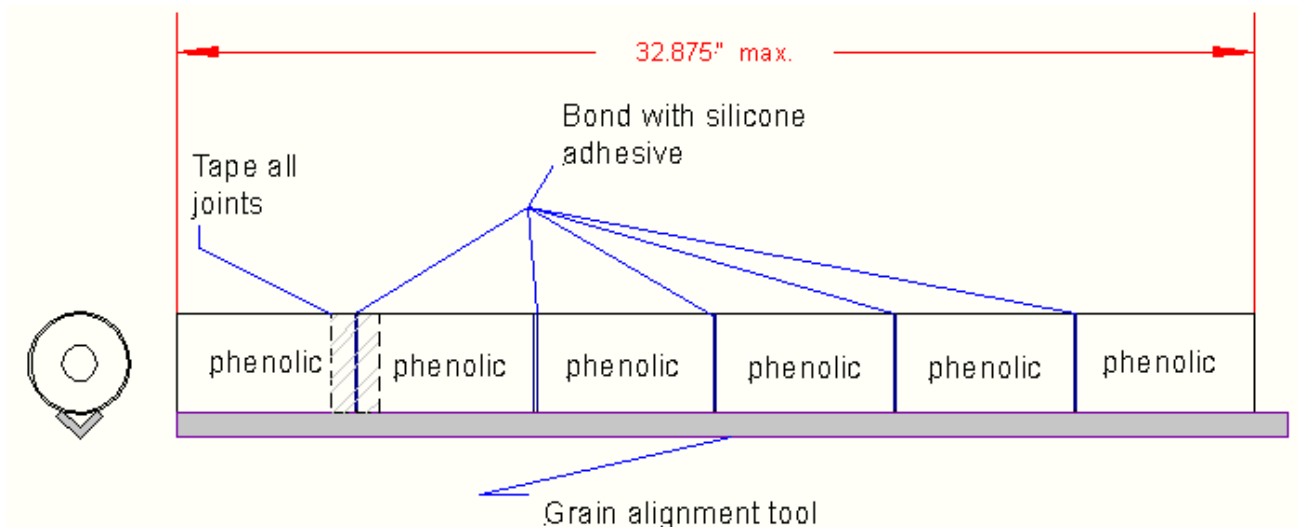


Figure 4 – Assembling grains for Forward Chamber

IV. Preparation of Phenolic Thermal Liner

- 1. Paint the Phenolic Thermal Liner (P2) with 2 coats of intumescent paint (P11) on exterior surface. Allow to dry between coats.

V. Installation of Nozzle Assembly into Aft Casing

- 1. Fill Nozzle (P3) o-ring grooves with silicone grease (P16) using a craft stick (T3). Coat two o-rings (P14) with silicone grease.
- 2. Install both o-rings into grooves.
- 3. Coat inside of Aft Casing (P0), aft end, with silicone grease.
- 4. Line up attachment holes in nozzle with attachment holes in casing and firmly push nozzle into casing. Push in far enough that holes are lined up as closely as possible.
- 5. Using centre punch (T2), align holes by inserting punch into hole and gently prying nozzle into aligned position. Do not use excessive force.
- 6. Install, but do not tighten, 24 screws (P15), using hex key (T1). DO NOT USE POWER DRIVER
- 7. Tighten all screws, one by one, until firmly seated. Finish by torquing hand-tight. Do not over-tighten. Order of tightening is not important.

VI. Installation of Phenolic Thermal Liner into Aft Casing

- 1. Slide Phenolic thermal Liner (P2) into Aft Casing (P0) until it seats against the Nozzle Assembly.

VII. Forward Motor Casing preparation

- 1. Using lacquer thinner (P18) on a piece of cloth, wipe clean the surface of the strip of aluminum tape on interior of Forward Casing (this tape covers the cork seam).
- 2. Cut a 33" length of stainless steel foil tape (P13).
- 3. Carefully apply the stainless tape onto the aluminum foil tape. Centre the tape over the cork seam. Note that the aluminum tape *may not have been centered* over the seam.
- 4. Using a suitable tool, press firmly down along the entire length of the tape to ensure a positive bond.

VIII. Installation of Mid-bulkhead Assembly into Forward Motor Casing.

Important: Make sure thermal sensor labels are installed on the Mid-bulkhead prior to assembly.

- 1. Protect exposed surface of Delay Plug from contamination by wrapping end of Mid-bulkhead (P4) with poly wrap held in place by elastic band (ref. Fig.5).

