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

7.1.74 RHIC 25 kW Helium Refrigerator Expander 7 Operation

Text Pages 2 through 14

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: _____***Signature on File***_____ _____
Collider-Accelerator Department Chairman Date

R. Than

7.1.74 RHIC 25 kW Helium Refrigerator Expander 7 Operation

1. Purpose

This procedure covers the basic operation of the expander 7 skid.

Sections
5.1 Scrub (cleaning) process
5.2 Skid Initialization
5.3 Startup
5.4 Shutdown
5.5 Turbine Trip Shutdown
5.6 Securing the skid
5.7 Turbine Cartridge Removal/Replacement

Expander T7 is a new turbine system added to the existing RHIC refrigerator for efficiency improvement. It is mounted in a separate vacuum insulated vessel, labeled turbine pod 7, and located at the cold end of the refrigerator in building 1005R. The turbo expander is a fixed nozzle dynamic gas bearing type expander, and it does not require any oil.

2. Responsibilities

2.1 A shift supervisor, or an operator designated by the Shift Supervisor, is responsible for implementing the procedure and providing documentation in the Cryogenic Control Room Log.

3. Prerequisites

3.1 P&ID

Operator shall become familiar with the expander 7 P&ID drawing 3A995143, the control system screen(s) on the operator station, and the physical location of components on the skid/pod.

See screen D59 for turbine 7 controls.

Basic System Component Identification

Tag			Tag	
PT65H	Expander inlet pressure		TT65H	Inlet temperature
PT66H	Expander outlet pressure		TT66H TSL-66H	Outlet temperature and switch
PSHL-66H	Turbine Exit pressure High / Low pressure switch		FSL-72W	Cooling water expander brake loop heat exchanger flow switch
TT-67H TAH-67H	Brake Loop compressor helium gas temperature and high alarm		FSL-73W	Cooling water expander bearing housing flow switch
DPS113H DPA113H	Bearing gas supply pressure switch and alarm		H205M	Expander EXP7 outlet isolation valve
TT68W	Brake loop water Temperature		ZSL-H205	Limit switch closed, Outlet valve H205M
ST-75H SAH-75H	Rotation speed sensor and alarm		ZSH-H205	Limit switch open, Outlet valve H205M
H75A UY-H75A	Brake Loop control valve			
H204A / UY-H204A	Inlet throttling control valve		HS-H204A	Expander inlet valve reset
ZSL-H204	Limit switch closed, Inlet valve H204A		US-204H	Turbine safety chain trip
UIZ-204H	Inlet valve permissive, hardwire safety chain reset status		PI-68H	Clean helium supply pressure bearing gas
H259A	Bearing gas startup supply valve		PSL075N	Instrument Air supply, low pressure switch
FO-200H	Flow restriction orifice for purge vent		FO-201H	Flow restriction orifice for purge vent
H250M	Manual isolation valve purge vent		H249M	Manual isolation valve purge vent
H253M	Clean helium Purge supply manual valve			
DPT112H	Inlet filter differential pressure sensor			

3.2 ESH

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

The new equipment added has not changed the safety rating in the refrigerator building, and existing protocols are followed when working inside the building.

3.3 The skid/pod has been prepared as follows:

_____ Cooling water is available to the skid/pod.
_____ Instrument air is available to the skid/pod.
_____ Pure helium: Bearing gas is available to the skid/pod.

4. Precautions

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

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

4.3 **If the refrigerator is operating, all personnel entering the refrigerator wing of Bldg 1005R must have a Personal Oxygen Monitor (POM) and carry an emergency escape pack.**

Note:
Addition of the new equipment has not changed the existing ODH procedure for the building.

When the turbine is shutdown *and inlet and outlet valves are closed,* before any valves are opened, to prevent spinning the turbines accidentally, the pressure has to be equalized across the valve being opened.
See detail procedures before taking action.

5. Procedures

5.1 Scrubbing (cleaning) process

The scrubbing (cleaning) of the turbine and lines is carried out by circulating clean gas using the turbine purge supply line and the cooldown return lines. Clean

gas is supplied to the turbine purge supply line, from main the compressors supply, through manual valve H253M, and out via valves H250M and H249M.

