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Hanford EPICS Vacuum Controls 2500l/s Ion Pump Test Specifications

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Hanford CDS, Operators, Vacuum and PSI

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Hanford EPICS Vacuum Controls Test Specifications

SYSTEM TESTED: _____

SOFTWARE TESTED: _____

HARDWARE CONFIGURATION:

Equipment List	Date	Revision	Serial Number

TESTED BY:

Name	Title	Date

TESTS COMPLETED:

Test Name	Sign Off	Date

APPROVED BY:

Signature	Date

Table of Contents

Table of Contents

Table of Contents

Table of Contents

1 Introduction

The Varian 2500l/s ion pump is used in most of the Hanford Vacuum Areas as a high capacity high vacuum pump. The Varian is composed of two identical ion pumps, arranged in parallel. The EPICS control system allows the operator to control each pump separately.

Each pump supplies two analog and one digital signal. The analog signals are:

- Ion Pump Vacuum (0-5V representing 1.0E-10 1.0E-4 Torr)
- Ion Pump High Voltage (0 - 3.75V representing 0 - 7000V)

The digital signal is:

- Pump Fault (high represents OK state)

The control system sends two digital signals to each pump. These signals are:

- Start Ion Pump (momentary binary, normally 0V, active +24V) referred to as “confirm” signal in documentation.
- Stop Ion Pump (momentary binary, normally +24V, active 0V) referred to as “enable” signal in documentation.

1.1. Signal Conversions

The Ion Pump High Voltage signal is a linear signal. 0.0V input corresponds to 0.0kV, 3.75V input corresponds to 7.0kV.

The Ion Pump Vacuum signal is log-linear conversion. A linear voltage corresponds to a linear Vacuum when plotted in logarithmic units. The conversion is:

$$Vacuum=10^{(-10+(6*V/5))}$$

where V is the input voltage in the range 0.0V to 5.0V, Vacuum is in Torr.

1.2. Purpose

This document is the test specification for the EPICS controls of this device. With the EPICS system running in simulation mode, this test spec. allows the user to fully test the control system functionality with no impact on PSI. In non-simulation mode, both the EPICS controls, the PSI interface and the Ion Pump itself can be tested.

1.3. Test Description.

The Ion Pump database will be tested in three phases:

- Simulation mode.
- Non-simulation mode, not connected to PSI wiring (Emulation Mode).
- Non-simulation mode, fully connected to PSI wiring (Real Mode).

THE TEST MAY ONLY BE RUN FULLY CONNECTED TO PSI WIRING WHEN PSI AND CALTECH VACUUM MANAGEMENT HAVE GIVEN EXPRESS PERMISSION TO DO SO. Ignoring this warning may cause damage to the Ion Pump and the Vacuum System. **Remember, the ion pump contains potentially lethal voltages (7kV).**

In simulation mode the user can only test the basics of database execution. In non-simulation mode the user will inject voltages to emulate the PSI wiring. Output voltages and/or currents will be measured.

When running directly to the PSI vacuum system, the actual operation of the ion pump will be tested. These tests will be performed with the Hanford Vacuum team and PSI.

This document will show the testing of the Right Mid Station Ion Pump HVE-MX:IP10. Replace this name with the name of the pump you are testing.

1.4. Test Initialization

The user must have booted the IOC with the correct EPICS database for the system to be tested. It is assumed throughout this document that the user is familiar with EPICS configuration and operation.

The Ion Pump does not use any sequencers.

Run the Alarm Handler for the system containing the Ion Pump under test.

1.4.1. Simulation Mode

EPICS.

The database file HVE-MX:IP10.db and its simulation database file HVE-MX:IP10S.db have been loaded and initialised.

MEDM.

The 2500l/s Ion Pump MEDM screen HVE-MX:IP10.adl and its simulation screen HVE-MX:IP10S.adl are running. All widgets are connected to the database.

SAMMI.

The Ion Pump Sammi formats HVE-MX:IP10 and its simulation screen HVE-MX:IP10_S are running. All DDOs are connected to the database.

1.4.2. Non-Simulation Mode, Not Connected to PSI Wiring

Ensure all signals are disconnected to PSI. The user is required to inject DC voltages into the Ion Pump controls (0 - 5V range), emulate a relay contact closure and measure output voltages in the 0 - 24V range.

(QT) Tests marked with this symbol and are underlined define a Quick Test. Quick Tests allow the user to just test the hardware interface to the EPICS controls, and not test the control logic itself.

1.4.3. Non-Simulation Mode, Full Connection to PSI Wiring

These tests will be performed with Hanford Operators, Hanford Vacuum management and PSI. They will be fully co-ordinted with these teams and will only proceed with the express permission of all parties. Full lock and tag procedures will be followed.

THIS TEST WILL ONLY PROCEED WHEN IT IS DEEMED SAFE TO DO SO.

All PSI wiring will be attached to the PSI interface wiring block.

THESE TEST SPECS ARE TO BE DETERMINED.

