Unnamed Liquid Rocket Engine
Static Fire 1

Static Fire Test Operations Procedures

Compiled on 2020-02-29

Static Fire Test Operations Procedures

Contents

This document contains one procedure:

- The *Static Fire Test* procedure comprises steps for operating the fill system and conducting a static fire of the engine.

Personnel Required

The test operations team consists of five personnel:

1 ☐ The **Operations Director [OPS]** directs operations procedures and communicates with the other test personnel.

2 ☐ The **Primary Fill Operator [PRIMARY]** operates all manual valves for the fill 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 and engine ignition.

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]** _____ _____

Prior to Start

- ☐ Ensure that all personnel as defined above are available and have completed the sign-off.
- ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
  - ☐ **OPS**
  - ☐ **SECONDARY**
  - ☐ **DAQ**
  - ☐ **CONTROL**
- ☐ Ensure that all spectators and test personnel are wearing safety glasses and hearing protection.
- ☐ Ensure that **PRIMARY** and **SECONDARY** are wearing face shields and have no exposed skin.
- ☐ Ensure that **PRIMARY** is wearing thermal gloves.
- ☐ Ensure that **SECONDARY** is in possession of a multimeter.
- ☐ Ensure that **OPS** is in possession of the system control key.

Static Fire Test - Remote Control Procedure

- ☐ **SECONDARY**: Confirm that the ignition wires are not connected to the engine.
- ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - ☐ SC-1 (Oxidizer Supply Valve)
  - ☐ TK-1 (Pressurant Supply Valve)
  - ☐ BA-1 (Oxidizer Pressurant Shutoff Valve)
  - ☐ BA-2 (Fuel Pressurant Shutoff Valve)
  - ☐ BA-3 (Oxidizer Parallel Fill Valve)
  - ☐ BA-5 (Oxidizer Fill Line Vent Valve)
  - ☐ BA-8 (Oxidizer Tank Dump Valve)
  - ☐ BA-9 (Fuel Tank Vent Valve)
  - ☐ BA-10 (Pressurant Line Vent Valve)
  - ☐ MV-1 (Oxidizer Motorized Fill Valve)
  - ☐ MV-2 (Pressurant Remote Valve)
  - ☐ MV-3 (Oxidizer Motorized Vent Valve)
  - ☐ MV-4 (Fuel Injector Valve)
  - ☐ IJ-1 (Oxidizer Injector Valve)
- ☐ **PRIMARY**: Confirm that the following valves are initially open:
  - ☐ BA-4 (Oxidizer Series Fill Valve)
  - ☐ BA-6 (Oxidizer Shutoff Valve)
  - ☐ BA-7 (Fuel Shutoff Valve)
- ☐ **PRIMARY**: Confirm that CV-1 is adjusted to the lowest pressure setting.
- ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- ☐ **DAQ**: Confirm that all thermistors are reading ambient temperature.
- ☐ **PAUSE POINT**
- ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- ☐ **PRIMARY**: Remove all plastic plugs and covers from the plumbing:
  - ☐ Oxidizer Tank Remote Vent Line
  - ☐ Oxidizer Tank Dump Line
  - ☐ Oxidizer Fill Vent Line
  - ☐ Fuel Tank Vent Line
  - ☐ Pressurant Vent Line
  - ☐ Nozzle
- ☐ **PRIMARY**: Remove the cap from the pressurant supply cylinder.
- ☐ **PRIMARY**: Connect the pressurant line to the cylinder, hand tighten, and tighten with a wrench.
- ☐ **PRIMARY**: Slowly open TK-1, watching for leaks.

- If leaks are observed:
  - ☐ **PRIMARY**: Close TK-1.
  - ☐ **PRIMARY**: Adjust CV-1 until PI-1 shows at least 100 psi.
  - ☐ **PRIMARY**: Slowly open BA-10 to vent the pressurant lines.
  - ☐ **PRIMARY**: Close BA-10.
  - ☐ **PRIMARY**: Inspect the plumbing connections at the pressurant lines.

☐ **PRIMARY**: Adjust CV-1 until PI-1 shows 600 psi.

- If leaks are observed:
  - ☐ **PRIMARY**: Close TK-1.
  - ☐ **PRIMARY**: Slowly open BA-10 to vent the pressurant lines.
  - ☐ **PRIMARY**: Close BA-10.
  - ☐ **PRIMARY**: Inspect the plumbing connections at the pressurant lines.

☐ **DAQ**: Confirm that PT-5 reads 600 psi.

☐ **PRIMARY**: Open BA-1.

☐ **PRIMARY**: Open BA-2.

☐ **DAQ**: Confirm that PT-1 and PT-3 read atmospheric pressure.

☐ **SECONDARY**: Confirm that the resistance across the ignition coils is between 2.5 Ω and 3 Ω:

- ☐ Primary ignition coil
- ☐ Secondary ignition coil

☐ **SECONDARY**: Connect the ignition connectors to the remote control box.

☐ **PRIMARY**: Remove the cap from the nitrous oxide supply cylinder.

☐ **PRIMARY**: Connect the fill line to the supply cylinder, hand tighten, and then tighten with a wrench. Do not force the connection.

