



Shark of the Sky Hybrid Rocket 2019 Wet Dress Rehearsal (WDR)

WDR Operations Procedures

Compiled on 2019-06-02

Background and Reference

Contents

This document contains the following procedures:

- **N1**, *Final Setup and "Pre-Launch" Checks*, comprises partial rocket assembly and testing of avionics in full flight configuration
- **N2**, *Fill Operations*, comprises propellant loading and off-loading

Additionally, this document contains five abort procedures:

- **A1**, *Abort Procedure - Leak At Supply Plumbing*, is used if a plumbing leak is detected when the supply cylinder is initially opened.
- **A2**, *Abort Procedure - Low Supply Pressure*, is used if the oxidizer pressure is below the acceptable limit for test purposes.
- **A3**, *Abort Procedure - High Supply Pressure*, is used if the oxidizer pressure is above the acceptable limit for test purposes.
- **A4**, *Abort Procedure - Leak At Fill Plumbing*, is used if a plumbing leak is detected during manual fill leak checks.
- **A5**, *Abort Procedure - Remote Disconnect Failure*, is used if the remote disconnect system fails, necessitating a full vent of the oxidizer tank.

Personnel Required

The launch operations team consists of four personnel:

- 1 ☐ The **Operations Director [OPS]** is stationed at Launch Control. **OPS** directs operations procedures and communicates with the other launch personnel.
- 2 ☐ The **Control System Operator [CONTROL]** is stationed at Launch Control and is responsible for operation of RLCS, remote fill, and disconnect.
- 3 ☐ The **Primary Fill Operator [PRIMARY]** is initially stationed at the Launch Tower and carries out all tasks occurring at the Launch Tower. **PRIMARY** engages the remote disconnect system, connects the ignition wires to the rocket, and operates all manual valves during the manual portion of fill.
- 4 ☐ The **Secondary Fill Operator [SECONDARY]** is the backup for **PRIMARY**, and communicates with **OPS**. If **PRIMARY** becomes incapacitated, **SECONDARY** is responsible for removing them from danger.

Sign-Off

To be completed by all test personnel after reading and familiarization with procedures

- | | | | |
|---|---|-------|-------|
| 1 | <input type="checkbox"/> Operations Director [OPS] | _____ | _____ |
| 2 | <input type="checkbox"/> Control System Operator [CONTROL] | _____ | _____ |
| 3 | <input type="checkbox"/> Primary Fill Operator [PRIMARY] | _____ | _____ |
| 4 | <input type="checkbox"/> Secondary Fill Operator [SECONDARY] | _____ | _____ |

[N1] Final Setup and "Pre-Launch" Checks

Prior to Start

- 1 ☐ Ensure that the following procedures are complete:
 - 2 ☐ Rocket Assembly procedure
 - 3 ☐ RLCS Setup procedure
 - 4 ☐ Launch Tower Setup procedure
- 5 ☐ Ensure that all personnel as defined above are available and have completed the sign-off.
- 6 ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
 - 7 ☐ **OPS**
 - 8 ☐ **CONTROL**
 - 9 ☐ **PRIMARY**
 - 10 ☐ **SECONDARY**
- 11 ☐ Ensure that **OPS** is in possession of the system control key.
- 12 ☐ Ensure that the client-side RLCS box is powered off.
- 13 ☐ Ensure that the locations of Launch Control, Launch Tower, and the Minimum Safe Distance are clearly defined.

Launch Control	Launch Tower	Minimum Safe Distance

Nominal Procedure

- 1 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
 - 2 ☐ Cylinder Valve
 - 3 ☐ Remote Fill Valve
 - 4 ☐ Parallel Fill Valve
 - 5 ☐ Line Vent Valve
 - 6 ☐ Parallel Vent Valve
- 7 ☐ **PRIMARY**: Confirm Series fill valve is initially open.
- 8 ☐ **PRIMARY**: Confirm that the ignition connectors are disconnected from the rocket.
- 9 ☐ **CONTROL**: Power on the client-side RLCS box.
- 10 ☐ **CONTROL** and **SECONDARY**: Confirm that the following actuators fail to move:
 - 11 ☐ Remote Fill Valve