1.4.4. Data Tables

Attached to this Test Spec are two data tables:

PSI Signal Matrix for Hanford 2500l/s Ion Pumps. This specifies the PSI interface connectors used by all the Ion Pumps at the Hanford site.

Signal Data Matrix for Hanford 2500l/s Ion Pumps. This specifies Ion Pump input and output signal limits, units, engineering conversions and alarm limits.

	PASS	FAIL	COMMENTS

2 Testing in Simulation Mode

2.1. Test Setup

2.1.1. Run the Alarm Handler with the alarm configuration file appropriate for the Ion Pump being tested.

- Acknowledge all outstanding alarms (e.g. Faults or out of range inputs). On the Alarm Handler, acknowledge all simulation alarms. Refer to Table 2: Signal Data Matrix for Hanford 2500l/s Ion Pumps.

2.1.2. On the simulation screen, switch the database into simulation mode by pushing the Sim On button.

- Verify simulation is on, and the simulated signals have entered the SIMULATION alarm state (foreground colours set to YELLOW and a MINOR alarm on the alarmhandler.

2.1.3. On the main screen, initialise the stop command signal by pressing the STOP button on both Pump A and Pump B. On the simulation screen, both Pump A and B stop command signal should have a steady state value of 1.

2.2. Test Pump A Vacuum

In the following tests the user will simulate the input of various voltages from PSI and check that the screens show the correct vacuums corresponding to these voltages.

Voltages below 0.0V or above 5.0V are out of the operating range of the Ion Pump and will be flagged by a zero vacuum reading and a major alarm.

Voltages on the edge of the operating range (0.0V and 5.0V) will show the vacuum (1.0e-10 and 1.0e-4 respectively), but will also show a major alarm.

2.2.1. Simulate invalid vacuum voltage from the Ion Pump (below valid range).

2.2.1.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows zero and a major alarm

- Verify the Pump A vacuum reading on the alarm handler shows a major alarm

2.2.1.b Type in -1.0 into the Pump A Vacuum entry widget for Pump A on the Simulation Screen to start the test.

2.2.2. Simulate low vacuum voltage from the Ion Pump (low edge of valid range).

2.2.2.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows 1.0E-10 and a major alarm

- Verify the Pump A vacuum signal on the alarm handler shows a major alarm

	PASS	FAIL	COMMENTS

2.2.2.b Type in 0.0 into the Pump A Vacuum entry widget for Pump A on the Simulation Screen to start the test.

2.2.3. Simulate valid vacuum voltage from the Ion Pump (middle of valid range).

2.2.3.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows 1.0E-7 and a simulation alarm
- Verify the Pump A vacuum signal on the alarm handler shows a simulation alarm

2.2.3.b Type in 2.5 into the Pump A Vacuum entry widget for Pump A on the Simulation Screen to start the test.

2.2.4. Simulate high vacuum voltage from the Ion Pump (upper edge of valid range).

2.2.4.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows 1.0E-4 and a major alarm
- Verify the Pump A vacuum signal on the alarm handler shows a major alarm

2.2.4.b Type in 5.0 into the Pump A Vacuum entry widget for Pump A on the Simulation Screen to start the test.

2.2.5. Simulate invalid vacuum voltage from the Ion Pump (above valid range).

2.2.5.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump A vacuum signal on the alarm handler shows a major alarm

2.2.5.b Type in 6.0 into the Pump A Vacuum entry widget for Pump A on the Simulation Screen to start the test.

2.2.6. Return vacuum to valid range.

2.2.6.a Type in 2.5 into the Pump A Vacuum entry widget on the Simulation screen.

2.3. Test Pump A High Voltage

The Ion Pump High Voltage reading has a range from 0 to 7kV. MAJOR alarms are set for a low out of range voltage less than 0Kv and for a high voltage of 7kV or more. These tests will check that the alarms are raised at the appropriate values.

2.3.1. Simulate negative voltage from Ion Pump.

2.3.1.a You will check the following during this test;

- Pump A voltage on the main screen changes to -1kV within one second,

	PASS	FAIL	COMMENTS

and shows a MAJOR alarm state.

- On the alarm handler this signal shows a MAJOR alarm state.

2.3.1.b On the simulation screen, type -1 (negative) in the Pump A voltage input widget to start the test.

2.3.2. Simulate voltage in valid range from Ion Pump.

2.3.2.a You will check the following during this test;

- Verify that on the main screen this signal leaves the MAJOR alarm state (shows SIMULATION alarm state) and shows a value of 3kV.

- Verify that on the alarm handler this signal leaves the MAJOR alarm state (shows SIMULATION alarm state).

2.3.2.b On the simulation screen, type 3 in the Pump A voltage input widget to start the test.

2.3.3. Simulate voltage above valid range from the Ion Pump.

2.3.3.a You will check the following during this test;

- Verify that on the main screen this signal goes into a MAJOR alarm state and shows a value of 8kV.

- Verify that on the alarm handler this signal goes into a MAJOR alarm state.

2.3.3.b On the simulation screen, type 8 in the Pump A voltage input widget to start the test.

