C-A OPERATIONS PROCEDURES MANUAL

18.8.2 ERL Cold Emission Test Vacuum System Operation

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18.8.2 ERL Cold Emission Test Vacuum System Operation

1. Purpose

This procedure covers the basic operation of the ERL Vacuum System for the Cold Emission Test.

The vacuum systems for the Cold Emission Test (CET) consist of the cryomodule beamline vacuum and insulating vacuum for the liquid helium cooled cryomodule.

2. Responsibility:

Supervisor: A shift supervisor, or an operator designated by the Shift Supervisor, is responsible for implementing the procedure.

3. Prerequisites

Operators shall become familiar with the system SCHEMATIC E010605054, the control system screen(s) on the operator station, and the physical location of components and low-level controls.

Operators should already be familiar with the operation of the associated low-level vacuum gauge and pump controllers used on the CET Vacuum systems.

4. System Description

4.1 Beamline Vacuum

The beamline vacuum extends from electropneumatic gate valve VB1 to electropneumatic gate valve VB2. The entire assembly from GVB1 to GVB2 constitutes the string assembly. The beamline vacuum volume contains the vacuum envelope of the 2°K 5-cell cavity, the Fundamental Power Coupler, the thermal transitions to room temperature the high order mode ferrite absorbers and beamline diameter transitions. In addition to the cryopumping, two 20 liter/sec ion pumps IPB1 and IPB2 on either end of the string assembly provide pumping of the warm ends of this volume and also of the 5-cell RF cavity when warm. Current readings indicating vacuum level within the beamline volume are always available. A thermal conductivity TCB1 and cold cathode ionization gauge CCB1 on the upstream end of the string assembly also monitor the beamline vacuum continuously. The Fundamental Power Coupler vacuum is monitored by two independent cold cathode ionization gauges CCF1 and CCF2.

The CET beamline vacuum envelope is bounded by gate valves GVB1 and GVB2 when in the closed position. The boundary of the beamline vacuum will extend to the beamline pick-up probes installed on the gatevalves GVB1 and GVB2 when the gatevalves are in the open position. This extended volume includes the valve body vacuum volume, the volume of the vacuum gauges CCP1,2 and TCP1,2 to monitor the extended volumes and the volume of the associated manifolds. In order for the pick-up probes to acquire signals during the CET, gate valves GVB1 and GVB2 must be open. Actuation of GVB1 and GVB2 shall be interlocked to vacuum gauge and ion pump readings to protect the 5-cell cavity vacuum.

The logic to interlock and control gate valves GVB1 and GVB2 resides in the vacuum plc located in the 912 ERL mezzanine. Low level vacuum pump and gauge controls also reside in the 912 ERL mezzanine.

4.2 Cryostat Insulating Vacuum

The cryomodule insulating vacuum envelope is bounded externally by the vacuum vessel and internally by the liquid helium vessel. Various ports of the external vacuum vessel accommodate feedthrus for various functions and for vacuum pumping and gauging.

A turbomolecular pump station provides the vacuum pumping to rough and maintain insulating vacuum in the cryostat. A thermal conductivity and cold cathode ionization gauge TCC1 and CCC1 to monitor cryostat vacuum are located on another cryostat port monitor the cryostat vacuum. A right angle electropneumatic valve AVC1 isolates the turbomolecular pump system from the cryostat. Actuation of AVC1 shall be interlocked to vacuum gauge readings on the pump station and cryostat port to protect both the turbopump station and cryostat vacuum.

The logic to interlock and control valves AVC1 resides in a vacuum plc located in the 912 ERL mezzanine. Low level pump and gauge controls also reside in the 912 ERL mezzanine.

5. Vacuum System Components

5.1 Beamline Vacuum

Ion Pumps- The ion pumps are diode type Gamma 20S and are operated at 7kV. The ion pump controllers are Varian Dual Controllers 929-7011.

Vacuum Gauges- The vacuum gauges are HPS pirani enhanced thermal conductivity and cold cathode ionization gauges. The gauge controller is an MKS 937, equipped for RS-232 serial communication, relay set point contacts and 0-10V analog outputs.

Valves- The beamline gate valves are VAT 24VDC solenoid controlled electropneumatic actuated type valves, requiring 60-90 psig pressure to operate. Actuation of the valves shall be accomplished strictly through the vacuum PLC to protect the 5-cell cryomodule from potential damage. Various VAT manual all-metal right angle valves are installed on the warm ends of the string assembly. These valves shall not be operated during the CET test phase.

