



# UXO Hybrid Rocket Engine Cold Flow 3

Cold Flow Test Operations Procedures

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# Cold Flow Test Operations Procedures

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## Contents

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This document contains the following procedures:

- The *Cold Flow Test - Remote Control* procedure comprises steps for operating the fill system using the electrical control system and motorized ball valves.
- The *Cold Flow Test - Manual Control* procedure comprises steps for operating the fill system using manual ball valves.

## Personnel Required

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The test operations team consists of seven personnel:

- 1 ☐ The **Operations Director [OPS]** directs operations procedures and communicates with the other test personnel.
- 2 ☐ The **Primary Fill Operator [PRIMARY]** is the main system operator. **PRIMARY** operates all manual valves as well as the test control system.
- 3 ☐ 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.
- 4 ☐ The **DAQ Technician [DAQ]** monitors and operates the test data acquisition system.
- 5 ☐ The **Heating Technician [HEAT]** operates the valves for the tank heating system.
- 6 ☐ **Perimeter Guard 1 [P1]**, **Perimeter Guard 2 [P2]**, and **Perimeter Guard 3 [P3]** ensure that no unauthorized personnel enter the testing area during test operations.

## Sign-Off

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

- |   |   |       |       |
|---|---|-------|-------|
| 1 | <input type="checkbox"/> <b>Operations Director [OPS]</b>           | _____ | _____ |
| 2 | <input type="checkbox"/> <b>Primary Fill Operator [PRIMARY]</b>     | _____ | _____ |
| 3 | <input type="checkbox"/> <b>Secondary Fill Operator [SECONDARY]</b> | _____ | _____ |
| 4 | <input type="checkbox"/> <b>DAQ Technician [DAQ]</b>                | _____ | _____ |
| 5 | <input type="checkbox"/> <b>Heating Technician [HEAT]</b>           | _____ | _____ |
| 6 | <input type="checkbox"/> <b>Perimeter Guard 1 [P1]</b>              | _____ | _____ |
| 7 | <input type="checkbox"/> <b>Perimeter Guard 2 [P2]</b>              | _____ | _____ |
| 8 | <input type="checkbox"/> <b>Perimeter Guard 3 [P3]</b>              | _____ | _____ |

## Prior to Start

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- 1    ☐ Ensure that the following procedures are complete:
- 2        ☐ Oxidizer Tank Assembly procedure
- 3        ☐ Plumbing Setup procedure
- 4        ☐ Oxidizer Tank Stand Setup procedure
- 5        ☐ Tank Heating Setup procedure
- 6        ☐ Test Stand Setup procedure
- 7        ☐ Data Acquisition Setup procedure
- 8        ☐ Test Control System Setup procedure
- 9    ☐ Ensure that all technicians as defined above are available and have completed the sign-off.
- 10   ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
- 11        ☐ OPS
- 12        ☐ PRIMARY
- 13        ☐ SECONDARY
- 14        ☐ DAQ
- 15        ☐ HEAT
- 16        ☐ P1
- 17        ☐ P2
- 18        ☐ P3
- 19   ☐ Ensure that all spectators and test personnel are wearing safety glasses.
- 20   ☐ Ensure that PRIMARY and SECONDARY are wearing face shields and have no exposed skin.
- 21   ☐ Ensure that PRIMARY is wearing thermal gloves.
- 22   ☐ Ensure that SECONDARY is in possession of the system control key.

