If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match. The on-screen version of the Collider-Accelerator Department Procedure is the Official Version. Hard copies of all signed, official, C-A Operating Procedures are available by contacting the ESSHQ Procedures Coordinator, Bldg. 911A

C-A OPERATIONS PROCEDURES MANUAL

7.1.11 25 kW Helium Refrigerator Cooldown

Text Pages 2 through 8

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Collider-Accelerator Department Chairman Date

C. Salat

7.1.11 25 kW Helium Refrigerator Cooldown

1. Purpose

This procedure provides instructions for the cooldown of the RHIC 25 kW helium refrigerator. The procedure is divided into 2 phases. Phase 1 involves an initial flow path, warm train start-up, precooling VJRR, and diverting heat shield from 80K maintenance loop and placing it on refrigerator. Phase 2 involves cold train start-up, LSA pre-cool, liquid production in CB5, and liquid production at LSA in anticipation of LHe delivery.

2. Responsibilities

2.1 The Shift Supervisor, or an Operator designated by the Shift Supervisor, is responsible for conducting the procedure and providing documentation in the Cryogenic Control Room Log.

2.2 Should a problem arise during the completion of this procedure, the Shift Supervisor shall contact the Technical Supervisor for instructions before continuing.

3. Prerequisites

3.1 The performance of the refrigerator relies heavily on the system being free of contaminants. Prior to cooldown, the cryogenic system shall be pumped, purged, and scrubbed. For instructions on scrubbing the refrigerator, please reference C-A OPM 7.1.13. The main compressor system shall be lined up and ready for operation.

3.2 Operator shall be familiar with the following drawings:

Drawing 3A995009 25 KW Helium Refrigerator P & ID
Drawing 3A995066 6:00 Yellow Ring P & ID (used with C-A OPM 7.1.11.a)
Drawing 3A995086 6:00 Blue Ring P & ID (used with C-A OPM 7.1.11.a)
Refrigerator Valve Reference Guide

3.3 Operator shall be familiar with the physical location of components on the drawings listed under 3.2.

3.4 Nitrogen heat shield operating at LSA.

3.5 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.

4. Precautions

4.1 Confirm the availability of Particle Accelerator Safety System (PASS) in the refrigeration wing of 1005R.

4.2 Hearing protection shall be worn when the compressors are in operation.

4.3 Approved eye protection and safety shoes shall be worn at all times.

4.4 All personnel entering the refrigeration wing of 1005R must have a personal ODH monitor and carry an emergency escape pack, if there is liquid helium in the pots.

4.5 This procedure assumes that cooldown of the refrigerator will use HX1A/2A, adsorber bed A, and all "A" string turbines. If HX1B/2B, adsorber bed B, or "B" string turbines are used, valve selection must be adjusted accordingly.

5. Procedure

5.1 Align compressor building valves.

5.2 Align the hygrometer and oxygen monitor in compressor building to sample compressor discharge.

5.3 Verify valve positions as specified in C-A-OPM-ATT 7.1.11.a.

5.4 Line-up:

_____ 5.4.1 Close/check closed the following valves:

H9A	H204A
H86A	H205A
H100A	H206A

_____ 5.4.2 Ensure closed the following valves:

H328A	H385A
H352A	H402A

_____ 5.4.3 Open the following valves:

H33A
H123A
H131A

_____ 5.4.4 Put H90A in auto with a setpoint of 2.0 atm.

_____ 5.4.5 Put pump-back valve H3025A in auto with a setpoint of 14.5 atm. Ensure H3038M is open.

_____ 5.4.6 Ensure low pressure make-up valve H3031A and mid pressure make-up valve H876A are closed in manual. Put set points at 14.2 atm.

_____ 5.4.7 Ensure 1005H cryogenic purifier is ready for operation as per C-A-OPM 7.1.28.

_____ 5.4.8 Ensure storage pressure control valve H3065A closed in manual.

_____ 5.4.9 Open 3 GHe storage tanks that are above 9 atms to pump-back and make-up.

_____ 5.4.10 Line up normal make-up path through purifier and up to H876A and H3031A. Slowly open H3065A to charge purifier and make-up line. When pressure is equalized, open H3065A 100% in manual.

_____ 5.4.11 Verify aerosol skid is lined up with 2 carbon adsorbers online. The adsorber that was used during scrub should be isolated.

_____ 5.4.12 Put 1st stage bypass valve H3019A in auto with a setpoint of 1.05. Put 2nd stage bypass valve H3007A in auto with a setpoint of 2.5 atm.

_____ 5.4.13 Start one 2nd stage and one 1st stage compressor. Load the compressors and place mid-pressure make-up valve H876A to auto with a setpoint of 14.2 atm. Note: Throughout this procedure, monitor return pressure and mid-pressure and start additional compressors as necessary.