Verify Main valves H204A and H205M are already closed and LOTO applied.

Verify that the following valves are closed:

___ H253M
___ H254M
___ H255M
___ H261M

____ Open both H249M and H250M

____ Open H253M gradually

The cleaning process is considered complete when the purity of helium achieves 1 ppm or less for water and 5 ppm or less for nitrogen.

Close valves H249M and H250M, and H253M after the scrub is complete.

> **Note:**
> A pump and back fill with clean helium gas process can be used to clean the turbine as an alternative.

In this case:

Always use a cold trap on the vacuum pump.
Depressurize the volume to 1 atm via restrictive orifice FO-200H and FO-201H (this controls flow during blowdown, to prevent the turbine from spinning).

5.1.1 Cleanliness

____ Confirm that the piping has been evacuated and purged according to section 5.1.1

5.2 Skid Initialization

The procedure describes the check out and configuring the turbine 7 pod prior to start-up.

5.2.1 Utilities

Cooling Water

____Verify one filter is online.
Open the following cooling Water valves.
____ W0002M
____ W0003M
____ W0009M
____ W0010M
____ W0011M
____ W0012M

Confirm that:
____ Verify Flow rotameter FI-72W is reading minimum 3 GPM

____ Verify Flow rotameter FI-73W is reading minimum 2 GPM

Instrument air
____ Verify instrument air distribution isolation valves to control valves H204A and H75A are open.

Bearing Gas Supply
____ Bearing gas supply is from main compressors via the bearing gas supply line. Check pressure sensor PI68H is indicating close to main compressor discharge.

Verify the following valves are closed.
___ H249M
___ H250M
___ H253M
___ H254M
___ H255M

5.2.2 Open H205M and Pressure Equalization

Before opening OUTLET valve H205M, equalization of the turbine piping volume with the system downstream of the turbine outlet valve is required.

If the turbine pressure is lower than the downstream pressure (PT-79H), open the purge valve H253M a few turns and let the turbine piping volume pressurize to match the pressure downstream (~ 4 atm), and close the manual purge valve H253M.

If the turbine pressure is higher than the downstream pressure (PT-79H), open the purge exhaust valve H250M and H249M a few turns and let the turbine piping volume depressurize to match the pressure downstream (~ 4 atm), and close valves H250M / H249M.

Remove LOTO on H205M and H204A

5.2.3 Instruments and settings

Settings

Operators should get familiar with the control logic screen .
Settings are preset and locked at their required values. Any change to these values
can only be done by the process engineer.,.

Speed: High Limit:
Speed: Low Limit:
Thrust Speed Low Limit:
Speed Set-point: High Limit:
Speed Set-point Ramp Rate:
Pressure High Limit:
Pressure Low Limit:
Maximum Pressure Ratio Start:
Minimum Pressure Ratio Operation:
Temperature Low Limit:
Brake Start Position:
Brake Loop Temperature High Limit:
Ax Thrust Gain:
Temporary Stop Time Limit:
Temporary Stop Max allowed number:

Minimum Brake Position:

Instruments

Verify that instruments are indicating on the screen
____ TT-65H
____ PT-65H
____ TT-66H
____ PT-66H
____ SI-75H
____ DPT112H

5.2.4 Trips and Status

Status (lower far left and lower far right on screen D59)
Verify the following status on the screen
____ "Warm compressor are ready"
____ "Instrument N2 is OK"
____ "EXP7 is not running"
____ "Status …. Off "
____ "Temporary Stop is not required"
____ "Restart now enabled"

____ "Bearing gas signal" Close
____ "Bearing gas required" No
____ "Purge Gas required" No
____ "Cooling water" OK

____ String On: No
____ String Temporarily Stopped: No
____ On Not Temporarily Stopped: No

Trips
The trips should all be cleared, indicating green check mark. If they are not cleared, hit the reset button. If the trips are still not cleared, the corresponding safety trips need to be checked out. Contact your supervisor for help.