## Cold Flow Test - Remote Control Procedure

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- 1 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - 2 ☐ Cylinder Valve
  - 3 ☐ Remote Fill Valve
  - 4 ☐ Parallel Fill Valve
  - 5 ☐ Tank Vent Valve
  - 6 ☐ Pressure Relief Valve
  - 7 ☐ Injector Valve
- 8 ☐ **PRIMARY**: Confirm that the following valves are initially open:
  - 9 ☐ Series Fill Valve
- 10 ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 11 ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 12 ☐ **PAUSE POINT**
- 13 ☐ **P1, P2, and P3**: Close the perimeter and do not allow any further personnel to enter the testing area.
- 14 ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 15 ☐ **PRIMARY**: Remove the cap from the carbon dioxide supply cylinder.
- 16 ☐ **PRIMARY**: Connect the fill line to the supply cylinder, hand tighten, and then tighten with a wrench. Do not force the connection.
- 17 ☐ **PRIMARY**: Slowly open the Cylinder Valve through  $\frac{3}{4}$  of a turn.
  - If leaks are observed:
    - 18 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 19 ☐ **PRIMARY**: Open the Injector Valve.
    - 20 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
    - 21 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 22 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- 23 ☐ **PRIMARY**: Communicate the supply cylinder pressure as visible on the Pressure Gauge.
- 24 ☐ **DAQ**: Communicate the supply cylinder pressure as read by the Fill Pressure Transducer.
- 25 ☐ **DAQ**: Confirm that the two pressure measurements are in agreement.
- 26 ☐ **PRIMARY** and **SECONDARY**: Retreat to the test control area, behind the blast shield.
- 27 ☐ **PRIMARY**: Perform the following control system checks:
  - 28 ☐ Confirm that all actuator controls are in the "off" position:
    - 29 ☐ Remote Fill Valve
    - 30 ☐ Tank Vent Valve
    - 31 ☐ Injector Valve
- 32 ☐ **PAUSE POINT**
- 33 ☐ **OPS**: Poll the following personnel for GO/NO GO status:

- 34 ☐ **P1**
- 35 ☐ **P2**
- 36 ☐ **P3**
- 37 ☐ **HEAT**
- 38 ☐ **DAQ**
- 39 ☐ **PRIMARY**
- 40 ☐ **SECONDARY**
- 41 ☐ **SECONDARY**: Give the system control key to **PRIMARY**.
- 42 ☐ **PRIMARY**: Engage the key switch and power on the control boxes.
- 43 ☐ **PRIMARY**: Open the Tank Vent Valve.
- 44 ☐ **PRIMARY**: Open the Remote Fill Valve.
  - If leaks are observed:
    - 45 ☐ **PRIMARY**: Close the Remote Fill Valve.
    - 46 ☐ **PRIMARY**: Open the Injector Valve.
    - 47 ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.
    - 48 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - 49 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 50 ☐ **PRIMARY**: Open the Remote Fill Valve.
    - 51 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 52 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
  - If the Remote Fill Valve fails to open:
    - 53 ☐ **OPS**: Proceed to the Manual Control procedure.
- 54 ☐ **SECONDARY**: Proceed only when a white plume is visible from the Tank Vent Valve.
- 55 ☐ **PRIMARY**: Close the Tank Vent Valve.
- 56 ☐ **PRIMARY**: Close the Remote Fill Valve.
  - If the Remote Fill Valve fails to close:
    - 57 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - 58 ☐ **PRIMARY**: Close the Series Fill Valve.
    - 59 ☐ **PRIMARY** and **SECONDARY**: Retreat to the test control area, behind the blast shield.
- 60 ☐ **HEAT**: Open the Tank Heating Valve.
- 61 ☐ **DAQ**: Proceed only when the oxidizer tank pressure is at least 750 psi.
  - If the oxidizer tank pressure does not reach 750 psi:
    - 62 ☐ **HEAT**: Close the Tank Heating Valve.
    - 63 ☐ **PRIMARY**: Open the Injector Valve.
    - 64 ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.
    - 65 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - 66 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 67 ☐ **PRIMARY**: Open the Remote Fill Valve.
    - 68 ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
    - 69 ☐ **OPS**: Abort test procedures and revisit plumbing setup.

- 70    ☐ **HEAT**: Close the Tank Heating Valve.
- 71    ☐ **PAUSE POINT**
- 72    ☐ **PRIMARY**: Conduct the cold flow test by opening the Injector Valve.
- 73    ☐ **PAUSE POINT**
- 74    ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 75    ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 76    ☐ **PRIMARY**: Open the Tank Vent Valve.
- 77    ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 78    ☐ **PRIMARY**: Close the Cylinder Valve.
- 79    ☐ **PRIMARY**: Open the Remote Fill Valve.
- 80    ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 81    ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 82    ☐ **PRIMARY**: Replace the cap on the carbon dioxide supply cylinder.
- 83    ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
- 84    ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 85    ☐ **P1**, **P2**, and **P3**: Open the perimeter.
- 86    ☐ **OPS**: Proceed with teardown and disassembly.