Return voltage back to valid range by entering 3 in the Pump A voltage input widget on the simulation screen.

2.4. Test Pump A Fault

Pump A fault values are; fault=0 or OK=1. These tests will check that a simulated Ion Pump Fault/No-Fault changes the displays accordingly. It is assumed that the Pump is in the Faulted state (0 on fault simulation entry).

2.4.1. Test pump A No Fault reading and alarm.

2.4.1.a You will check the following during this test;

- Confirm Pump A fault on the main screen changed from fault (MAJOR alarm color) to OK within one second.

- Verify the text immediately above the Pump A Start button changed from “Start Disabled “ in MAJOR alarm state to “Start Enabled” in NO_ALARM colors within one second.

- Verify the alarm handler stops showing Pump A fault MAJOR alarm within one second.

2.4.1.b Type 1 into the Pump A Fault widget on the Simulation screen to run

	PASS	FAIL	COMMENTS

this test.

2.4.2. Test pump A Fault reading and alarm.

2.4.2.a You will check the following during this test;

- Confirm Pump A fault on the main screen changed to fault (red) within one second.
- Verify the text immediately above the Pump A Start button changed to “Start Disabled” in MAJOR alarm colors within one second.
- Verify the alarm handler shows Pump A Fault MAJOR alarm within one second.

2.4.2.b Type 0 into the Pump A Fault widget on the Simulation screen to run this test.

Reset Fault back to 1 (no fault) condition.

2.5. Test Pump A Start

Check that on the simulation screen the pump A command signals are; start=0, stop=1. If not, see section on setting up simulation mode.

2.5.1. Test Start of Pump A with no fault.

Check the Simulation value for Pump A Fault is one. Verify that on the main screen, the pump A Start message reads “Start Enabled”.

2.5.1.a You will check the following during this test;

- On the simulation screen check that the pump A start cmd signal goes high (1) for 1 second and returns to zero.

2.5.1.b On the main screen, press the pump A Start button (and confirm entry) to start the test.

2.5.2. Test Start of Pump A with Fault.

Set the Simulation value for Pump A Fault to zero. Verify that on the main screen, the Pump A Start message reads “Start Disabled” in red.

2.5.2.a You will check the following during this test;

- On the simulation screen check that the pump A start cmd signal stays low (0).

2.5.2.b On the main screen, press the pump A Start button (and confirm entry) to start the test.

2.6. Test Pump A Stop.

2.6.1. Test Stop of Pump A.

Check that on the simulation screen the pump A commands are; start=0, stop=1.

2.6.1.a You will check the following during this test;

- On the simulation screen check that the pump A stop cmd signal goes low

	PASS	FAIL	COMMENTS

(0) for 1 second.

2.6.1.b On the main screen, press the pump A Stop button (and confirm entry)

Return Pump A fault to no-fault by entering 1 into Pump A fault simulation widget.

2.7. Test Pump B Vacuum

In the following tests the user will simulate the input of various voltages from PSI and check that the screens show the correct vacuums corresponding to these voltages.

Voltages below 0.0V or above 5.0V are out of the operating range of the Ion Pump and will be flagged by a zero vacuum reading and a major alarm.

Voltages on the edge of the operating range (0.0V and 5.0V) will show the vacuum (1.0e-10 and 1.0e-4 respectively), but will also show a major alarm.

2.7.1. Simulate invalid vacuum voltage from the Ion Pump (below valid range).

2.7.1.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump B vacuum reading on the alarm handler shows a major alarm

2.7.1.b Type in -1.0 into the Pump B Vacuum entry widget for Pump B on the Simulation Screen to start the test.

2.7.2. Simulate low vacuum voltage from the Ion Pump (low edge of valid range).

2.7.2.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows 1.0E-10 and a major alarm
- Verify the Pump B vacuum signal on the alarm handler shows a major alarm

2.7.2.b Type in 0.0 into the Pump B Vacuum entry widget for Pump B on the Simulation Screen to start the test.

2.7.3. Simulate valid vacuum voltage from the Ion Pump (middle of valid range).

2.7.3.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows 1.0E-7 and a simulation alarm
- Verify the Pump B vacuum signal on the alarm handler shows a simulation alarm

2.7.3.b Type in 2.5 into the Pump B Vacuum entry widget for Pump B on the Simulation Screen to start the test.

	PASS	FAIL	COMMENTS

2.7.4. Simulate high vacuum voltage from the Ion Pump (upper edge of valid range).

2.7.4.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows 1.0E-4 and a major alarm
- Verify the Pump B vacuum signal on the alarm handler shows a major alarm

2.7.4.b Type in 5.0 into the Pump B Vacuum entry widget for Pump B on the Simulation Screen to start the test.

2.7.5. Simulate invalid vacuum voltage from the Ion Pump (above valid range).

2.7.5.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump B vacuum signal on the alarm handler shows a major alarm

2.7.5.b Type in 6.0 into the Pump B Vacuum entry widget for Pump B on the Simulation Screen to start the test.