- 12 ☐ Line Vent Valve
- 13 ☐ Remote Disconnect
- 14 ☐ Injector Valve
- 15 ☐ **SECONDARY**: Confirm that the voltage across the ignition connectors is 0 V.
- 16 ☐ **OPS**: Give the system control key to **CONTROL**.
- 17 ☐ **CONTROL**: Confirm that all actuator controls are in the off state:
- 18 ☐ Remote Fill Valve
- 19 ☐ Line Vent Valve
- 20 ☐ Remote Disconnect
- 21 ☐ Tank Vent Valve
- 22 ☐ Primary Ignition
- 23 ☐ Secondary Ignition
- 24 ☐ Injector Valve
- 25 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 26 ☐ **CONTROL** and **SECONDARY**: Confirm that all actuators actuate as intended:
- 27 ☐ Remote Fill Valve
- 28 ☐ Line Vent Valve
- 29 ☐ Remote Disconnect
- 30 ☐ Tank Vent Valve
- 31 ☐ Injector Valve
- 32 ☐ **CONTROL** and **SECONDARY**: Confirm that the ignition voltage is 12 V when the ignition button is fired:
- 33 ☐ Primary Ignition
- 34 ☐ Secondary Ignition
- 35 ☐ **CONTROL**: Confirm that all DAQ readings are displaying appropriately.
- 36 ☐ **OPS**: Record the resting DAQ values:

[M] Dry Mass (lbs)	[PF] Supply Pressure (psi)	[PL] Fill Line Pressure (psi)	[pt] Oxidizer Tank Pressure (psi)

- 37 ☐ **CONTROL**: Remove the system control key and give it to **OPS**.
- 38 ☐ **PRIMARY**: Arm remote disconnect by connecting the springs, fill adapter, and strap.
- 39 ☐ **PRIMARY**: Remove the cylinder cap and connect the supply line.

[N2] Fill Operations

Prior to Start

- 1 ☐ Ensure that the following procedure is complete:
- 2 ☐ **N1**, *Final Setup and "Pre-Launch" Checks*
- 3 ☐ Ensure that all personnel are available and have completed the sign-off.
- 4 ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
- 5 ☐ **OPS**
- 6 ☐ **CONTROL**
- 7 ☐ **PRIMARY**
- 8 ☐ **SECONDARY**
- 9 ☐ Ensure that **PRIMARY** and **SECONDARY** are wearing face shields and have no exposed skin.
- 10 ☐ Ensure that **PRIMARY** is wearing thermal gloves.
- 11 ☐ Ensure that **OPS** is in possession of the system control key.

Nominal Procedure

- 1 ☐ **SECONDARY**: Confirm that no personnel other than **PRIMARY** and **SECONDARY** are within the Minimum Safe Distance.
- 2 ☐ **OPS**: Confirm that the actuator key switch is disabled and that only **OPS** is in possession of the system control key.
- 3 ☐ **CONTROL**: Confirm that the RLCS client-side box is on and displaying DAQ information.
- 4 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
- 5 ☐ Cylinder Valve
- 6 ☐ Remote Fill Valve
- 7 ☐ Parallel Fill Valve
- 8 ☐ Line Vent Valve
- 9 ☐ Parallel Vent Valve
- 10 ☐ **PRIMARY**: Confirm Series fill valve is initially open.
- 11 ☐ **CONTROL**: Confirm that the Tank Vent Valve is initially open.
- 12 ☐ **CONTROL**: Confirm that the Injector Valve is initially closed.
- 13 ☐ **PRIMARY**: Slowly open the Cylinder Valve through $\frac{3}{4}$ of a turn.
 - If leaks are observed:
- 14 ☐ **OPS**: Proceed to procedure A1.
- 15
 - If leaks are not observed:
 - ☐ **PRIMARY**: Open the cylinder valve fully.
- 16 ☐ **PRIMARY**: Communicate the supply line pressure as visible on the Pressure Gauge.

- If the supply line pressure is below 800 psi:

☐ **OPS:** Proceed to procedure **A2**.

- If the supply line pressure exceeds 1000 psi:

☐ **OPS:** Proceed to procedure **A3**.

☐ **CONTROL:** Confirm that the supply line pressure as read by **PRIMARY** agrees with the supply line pressure [PF] measured by the DAQ system.

☐ **OPS:** Record the resting rocket dry mass and supply pressure:

[M] Dry Mass (lbs)	[PF] Supply Pressure (psi)

☐ **PRIMARY** and **SECONDARY:** Retreat 100 ft from the fill system.

☐ **OPS:** Give the system control key to **CONTROL**.

