Rocket Assembly Procedure

Vidar III, IREC 2017

Compiled on 2018-01-29

Contents

This document contains the following:

Engine Assembly Checklist

Oxidizer Tank Assembly

1 ☐ Injector Bulkhead

2 ☐ Make sure the injector bulkhead is sanitized, all the openings are sealed, and all the old o-rings are removed

3 ☐ Prepare the pellet fuse assembly by epoxying the fuse to the pellet. Ensure that the epoxy layer is thin and the connection is rigid

4 ☐ Ensure you are wearing gloves when working with any components of the oxidizer tank

5 ☐ Make sure the vent bulkhead is sanitized, all the openings are sealed, and all the old o-rings are removed

6 ☐ Install the 3" dip tube

7 ☐ Remove the rubber plug to install vent plug. Ensure the Teflon is not too thick or too wide. Extra thickness of Teflon tape will lead to improper installation, and extra width of Teflon tape can block the vent hole from the inside

8 ☐ Seal the vent plug with aluminium foil and masking tape

9 ☐ Install oxidizer tank external o-rings (size: 238) with o-ring lubricant

10 ☐ Align the vent bulkhead to the fill port. Make sure the vent hole is on the opposite direction as the fill port

11 ☐ Ensure to use the correct (shorter) O-ring fillers

12 ☐ Insert vent bulkhead in the oxidizer tank

13 ☐ Check if any of the O-rings ruptured during installation through the bolt holes. If so, remove vent bulkhead, replace O-rings, and reinstall bulkhead

14 ☐ Fasten with twelve 1/4"-28 (1/2") screws

15 ☐ Install check valve on the other side of the injector bulkhead. Ensure that it is in proper orientation by observing the flow direction arrow on the side of the check valve. This should be pointing up towards the oxidizer tank after installation

16 ☐ Install piston o-ring (size: 112) with o-ring lubricant

17 ☐ Install piston. Make sure the piston is installed in the proper orientation, with the more heavily chamfered/dented side facing towards the oxidizer tank

18 ☐ Install injector o-ring (size: 031) with o-ring lubricant

19 ☐ Place pellet inside injector with the fuse sticking out of the central hole

20 ☐ Cap the injector on the piston and bolt it down using six 6-32 screws

21 ☐ Use a plug to seal the fill port

22 ☐ Install oxidizer tank external o-rings (size: 238) with o-ring lubricant

23 ☐ Make sure oxidizer tank is sanitized

24 ☐ Ensure to use the correct (shorter) O-ring fillers

25 ☐ Insert injector bulkhead to the oxidizer tank

26 ☐ Check whether any of the O-rings ruptured during installation through the bolt holes

27 ☐ Check if the O-ring fillers ruptured after installation

28 ☐ Fasten with twelve 1/4"-28 (1/2") screws

Combustion Chamber Assembly

1 ☐ Align fuel grain to injector ports (align one star corner to one injector port)

2 ☐ Align bulkhead holes on injector bulkhead to retaining ring holes to help the alignment in the previous step

3 ☐ Mark alignment using a permanent marker

4 ☐ Make sure the nozzle is cleaned (using a toothbrush), and all the old o-rings are removed.

5 ☐ Install o-rings on the nozzle (size: 236) with o-ring lubricant

6 ☐ Wrap o-rings in a thin layer of painters tape to keep it clean

7 ☐ Place nozzle on retaining ring

8 ☐ Apply high temperature caulking on female lip of fuel grain

9 ☐ Use a popsicle stick to evenly spread the caulking

10 ☐ Add a little caulking on the male end of the nozzle

11 ☐ Use a popsicle stick to evenly spread the caulking

12 ☐ Join fuel grain and the nozzle together

13 ☐ Clean excess caulking using paper towel

14 ☐ Ensure the caulking did not spread on to the o-rings

15 ☐ Align combustion chamber to the retaining ring

16 ☐ Place fin can on the bottom of combustion chamber, but do not fasten

17 ☐ Take off the tape on the nozzle o-rings

18 ☐ Slide the combustion chamber and fin can onto the fuel grain assembly

19 ☐ Make sure no component of the fuel grain assembly rotates

20 ☐ Rotate the fin can until the bolt hole for rail button and the pre-marked fill port location are 90 degrees apart clockwise.