2.7.6. Return vacuum to valid range.

2.7.6.a Type in 2.5 into the Pump B Vacuum entry widget on the Simulation screen.

2.8. Test Pump B High Voltage

The Ion Pump High Voltage reading has a range from 0 to 7kV. MAJOR alarms are set for a low out of range voltage less than 0Kv and for a high voltage of 7kV or more. These tests will check that the alarms are raised at the appropriate values.

2.8.1. Simulate negative voltage from Ion Pump.

2.8.1.a You will check the following during this test;

- Pump B voltage on the main screen changes to -1kV within one second, and shows a MAJOR alarm state.
- On the alarm handler this signal shows a MAJOR alarm state.

2.8.1.b On the simulation screen, type -1 (negative) in the Pump B voltage input widget to start the test.

2.8.2. Simulate voltage in valid range from Ion Pump.

2.8.2.a You will check the following during this test;

- Verify that on the main screen this signal leaves the MAJOR alarm state (shows SIMULATION alarm state) and shows 3kV.
- Verify that on the alarm handler this signal leaves the MAJOR alarm state

	PASS	FAIL	COMMENTS

(shows SIMULATION alarm state).

2.8.2.b On the simulation screen, type 3 in the Pump B voltage input widget to start the test.

2.8.3. Simulate voltage above valid range from the Ion Pump.

2.8.3.a You will check the following during this test;

- Verify that on the main screen this signal goes into a MAJOR alarm state and shows 8kV.
- Verify that on the alarm handler this signal goes into a MAJOR alarm state.

2.8.3.b On the simulation screen, type 8 in the Pump B voltage input widget to start the test.

Return voltage back to valid range by entering 3 in the Pump B voltage input widget on the simulation screen.

2.9. Test Pump B Fault

Pump B fault values are; fault=0 or OK=1. These tests will check that a simulated Ion Pump Fault/No-Fault changes the displays accordingly. It is assumed that the Pump is in the Faulted state (0 on fault simulation entry).

2.9.1. Test pump B No Fault reading and alarm.

2.9.1.a You will check the following during this test;

- Confirm Pump B fault on the main screen changed from fault (MAJOR alarm color) to OK within one second.
- Verify the text immediately above the Pump B Start button changed from “Start Disabled “ in MAJOR alarm state to “Start Enabled” in NO_ALARM colors within one second.
- Verify the alarm handler stops showing Pump B fault MAJOR alarm within one second.

2.9.1.b Type 1 into the Pump B Fault widget on the Simulation screen to run this test.

2.9.2. Test pump B Fault reading and alarm.

2.9.2.a You will check the following during this test;

- Confirm Pump B fault on the main screen changed to fault (red) within one second.
- Verify the text immediately above the Pump B Start button changed to “Start Disabled” in MAJOR alarm colors within one second.
- Verify the alarm handler shows Pump B Fault MAJOR alarm within one second.

	PASS	FAIL	COMMENTS

2.9.2.b Type 0 into the Pump B Fault widget on the Simulation screen to run this test.

Reset Fault back to 1 (no fault) condition.

2.10. Test Pump B Start.

Check that on the simulation screen the pump B command signals are; start=0, stop=1. If not, see section on setting up simulation mode.

2.10.1. Test Start of Pump B with no fault.

Check the Simulation value for Pump B Fault is one. Verify that on the main screen, the pump B Start message reads “Start Enabled”.

2.10.1.a You will check the following during this test;

- On the simulation screen check that the pump B start cmd signal goes high (1) for 1 second and returns to zero.

2.10.1.b On the main screen, press the pump B Start button (and confirm entry) to start the test.

2.10.2. Test Start of Pump B with Fault.

Set the Simulation value for Pump B Fault to zero. Verify that on the main screen, the Pump B Start message reads “Start Disabled” in red.

2.10.2.a You will check the following during this test;

- On the simulation screen check that the pump B start cmd signal stays low (0).

2.10.2.b On the main screen, press the pump B Start button (and confirm entry) to start the test.

2.11. Test Pump B Stop.

2.11.1. Test Stop of Pump B.

Check that on the simulation screen the pump B commands are; start=0, stop=1.

2.11.1.a You will check the following during this test;

- On the simulation screen check that the pump B stop cmd signal goes low (0) for 1 second.

2.11.1.b On the main screen, press the pump B Stop button (and confirm entry)

Return Pump B fault to no-fault by entering 1 into Pump B fault simulation widget.

2.12. Test of Ion Pump Status.

The Ion Pump display shows the status of Pump A, Pump B and of the Ion Pump as a color code. Green shows normal pumping operations, Red shows that the vacuum is out of range.

The overall Ion Pump status is the logical AND of the A and B status. The Ion Pump will only show GREEN when both Pump A AND Pump B are GREEN.