Software String trips
___ Full Stop
___ Pressure High
___ Pressure Low
___ Temperature Low
___ Instrument Air
___ Warm Compressor Ready

Software Single Turbine trips
___ Bearing Gas
___ Brake Temperature
___ High Speed
___ Low Speed
___ Not Started
___ No Stop High
___ Outlet Valve

HardWire trips

___ High Speed
___ Brake Temperature
___ Outlet Temperature
___ Outlet Pressure
___ Inlet valve Permissive

5.3 Start-up

Start-up of the turbine is fully automatic.
The plant is cold and operating with the cold end loop using bypass valve H206A. H206A will respond automatically as the turbine starts up.
With all the permissives / interlocks/trips satisfied or cleared the turbine can be started.

- Press the "**START EXP7**" button on the screen.
- The bearing gas valve will open.
- There will be a 60 second delay before the inlet valve H204A starts to open.
- The inlet valve will open gradually and the turbine will spin up to speed.
- The turbine status will indicate "Starting".
- Once the turbine gets above the Low Speed Limit the turbine status will indicate "Running" and the bearing gas valve H259A will close.
- After 300 seconds the turbine status will indicate "Conditioning".

The turbine will spin at the conditioning speed or the maximum allowed speed limit set by other factors.

- After 600 seconds of conditioning the turbine status will indicate "Running".
- The turbine's speed will change after the conditioning phase to the optimum speed or the maximum allowed speed limit set by other conditions.

During cooldown of the turbine, the inlet valve will not necessarily open completely, but will open up to the point where the brake capacity (valve H75A) of the turbine has been reached.

5.4 Shutdown

Shutdown of the turbine is fully automatic.

- Press the "**START/STOP EXP7**" button on the screen
- The turbine inlet valve (H204A) will start closing at a controlled rate
- Once the rotation speeds drops below the low speed limit, the bearing gas valve H259A will open and the turbine status will switch from "Running to "Off".
- Bearing gas valve will remain open for 180 seconds after the turbine status has switched to "Off" indication.

5.5 Turbine Trip Shutdown

The turbine itself will not pose a danger to the equipment or personnel when it fails, and therefore there is no emergency shutdown button. The turbine safeties will eventually trip the turbine. The turbine has a back-up hardwire control system that stops the turbine under certain conditions (see below).

PLC Logic Shutdown

The PLC is programmed to trip the turbine on the following

a. Bearing gas failed trip
b. High brake loop gas temperature trip
c. High Speed trip
d. Low Speed trip
e. Thrust Low Speed
f. Turbine Not started trip
g. Number of Temporary Stops High
h. Low Turbine exit temperature trip
i. Low turbine exit pressure trip
j. High turbine exit pressure trip
k. Instrument Air Not ready trip
l. Turbine Outlet valve open limit switch trip

Hardwire safety chain shutdown

The turbine has a hardwired safety system, in the event the PLC loses control to the skid. The safety chain shuts the turbine inlet valve by removing the signal to the valve positioner. A bleeddown valve on the actuator valve allows the valve to close at a controlled rate.

The hardwire safety trips on the following:

m. Overspeed (SSH-75H)
n. High brake loop gas temperature (TSH-67H)
o. Low Turbine exit temperature (TSL-66H)
p. Low or High turbine exit pressure (PSHL-66H)

Caution:

In the event the PLC loses control to the skid

- ***Immediately report to the shift supervisor for direction.***
- ***Do not restart the turbine. An engineer has to be called in to diagnose and resolve the problems and to restart the turbine.***

Verify that the inlet valve H204A is completely closed.

a. If the inlet valve is suspected of leaking, the turbine may still be spinning at a low speed.
   Close outlet valve H205M slowly and let the turbine volume pressurize to the inlet pressure to allow the flow to stop.

5.6 Securing the skid and LOTO

After a shutdown, if the system will be down for a long period, or if maintenance needs to be done on the turbine, the system needs to be secured and warmed up to room temperature.

Before stopping cooling water flow to the bearing housing, the turbine has to be warmed up.

Isolate and depressurize the instrument air to the inlet valve H204A and apply **LOTO** to valve H204A.

Close outlet valve H205M and apply **LOTO** to H205M.

5.6.1 Turbine warm-up

Warm-up is done by purging the turbine using clean helium gas supplied from the main compressors, through manual valve H253M, and ***out via valves H250M and H249M*** (via flow orifices FO-200H and FO-201H).

