



# UXO Hybrid Rocket Engine Static Fire 1

Static Fire Test Operations Procedures

Compiled on 2018-02-15

# Static Fire Test Operations Procedures

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## Contents

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This document contains three procedures:

- The *Fill System Check* procedure comprises steps for validating the integrity of the system plumbing and correct operation of the test data acquisition system, using carbon dioxide.
- The *Static Fire Test Remote Control* procedure comprises steps for operating the fill system using the electrical control system and motorized ball valves.
- The *Static Fire Test Manual Control* procedure comprises steps for operating the fill system using manually operated 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]** and **Perimeter Guard 2 [P2]** 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>              | _____ | _____ |

## Prior to Start

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- 1    ☐ Ensure that the following procedures are complete:
- 2        ☐ Combustion Chamber Assembly procedure
- 3        ☐ Oxidizer Tank Assembly procedure
- 4        ☐ Plumbing Setup procedure
- 5        ☐ Oxidizer Tank Stand Setup procedure
- 6        ☐ Tank Heating Setup procedure
- 7        ☐ Test Stand Setup procedure
- 8        ☐ Data Acquisition Setup procedure
- 9        ☐ Test Control System Setup procedure
- 10    ☐ Ensure that all technicians as defined above are available and have completed the sign-off.
- 11    ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
- 12        ☐ OPS
- 13        ☐ PRIMARY
- 14        ☐ SECONDARY
- 15        ☐ DAQ
- 16        ☐ HEAT
- 17        ☐ P1
- 18        ☐ P2
- 19    ☐ Ensure that all spectators and test personnel are wearing safety glasses and hearing protection.
- 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.

## Fill System Check 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        ☐ Line Vent Valve
  - 8        ☐ Injector Valve
- 9    ☐ **PRIMARY**: Confirm that the following valves are initially open:
  - 10       ☐ Series Fill Valve
- 11   ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 12   ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 13   ☐ **OPS**: Confirm that all personnel in the testing area are aware of the test.
- 14   ☐ **P1** and **P2**: Close the perimeter and do not allow any further personnel to enter the testing area.
- 15   ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 16   ☐ **PRIMARY**: Remove all plastic plugs and covers from the plumbing:
  - 17       ☐ Tank Vent Valve
  - 18       ☐ Pressure Relief Valve
  - 19       ☐ Line Vent Valve
  - 20       ☐ Nozzle
- 21   ☐ **PRIMARY**: Remove the cap from the carbon dioxide supply cylinder.
- 22   ☐ **PRIMARY**: Connect the fill line to the supply cylinder, hand tighten, and then tighten with a wrench. Do not force the connection.
- 23   ☐ **PRIMARY**: Slowly open the Cylinder Valve through  $\frac{3}{4}$  of a turn.
  - If leaks are observed:
    - 24       ☐ **PRIMARY**: Close the Cylinder Valve.
    - 25       ☐ **PRIMARY**: Slowly open the Line Vent Valve.
    - 26       ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
    - 27       ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 28       ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- 29   ☐ **PRIMARY**: Communicate the supply cylinder pressure as visible on the Pressure Gauge.
- 30   ☐ **DAQ**: Communicate the supply cylinder pressure as read by the Fill Pressure Transducer.
- 31   ☐ **DAQ**: Confirm that the two pressure measurements are in agreement.
- 32   ☐ **SECONDARY**: Give the system control key to **PRIMARY**.
- 33   ☐ **PRIMARY**: Engage the key switch and power on the control boxes.

- 34    ☐ **PRIMARY**: Open the Tank Vent Valve.
- 35    ☐ **PRIMARY**: Open the Remote Fill Valve.
- If leaks are observed:
- 36        ☐ **PRIMARY**: Close the Remote Fill Valve.
- 37        ☐ **PRIMARY**: Close the Cylinder Valve.
- 38        ☐ **PRIMARY**: Slowly open the Line Vent Valve.
- 39        ☐ **PRIMARY**: Slowly open the Parallel Fill 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.
- If the Remote Fill Valve fails to open:
- 43        ☐ **OPS**: Abort test procedures and revisit control system setup.
- 44    ☐ **DAQ**: Confirm that the oxidizer tank mass is increasing.
- 45    ☐ **DAQ**: Confirm that the oxidizer tank pressure is increasing.
- 46    ☐ **PRIMARY**: Close the Remote Fill Valve
- 47    ☐ **PRIMARY**: Open the Line Vent Valve.
- 48    ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 49    ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 50    ☐ **PRIMARY**: Close the Cylinder Valve.
- 51    ☐ **PRIMARY**: Open the Remote Fill Valve.
- 52    ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
- 53    ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 54    ☐ **PRIMARY**: Replace the cap on the carbon dioxide supply cylinder.
- 55    ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 56    ☐ **P1** and **P2**: Open the perimeter.
- 57    ☐ **OPS**: Proceed with teardown and disassembly.