☐ **CONTROL:** Confirm the following valves are closed:

☐ Remote Fill Valve

☐ Line Vent Valve

☐ Tank Vent Valve

☐ **CONTROL:** Engage the key switch and enable actuators.

☐ **CONTROL:** Open and close the Tank Vent Valve, ensuring that the limit switch reading updates accordingly.

☐ **CONTROL:** Open the Remote Fill Valve.

☐ **CONTROL:** Confirm the following pressures are increasing:

☐ [PL] Fill line pressure

☐ [pt] Oxidizer tank pressure

☐ **CONTROL:** Close the Remote Fill Valve.

☐ **CONTROL:** Confirm the following pressures are stable:

☐ [PL] Fill line pressure

☐ [pt] Oxidizer tank pressure

- If the pressures are decreasing:

☐ **OPS:** Proceed to procedure **A4**.

☐ **CONTROL:** Open the Line Vent Valve.

☐ **CONTROL:** Confirm the following pressures are atmospheric:

☐ [PL] Fill line pressure

☐ **CONTROL:** Confirm Oxidizer tank pressure is unchanged.

☐ **CONTROL:** Close the Line Vent Valve.

- 43 ☐ **PRIMARY** and **SECONDARY**: Retreat to the Minimum Safe Distance.
- 44 ☐ **CONTROL**: Open the Remote Fill Valve.
- 45 ☐ **OPS**: Start the fill timer.
- 46 ☐ **OPS**: Stop the timer at 2 minutes.
- 47 ☐ **PRIMARY**: Close the cylinder valve.
- 48 ☐ **CONTROL**: Open the line vent valve.
- 49 ☐ **CONTROL**: Confirm the vent lines are atmospheric.
- 50 ☐ **PRIMARY**: Disconnect the supply line, replace the cylinder cap.
- 51 ☐ **PRIMARY**: Exchange cylinders.
- 52 ☐ **PRIMARY**: Connect the supply line to the cylinder.
- 53 ☐ **CONTROL**: Close the line vent valve.
- 54 ☐ **PRIMARY**: Slowly open the Cylinder Valve through $\frac{3}{4}$ of a turn.
- If leaks are observed:

55 ☐ **OPS**: Proceed to procedure A1.
 - If leaks are not observed:

56 ☐ **PRIMARY**: Open the cylinder valve fully.
- 57 ☐ **PRIMARY** and **SECONDARY**: Retreat to the Minimum Safe Distance.
- 58 ☐ **CONTROL**: Open the Remote Fill Valve.
- 59 ☐ **OPS**: Start the fill timer.
- 60 ☐ **OPS**: Proceed only when the load cell mass plateaus.
- 61 ☐ **OPS**: Stop the fill timer.
- 62 ☐ **CONTROL**: Close the Tank Vent Valve.
- 63 ☐ **CONTROL**: Close the Remote Fill Valve.
- 64 ☐ **CONTROL**: Open the Line Vent Valve.
- 65 ☐ **CONTROL**: Confirm the Fill line pressure is atmospheric
- 66 ☐ **CONTROL**: Actuate remote disconnect
- If remote disconnect fails to actuate:

67 ☐ **OPS**: Proceed to procedure **A5**.
- 68 ☐ **CONTROL**: Confirm that limit switch indicates successful disconnection
- 69 ☐ **CONTROL**: Open the Tank Vent Valve.
- 70 ☐ **OPS**: Start the vent timer.
- 71 ☐ **OPS**: Wait for tank to vent
- 72 ☐ **OPS**: Stop the vent timer.
- 73 ☐ **CONTROL**: Confirm the following pressures are atmospheric:

- 74 ☐ [PL] Fill line pressure
- 75 ☐ [pt] Oxidizer tank pressure
- 76 ☐ **CONTROL**: Disengage the key switch and disable actuators
- 77 ☐ **CONTROL**: Disarm RLCS:
 - 78 ☐ Disable actuator control by removing the system control key.
 - 79 ☐ Give the system control key to **OPS**.
- 80 ☐ **OPS**: Confirm that RLCS is disarmed and **OPS** is in possession of the system control key.
- 81 ☐ **OPS**: Proceed only when clearance is received from the Launch Control Officer to approach the Launch Tower.
- 82 ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.
- 83 ☐ **PRIMARY**: Close the Cylinder Valve.
- 84 ☐ **PRIMARY**: Open the Parallel Vent Valve.
- 85 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 86 ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
- 87 ☐ **OPS**: Give the master key to **CONTROL**
- 88 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 89 ☐ **CONTROL**: Open the Remote Fill Valve.
- 90 ☐ **CONTROL**: Confirm that the supply line pressure [PF] is atmospheric.
- 91 ☐ **PRIMARY**: Disconnect the supply line from the supply cylinder.
- 92 ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 93 ☐ **OPS**: Proceed with teardown and disassembly.