- 2. Fill the two forward o-ring grooves (nearest the burst diaphragm) with silicone grease (P16) using a craft stick (T3). Coat two o-rings (P14) with silicone grease.
- 3. Install both o-rings into grooves.
- 4. Lightly coat inside of Forward Casing (P1), aft end, with silicone grease.
- 5. Line up attachment holes in Mid-bulkhead with attachment holes in casing and firmly push Mid-bulkhead into casing. Push in far enough that holes are lined up as closely as possible.
- 6. Using centre punch (T2), align holes by inserting punch into hole and gently prying Mid-bulkhead into aligned position. Do not use excessive force.
- 7. Install, but do not tighten, 24 screws (P15), using hex key (T1). DO NOT USE POWER DRIVER
- 8. Tighten all screws, one by one, until firmly seated. Finish by torquing hand-tight. Do not over-tighten. Order of tightening is not important.

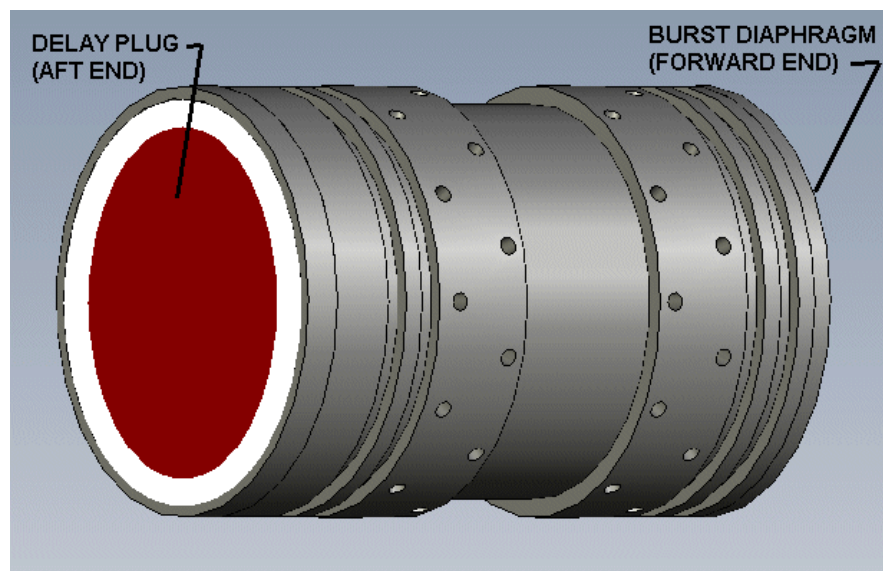


Figure 5 – Mid-bulkhead assembly, indicating Delay Plug (aft end) and Burst Diaphragm

IX. Loading Propellant Grain into Aft Motor Casing

- 1. Remove stretch wrap from Aft Grain Assembly
- 2. Insert Grain Assembly into Thermal Liner in Aft Casing and slide fully in. Make certain grain Head-end Ring is installed facing forward (toward Mid-bulkhead).

X. Installation of Mid-bulkhead/Forward Casing Assembly into loaded Aft Casing

- 1. Do a trial fit of Midbulkhead into aft casing by inserting Midbulkhead until attachment holes line up.
- 2. Fill the two o-ring grooves of Mid-bulkhead with silicone grease (P16) using a craft stick (T3). Coat two o-rings (P14) with silicone grease.
- 3. Install both o-rings into grooves.

- 4. Apply a generous amount of silicone grease in the ablative “step” adjacent to the burst diaphragm, as illustrated in Figure 6.
- 5. Lightly coat inside of Aft Casing with silicone grease. .
- 6. Remove protective poly bag covering Delay Plug (*be careful not to contaminate surface*)
- 7. Line up attachment holes in Mid-bulkhead with attachment holes in casing and firmly push Mid-bulkhead into casing. Push in far enough that holes are lined up as closely as possible.
- 8. Using centre punch (T2), align holes by inserting punch into hole and gently prying Mid-bulkhead into aligned position. Do not use excessive force.
- 9. Install, but do not tighten, 24 screws (P15), using hex key (T1). DO NOT USE POWER DRIVER
- 10. Tighten all screws, one by one, until firmly seated. Finish by torquing hand-tight. Do not over-tighten. Order of tightening is not important.