5.5 Phase I – initial cooldown flow path

_____ 5.4.1 At 6:00 blue and yellow valve boxes, ensure closed all automatic valves.

_____ 5.5.2 At LSA, ensure closed automatic helium process valves.

_____ 5.5.3 At LSA, open H9703A, H4526A, H4505A.

_____ 5.5.4 At refrigerator, open H82M, H74A, H147A, H146A.

_____ 5.5.5 Initiate flow by opening H206A until flow rate = 50 g/s as read on FE210H. Open H100A until flow rate = 50 g/s as read on FI229. Open H9A until flow rate = 50 g/s as read on FI476.

5.6 Warm Turbine Start-up.

_____ 5.6.1 Select a warm turbine inlet filter. Ensure filter outlet valve open. Slowly open filter inlet valve.

_____ 5.6.2 Initialization warm turbines 1A, 2A, 3A, and 4A per C-A-OPM 7.1.40 "Warm Turbines" A "Train Initialization".

_____ 5.6.3 Ensure warm turbine mid pressure is less than 6 atm.

_____ 5.6.4 Place turbine outlet valve H380A in automatic with a setpoint of 1.40 atm.

_____ 5.6.5 Start warm turbines.

Caution:
Throughout this procedure, monitor temperature sensor TI3063 on the low pressure return to the compressors. If TI3063 drops below 270°K, quickly utilize appropriate refrigerator bypass. Keep in mind overall refrigerator cooldown rate should be <20K/hr**.**

_____ 5.6.6 Monitor TI8H (H9A inlet). When TI8H reads 120°K, reduce flowrate through H9Ato maintain 120K. Set H9A in auto at that rate.

_____ 5.6.7 Increase flow rates through H206A and H100A as necessary to maintain cooldown rate < 20K.

_____ 5.6.8 Monitor TI228 (upstream of H123A). When TI228 is within 10K of TI3 (return outlet of HX3M), open H425M and close H827M.

_____ 5.6.9 When TI228 is within 10K of TI22 (return outlet of HX5/6), open H157M and close H425M.

_____ 5.6.10 Enable balance heat exchanger HX3 logic. This step usually creates a temporary swing. This can be minimized by temporarily increasing PID gain and reset. Log original values. When H344A is 100% open and H153A is 35% open, slowly decrease gain and reset in steps back to original values. Going back to original values too quickly will cause a disturbance.

_____ 5.6.11 Once balance valves are stable, and adsorber outlet temperature is under 85K, enable adsorber logic.

5.7 Cooling VJRR HS and HR lines:

_____ 5.7.1 Isolate 80K cooler from blue and yellow heat shield. Prior to valve manipulations, log 80K cooler blue and yellow "M" line flow rates. Close blue and yellow 80K cooler heat shield supply and return valves H9365A, H9355A, H9364A, and H9354A.

_____ 5.7.2 Adjust 80K cooler blue and yellow “M” line flow to previously logged flow rates by slowing 80K circulators.

_____ 5.7.3 At 4:00 BVB, close H4402A. Ensure closed H4410A and H4416A.

_____ 5.7.4 At 4:00 YVB, close H6402A. Ensure closed H6410A and H6416A.

_____ 5.7.5 Put H9A in manual and close. Close H413M.

_____ 5.7.6 At 6:00 BVB, open H4502A. At 6:00 YVB, open H6602A.

_____ 5.7.7 Slowly open H25A to charge HS line out to 6:00. At 6:00 BVB, open H4645A. At 6:00 YVB, open H6745A.

_____ 5.7.8 Start opening H9A to establish VJRR flow through H156M and into refrigerator CR line. Maintain flow rate between 50-70 g/s. Note that heat shield return is mixing with refrigerator cold end return, and is lined up to the current refrigerator bypass. Operator experience and knowledge will dictate appropriate utilization of refrigerator bypasses during this step.

_____ 5.7.9 Once VJRR HS and HR lines are cooled: Close H4645A at 6:00 BVB. Close H6745A at 6:00 YVB. Open H4402A at 4:00 BVB. Open H6402A at 4:00 YVB.

_____ 5.7.10 Establish heat shield flow through rings: At 6:00 BVB, throttle open H4602A to 100%. At 6:00 YVB, throttle open H6702A to 100%. Adjust H9A flow rate to 120 g/s in auto.

_____ 5.7.11 Slightly open H9500M ($^1/_8$ to ¼ turn) to establish CB5 heat shield flow. Use TI109 for reference.

_____ 5.7.12 Slowly divert all heat shield return flow to turbine string when temperatures are appropriate. When TI8 is within 5K of TI347, slowly throttle down H156M until PI17 = PI300. Slowly open H376M and close H156M.