## Cold Flow Test - Manual Control Procedure

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- 1 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
- 2 ☐ Cylinder Valve
- 3 ☐ Remote Fill Valve
- 4 ☐ Parallel Fill Valve
- 5 ☐ Pressure Relief Valve
- 6 ☐ Shutoff Valve
- 7 ☐ Series Fill Valve
- 8 ☐ **PRIMARY**: Confirm that the following valves are initially open:
- 9 ☐ Tank Vent Valve
- 10 ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 11 ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 12 ☐ **PAUSE POINT**
- 13 ☐ **P1, P2, and P3**: Close the perimeter and do not allow any further personnel to enter the testing area.
- 14 ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 15 ☐ **PRIMARY**: Remove the cap from the carbon dioxide supply cylinder.
- 16 ☐ **PRIMARY**: Connect the fill line to the supply cylinder, hand tighten, and then tighten with a wrench. Do not force the connection.
- 17 ☐ **PRIMARY**: Slowly open the Cylinder Valve through  $\frac{3}{4}$  of a turn.
  - If leaks are observed:
- 18 ☐ **PRIMARY**: Close the Cylinder Valve.
- 19 ☐ **PRIMARY**: Open the Shutoff Valve using the ropes.
- 20 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 21 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
- 22 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- 23 ☐ **PRIMARY**: Communicate the supply cylinder pressure as visible on the Pressure Gauge.
- 24 ☐ **DAQ**: Communicate the supply cylinder pressure as read by the Fill Pressure Transducer.
- 25 ☐ **DAQ**: Confirm that the two pressure measurements are in agreement.
- 26 ☐ **PAUSE POINT**
- 27 ☐ **OPS**: Poll the following personnel for GO/NO GO status:
- 28 ☐ **P1**
- 29 ☐ **P2**
- 30 ☐ **P3**
- 31 ☐ **HEAT**
- 32 ☐ **DAQ**
- 33 ☐ **PRIMARY**
- 34 ☐ **SECONDARY**

- 35 ☐ **PRIMARY**: Open the Series Fill Valve.
  - If leaks are observed:
    - 36 ☐ **PRIMARY**: Close the Series Fill Valve.
    - 37 ☐ **PRIMARY**: Open the Shutoff Valve using the ropes.
    - 38 ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.
    - 39 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 40 ☐ **PRIMARY**: Open the Remote Fill Valve.
    - 41 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 42 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- 43 ☐ **SECONDARY**: Proceed only when a white plume is visible from the Tank Vent Valve.
- 44 ☐ **HEAT**: Open the Tank Heating Valve.
- 45 ☐ **DAQ**: Proceed only when the oxidizer tank pressure is at least 750 psi.
  - If the oxidizer tank pressure does not reach 750 psi:
    - 46 ☐ **HEAT**: Close the Tank Heating Valve.
    - 47 ☐ **PRIMARY**: Open the Shutoff Valve using the ropes.
    - 48 ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.
    - 49 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - 50 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 51 ☐ **PRIMARY**: Slowly open the Series Fill Valve.
    - 52 ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
    - 53 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- 54 ☐ **HEAT**: Close the Tank Heating Valve.
- 55 ☐ **PAUSE POINT**
- 56 ☐ **PRIMARY**: Conduct the cold flow test by opening the Shutoff Valve using the ropes.
- 57 ☐ **PAUSE POINT**
- 58 ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 59 ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 60 ☐ **PRIMARY**: Open the Tank Vent Valve.
- 61 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 62 ☐ **PRIMARY**: Close the Cylinder Valve.
- 63 ☐ **PRIMARY**: Slowly open the Series Fill Valve.
- 64 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 65 ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 66 ☐ **PRIMARY**: Replace the cap on the carbon dioxide supply cylinder.
- 67 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
- 68 ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 69 ☐ **P1**, **P2**, and **P3**: Open the perimeter.
- 70 ☐ **OPS**: Proceed with teardown and disassembly.