	PASS	FAIL	COMMENTS
The following tests refer to setting pump A and B into GOOD and BAD states. GOOD STATE: enter 2.5 into the Pump's simulation vacuum entry widget. BAD STATE: enter 0.0 into the Pump's simulation vacuum entry widget. 2.12.1. Pump A BAD, Pump B BAD. 2.12.1.a Set both Pump A and Pump B BAD. Verify Ion Pump is RED. 2.12.2. Pump A BAD, Pump B GOOD. 2.12.2.a Set Pump A BAD, Pump B GOOD. Verify Ion Pump is RED. 2.12.3. Pump A GOOD, Pump B BAD. 2.12.3.a Set Pump A GOOD, Pump B BAD. Verify Ion Pump is RED. 2.12.4. Pump A GOOD, Pump B GOOD. 2.12.4.a Set both Pump A and Pump B GOOD. Verify Ion Pump is GREEN.			

	PASS	FAIL	COMMENTS

3 Testing in Non-simulation Mode, not connected to PSI

Items needed to perform these tests; DC voltage source with range 0.00 to 10.00 V (resolution 2 decimal places), 2 DVMs, cables necessary to connect to PSI DIN-rail connectors, shorting cables. Refer to Table 1: PSI Signal Matrix for Hanford 2500l/s Ion Pumps for the PSI DIN-rail connector numbers for each signal.

Complete test setup requires one of the voltage sources be connected to the PSI connectors for the Pump A Voltage and the other voltage source connected to the PSI connectors for the Pump B Voltage. A voltage range from -1.16V (negative) to 3.00V will be needed. Two shorting connectors will be needed to short the Pump A and Pump B faults. The two DVMs are to be used on the DC Voltage 24V range. Connect the DVMs first to the Pump A Start and Stop (or confirm and enable) lines at the PSI interface and later to the Pump B Start and Stop (or confirm and enable) lines at the PSI interface.

3.1. Test Pump A Vacuum Alarms.

In the following tests the user will emulate the input of various voltages from PSI and check that the screens show the correct vacuum alarms corresponding to these voltages.

Voltages below 0.0V or above 5.0V are out of the operating range of the Ion Pump and will be flagged by a zero vacuum reading and a major alarm.

Voltages on the edge of the operating range (0.0V and 5.0V) will show the vacuum (1.0e-10 and 1.0e-4 respectively), but will also show a major alarm.

3.1.1. Emulate invalid vacuum voltage from the Ion Pump (below valid range).

3.1.1.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump A vacuum reading on the alarm handler shows a major alarm

3.1.1.b Inject a voltage of -1.0V (negative) into the Pump A Vacuum PSI connector to start the test.

3.1.2. Emulate valid vacuum voltage from the Ion Pump (middle of valid range).

3.1.2.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows 1.0E-7(+/-0.1E-7) and NO_ALARM.
- Verify the Pump A vacuum signal on the alarm handler shows NO_ALARM.

3.1.2.b Inject a voltage of 2.5V into the Pump A Vacuum PSI connector to start the test.

3.1.3. Emulate invalid vacuum voltage from the Ion Pump (above valid range).

	PASS	FAIL	COMMENTS

3.1.3.a You will check the following during this test;

- Verify the Pump A vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump A vacuum signal on the alarm handler shows a major alarm

3.1.3.b Inject a voltage of 6.0V into the Pump A Vacuum PSI connector to start the test.

3.2. Test Pump A Vacuum Conversion.

This will test the conversion of input voltage (Volts) to vacuum (Torr) over the range of the Ion Pump.

3.2.0.a Inject a voltage of 1.0V into the Pump A Vacuum PSI connector. Verify the main screen Pump A Vacuum shows a value of 1.6E-9 (+/- 0.1E-9).

(QT) 3.2.0.b Inject a voltage of 2.0V into the Pump A Vacuum PSI connector. Verify the main screen Pump A Vacuum shows a value of 2.9E-8 (+/- 0.2E-8).

3.2.0.c Inject a voltage of 3.0V into the Pump A Vacuum PSI connector. Verify the main screen Pump A Vacuum shows a value of 4.0E-7 (+/- 0.3E-7).

3.2.0.d Inject a voltage of 4.0V into the Pump A Vacuum PSI connector. Verify the main screen Pump A Vacuum shows a value of 6.3E-6 (+/- 0.9E-6).

3.3. Test Pump A High Voltage Alarms.

Test the Pump A Voltage goes into alarm when out of operating range.

3.3.1. Test invalid voltage (below operating range).

3.3.1.a You will check the following during the test;

- Main screen shows Pump A voltage in MAJOR alarm state.
- Alarm handler shows Pump A voltage in MAJOR alarm state.

3.3.1.b Inject -1.0V (negative) into the PSI connector for Pump A Voltage to start the test.

3.3.2. Test valid voltage (within operating range).

3.3.2.a You will check the following during the test;

- Main screen shows Pump A voltage in NO_ALARM alarm state.
- Alarm handler shows Pump A voltage in NO_ALARM alarm state.

3.3.2.b Inject 1.0V into the PSI connector for Pump A Voltage to start the test.