☐ **PRIMARY**: Slowly open SC-1.

- If leaks are observed:
  - ☐ **PRIMARY**: Close SC-1.
  - ☐ **PRIMARY**: Open BA-8.
  - ☐ **PRIMARY**: Slowly open BA-3.
  - ☐ **DAQ**: Confirm that PT-2 is reading atmospheric pressure.
  - ☐ **PRIMARY**: Inspect the plumbing connections at the oxidizer fill lines.

☐ **PRIMARY**: Communicate the supply cylinder pressure as visible on the Pressure Gauge.

☐ **DAQ**: Communicate the supply cylinder pressure as read by the Fill Pressure Transducer.

☐ **DAQ**: Confirm that the two pressure measurements are in agreement.

☐ **PRIMARY** and **SECONDARY**: Retreat to the test control area.

☐ **CONTROL**: Confirm that all actuator controls are in the "off" position:

- ☐ Motorized Fill Valve
- ☐ Motorized Vent Valve
- ☐ Pressurant Remote Valve

- ☐ Injector Valve
- ☐ Primary Ignition
- ☐ Secondary Ignition

☐ **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 Motorized Fill Valve.

- If leaks are observed:
  - ☐ **CONTROL**: Close the Motorized Fill Valve.
  - ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
  - ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
  - ☐ **PRIMARY**: Close SC-1.
  - ☐ **CONTROL**: Open the Motorized Fill Valve.
  - ☐ **DAQ**: Confirm that PT-1 and PT-3 are reading atmospheric pressure.
  - ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- If the Remote Fill Valve fails to open:
  - ☐ **OPS**: Abort test procedures and revisit control system setup.

☐ **DAQ**: Proceed only when the oxidizer tank mass reaches a steady state.

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

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

☐ **PAUSE POINT**

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

☐ **DAQ**: Proceed only when PT-1 and PT-3 read 600 psi.

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

☐ **PAUSE POINT**

☐ **OPS**: Poll the following personnel for GO/NO GO status:

- ☐ **PRIMARY**
- ☐ **SECONDARY**
- ☐ **DAQ**
- ☐ **CONTROL**

☐ **CONTROL**: Perform engine startup procedure:

- ☐ Arm the Primary Ignition switch.
- ☐ Hold down the Fire button until the Primary ignition current drops to 0 A.
  - In the event of a failed ignition (current drop not observed within 1 minute):
    - ☐ **CONTROL**: Disarm the Primary Ignition switch.
    - ☐ **CONTROL**: Arm the Secondary Ignition switch.
    - ☐ **OPS**: Revisit ignition procedure.

- In the event of a second failed ignition (current drop not observed within 1 minute):
    - ☐ **CONTROL**: Disarm the Secondary Ignition switch.
    - ☐ **CONTROL**: Open the Motorized Vent Valve to vent the oxidizer tank.
    - ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
    - ☐ **DAQ**: Confirm that PT-1 is reading atmospheric pressure.
    - ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - ☐ **PRIMARY**: Open BA-9 using the ropes to depressurize the fuel tank.
    - ☐ **DAQ**: Confirm that PT-3 is reading atmospheric pressure.
    - ☐ **PRIMARY**: Close SC-1.
    - ☐ **CONTROL**: Open the Motorized Fill Valve to vent the oxidizer supply lines.
    - ☐ **DAQ**: Confirm that PT-2 is reading atmospheric pressure.
    - ☐ **PRIMARY**: Close TK-1.
    - ☐ **PRIMARY**: Slowly open BA-10 to vent the pressurant lines.
    - ☐ **DAQ**: Confirm that PT-5 is reading atmospheric pressure.
    - ☐ **OPS**: Abort test procedures and proceed to teardown.
- ☐ **CONTROL**: Start the engine by opening the Injector Valve.

☐ **ALL**: Observe the plume.

☐ **PAUSE POINT**

☐ **OPS**: Wait for at least 3 minutes before proceeding.

☐ **DAQ**: Confirm that PT-1 and PT-3 are reading atmospheric pressure.

☐ **CONTROL**: Open MV-3.

☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.

☐ **PRIMARY**: Close SC-1.

☐ **CONTROL**: Open the Motorized Fill Valve to vent the oxidizer supply lines.

☐ **DAQ**: Confirm that PT-2 is reading atmospheric pressure.

☐ **PRIMARY**: Close TK-1.

☐ **PRIMARY**: Slowly open BA-10 to vent the pressurant lines.

☐ **DAQ**: Confirm that PT-5 is reading atmospheric pressure.

☐ **PRIMARY**: Disconnect the fill line from the oxidizer supply cylinder.

☐ **PRIMARY**: Replace the cap on the oxidizer supply cylinder.

☐ **PRIMARY**: Disconnect the fill line from the pressurant supply cylinder.

☐ **PRIMARY**: Replace the cap on the pressurant supply cylinder.

☐ **OPS**: Wait for at least 3 minutes before proceeding.

☐ **DAQ**: Continue to monitor thermistor readings.

☐ **OPS**: Proceed with teardown and disassembly.