5.8 Phase II

_____ 5.8.1 Initialize cold turbines 5A and 6A as pre C-A OPM 7.1.42.

_____ 5.8.2 Ensure H406A and H159A are 100% open in manual. Ensure H398M and H166M open.

_____ 5.8.3 Open H410M.

_____ 5.8.4 Select a cold turbine inlet filter. Ensure filter outlet valve open. Slowly open filter inlet valve.

_____ 5.8.5 Start turbines. Start additional compressors as necessary.

_____ 5.8.6 Utilize H159A to maintain uniform cooldown rate of HX7M and HX7A.

> **Note:**
> Comprehend steps 5.8.7 through 5.8.14. While waiting for conditions to be appropriate to perform these steps, proceed with step 5.9 – LSA cooldown.

_____ 5.8.7 As return temperature decreases (TI228), utilize appropriate cold end refrigerator bypasses. i.e. H409A, H38A.

_____ 5.8.8 When the delta T between TI404 (6A inlet) and TI31 (HX8/18/9 inlet) is less than 10K, and the delta T between TI389 (5A outlet) and TI400 (HX7A outlet) is within 10K, and TI408 (6A outlet) is under 12K, place balance HX logic in auto.

_____ 5.8.9 Open H125M. Close H106A and H114A.

_____ 5.8.10 Set PID controller HX24 outlet temp for valve H100A in auto with a setpoint of 5.5 K. Ensure EX7 Logic is in override mode.

_____ 5.8.11 Once return temp (TI228) is under 7K, reconfigure cold end return. Open H88M. Ensure H89A, H54A, and H58A are in manual mode at 100% open. Close H123A.

_____ 5.8.12 Ensure H33A/H131A logic is disabled. Ensure H131 in auto with setpoint of 1.2 atm. Close H33A in manual.

_____ 5.8.13 Ensure H1100A in auto with setpoint of 6.5K.

_____ 5.8.14 While liquid production continues in intermediate pot, complete section 5.9 – LSA cooldown.

5.9 LSA Cooldown

> **Note:**
> If bulk helium tanker is available at CB5, proceed to C-A OPM 7.1.25, Section 5.2 "Fill of Intermediate Pot from Bulk Helium Tanker."

_____ 5.9.1 Close H5M. Open H849A and H9935M.

_____ 5.9.2 Align path from available LHe dewars to CDR. Slowly open H4525A to bleed excess dewar pressure.

_____ 5.9.3 Slowly Open LHe J-T valves to establish flow to CDR. Keep dewar pressure under 2 atm.

_____ 5.9.4 Throttle back on return valve H4505A. Maintain enough flow to keep R-line cooling back to refrigerator.

_____ 5.9.5 Monitor TI105 (inlet to H9935M). As temperature drops, utilize appropriate refrigerator bypass.

_____ 5.9.6 Once available dewars are cold and pressure can be maintained under 1.7 atm, reconfigure CDR to normal dewar venting path. Continue to make liquid until dewar = 125 Kg. Close dewar J-T valves and readjust return valve H4505A. If tanker is available, see Phase III of C-A-OPM 7.1.25.

6. Documentation

6.1 The Shift Supervisor shall document the completion of the procedure in the Cryogenics Control Room Log

6.2 The check-off links are for place-keeping only. The procedure is not to be initialed or signed, it is not a record.

7. References

7.1 C-A-OPM 1.5, “Electrical Safety Implementation Plan”.
7.2 C-A-OPM 1.5.3 “Procedure to Open or Close Breakers and Switches and Connecting/Disconnecting Plugs”.
7.3 C-A-OPM 2.36, “Lockout/Tagout for Control of Hazardous Energy”.
7.4 SBMS Electrical Safety.
7.5 SBMS Lockout/Tagout (LOTO).
7.6 Drawing 3A995009, 25°kW Helium Refrigerator P&ID.
7.7 Drawing 3A995066, 6:00 Yellow Ring P&ID.
7.8 Drawing 3A995086, 6:00 Blue Ring P&ID.
7.9 Refrigerator Valve Reference Guide.
7.10 C-A-OPM 7.1.25 “Liquid Storage Cooldown and Fill Procedure”.
7.11 C-A-OPM 7.1.40, "Warm Turbines "A" Train Initialization".
7.12 C-A-OPM 7.1.50, "Purge of Warm Expander Inlet Filter".
7.13 C-A-OPM 7.1.51, "Purge of Cold Expander Inlet Filter".
7.14 C-A-OPM 7.1.42, "Cold Turbines "A" Train Initialization".

8. Attachments

8.1 C-A-OPM-ATT 7.1.11.a “Valve Position Tables”.