



Unnamed Liquid Rocket Engine Static Fire 1

Static Fire Test Operations Procedures

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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 nine 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 | <input type="checkbox"/> Operations Director [OPS] | _____ | _____ |
| 2 | <input type="checkbox"/> Primary Fill Operator [PRIMARY] | _____ | _____ |
| 3 | <input type="checkbox"/> Secondary Fill Operator [SECONDARY] | _____ | _____ |
| 4 | <input type="checkbox"/> DAQ Technician [DAQ] | _____ | _____ |
| 5 | <input type="checkbox"/> Control System Operator [CONTROL] | _____ | _____ |

Prior to Start

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

Static Fire Test - Remote Control Procedure

- 1 ☐ **SECONDARY**: Confirm that the ignition wires are not connected to the engine.
- 2 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
 - 3 ☐ SC-1 (Oxidizer Supply Valve)
 - 4 ☐ TK-1 (Pressurant Supply Valve)
 - 5 ☐ BA-1 (Oxidizer Pressurant Shutoff Valve)
 - 6 ☐ BA-2 (Fuel Pressurant Shutoff Valve)
 - 7 ☐ BA-3 (Oxidizer Parallel Fill Valve)
 - 8 ☐ BA-5 (Oxidizer Fill Line Vent Valve)
 - 9 ☐ BA-8 (Oxidizer Tank Dump Valve)
 - 10 ☐ BA-9 (Fuel Tank Vent Valve)
 - 11 ☐ BA-10 (Pressurant Line Vent Valve)
 - 12 ☐ MV-1 (Oxidizer Motorized Fill Valve)
 - 13 ☐ MV-2 (Pressurant Remote Valve)
 - 14 ☐ MV-3 (Oxidizer Motorized Vent Valve)
 - 15 ☐ MV-4 (Fuel Injector Valve)
 - 16 ☐ IJ-1 (Oxidizer Injector Valve)
- 17 ☐ **PRIMARY**: Confirm that the following valves are initially open:
 - 18 ☐ BA-4 (Oxidizer Series Fill Valve)
 - 19 ☐ BA-6 (Oxidizer Shutoff Valve)
 - 20 ☐ BA-7 (Fuel Shutoff Valve)
- 21 ☐ **PRIMARY**: Confirm that CV-1 is adjusted to the lowest pressure setting.
- 22 ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 23 ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 24 ☐ **DAQ**: Confirm that all thermistors are reading ambient temperature.
- 25 ☐ **PAUSE POINT**
- 26 ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 27 ☐ **PRIMARY**: Remove all plastic plugs and covers from the plumbing:
 - 28 ☐ Oxidizer Tank Remote Vent Line
 - 29 ☐ Oxidizer Tank Dump Line
 - 30 ☐ Oxidizer Fill Vent Line
 - 31 ☐ Fuel Tank Vent Line
 - 32 ☐ Pressurant Vent Line
 - 33 ☐ Nozzle
- 34 ☐ **PRIMARY**: Remove the cap from the pressurant supply cylinder.
- 35 ☐ **PRIMARY**: Connect the pressurant line to the cylinder, hand tighten, and tighten with a wrench.
- 36 ☐ **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 ignition 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

- 71 ☐ Injector Valve
- 72 ☐ Primary Ignition
- 73 ☐ Secondary Ignition
- 74 ☐ **PAUSE POINT**
- 75 ☐ **OPS**: Give the system control key to **CONTROL**.
- 76 ☐ **CONTROL**: Engage the key switch and power on the control boxes.
- 77 ☐ **CONTROL**: Open the Motorized Vent Valve.
- 78 ☐ **CONTROL**: Open the Motorized Fill Valve.
 - If leaks are observed:
 - 79 ☐ **CONTROL**: Close the Motorized Fill Valve.
 - 80 ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
 - 81 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
 - 82 ☐ **PRIMARY**: Close SC-1.
 - 83 ☐ **CONTROL**: Open the Motorized Fill Valve.
 - 84 ☐ **DAQ**: Confirm that PT-1 and PT-3 are reading atmospheric pressure.
 - 85 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
 - If the Remote Fill Valve fails to open:
 - 86 ☐ **OPS**: Abort test procedures and revisit control system setup.
- 87 ☐ **DAQ**: Proceed only when the oxidizer tank mass reaches a steady state.
- 88 ☐ **CONTROL**: Close the Motorized Vent Valve.
- 89 ☐ **CONTROL**: Close the Motorized Fill Valve.
- 90 ☐ **PAUSE POINT**
- 91 ☐ **CONTROL**: Open the Pressurant Remote Valve.
- 92 ☐ **DAQ**: Proceed only when PT-1 and PT-3 read 600 psi.
- 93 ☐ **CONTROL**: Close the Pressurant Remote Valve.
- 94 ☐ **PAUSE POINT**
- 95 ☐ **OPS**: Poll the following personnel for GO/NO GO status:
 - 96 ☐ **PRIMARY**
 - 97 ☐ **SECONDARY**
 - 98 ☐ **DAQ**
 - 99 ☐ **CONTROL**
- 100 ☐ **CONTROL**: Perform engine startup procedure:
 - 101 ☐ Arm the Primary Ignition switch.
 - 102 ☐ 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):
 - 103 ☐ **CONTROL**: Disarm the Primary Ignition switch.
 - 104 ☐ **CONTROL**: Arm the Secondary Ignition switch.
 - 105 ☐ **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 and inform **OPS** if the combustion chamber temperature exceeds 190 °C.
- ☐ **OPS**: Proceed with teardown and disassembly.