3.3.3. Test invalid voltage (above operating range).

3.3.3.a You will check the following during the test;

- Main screen shows Pump A voltage in MAJOR alarm state.

	PASS	FAIL	COMMENTS

- Alarm handler shows Pump A voltage in MAJOR alarm state.

3.3.3.b Inject 5.0V into the PSI connector for Pump A Voltage to start the test.

3.4. Test Pump A High Voltage Conversion.

This will test the conversion of input voltage to High Voltage across the valid operating range.

3.4.0.a Inject a voltage of 1.16V into the PSI connector for Pump A voltage. Verify the main screen shows a high voltage of 3.0kv (+/- 0.1kV).

(QT) 3.4.0.b Inject a voltage of 1.96V into the PSI connector for Pump A voltage. Verify the main screen shows a high voltage of 5.0kv (+/- 0.1kV).

3.4.0.c Inject a voltage of 2.35V into the PSI connector for Pump A voltage. Verify the main screen shows a high voltage of 6.0kv (+/- 0.1kV).

Reset the Pump A Voltage to 1.16V.

3.5. Test Pump A Fault.

Pump A fault values are; fault= open connector or OK=shorted connector. These tests will check that a emulated Ion Pump Fault/No-Fault changes the displays accordingly. It is assumed that the Pump is in the Faulted state (no shorts on PSI connectors).

(QT) 3.5.1. Test pump A No Fault reading and alarm.

3.5.1.a You will check the following during this test;

- Confirm Pump A fault on the main screen changed from fault (red) to OK within one second.
- Verify the text immediately above the Pump A Start button changed from “Start Disabled “ in MAJOR alarm state to “Start Enabled” in NO_ALARM colors within one second.
- Verify the alarm handler stops showing Pump A fault MAJOR alarm within one second.

3.5.1.b On the PSI connector for Pump A Fault, short the connectors together to start the test.

3.5.2. Test pump A Fault reading and alarm.

3.5.2.a You will check the following during this test;

- Confirm Pump A fault on the main screen changed to fault (red) within one second.
- Verify the text immediately above the Pump A Start button changed to “Start Disabled” in MAJOR alarm colors within one second.
- Verify the alarm handler shows Pump A Fault MAJOR alarm within one second.

	PASS	FAIL	COMMENTS

3.5.2.b On the PSI connector for Pump A Fault, remove the short to start the test

Reset Fault back to the no fault condition by replacing the short.

3.6. Test Pump A Start.

Check that on the PSI connector for the Pump A Start and Stop commands the signals read; start=0.0V, stop=24.0V.

(QT) 3.6.1. Test Start of Pump A with no fault.

Check the PSI connectors for Pump A Fault are shorted. Verify that on the main screen, the pump A Start message reads “Start Enabled”.

3.6.1.a You will check the following during this test;

- On the PSI connector for Pump A Start, check that the pump A start cmd signal goes high (24.0V) for 1 second and returns to zero.

3.6.1.b On the main screen, press the pump A Start button (and confirm entry) to start the test.

3.6.2. Test Start of Pump A with Fault.

Remove the PSI short for Pump A Fault. Verify that on the main screen, the Pump A Start message reads “Start Disabled” in MAJOR alarm.

3.6.2.a You will check the following during this test;

- On the PSI connector for Pump A Start, check that the pump A start cmd signal stays low (0.0V).

3.6.2.b On the main screen, press the pump A Start button (and confirm entry) to start the test.

3.7. Test Pump A Stop.

(QT) 3.7.1. Test Stop of Pump A.

Check that on the PSI connector for the Pump A Start and Stop commands the signals read; start=0.0V, stop=24.0V

3.7.1.a You will check the following during this test;

- On the PSI connector for Pump A Stop, check that the pump A stop cmd signal goes low (0.0V) for 1 second.

3.7.1.b On the main screen, press the pump A Stop button (and confirm entry)

Return Pump A fault to no-fault by shorting the PSI Pump A fault connectors.

3.8. Test Pump B Vacuum Alarms.

In the following tests the user will emulate the input of various voltages from PSI and check that the screens show the correct vacuum alarms corresponding to these voltages.

Voltages below 0.0V or above 5.0V are out of the operating range of the Ion Pump and will be flagged by a zero vacuum reading and a major alarm.

	PASS	FAIL	COMMENTS

Voltages on the edge of the operating range (0.0V and 5.0V) will show the vacuum (1.0e-10 and 1.0e-4 respectively), but will also show a major alarm.

3.8.1. Emulate invalid vacuum voltage from the Ion Pump (below valid range).

3.8.1.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump B vacuum reading on the alarm handler shows a major alarm

3.8.1.b Inject a voltage of -1.0V (negative) into the Pump B Vacuum PSI connector to start the test.

3.8.2. Emulate valid vacuum voltage from the Ion Pump (middle of valid range).

3.8.2.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows 1.0E-7(+/- 0.1E-7) and NO_ALARM.
- Verify the Pump B vacuum signal on the alarm handler shows NO_ALARM.