5.2 Cryostat Vacuum

Vacuum Pumps- The cryostat is pumped by a 300 Liter/second Varian Navigator turbomolecular pump which is backed by a Varian 10 cfm dual stage oil sealed rotary vane mechanical pump. The pumps are operated remotely by a Varian Turbo V-301 pump controller.

Vacuum Gauges- The vacuum gauges are HPS pirani enhanced thermal conductivity and cold cathode ionization gauges. The gauge controller is an MKS 937, equipped for RS-232 serial communication, relay set point contacts and 0-10V analog outputs.

Valves- The cryostat and cryostat pumping system are isolated from each other by a VAT 24VDC solenoid controlled electropneumatic actuated right angle valve, requiring 60-90 psig pressure to operate. Actuation of this valve shall be accomplished strictly through the vacuum PLC to protect the 5-cell cryomodule from potential damage. Analog vacuum gauge readings and turbopump speed are continuously monitored by the vacuum PLC to interlock and protect the cryostat and pump station.

6. <u>Vacuum System Operation</u>

6.1 Beamline Vacuum

Ion pumps IPB1 and IPB2 shall be on at 7kV and in Protect mode with a current limit of 20 mA at all times during the CET phase. If an ion pump trips off, vacuum gauge readings shall be checked to verify that the beamline vacuum level is suitable for ion pump operation.

When the cryomodule is warm, the beamline vacuum (CCB1,2 and CCF1,2) should be better than $1x10^{-8}$ torr with the ion pumps on. If the cryomodule is warm and the ion pumps have been off for an extended time the vacuum may rise to $\sim 1x10^{-5}$ torr. If gauge readings (CCB1,2 and CCF1,2) are $\leq 1x10^{-5}$ torr the ion pump can be restarted via the pump controller front panel in Start mode and switched to Protect mode, once the current drops below the Protect mode limit. If the pressure is $\geq 1x10^{-5}$ torr contact the lead physicist and vacuum engineer for further instructions.

All gauges shall remain on throughout the CET. If a gauge trips off it should be restarted via the gauge controller front panel.

Gate valves GVB1 and GVB2 should be actuated to open prior to cool down of the cryomodule. If the pressure of the valve and pick-up probe volume is $>1x10^{-6}$ torr, the valve and pick-up probe volume will need to be pumped down by the external portable turbo pump cart prior to opening the gate valve. Once open, the gate valve should remain open to allow the valve and pick-up probe volume to be pumped.

Gate valves may be open or closed during the CET phase depending on the specific tests being conducted. The request to position the valves shall come from the lead physicist. Actuation of the gate valves shall be accomplished through the Vacuum PLC interface. Consideration to minimize the valve closed duration is important to insure the pressure of the valve and pick-up probe vacuum volume does not rise to $>1x10^{-6}$ torr, which would necessitate additional pumpdown steps described above, and in the initial installation section to follow herein.

Although the valve actuation is interlocked by the vacuum plc with analog gauge readings and ion pump currents, the vacuum gauge readings and ion pump currents should be checked at the controller front panel display before proceeding to command a valve to open. The gauge readings should all match within 1 decade of pressure and all readings should be in the UHV range ($\leq 1x10^{-6}$ torr). If there is a discrepancy in gauge readings, and ion pump currents, the vacuum equipment should be diagnosed for problems. A leak should be suspected if all equipment checks out.

If the valve closes and the pick-up probe volume pressure rises to $\geq 1x10^{-5}$ torr, the volume will need to be pumped down from the external portable turbo pump cart and leak checked prior to opening the gate valve.

Gauge setpoints shall interlock the safe actuation of the gate valves. The gauge setpoints shall be established by the vacuum engineer in coordination with the lead physicist prior to commencing CET. These values shall be posted and shall not be altered unless agreed upon by the lead scientist and vacuum engineer.

If a gate valve closes without a close command the cause should be investigated prior to re-opening the valve. The investigation shall begin with a check of the vacuum readings to insure a leak hasn't caused the closure.

Setpoint outputs corresponding to the 5-cell vacuum cold cathode gauge and the FPC cold cathode gauges shall be used as part of the interlock logic to permit RF power to the cavity. The setpoints shall be established by the lead scientist and RF engineer. These values shall be posted and shall not be altered unless agreed upon by the lead scientist, RF engineer and vacuum engineer.

Setpoint outputs corresponding to the 5-cell vacuum cold cathode gauge shall be used as part of the interlock logic to permit cryogenic cooldown of the cavity. The setpoints shall be established by the lead scientist, cryogenic engineer and vacuum engineer. These values shall be posted and shall not be altered unless agreed upon by the lead scientist, cryogenic engineer and vacuum engineer.