21 ☐ Screw the fin can in using ten 1/4"-28 (5/8") screws and a 1/4"-28 (1") screw with rail button

22 ☐ Ensure that the rail button is between two fins

23 ☐ Install the break link adapter onto the retaining ring using a 1/4"-28 (1.5") screw

24 ☐ Join the end of ignition wiring to a thin tube using masking tape

25 ☐ Pass this tube through the fuel grain and nozzle while making sure not to damage the nozzle

26 ☐ Support the engine so that the ignition wires are not pinched underneath the retaining ring

27 ☐ Apply caulking to the male end of the fuel grain

28 ☐ Use a popsicle stick to evenly spread the caulking

29 ☐ Apply caulking to the female end of the spacer

30 ☐ Use a popsicle stick to evenly spread the caulking

31 ☐ Press the spacer onto the fuel grain

32 ☐ Check continuity on both ignition cables to ensure good assembly

33 ☐ Slide the fiberglass sleeve on the injector bulkhead

34 ☐ Install combustion chamber external o-rings (size: 236) onto injector bulkhead with o-ring lubricant

35 ☐ Apply caulking to the male end of the spacer

36 ☐ Use a popsicle stick to evenly spread the caulking

37 ☐ Apply caulking to the female end of the injector bulkhead

38 ☐ Use a popsicle stick to evenly spread the caulking

39 ☐ Make sure the alignment between injector bulkhead and combustion chamber is correct

40 ☐ Ensure to use the correct (longer) O-ring fillers

41 ☐ Insert oxidizer tank assembly onto the combustion chamber assembly

42 ☐ Check if any of the O-rings ruptured during installation through the bolt holes. If so, remove vent bulkhead, replace O-rings, and reinstall bulkhead

43 ☐ Fasten with twelve 1/4"-28 (1/2") screws

44 ☐ Check continuity on both ignition cables to ensure good assembly

45 ☐ Strain relief the ignition cables by using masking tape to connect it to the outside of the engine

46 ☐ Close the nozzle end of the engine using a plastic bag and masking tape

47 ☐ Short the ends of the ignition wires

Avionics and Recovery Assembly Checklist

Pre-Inspection

1 ☐ Ensure all bulkheads, fiberglass and electronics sled is undamaged

2 ☐ Ensure that all pyrotechnics and batteries are disconnected and shorted before starting

Electrical Checks

1. ☐ Ensure that all pyrotechnics and batteries are disconnected and shorted before wiring
2. ☐ Check that all circuit components are properly mounted to the sled with proper spacers, screws and nuts.
3. ☐ Ensure all switches are in the energized position
4. ☐ Check continuity between batteries and the Raven
5. ☐ Check continuity between recovery bay connector pins and the Raven
6. ☐ Turn all switches to the non-energized position
7. ☐ Check nine volt battery for full capacity (nominal 9V)
8. ☐ End of procedure

CO_2 System Installation

1. ☐ Ensure all ejection device wires and batteries are disconnected from the electronics bay before proceeding
2. ☐ Ensure the two CO_2 ejection devices are installed into the bulkhead
3. ☐ Install two 38 gram CO_2 cylinders into the ejection devices using two washers to ensure CO_2 vent holes are unobstructed. Do not forget to use teflon tape on the threads of the CO_2 cylinder
4. ☐ End of procedure

GPS System

1. ☐ Ensure GPS battery is fully charged Ensure GPS is functional after connecting battery
2. ☐ Turn GPS system off by waving magnet over the magnetic switch
3. ☐ End of procedure

Sled Installation

1. ☐ Ensure all wires are tucked away to prevent pinching during installation
2. ☐ Ensure the CO_2 cylinders are installed into the CO_2 ejection device
3. ☐ Ensure that the batteries are installed in the battery holder
4. ☐ Install fiberglass onto upper bulkhead
5. ☐ Line up the sled rod guide with the center rod
6. ☐ Insert sled into fiberglass slowly checking for obstructions to installation
7. ☐ Ensure sled is fully inserted and lower bulkhead is fully seated on fiberglass
8. ☐ Place rubber washer and aluminium sleeve over the remaining center rod
9. ☐ Screw eyebolt onto center rod until snug with washer
10. ☐ End of procedure

