



UXO Hybrid Rocket Engine Static Fire 1

Static Fire Test Operations Procedures

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Static Fire Test Operations Procedures

Contents

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

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

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"/> Heating Technician [HEAT] | _____ | _____ |
| 6 | <input type="checkbox"/> Perimeter Guard 1 [P1] | _____ | _____ |
| 7 | <input type="checkbox"/> Perimeter Guard 2 [P2] | _____ | _____ |

Prior to Start

- 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 ☐ SECONDARY
- 14 ☐ DAQ
- 15 ☐ HEAT
- 16 ☐ P1
- 17 ☐ P2
- 18 ☐ Ensure that all spectators and test personnel are wearing safety glasses and hearing protection.
- 19 ☐ Ensure that PRIMARY and SECONDARY are wearing face shields and have no exposed skin.
- 20 ☐ Ensure that PRIMARY is wearing thermal gloves.
- 21 ☐ Ensure that SECONDARY is in possession of the system control key.

Fill System Check Procedure

- 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

- 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 Ω and 3 Ω :
 - 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 ignition 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

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