3.8.2.b Inject a voltage of 2.5V into the Pump B Vacuum PSI connector to start the test.

3.8.3. Emulate invalid vacuum voltage from the Ion Pump (above valid range).

3.8.3.a You will check the following during this test;

- Verify the Pump B vacuum reading on the main screen shows zero and a major alarm
- Verify the Pump B vacuum signal on the alarm handler shows a major alarm

3.8.3.b Inject a voltage of 6.0V into the Pump B Vacuum PSI connector to start the test.

3.9. Test Pump B Vacuum Conversion.

This will test the conversion of input voltage (Volts) to vacuum (Torr) over the range of the Ion Pump.

3.9.0.a Inject a voltage of 1.0V into the Pump B Vacuum PSI connector. Verify the main screen Pump B Vacuum shows a value of 1.6E-9 (+/- 0.1E-9).

(QT) 3.9.0.b Inject a voltage of 2.0V into the Pump B Vacuum PSI connector. Verify the main screen Pump B Vacuum shows a value of 2.9E-8 (+/- 0.2E-8).

3.9.0.c Inject a voltage of 3.0V into the Pump B Vacuum PSI connector. Verify the main screen Pump B Vacuum shows a value of 4.0E-7 (+/- 0.3E-7).

3.9.0.d Inject a voltage of 4.0V into the Pump B Vacuum PSI connector. Verify the main screen Pump B Vacuum shows a value of 6.3E-6 (+/- 0.9E-6).

	PASS	FAIL	COMMENTS

3.10. Test Pump B High Voltage Alarms.

Test the Pump B Voltage goes into alarm when out of operating range.

3.10.1. Test invalid voltage (below operating range).

3.10.1.a You will check the following during the test;

- Main screen shows Pump B voltage in MAJOR alarm state.
- Alarm handler shows Pump B voltage in MAJOR alarm state.

3.10.1.b Inject -1.0V (negative) into the PSI connector for Pump B Voltage to start the test.

3.10.2. Test valid voltage (within operating range).

3.10.2.a You will check the following during the test;

- Main screen shows Pump B voltage in NO_ALARM alarm state.
- Alarm handler shows Pump B voltage in NO_ALARM alarm state.

3.10.2.b Inject 1.0V into the PSI connector for Pump B Voltage to start the test.

3.10.3. Test invalid voltage (above operating range).

3.10.3.a You will check the following during the test;

- Main screen shows Pump B voltage in MAJOR alarm state.
- Alarm handler shows Pump B voltage in MAJOR alarm state.

3.10.3.b Inject 5.0V into the PSI connector for Pump B Voltage to start the test.

3.11. Test Pump B High Voltage Conversion.

This will test the conversion of input voltage to High Voltage across the valid operating range.

3.11.0.a Inject a voltage of 1.16V into the PSI connector for Pump B voltage. Verify the main screen shows a high voltage of 3.0kv (+/- 0.1kV).

(QT) 3.11.0.b Inject a voltage of 1.96V into the PSI connector for Pump B voltage. Verify the main screen shows a high voltage of 5.0kv (+/- 0.1kV).

3.11.0.c Inject a voltage of 2.35V into the PSI connector for Pump B voltage. Verify the main screen shows a high voltage of 6.0kv (+/- 0.1kV).

Reset the Pump B Voltage to 1.16V.

3.12. Test Pump B Fault.

Pump B fault values are; fault= open connector or OK=shorted connector. These tests will check that a emulated Ion Pump Fault/No-Fault changes the displays accordingly. It is assumed that the Pump is in the Faulted state (no shorts on PSI connectors).

	PASS	FAIL	COMMENTS

3.12.1. Test pump B No Fault reading and alarm.

(QT)

3.12.1.a You will check the following during this test;

- Confirm Pump B fault on the main screen changed from fault (red) to OK within one second.
- Verify the text immediately above the Pump B Start button changed from “Start Disabled “ in MAJOR alarm state to “Start Enabled” in NO_ALARM colors within one second.
- Verify the alarm handler stops showing Pump B fault MAJOR alarm within one second.

3.12.1.b On the PSI connector for Pump B Fault, short the connectors together to start the test.

3.12.2. Test pump B Fault reading and alarm.

3.12.2.a You will check the following during this test;

- Confirm Pump B fault on the main screen changed to fault (red) within one second.
- Verify the text immediately above the Pump B Start button changed to “Start Disabled” in MAJOR alarm colors within one second.
- Verify the alarm handler shows Pump B Fault MAJOR alarm within one second.

3.12.2.b On the PSI connector for Pump B Fault, remove the short to start the test

Reset Fault back to the no fault condition by replacing the short.

3.13. Test Pump B Start.

Check that on the PSI connector for the Pump B Start and Stop commands the signals read; start=0.0V, stop=24.0V.

(QT)

3.13.1. Test start of Pump B with no fault.

Check the PSI connectors for Pump B Fault are shorted. Verify that on the main screen, the pump B Start message reads “Start Enabled”.