## Static Fire Test - Remote Control Procedure

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- 1    ☐ **SECONDARY**: Confirm that the ignition wires are not connected to the engine.
- 2    ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - 3        ☐ Cylinder Valve
  - 4        ☐ Remote Fill Valve
  - 5        ☐ Parallel Fill Valve
  - 6        ☐ Pressure Relief Valve
  - 7        ☐ Tank Vent Valve
  - 8        ☐ Line Vent Valve
  - 9        ☐ Injector Valve
- 10   ☐ **PRIMARY**: Confirm that the following valves are initially open:
  - 11        ☐ Series Fill Valve
- 12   ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 13   ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 14   ☐ **PAUSE POINT**
- 15   ☐ **P1** and **P2**: Close the perimeter and do not allow any further personnel to enter the testing area.
- 16   ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 17   ☐ **PRIMARY**: Remove all plastic plugs and covers from the plumbing:
  - 18        ☐ Tank Vent Valve
  - 19        ☐ Pressure Relief Valve
  - 20        ☐ Line Vent Valve
  - 21        ☐ Nozzle
- 22   ☐ **SECONDARY**: Confirm that the impedance across the ignition coils is between 2.5  $\Omega$  and 3  $\Omega$ :
  - 23        ☐ Primary ignition coil
  - 24        ☐ Secondary ignition coil
- 25   ☐ **SECONDARY**: Connect the ignition connectors to the ignition box.
- 26   ☐ **PRIMARY**: Remove the cap from the nitrous oxide supply cylinder.
- 27   ☐ **PRIMARY**: Connect the fill line to the supply cylinder, hand tighten, and then tighten with a wrench. Do not force the connection.
- 28   ☐ **PRIMARY**: Slowly open the Cylinder Valve through  $\frac{3}{4}$  of a turn.
  - If leaks are observed:
    - 29        ☐ **PRIMARY**: Close the Cylinder Valve.
    - 30        ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
    - 31        ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
    - 32        ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 33        ☐ **OPS**: Abort test procedures and revisit plumbing setup.

- 34 ☐ **PRIMARY**: Communicate the supply cylinder pressure as visible on the Pressure Gauge.
- 35 ☐ **DAQ**: Communicate the supply cylinder pressure as read by the Fill Pressure Transducer.
- 36 ☐ **DAQ**: Confirm that the two pressure measurements are in agreement.
- 37 ☐ **PRIMARY** and **SECONDARY**: Retreat to the test control area, behind the blast shield.
- 38 ☐ **PRIMARY**: Confirm that all actuator controls are in the “off” position:
- 39 ☐ Remote Fill Valve
- 40 ☐ Tank Vent Valve
- 41 ☐ Injector Valve
- 42 ☐ Primary Ignition
- 43 ☐ Secondary Ignition
- 44 ☐ **PAUSE POINT**
- 45 ☐ **OPS**: Poll the following personnel for GO/NO GO status:
- 46 ☐ **P1**
- 47 ☐ **P2**
- 48 ☐ **HEAT**
- 49 ☐ **DAQ**
- 50 ☐ **PRIMARY**
- 51 ☐ **SECONDARY**
- 52 ☐ **SECONDARY**: Give the system control key to **PRIMARY**.
- 53 ☐ **PRIMARY**: Engage the key switch and power on the control boxes.
- 54 ☐ **PRIMARY**: Open the Tank Vent Valve.
- 55 ☐ **PRIMARY**: Open the Remote Fill Valve.
- If leaks are observed:

56 ☐ **PRIMARY**: Close the Remote Fill Valve.

57 ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.

58 ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.

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

60 ☐ **PRIMARY**: Close the Cylinder Valve.

61 ☐ **PRIMARY**: Open the Remote Fill Valve.

62 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.

63 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
  - If the Remote Fill Valve fails to open:

64 ☐ **OPS**: Proceed to the Manual Control procedure.
- 65 ☐ **SECONDARY**: Proceed only when a white plume is visible from the Tank Vent Valve.
- 66 ☐ **PRIMARY**: Close the Tank Vent Valve.
- 67 ☐ **PRIMARY**: Close the Remote Fill Valve.
- If the Remote Fill Valve fails to close:

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

- 69           ☐ **PRIMARY**: Close the Series Fill Valve.
- 70           ☐ **PRIMARY** and **SECONDARY**: Retreat to the test control area, behind the blast shield.
- 71   ☐ **HEAT**: Open the Tank Heating Valve.
- 72   ☐ **DAQ**: Proceed only when the oxidizer tank pressure is at least 750 psi.
- If the oxidizer tank pressure does not reach 750 psi:
- 73           ☐ **HEAT**: Close the Tank Heating Valve.
- 74           ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
- 75           ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.
- 76           ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 77           ☐ **PRIMARY**: Close the Cylinder Valve.
- 78           ☐ **PRIMARY**: Open the Tank Vent Valve.
- 79           ☐ **PRIMARY**: Open the Remote Fill Valve.
- 80           ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 81           ☐ **OPS**: Abort test procedures and revisit water jacket setup.
- 82   ☐ **HEAT**: Close the Tank Heating Valve.
- 83   ☐ **PAUSE POINT**
- 84   ☐ **PRIMARY**: Perform engine startup procedure:
- 85           ☐ Arm the Primary Ignition switch.
- 86           ☐ Hold down the Fire button until black smoke is observed.
- In the event of a failed ignition (smoke not observed within 1 minute):
- 87           ☐ **PRIMARY**: Disarm the Primary Ignition switch.
- 88           ☐ **PRIMARY**: Arm the Secondary Ignition switch.
- 89           ☐ **OPS**: Revisit ignition procedure.
- In the event of a second failed ignition (smoke not observed within 1 minute):
- 90           ☐ **PRIMARY**: Disarm the Secondary Ignition switch.
- 91           ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
- 92           ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
- 93           ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 94           ☐ **PRIMARY**: Close the Cylinder Valve.
- 95           ☐ **PRIMARY**: Open the Remote Fill Valve.
- 96           ☐ **PRIMARY**: Open the Tank Vent Valve.
- 97           ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 98           ☐ **OPS**: Abort test procedures and proceed to teardown.
- 99   ☐ **PRIMARY**: Start the engine by opening the Injector Valve.
- 100   ☐ **PRIMARY**: Observe the plume:
- If any unexpected events occur during the engine firing:
- 101           ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
- 102           ☐ **PRIMARY**: Wait for 3 seconds.
- 103           ☐ **PRIMARY**: Close the Injector Valve.
- 104   ☐ **PAUSE POINT**
- 105   ☐ **OPS**: Wait for at least 3 minutes before proceeding.



- 106    ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 107    ☐ **PRIMARY**: Open the Tank Vent Valve.
- 108    ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 109    ☐ **PRIMARY**: Close the Cylinder Valve.
- 110    ☐ **PRIMARY**: Open the Remote Fill Valve.
- 111    ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
- 112    ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 113    ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 114    ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 115    ☐ **P1** and **P2**: Open the perimeter.
- 116    ☐ **OPS**: Proceed with teardown and disassembly.

## Static Fire Test - Manual Control Procedure

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- 1    ☐ **SECONDARY**: Confirm that the ignition wires are not connected to the engine.
- 2    ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - 3        ☐ Cylinder Valve
  - 4        ☐ Remote Fill Valve
  - 5        ☐ Parallel Fill Valve
  - 6        ☐ Pressure Relief Valve
  - 7        ☐ Line Vent Valve
  - 8        ☐ Injector Valve
  - 9        ☐ Series Fill Valve
- 10   ☐ **PRIMARY**: Confirm that the following valves are initially open:
  - 11        ☐ Tank Vent Valve
- 12   ☐ **DAQ**: Confirm that all pressure transducers are reading atmospheric pressure.
- 13   ☐ **DAQ**: Confirm that all load cells are reading the determined zero point.
- 14   ☐ **PAUSE POINT**
- 15   ☐ **P1** and **P2**: Close the perimeter and do not allow any further personnel to enter the testing area.
- 16   ☐ **SECONDARY**: Confirm that no personnel are present in the testing area other than **PRIMARY** and **SECONDARY**.
- 17   ☐ **PRIMARY**: Remove all plastic plugs and covers from the plumbing:
  - 18        ☐ Tank Vent Valve
  - 19        ☐ Pressure Relief Valve
  - 20        ☐ Line Vent Valve
  - 21        ☐ Nozzle
- 22   ☐ **SECONDARY**: Confirm that the impedance across the ignition coils is between 2.5  $\Omega$  and 3  $\Omega$ :
  - 23        ☐ Primary ignition coil
  - 24        ☐ Secondary ignition coil
- 25   ☐ **SECONDARY**: Connect the ignition connectors to the ignition box.
- 26   ☐ **PRIMARY**: Remove the cap from the nitrous oxide supply cylinder.
- 27   ☐ **PRIMARY**: Connect the fill line to the supply cylinder, hand tighten, and then tighten with a wrench. Do not force the connection.
- 28   ☐ **PRIMARY**: Slowly open the Cylinder Valve through  $\frac{3}{4}$  of a turn.
  - If leaks are observed:
    - 29        ☐ **PRIMARY**: Close the Cylinder Valve.
    - 30        ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
    - 31        ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
    - 32        ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 33        ☐ **OPS**: Abort test procedures and revisit plumbing setup.