CO_2 Ejector Setup

1. ☐ Place igniter and wires inside igniter cylinder and center igniter in cylinder using tissue paper
2. ☐ Place epoxy on igniter wires so that when the igniters are pulled, the wires do not pull out of the igniter cylinder
3. ☐ Ensure igniter is placed so that it is flush with the rim of the cylinder that touches the puncturing cylinder
4. ☐ Place aluminium foil on the working surface
5. ☐ Place a separate piece of aluminium foil on the working surface for holding and pouring the gunpowder
6. ☐ Place avionics assembly on the first aluminium sheet with the injector body opening upwards such that the entire body is grounded
7. ☐ Place O-ring on puncturing cylinder and lightly lubricate with spray silicone lubricant making sure to wipe off excess lubricant
8. ☐ Place puncturing cylinder in injector body
9. ☐ Fill puncturing cylinder to the rim with gunpowder
10. ☐ Ensure igniter leads remain shorted
11. ☐ Place O-ring on igniter cylinder and lubricate
12. ☐ Place igniter cylinder on top of puncturing cylinder and push down until igniter cylinder is flush with injector body
13. ☐ Ensure gunpowder vent holes are clear of obstructions
14. ☐ Run igniter wires through body cap and screw cap on tightly
15. ☐ Check for movement of the igniter wires
16. ☐ If moving, take apart and reseat igniter so that it is seated firmly in place
17. ☐ End of procedure

Pyrotechnic Line Cutter Setup

1. ☐ Slide an O-Ring into the bottom of the pyrotechnic line cutter to act as a bumper for the piston
2. ☐ Insert recovery dual ring rope through the hole of the pyrotechnic line cutter
3. ☐ Trim excess rope
4. ☐ Insert shearing piston
5. ☐ Insert black powder or Pyrodex (0.1mL of Pyrodex is recommended)
6. ☐ Insert E-match
7. ☐ Place o-rings on E-match along with screw cap to create a seal
8. ☐ Slide hex screw over E-match leads and screw into pyrotechnic line cutter
9. ☐ End of procedure

Recovery Module Assembly

1. ☐ Ensure that all recovery lines are free and not tangled
2. ☐ Ensure that the 9V batteries are disconnected
3. ☐ Fold the main parachute, gore by gore, in an accordion-style pattern
4. ☐ Fold the main parachute vertically in half
5. ☐ Roll the main parachute from the top towards the main parachute lines
6. ☐ Pack the rolled parachute into the parachute bag so that the main parachute lines extend from one of the open corners
7. ☐ Secure the main parachute lines over the parachute bag cover using the elastics
8. ☐ Use the carabiner to connect the main parachute line to the main coupling line
9. ☐ Connect the modified three-ring release mechanism and secure using the dual ring rope
10. ☐ Secure the pyrotechnic line cutters to the primary recovery line using electrical tape
11. ☐ Connect the pyrotechnic leads to the connectors on the primary recovery line
12. ☐ Secure the drogue parachute line to the base of the avionics module
13. ☐ Pack the parachute bag into the recovery module and push it towards the engine end
14. ☐ Fasten the eyebolt to the top of the vent bulkhead
15. ☐ Wrap a fireproof cloth around the pyrotechnic line cutters to protect main parachute and recovery lines from the black powder burn
16. ☐ Apply a thick layer of grease to the coupler at the base of the recovery tube and a thin layer of grease on the velt bulkhead
17. ☐ Insert the vent bulkhead into the recovery module
18. ☐ Secure the vent bulkhead to the recovery module coupler using 6x 1/4"-28 (1/2") screws
19. ☐ Connect the 4 pin connector from the primary recovery line to the avionics module
20. ☐ Pack the drogue parachute and the remaining recovery lines into the recovery module
21. ☐ Confirm that the Raven altimeters are off
22. ☐ Make all appropriate electrical connections at the avionics terminals
23. ☐ Wrap a fireproof cloth around the igniter cylinders to protect recovery lines and parachutes from the black powder burn
24. ☐ Apply a layer of grease to the avionics and recovery couplers
25. ☐ Place the avionics module coupler over the recovery module coupler
26. ☐ Secure the avionics and recovery modules together with shear pins
27. ☐ Insert the 9V batteries into their mounts
28. ☐ End of procedure