3.13.1.a You will check the following during this test;

- On the PSI connector for Pump B Start, check that the pump B start cmd signal goes high (24.0V) for 1 second and returns to zero.

3.13.1.b On the main screen, press the pump B Start button (and confirm entry) to start the test.

3.13.2. Test Start of Pump B with Fault.

Remove the PSI short for Pump B Fault. Verify that on the main screen, the Pump B Start message reads “Start Disabled” in MAJOR alarm.

	PASS	FAIL	COMMENTS

3.13.2.a You will check the following during this test;

- On the PSI connector for Pump B Start, check that the pump B start cmd signal stays low (0.0V).

3.13.2.b On the main screen, press the pump B Start button (and confirm entry) to start the test.

3.14. Test Pump B Stop.

(QT) 3.14.1. Test stop of Pump B.

Check that on the PSI connector for the Pump B Start and Stop commands the signals read; start=0.0V, stop=24.0V

3.14.1.a You will check the following during this test;

- On the PSI connector for Pump B Stop, check that the pump B stop cmd signal goes low (0.0V) for 1 second.

3.14.1.b On the main screen, press the pump B Stop button (and confirm entry)

Return Pump B fault to no-fault by shorting the PSI Pump B fault connectors.

	PASS	FAIL	COMMENTS

4 Testing in Non-Simulation Mode, Full Connection to PSI Wiring

To Be Determined.

Table 1: PSI Signal Matrix for Hanford 2500l/s Ion Pumps

Location	ID	PUMP A										PUMP B									
		Voltage		Current		Fault		Start		Stop		Voltage		Current		Fault		Start		Stop	
		+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Mechanical Room	IP1	044	045	047	048	093	094	111	113	114	116	050	051	053	054	095	096	117	119	120	122
Mechanical Room	IP2	056	057	059	060	097	098	123	125	126	128	062	063	065	066	099	100	129	131	132	134
Mechanical Room	IP3	068	069	071	072	101	102	135	137	138	140	074	075	077	078	103	104	141	143	144	146
Mechanical Room	IP4	080	081	083	084	105	106	147	149	150	152	086	087	089	090	107	108	153	155	156	158
Mechanical Room	IP5	159	160	162	163	208	209	228	230	231	233	165	166	168	169	210	211	234	236	237	239
Mechanical Room	IP6	171	172	174	175	212	213	240	242	243	245	177	178	180	181	214	215	246	248	249	251
Mechanical Room	IP7	183	184	186	187	216	217	252	254	255	257	189	190	192	193	218	219	258	260	261	263
Mechanical Room	IP8	195	196	198	199	220	221	264	266	267	269	201	202	204	205	222	223	270	272	273	275
Left Mid Station	IP9	150	151	153	154	245	246	250	252	253	255	156	157	159	160	247	248	256	258	259	261
Right Mid Station	IP10	150	151	153	154	245	246	250	252	253	255	156	157	159	160	247	248	256	258	259	261
Left End Station	IP11	090	091	093	094	150	151	155	157	158	160	096	097	099	100	152	153	161	163	164	166
Right End Station	IP12	090	091	093	094	150	151	155	157	158	160	096	097	099	100	152	153	161	163	164	166

Table 1: Signal Data Matrix for Hanford 2500l/s Ion Pumps

Pump	Signal	Type	Input Value Limits					Engineering Value Limits.				Alarm Limits				
			OFF/ Invalid	Low/ OFF	High/ ON	Tolerance	Units	Low OFF	HighON	Units	Tolerance	Src	LO-LO/ ZSV	LOW/ ZSV	HIGH\ OSV	HIHI/ OSV
A	Vacuum	ai	<0.0, >5.0	0.0	5.0	+/- 0.03	Volts	1.0e-10	1.0e-4	Torr	Non Lin	Val	0.0			5.0
A	Voltage	ai	< 0.0, >5.0	0.0	3.75	+/- 0.03	Volts	0.0	7.0	kV	+/- 0.02	Eng	0.0			7.0
A	Fault	bi						TRUE	FALSE			Eng	YES			
A	Start Cmd	bo						FALSE	TRUE							
A	Stop Cmd	bo						TRUE	FALSE							
B	Vacuum	ai	<0.0, >5.0	0.0	5.0	+/- 0.03	Volts	1.0e-10	1.0e-4	Torr	Non Lin	Val	0.0			5.0
B	Voltage	ai	< 0.0, >5.0	0.0	3.75	+/- 0.03	Volts	0.0	7.0	kV	+/- 0.02	Eng	0.0			7.0
B	Fault	bi						TRUE	FALSE			Eng	YES			
B	Start Cmd	bo						FALSE	TRUE							
B	Stop Cmd	bo						TRUE	FALSE							

Hanford LIGO EPICS Test Specification Comments Sheet.

Comment ID: | Sheet | of

Raised By: | Test Spec ID:

Date: | Change Request Raised:

☐ **Hardware related** ☐ **Software related**

☐ **High priority, no work around exists** ☐ **Low priority**

☐ **High priority, work around exists** ☐ **For information only.**