Verify that the following valves are closed:

Main valves: H204A and H205M are already closed.

___ H253M
___ H254M
___ H255M
___ H261M

____ Open both H249M and H250M

____ Open H253M gradually

Warm up turbine volume to ambient temperature.

After warm-up close supply valve H253M and allow the turbine volume to depressurize to 1 atmosphere.

Cooling water flow can now be stopped to the turbine, after warm-up.

Shut off water supply valves W0010M and W0011M.

Leave water return valves W0009M and W0012M open unless the water lines needs to be disconnected to remove the turbine cartridge.

5.6.2 Apply full LOTO

Apply LOTO to valves H259A, H253M, H249M, H250M, H254M, H255M, H261M.

5.7 Turbine Cartridge Removal/Replacement

5.7.1 Disconnect

Insure that the turbine is warm before attempting to remove/replace the cartridge

___ Verify H204A has been LOTO
___ Verify H205M has been LOTO
___ Verify LOTO to valves H259A, H253M, H249M, H250M
___ Apply LOTO to water supply and return valves W0010M, W0011M, W0009M, and W0012M.
___ Disconnect the 2 gas bearing flex lines to the housing.
___ Disconnect the 4 water lines to the housing and the heat exchanger.
___ Disconnect air supply lines to brake valve actuator on valve H75A.
___ Disconnect 4-20mA signal lines brake valve positioner on valve H75A.
___ Disconnect the temperature sensor cable to TT-67H
___ Disconnect the speed sensor cable to ST-75H

5.7.2 Cartridge Removal

The overhead crane is required for removal of the turbine housing heat exchanger assembly.
The whole assembly weights 400 lbs.
Appropriate PPE is required for crane operation.

Follow manufacturer's manual for removal of cartridge.

After completion of cartridge replacement the turbine needs to be cleaned prior to be put into service.

5.7.3 Reconnect

___ Reconnect the water lines to turbine heat exchanger and housing.
___ Reconnect the instrument air and control signal lines to H75A.
___ Reconnect the 2 gas bearing flex lines to the housing.
___ Reconnect the 4 water lines to the housing and the heat exchanger.
___ Reconnect air supply lines to brake valve actuator on valve H75A.
___ Reconnect 4-20mA signal lines to brake valve positioner on valve H75A.
___ Reconnect the temperature sensor cable to TT-67H
___ Reconnect the speed sensor cable to ST-75H

5.7.4 Cleaning

Perform a pump and purge operation at least four times to make sure the turbine is clean.

___ Always use a cold trap on the vacuum pump.
___ Pumpout via valve H261M.
___ Close H261M
___ Purge/backfill by opening H253M.
___ Depressurize the volume to 1 atm via restrictive orifice FO-200H and FO-201H using valves H250M and H249M (this controls flow during blowdown, to prevent the turbine from spinning) before carrying out the pumpdown.
___ Close valves H250M and H249M and repeat pumpout.

After the pump and purge, scrub the system per section 5.1.

5.7.5 Preparation

Follow procedures in sections 5.1 and 5.2 to prepare the skid for operation if required otherwise leave main valves H204A and H205M on LOTO, and verify the following valves are closed.

Verify the following valves are closed.

___ H249M
___ H250M
___ H253M
___ H254M
___ H255M

6. Documentation

6.1 Record

The check off lines in the procedure are for place keeping only. The procedure is not to be initialed or signed, it is not a record.

6.2 Log

The shift supervisor shall document the completion of the procedure in the cryogenics control room log book.

7. References

7.1 Drawing 3A995143: Turbine Pod 7 P&ID 3A995143

7.2 Drawing 3A995009: 25kW Helium refrigerator P&ID

7.3 C-A-OPM 1.5, “Electrical Safety Implementation Plan”.

7.4 C-A-OPM 1.5.3, “Procedure for Open or Close Breakers and Switches”.

7.5 C-A-OPM 2.36, “Lock and Tag Program for Control of Hazardous Energy”.

7.6 SBMS Electrical Safety.

7.7 SBMS Lockout/Tagout (LOTO).

8. Attachments

None