Payload Assembly Checklist

1. ☐ Place the battery in the battery mount
2. ☐ Place the electronics board over the battery mount and secure in place using 4 1/16" screws
3. ☐ Connect the battery to the female JST-PH connector on the electronics board
4. ☐ Place the GoPro camera in the back half of the GoPro mount and place the other half of the mount over the front of the camera
5. ☐ Secure the GoPro mount into the frame using 4 1/16" screws
6. ☐ Turn the GoPro camera to standby mode with WiFi enabled
7. ☐ Thread a 3/8" locknut onto one end of the threaded rod.
8. ☐ Push the threaded rod through the hole in the top coupler of the payload shroud, such that the locknut is inside the shroud
9. ☐ Place a 3.5" and a 1.5" steel block on the threaded rod, and thread a 3/8 locknut on the other side
10. ☐ Tighten the nut, securing the blocks in place
11. ☐ Place the nose cone over the steel blocks and secure in place using 1/4-28 screws
12. ☐ Place the 3.5" steel block on the threaded rod protruding from the top of the avionics bay
13. ☐ Place the payload on the threaded rod
14. ☐ Secure the payload by threading a 3/8" locknut onto the threaded rod
15. ☐ Connect a lock nut to 3/8" threaded rod, and pass the threaded rod through the top coupler of the acrylic section
16. ☐ Place the 3.5" and 1.5" steel block on the threaded rod and secure it with a nut
17. ☐ Place the nose cone over the blocks and secure it to the top coupler using 1/4-28 screws
18. ☐ Place the nose cone assembly over the payload
19. ☐ Secure the nose cone assembly to the avionics coupler using 6x 1/4-28 screws

Launch Tower Setup Checklist

Tower Base Assembly

1. ☐ Bolt side rods to centre rods of tower base
2. ☐ Place tower base on wooden supports
3. ☐ Secure base and supports with 4 stakes
4. ☐ Align launch pad so that it is tilted away from base camp by 5° from the horizontal
5. ☐ Install 3 guy wire anchorages and 1 winch anchorage
6. ☐ Hook winch onto winch anchorage

Tower Assembly

- ☐ Connect bottom tower segment to base
- ☐ Set out wooden supports
- ☐ Connect remaining 4 tower segments
- ☐ Install and connect 4 launch rail segments
- ☐ Check that all tower bolts are tightened
- ☐ Attach 3 guy wires and winch wire to tower
- ☐ Attach turnbuckles to guy wires

Load Cell Installation

- ☐ Install fixed and sliding supports on launch rail
- ☐ Ensure that load cell is mounted to fixed support
- ☐ Install load cell shield

Rocket Installation

- ☐ Ensure 2 launch lugs are installed on the rocket
- ☐ Slide rocket onto rail
- ☐ Ensure ignition wires are not damaged

Fill Disconnect Arm Installation

- ☐ Install L-brackets on tower
- ☐ Install arm between brackets

Pre-Erection Checklist

- Items to inspect:
  - ☐ All wooden supports are in place
  - ☐ Guy wires are firmly attached to the tower
  - ☐ Anchors are secure in the ground
  - ☐ Ratchet puller is operational
  - ☐ Launch pad is stable, no signs of damage on structural components
  - ☐ Launch pad base has been assembled properly according to the document Launch Pad Assembly Guide
- Items to have on hand:
  - ☐ Launch pad bolts to fix the pad to the base structure once the tower is erect
  - ☐ Wrench and/or ratchets to tighten bolts
  - ☐ Hard hats
  - ☐ Work gloves
  - ☐ Caution tape

- People to notify:
  - ☐ Competition organizers
  - ☐ All team members
- Installation Environment Conditions:
  - ☐ Ensure guy wires are untangled on the ground and do not pose as a tripping hazard
  - ☐ Ensure there are no other tripping hazards present
- Personnel positions:
  - ☐ Lifting team of 5 people
  - ☐ 1 coordinator
  - ☐ 1 team member supporting rocket
  - ☐ 1 winch operator
  - ☐ 3 team members at guy wire ends
  - ☐ 1 team member to remove wooden frames

Raising Procedure

- ☐ Lift tower to 30° and connect winch to winch cable
- ☐ Raise tower to 5° from vertical by winch
- ☐ Hook guy wires onto anchorages and hand-tighten turnbuckles
- ☐ Bolt top and bottom plates of launch pad
- ☐ Tension all guy wires with wrench
- ☐ Unhook winch cable from winch
- ☐ Tie caution tape onto each guy wire