6.2 Cryostat Vacuum

The turbomolecular pump station shall be on and valved into the cryostat during the normal CET phase. Prior to cooldown of the LN_2 Shield ,the pumpstation shall be used to establish the insulating vacuum required to insulate the cryomodule. Roughing the cryostat from atmospheric pressure to ~50 torr will require the isolation valve to be open prior to the turbopump reaching normal operating speed. Additionally a comparison of cryostat and pump analog gauge readings prevents the isolation valve from opening if the gradient would result in a negative flow (backstreaming) or in a high pressure in-rush that could damage the turbopump. These criteria bracket the window for actuating the isolation valve to the open position. The operator shall actuate the isolation valve open with the pump inlet pressure equal to the cryostat pressure.

Analog gauge readings into the vacuum PLC shall interlock the safe actuation of the cryostat isolation valve.

Setpoint outputs corresponding to the cryostat vacuum gauges shall be used as part of the interlock logic to permit cryogenic cooldown of the cavity. The setpoint shall be established by the cryogenic engineer and vacuum engineer. This value shall be posted and shall not be altered unless agreed upon by the lead scientist, cryogenic engineer and vacuum engineer.

7. ESH

All personnel working on any electrical system or equipment in the C-AD shall be familiar with BNL SBMS Electrical Safety, BNL SBMS Lockout/Tagout (LO/TO), C-A-OPM 1.5, "Electrical Safety Implementation Plan", C-A-OPM 1.5.3 "Procedure to Open or Close Breakers and Switches and Connecting/Disconnecting Plugs", C-A-OPM 2.36, "Lockout/Tagout for Control of Hazardous Energy". C-AD will provide on-site/work specific training to individuals in the electrical safety aspects of their job functions and assignments.

8. System Preparation

8.1 Cryomodule Installation

The ion pumps shall be turned off and the valve volume and cryomodule vacuum gauge readings shall be logged just prior to transporting the string assembly to the Building 912 experimental area.

The valve and cryomodule vacuum gauges and ion pumps shall be started as soon as possible after the string assembly is in position in the 912 block house. Gauge readings shall be monitored and logged. The logged data shall be compared to previously logged data to determine if leaks have developed during shipping and handling.

If a leak is suspected in a valve volume the dry turbo station and leak detector shall be connected to the temporary vent valve using the portable clean room tent and clean room installation practices. A leak check shall be performed.

If a leak is suspected in the cryomodule the dry turbo station and leak detector shall be connected to either temporary vent valve using the portable clean room tent and clean room installation practices. The ion pumps shall be turned off and the turbo valved into the valve volume when the turbo pressure is less than the valve volume pressure. The gate valve shall be opened when the turbo pressure is less than the cryomodule pressure. A leak check shall be performed.

The course of action to investigate suspected leaks or repair any leaks found in the cryomodule beamline or beam valve volumes will require a special procedure with the concurrence from vacuum engineering, mechanical engineering and accelerator physics.

8.2 Instrument Air

Verify that instrument air is available to the air supply line to the air actuated control valves.

8.3 Cryogenic Cooldown

Prior to cooldown of the 80K LN2 cooled shield the insulating vacuum space and the beam tube volume has to be pumped down to $<1x10^{-3}$ torr.

Beamline Vacuum: To minimize residual gas species in the cryomodule beamline from condensing on the cold cavity walls, the beam tube vacuum level shall be $<5x10^{-8}$ torr prior to cooldown.

Cryostat Vacuum: To allow degassing of the MLI, pumpdown shall begin 48 hours prior to cooldown of the LN2 shield.

9. Documentation

9.1 Varian Ion Pump Controller Manual
9.2 Gamma Ion Pump Manual
9.3 MKS Gauge Controller Manual
9.4 Varian Turbopump & Controller Manual

10. References

10.1 C-A-OPM 1.5, "Electrical Safety Implementation Plan".
10.2 C-A-OPM 1.5.3 "Procedure to Open or Close Breakers and Switches and Connecting/Disconnecting Plugs".
10.3 C-A-OPM 2.36, "Lockout/Tagout for Control of Hazardous Energy".
10.4 SBMS Electrical Safety.
10.5 SBMS Lockout/Tagout (LOTO).
10.6 E010605054: e-CX Cold Emission Test Vacuum System Schematic

11. Attachments

11.1 CET e-CX Vacuum Schematic, DWG: E010605054

Attachment 11.1 – CET e-CX Vacuum Schematic