



# Unnamed Liquid Rocket Engine Cold Flow 1

Cold Flow Test Operations Procedures

Compiled on 2020-01-26

# Cold Flow Test Operations Procedures

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This document contains the following procedure:

- The *Cold Flow Test* procedure comprises steps for conducting a cold flow test of the engine and fill system using the electrical control system and motorized ball valves.

## Personnel Required

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The test operations team consists of nine 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 **Control System Operator [CONTROL]** operates the test control system, including actuation of remote valves.
- 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>Control System Operator [CONTROL]</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 all spectators and test personnel are wearing safety glasses.
- 11   ☐ Ensure that **PRIMARY** and **SECONDARY** are wearing face shields and have no exposed skin.
- 12   ☐ Ensure that **PRIMARY** is wearing thermal gloves.
- 13   ☐ Ensure that **OPS** is in possession of the system control key.

## Cold Flow Test Procedure

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- 1 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
- 2 ☐ BA-1
- 3 ☐ BA-3
- 4 ☐ BA-5
- 5 ☐ BA-6
- 6 ☐ BA-9
- 7 ☐ MV-1
- 8 ☐ MV-2
- 9 ☐ MV-3
- 10 ☐ **PRIMARY**: Confirm that the following valves are initially open:
- 11 ☐ BA-2
- 12 ☐ BA-4
- 13 ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 14 ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 15 ☐ **PAUSE POINT**
- 16 ☐ **P1, P2, and P3**: Close the perimeter and do not allow any further personnel to enter the testing area.
- 17 ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 18 ☐ **PRIMARY**: Remove the cap from TK-1.
- 19 ☐ **PRIMARY**: Connect the pressurant line to TK-1, hand tighten, and then tighten with a wrench. Do not force the connection.
- 20 ☐ **PRIMARY**: Slowly open GA-1 through  $\frac{3}{4}$  of a turn.
  - If leaks are observed:
- 21 ☐ **PRIMARY**: Close GA-1.
- 22 ☐ **PRIMARY**: TODO
- 23 ☐ **PRIMARY**: Adjust CV-4 to 360 psi.
- 24 ☐ **DAQ**: Communicate the pressure reading of PT-1.
- 25 ☐ **OPS**: Record the pressure reading of PT-1.
- 26 ☐ **PRIMARY**: Communicate the pressure readings of PI-3 and PI-4.
- 27 ☐ **OPS**: Record the pressure readings of PI-3 and PI-4.
- 28 ☐ **PRIMARY** and **SECONDARY**: Retreat back to Mission Control.
- 29 ☐ **CONTROL**: Perform the following control system checks:
  - 30 ☐ Confirm that all actuator controls are in the “closed” position:
  - 31 ☐ Remote Fill Valve
  - 32 ☐ Motorized Vent Valve
  - 33 ☐ Pressurant Valve

- 34 ☐ **PAUSE POINT**
- 35 ☐ **OPS:** Poll the following personnel for GO/NO GO status:
  - 36 ☐ **CONTROL**
  - 37 ☐ **DAQ**
  - 38 ☐ **PRIMARY**
  - 39 ☐ **SECONDARY**
  - 40 ☐ **P1**
  - 41 ☐ **P2**
  - 42 ☐ **P3**
- 43 ☐ **OPS:** Give the system control key to **CONTROL**.
- 44 ☐ **CONTROL:** Engage the key switch and power on the control boxes.
- 45 ☐ **CONTROL:** Open the Pressurant Valve.
- 46 ☐ **DAQ:** Monitor PT-1 and the fuel tank load cell during fuel pressurization.
- 47 ☐ **DAQ:** Proceed when the fuel tank mass is stable.
- 48 ☐ **PAUSE POINT**
- 49 ☐ **PRIMARY:** Conduct the cold flow test by opening BA-9 using the ropes.
- 50 ☐ **OPS:** Proceed when water flow has ceased or after 15 seconds have elapsed.
- 51 ☐ **CONTROL:** Close the Pressurant Valve.
- 52 ☐ **PAUSE POINT**
- 53 ☐ **DAQ:** Confirm that PT-1 is reading atmospheric pressure.
- 54 ☐ **CONTROL:** Disengage the key switch and disable actuators.
- 55 ☐ **PRIMARY** and **SECONDARY:** Approach the test plumbing.
- 56 ☐ **PRIMARY:** Close BA-2.
- 57 ☐ **PRIMARY:** Open BA-1.
- 58 ☐ **PRIMARY:** Adjust CV-4 to 600 psi.
- 59 ☐ **PRIMARY:** Disconnect the pressure relief valve assembly from the fuel plumbing and connect it to the oxidizer plumbing.
- 60 ☐ **DAQ:** Communicate the pressure reading of PT-1.
- 61 ☐ **OPS:** Record the pressure reading of PT-1.
- 62 ☐ **PRIMARY:** Communicate the pressure readings of PI-3 and PI-4.
- 63 ☐ **OPS:** Record the pressure readings of PI-3 and PI-4.
- 64 ☐ **PRIMARY:** Remove the cap from SC-1.
- 65 ☐ **PRIMARY:** Connect the fill line to SC-1, hand tighten, and then tighten with a wrench. Do not force the connection.
- 66 ☐ **PRIMARY:** Slowly open the Cylinder Valve through  $\frac{3}{4}$  of a turn.

