Unnamed Liquid Rocket Engine
Cold Flow 1

Cold Flow Test Operations Procedures

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Cold Flow Test Operations Procedures

Contents

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

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.

Background Information

All personnel should familiarize themselves with the following information prior to test start:

- All electrically actuated valves have two names: an alphanumeric code used in the plumbing master system, and a descriptive name used in control system code and documentation. For this test, the correspondence is as follows:
  - **MV-1** is the **Remote Fill Valve**
  - **MV-2** is the **Pressurant Valve**
  - **MV-1** is the **Motorized Vent Valve**

Sign-Off

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

1 ☐ **Operations Director [OPS]** _____ _____

2 ☐ **Primary Fill Operator [PRIMARY]** _____ _____

3 ☐ **Secondary Fill Operator [SECONDARY]** _____ _____

4 ☐ **DAQ Technician [DAQ]** _____ _____

5 ☐ **Control System Operator [CONTROL]** _____ _____

6 ☐ **Perimeter Guard 1 [P1]** _____ _____

7 ☐ **Perimeter Guard 2 [P2]** _____ _____

8 ☐ **Perimeter Guard 3 [P3]** _____ _____

Prior to Start

- ☐ Ensure that the following procedures are complete:
  - ☐ Oxidizer Tank Assembly procedure
  - ☐ Plumbing Setup procedure
  - ☐ Oxidizer Tank Stand Setup procedure
  - ☐ Tank Heating Setup procedure
  - ☐ Test Stand Setup procedure
  - ☐ Data Acquisition Setup procedure
  - ☐ Test Control System Setup procedure
- ☐ Ensure that all technicians as defined above are available and have completed the sign-off.
- ☐ Ensure that all spectators and test personnel are wearing safety glasses.
- ☐ Ensure that **PRIMARY** and **SECONDARY** are wearing face shields and have no exposed skin.
- ☐ Ensure that **PRIMARY** is wearing thermal gloves.
- ☐ Ensure that **OPS** is in possession of the system control key.

Cold Flow Test Procedure

- ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - ☐ BA-1
  - ☐ BA-3
  - ☐ BA-5
  - ☐ BA-6
  - ☐ BA-9
  - ☐ MV-1
  - ☐ MV-2
  - ☐ MV-3
- ☐ **PRIMARY**: Confirm that the following valves are initially open:
  - ☐ BA-2
  - ☐ BA-4
- ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- ☐ **PAUSE POINT**
- ☐ **P1**, **P2**, and **P3**: Close the perimeter and do not allow any further personnel to enter the testing area.
- ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- ☐ **PRIMARY**: Remove the cap from TK-1.
- ☐ **PRIMARY**: Connect the pressurant line to TK-1, hand tighten, and then tighten with a wrench. Do not force the connection.
- ☐ **PRIMARY**: Slowly open GA-1 through $\frac{3}{4}$ of a turn.
  - If leaks are observed:
    - ☐ **PRIMARY**: Close GA-1.
    - ☐ **PRIMARY**: TODO
- ☐ **PRIMARY**: Adjust CV-4 to 360 psi.
- ☐ **DAQ**: Communicate the pressure reading of PT-1.
- ☐ **OPS**: Record the pressure reading of PT-1.
- ☐ **PRIMARY**: Communicate the pressure readings of PI-3 and PI-4.
- ☐ **OPS**: Record the pressure readings of PI-3 and PI-4.
- ☐ **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**: Poll the following personnel for GO/NO GO status:
  - ☐ **CONTROL**
  - ☐ **DAQ**
  - ☐ **PRIMARY**
  - ☐ **SECONDARY**
  - ☐ **P1**
  - ☐ **P2**
  - ☐ **P3**
- ☐ **OPS**: Give the system control key to **CONTROL**.
- ☐ **CONTROL**: Engage the key switch and power on the control boxes.
- ☐ **CONTROL**: Open the Pressurant Valve.
- ☐ **DAQ**: Monitor PT-1 and the fuel tank load cell during fuel pressurization.
- ☐ **DAQ**: Proceed when the fuel tank mass is stable.
- ☐ **PAUSE POINT**
- ☐ **PRIMARY**: Conduct the cold flow test by opening BA-9 using the ropes.
- ☐ **OPS**: Proceed when water flow has ceased or after 15 seconds have elapsed.
- ☐ **CONTROL**: Close the Pressurant Valve.
- ☐ **PAUSE POINT**
- ☐ **DAQ**: Confirm that PT-1 is reading atmospheric pressure.
- ☐ **CONTROL**: Disengage the key switch and disable actuators.
- ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- ☐ **PRIMARY**: Close BA-2.
- ☐ **PRIMARY**: Open BA-1.
- ☐ **PRIMARY**: Adjust CV-4 to 600 psi.
- ☐ **PRIMARY**: Disconnect the pressure relief valve assembly from the fuel plumbing and connect it to the oxidizer plumbing.
- ☐ **DAQ**: Communicate the pressure reading of PT-1.
- ☐ **OPS**: Record the pressure reading of PT-1.
- ☐ **PRIMARY**: Communicate the pressure readings of PI-3 and PI-4.
- ☐ **OPS**: Record the pressure readings of PI-3 and PI-4.
- ☐ **PRIMARY**: Remove the cap from SC-1.
- ☐ **PRIMARY**: Connect the fill line to SC-1, hand tighten, and then tighten with a wrench. Do not force the connection.
- ☐ **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**

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