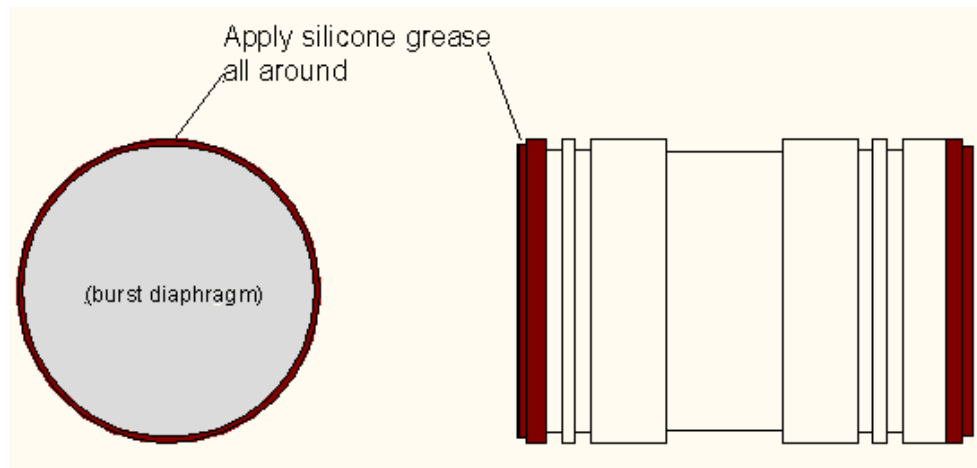


Figure 6 – Application of protective silicone grease on Mid-bulkhead

XI. Loading Propellant into Forward Motor Casing

- 1. Insert grain assembly (from step III) into casing and slide fully in until seated against Mid-bulkhead. Install end with outside chamfer first (toward Mid-bulkhead).

XII. Igniter Installation in Forward Bulkhead

- 1. Insert igniter leads through 0.109” hole in Forward Bulkhead. Seal wires in hole using Kwik J-B Weld (P25). Allow to cure undisturbed.
- 2. Prepare a 10 gram charge of Thermite (P21),:
 - 8.2 grams CuO & 1.8 grams Aluminum, blend thoroughly or
 - 7.7 grams CuO & 2.3 grams Magnesium, blend thoroughly
- 3. Place thermite charge in poly bag together with electric igniter (P19) and seal.
- 4. Perform igniter continuity check.

- 5. Shunt the lead wire pair for safety.

XIII. Installation of Forward Bulkhead into loaded Forward Motor Casing

- 1. Do a trial fit of Bulkhead into casing by inserting Bulkhead until attachment holes line up.
- 2. Confirm that pressure port fitting is installed in bulkhead and tightly fastened (ref. Fig.7)
- 3. Fill the two o-ring grooves of the Forward Bulkhead (P5) with silicone grease (P16) using a craft stick (T3). Coat two o-rings (P14) with silicone grease.
- 4. Install both o-rings into grooves.
- 5. Apply a generous amount of silicone grease on the bulkhead around the edge of the cork liner, as illustrated in Figure 7.
- 6. Lightly coat inside of Forward Casing (non-insulated portion only) with silicone grease.
- 7. Line up attachment holes in Forward Bulkhead with attachment holes in casing and firmly push bulkhead into casing. Push in far enough that holes are lined up as closely as possible.
- 8. Using centre punch (T2), align holes by inserting punch into hole and gently prying bulkhead into aligned position. Do not use excessive force.
- 9. Install, but do not tighten, 24 screws (P15), using hex key (T1). DO NOT USE POWER DRIVER
- 10. Tighten all screws, one by one, until firmly seated. Finish by torquing hand-tight. Do not over-tighten. Order of tightening is not important.

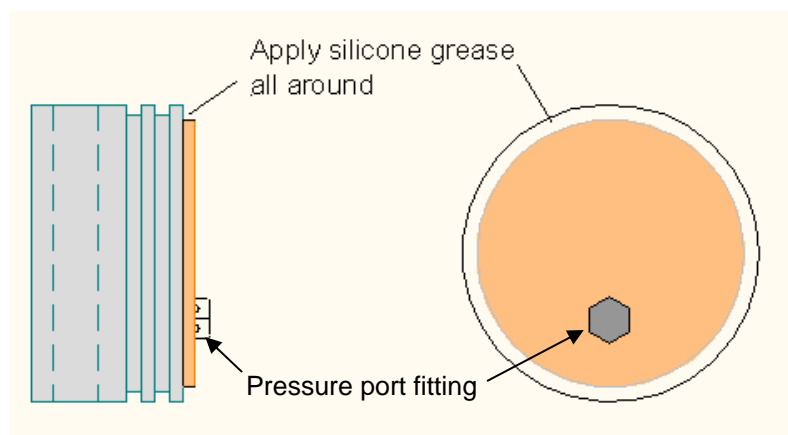


Figure 7 – Application of protective silicone grease on Forward Bulkhead

XIV. Handling and Storage

- 1. Seal the nozzle to avoid moisture and FOD ingress.

XV. Installation of Igniter into Aft Motor Casing

1. Stretch out igniter (P19) leads and attach to tip of wooden dowel (P22) with tape.
2. Insert through nozzle opening and secure in position.
3. Perform igniter continuity check.
4. Shunt the other end of lead wire pair for safety.

Firing and Post-firing Notes

1. Delay period between firing of the two phases is 10 seconds. This is the duration between 1st phase burnout and pressing of 2nd phase ignition button. First phase burnout is to be judged audibly by cessation of flow noise
2. Motor disassembly (nozzle & bulkhead removal) should be done as soon as possible after firing, to minimize seizure of components within the casings. Take great care to avoid damage to the casings as these are to be re-used. If excessive effort is needed, abandon disassembly & consult with Propulsion Leader as to course of action to be taken.