- If leaks are observed:
  - ☐ **PRIMARY**: Close the Cylinder Valve.
  - ☐ **PRIMARY**: Slowly open BA-3.
  - ☐ **PRIMARY**: Slowly open BA-5.
  - ☐ **DAQ**: Confirm that PT-2 is reading atmospheric pressure.
  - ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- ☐ **PRIMARY**: Communicate the reading of PI-2.
- ☐ **DAQ**: Communicate the reading of PT-2.
- ☐ **DAQ**: Confirm that the two pressure measurements are in agreement.
- ☐ **PRIMARY** and **SECONDARY**: Retreat back to Mission Control.
- ☐ **CONTROL**: Perform the following control system checks:
  - ☐ Confirm that all actuator controls are in the “closed” position:
    - ☐ Remote Fill Valve
    - ☐ Motorized Vent Valve
    - ☐ Pressurant Valve
- ☐ **PAUSE POINT**
- ☐ **OPS**: Give the system control key to **CONTROL**.
- ☐ **CONTROL**: Engage the key switch and power on the control boxes.
- ☐ **CONTROL**: Open the Motorized Vent Valve.
- ☐ **CONTROL**: Open the Remote Fill Valve.
  - If leaks are observed:
    - ☐ **CONTROL**: Close the Remote Fill Valve.
    - ☐ **PRIMARY**: Open BA-6 using the ropes.
    - ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
    - ☐ **PRIMARY**: Close the Cylinder Valve.
    - ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- ☐ **OPS**: Proceed only when a white plume is visible from the vent plug.
- ☐ **CONTROL**: Close the Motorized Vent Valve.
- ☐ **CONTROL**: Close the Remote Fill Valve.
- ☐ **CONTROL**: Open the Pressurant Valve.
- ☐ **DAQ**: Proceed when PT-1 is stable at 600 psi.
- ☐ **PAUSE POINT**
- ☐ **PRIMARY**: Conduct the cold flow test by opening BA-6 using the ropes.
- ☐ **OPS**: Proceed when carbon dioxide flow has ceased or after 15 seconds have elapsed.
- ☐ **CONTROL**: Close the Pressurant Valve.
- ☐ **PAUSE POINT**

- 102    ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
- 103    ☐ **DAQ**: Confirm that PT-1 is reading atmospheric pressure.
- 104    ☐ **CONTROL**: Open the Motorized Vent Valve.
- 105    ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 106    ☐ **PRIMARY**: Close the Cylinder Valve.
- 107    ☐ **PRIMARY**: Slowly open BA-3.
- 108    ☐ **CONTROL**: Open the Remote Fill Valve.
- 109    ☐ **PRIMARY**: Close GA-1.
- 110    ☐ **CONTROL**: Open MV-2.
- 111    ☐ **PRIMARY**: Slowly open BA-2.
- 112    ☐ **PRIMARY**: Slowly open BA-5.
- 113    ☐ **PRIMARY**: Disconnect the fill line from SC-1.
- 114    ☐ **PRIMARY**: Replace the cap on SC-1.
- 115    ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 116    ☐ **P1, P2, and P3**: Open the perimeter.
- 117    ☐ **OPS**: Proceed with teardown and disassembly.