- 34 ☐ **PRIMARY**: Communicate the supply cylinder pressure as visible on the Pressure Gauge.
- 35 ☐ **DAQ**: Communicate the supply cylinder pressure as read by the Fill Pressure Transducer.
- 36 ☐ **DAQ**: Confirm that the two pressure measurements are in agreement.
- 37 ☐ **SECONDARY**: Confirm that the following actuator controls are in the "off" position:
  - 38 ☐ Primary Ignition
  - 39 ☐ Secondary Ignition
- 40 ☐ **PAUSE POINT**
- 41 ☐ **OPS**: Poll the following personnel for GO/NO GO status:
  - 42 ☐ **P1**
  - 43 ☐ **P2**
  - 44 ☐ **HEAT**
  - 45 ☐ **DAQ**
  - 46 ☐ **PRIMARY**
  - 47 ☐ **SECONDARY**
- 48 ☐ **PRIMARY**: Open the Parallel Fill Valve.
  - If leaks are observed:
    - 49 ☐ **PRIMARY**: Close the Parallel Fill Valve.
    - 50 ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
    - 51 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 52 ☐ **PRIMARY**: Open the Parallel Fill Valve.
    - 53 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
    - 54 ☐ **OPS**: Abort test procedures and revisit plumbing setup.
- 55 ☐ **SECONDARY**: Proceed only when a white plume is visible from the Tank Vent Valve.
- 56 ☐ **PRIMARY**: Close the Parallel Fill Valve.
- 57 ☐ **PRIMARY** and **SECONDARY**: Retreat to the test control area, behind the blast shield.
- 58 ☐ **HEAT**: Open the Tank Heating Valve.
- 59 ☐ **DAQ**: Proceed only when the oxidizer tank pressure is at least 750 psi.
  - If the oxidizer tank pressure does not reach 750 psi:
    - 60 ☐ **HEAT**: Close the Tank Heating Valve.
    - 61 ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
    - 62 ☐ **SECONDARY**: Proceed only when the oxidizer tank has fully vented.
    - 63 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - 64 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 65 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
    - 66 ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
    - 67 ☐ **OPS**: Abort test procedures and revisit water jacket setup.
- 68 ☐ **HEAT**: Close the Tank Heating Valve.
- 69 ☐ **PAUSE POINT**

- 70 ☐ **PRIMARY**: Perform engine startup procedure:
- 71 ☐ Arm the Primary Ignition switch.
- 72 ☐ Hold down the Fire button until black smoke is observed.
  - In the event of a failed ignition (smoke not observed within 1 minute):
    - 73 ☐ **PRIMARY**: Disarm the Primary Ignition switch.
    - 74 ☐ **PRIMARY**: Arm the Secondary Ignition switch.
    - 75 ☐ **OPS**: Revisit ignition procedure.
  - In the event of a second failed ignition (smoke not observed within 1 minute):
    - 76 ☐ **PRIMARY**: Disarm the Secondary Ignition switch.
    - 77 ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
    - 78 ☐ **OPS**: Proceed only when the oxidizer tank has fully vented.
    - 79 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
    - 80 ☐ **PRIMARY**: Close the Cylinder Valve.
    - 81 ☐ **PRIMARY**: Open the Remote Fill Valve.
    - 82 ☐ **PRIMARY**: Open the Tank Vent Valve.
    - 83 ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
    - 84 ☐ **OPS**: Abort test procedures and proceed to teardown.
- 85 ☐ **PRIMARY**: Start the engine by opening the Injector Valve with the ropes.
- 86 ☐ **PRIMARY**: Observe the plume:
  - If any unexpected events occur during the engine firing:
    - 87 ☐ **PRIMARY**: Open the Line Vent Valve using the ropes.
- 88 ☐ **PAUSE POINT**
- 89 ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 90 ☐ **DAQ**: Confirm that the Oxidizer Tank Pressure Transducer is reading atmospheric pressure.
- 91 ☐ **PRIMARY** and **SECONDARY**: Approach the test plumbing.
- 92 ☐ **PRIMARY**: Close the Cylinder Valve.
- 93 ☐ **PRIMARY**: Open the Parallel Fill Valve.
- 94 ☐ **DAQ**: Confirm that the Fill Pressure Transducer is reading atmospheric pressure.
- 95 ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 96 ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 97 ☐ **OPS**: Wait for at least 3 minutes before proceeding.
- 98 ☐ **P1** and **P2**: Open the perimeter.
- 99 ☐ **OPS**: Proceed with teardown and disassembly.