Abort Procedures

[A1] Abort Procedure - Leak At Supply Plumbing

- 1 ☐ **PRIMARY**: Close the Cylinder Valve.
- 2 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ [PF] Supply pressure
 - 6 ☐ [PL] Fill line pressure
- 7 ☐ **PRIMARY**: Disarm the system:
 - 8 ☐ Disconnect the ignition leads from the rocket.
 - 9 ☐ Detatch the springs from the disconnect mechanism.
 - 10 ☐ Disconnect the fill line from the supply cylinder.
 - 11 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 12 ☐ **OPS**: Revisit plumbing setup.

[A2] Abort Procedure - Low Supply Pressure

- 1 ☐ **PRIMARY**: Close the Cylinder Valve.
- 2 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ [PF] Supply pressure
 - 6 ☐ [PL] Fill line pressure
- 7 ☐ **PRIMARY**: Allow the supply cylinder to warm up.
- 8 ☐ **OPS**: Revisit **N1**.

[A3] Abort Procedure - High Supply Pressure

- 1 ☐ **PRIMARY**: Close the Cylinder Valve.
- 2 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ [PF] Supply pressure
 - 6 ☐ [PL] Fill line pressure
- 7 ☐ **PRIMARY**: Disarm the system:
 - 8 ☐ Disconnect the ignition leads from the rocket.
 - 9 ☐ Detatch the torsion springs from the disconnect mechanism.
 - 10 ☐ Disconnect the fill line from the supply cylinder.
 - 11 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 12 ☐ **OPS**: Revisit cylinder cooling methods.

[A4] Abort Procedure - Leak At Fill Plumbing

- 1 ☐ **CONTROL**: Close the Remote Fill Valve.
- 2 ☐ **CONTROL**: Open the Tank Vent Valve.
- 3 ☐ **CONTROL**: Open the Line Vent Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ pL: Fill line pressure
 - 6 ☐ pt: Rocket Tank pressure
- 7 ☐ **PRIMARY** and **SECONDARY**: Return to plumbing setup
- 8 ☐ **PRIMARY**: Close the Cylinder Valve.
- 9 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 10 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 11 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 12 ☐ [PF] Supply pressure
 - 13 ☐ [PL] Fill line pressure
- 14 ☐ **PRIMARY**: Disarm the system:
 - 15 ☐ Disconnect the ignition leads from the rocket.
 - 16 ☐ Detach the springs from the disconnect mechanism.
 - 17 ☐ Disconnect the fill line from the supply cylinder.
 - 18 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 19 ☐ **OPS**: Revisit plumbing setup.

[A5] Abort Procedure - Remote Disconnect Failure

- 1 ☐ **CONTROL**: Open the Tank Vent Valve.
- 2 ☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure as the oxidizer tank vents.
- 3 ☐ **OPS**: Proceed only when the following is true:
 - 4 ☐ Rocket mass is equal to the pre-launch recorded mass
 - 5 ☐ Oxidizer tank pressure [pt] is atmospheric
 - 6 ☐ The Launch Control Officer has given clearance to approach the Launch Tower.
- 7 ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.
- 8 ☐ **PRIMARY**: Close the Cylinder Valve.
- 9 ☐ **PRIMARY**: Open the Parallel Vent Valve.
- 10 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 11 ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
- 12 ☐ **OPS**: Give the system control key to **CONTROL**
- 13 ☐ **CONTROL**: Engage the system control switch and enable actuators.
- 14 ☐ **CONTROL**: Open the Remote Fill Valve.
- 15 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 16 ☐ [PF] Supply pressure
 - 17 ☐ [PL] Fill line pressure
- 18 ☐ **PRIMARY**: Disarm the system:
 - 19 ☐ Disconnect the ignition leads from the rocket.
 - 20 ☐ Detach the torsion springs from the disconnect mechanism.
 - 21 ☐ Disconnect the fill line from the supply cylinder.
 - 22 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 23 ☐ **OPS**: Proceed with teardown and disassembly.