Pre-Lowering Checklist

- ☐ Items to inspect:
  - ☐ Ratchet puller is operational
  - ☐ Launch pad is stable, no signs of damage on structural components
- ☐ Items to have on hand:
  - ☐ Wrench and/or ratchets to loosen bolts
  - ☐ Hard hats
  - ☐ Work gloves
- ☐ People to notify:
  - ☐ Competition organizers
  - ☐ All team members
- ☐ Installation Environment Conditions:
  - ☐ Ensure there are no tripping hazards present
- ☐ Personnel positions:

- ☐ Lifting team of 5 people
- ☐ 1 coordinator
- ☐ 1 team member supporting rocket
- ☐ 1 winch operator
- ☐ 3 team members at guy wire ends
- ☐ 1 team member to set up wooden frames

Lowering Procedure

- ☐ Have lifting team ready to support the tower
- ☐ Connect winch to winch cable
- ☐ Tension winch cable
- ☐ De-tension guy wires
- ☐ Unhook guy wires from anchorages
- ☐ Lower tower by de-tensioning winch cable
- ☐ Disconnect winch when tower is at approximately 30° from the horizontal
- ☐ Lower tower onto wood frames
- ☐ Secure guy wires by coiling

Clean-Up Procedure

- ☐ Slide rocket off launch rail
- ☐ Remove launch rail from tower
- ☐ Disconnect tower segments
- ☐ Disconnect side rods from tower base
- ☐ Pull out stakes securing launch pad
- ☐ Remove anchorages from ground
- ☐ Pack away all components

Final Setup Checklist

Fill Line Setup

- ☐ Ensure that the plumbing setup agrees with the P&ID shown in Figure 1
- ☐ Ensure NPT to JIC adapter is connected to fill line
- ☐ Run fill hose through fill arm
- ☐ Secure fill hose on arm extension with zip ties
- ☐ Place run adapter mount and ring release on fill hose
- ☐ Remove aluminium foil from fill hose and fill adapter
- ☐ Connect hose and adapter
- ☐ Ensure fill adapter hole is still covered in aluminium foil
- ☐ Secure adapter mount to fill arm with steel zip ties

Fill Disconnect Setup

1. ☐ Remove aluminium foil from fill adapter
2. ☐ Install o-rings and spring on adapter
3. ☐ Secure adapter to rocket with ring release
4. ☐ Ensure o-rings did not tear when inserted into rocket

Break Link Setup

1. ☐ Ensure break link is installed on retaining ring
2. ☐ Connect break link adapter with nylon bolt
3. ☐ Connect break link cable to turnbuckle
4. ☐ Tighten turnbuckle to remove slack

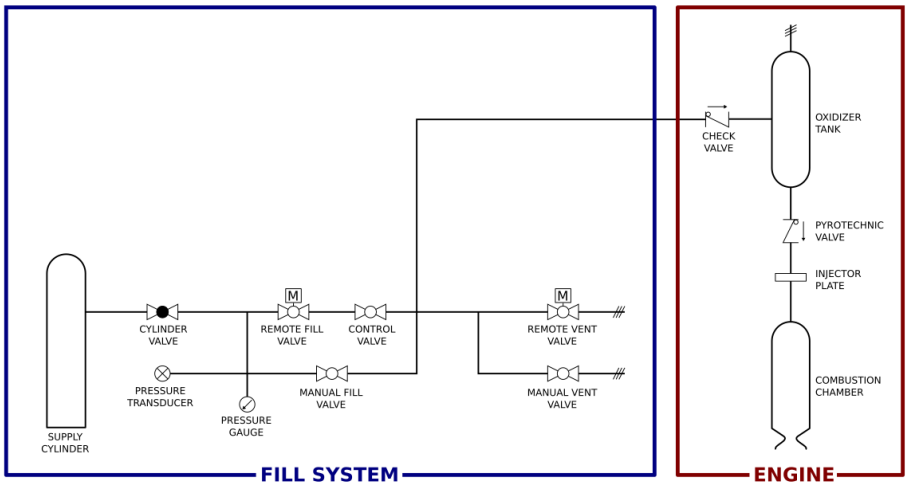

Figure 1: P&ID for the Vidar III engine and fill system