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F. M. E. A. RHIC Cryogenics

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USDOE Office of Science (SC)

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AD/RHIC/RD-123

RHIC PROJECT

Brookhaven National Laboratory

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R.H.I.C. CRYOGENICS

1.0 INTRODUCTION

1.1 GENERAL

The object of a Failure Mode and Effect Analysis is to identify all the postulated modes of failure, within a system or sub-system design, so that the resultant effects can be eliminated at the earliest possible time. The system must remain safe for all reasonable postulated equipment failures or operator errors. The analysis shall be used to assess existing high risk items and the systems or sub-systems, in the design stage. The analysis will then provide us with the information needed to minimize hazardous effects due to component failure. The end result of an F.M.E.A. is increased reliability and safety.

1.2 OUTLINE

To provide assurance that all of the subsystems of the RHIC cryogenic system were covered, the analysis was carried out in concert with the design effort when possible.

1.2.1 The cognizant engineer (CE) involved in the design of their respective subsystem or component have considered the potential failure modes and their effects on the subsystem or component.

1.2.2 The failure of a component of a subsystem, causing a complete failure of the subsystem, would be viewed upon as a component failure of the system. For example, a vacuum failure of one of the valve boxes would be viewed as a failure of the valve box for the system FMEA.

1.2.3 This F.M.E.A. will review the failure modes and effects of a component failure in subsystems, and in addition will study the effect of total failure modes, of the subsystems, and their effect on the Cryogenic system as a whole.

1.2.4 The FMEA is primarily component orientated. Each component of the system should be reviewed in each possible failed state, for each mode of operation, to evaluate its possible safety consequences to the system. When the FMEA is applied to a process, with different modes of operation, the steps or operating procedures have been carefully formulated or reviewed. In addition a safety analysis work sheet, with operating mode indicated, is used as a record of the specific failures. The work sheets will include information on system or subsystem modes in order to evaluate the components effect as a function of mode. The work sheets will contain specific information as follows:

1.2.4.1 The description of failure.
1.2.4.2 Mode or phase.

1.2.4.3 Cause(s) of failure.
1.2.4.4 The effect of this failure on the system.
1.2.4.5 Assignment of risk assessment values for severity and probability.
1.2.4.6 Recommended corrective action.
1.2.4.7 Effect of the recommended action

2.0 SCOPE

2.1 GENERAL

2.1.1 This FMEA is intended to cover the RHIC cryogenic distribution system and components.

2.2 SYSTEMS AND COMPONENTS FOR ANALYSIS

2.2.1 The broad categories that will be included in this study are as follows:

2.2.1.1 The cold helium distribution system associated with the ring magnets (valve boxes, transfer lines, etc.)

2.3 COMPONENTS REVIEWED

2.3.1 Types of components that are covered in this study include: valves, relief valves, sensors, filters, switches, gauges, interlocks, etc.

2.4 SYSTEMS OR SUBSYSTEMS NOT COVERED

2.4.1 Systems that are not a direct part of the Cryogenic System, i.e. magnet power supplies, quench protection devices, etc. will be subjected to an F.M.E.A., by others. The F.M.E.A. of these "other" systems is outside the scope of this F.M.E.A.

3.0 PROCEDURE

3.1 INTRODUCTION

3.1.1 To properly prepare an F.M.E.A. that includes the effects on the process and the potential hazards to personnel, we must systematically identify and analyze all of the possible faults.

3.2 GENERAL PROCEDURE FOR ANALYSIS

3.2.1 Identify the major systems and subsystems that in an event of failure will greatly affect the operation of the cryogenic system or could present a hazardous situation to personnel.

3.2.2 Meet with cognizant personnel, to discuss potential failure modes of equipment and systems. Compile this information (see appendix).

3.2.3 Review or establish operating procedures so that mode dependency can be established.

3.2.4 Study and list each component, in the analysis work sheets, and enter all required information. See appendix.

3.3 DETAILED PROCEDURE FOR ANALYSIS

3.3.1 As the analysis of systems differ, in that some are operational mode dependant, the detailed method is contained as a cover sheet with the analysis work sheets.

4.0 METHODOLOGY

To apply an FMEA, to the valve boxes and magnet strings, a detailed study of the valve box P&ID's and the development of detailed operating procedures was completed. The operating procedures covered the various modes of operation, **A to G**, below. The development of the procedures was the first exercise verifying the capability of the valve box P&ID's. Some modifications, noted below, were made before the actual FMEA. The modes studied for the analysis of the valve box and magnet strings are as follows:

A) ***Normal*** full-ring operation.

B) ***Warm-up*** of the sextant at ***5:00*** including: isolation, reestablishment of heat shield flow to other sextants, liquid and gas recovery via CR line, reestablishment of helium coolant to other sextants (circulator off, refrigerator supply to magnet loop to recooler JT valves to return), circulation of warm helium from compressor discharge.

Note: Isolation of lead flow problem

C) ***Warm-up*** of the ***3:00*** *sextant which, schematically, is the same as 9:00*

D) ***Warm-up*** of the ***9:00*** sextant including: isolation, reestablishment of heat shield flow to other sextants except 7:00, liquid and gas recovery via CR line, reestablishment of helium coolant to other sextants except 7:00 (circulator off, refrigerator supply to magnet loop to recooler JT valves to return); ***7:00 sextant, magnet and heat shield, will be vented periodically via H4806A and H4810A/H4811A.***

Note: warm helium for final warmup step is circulated through the cold sextant at 7:00, with subsequent increase in conductive heat load to the 7:00 cold mass. An alternate scheme is a remote helium circulation pump. This would require warm tap points at individual valve boxes.

Note: Modification of P&ID .....86 (6:00 valve box) as follows: move the tap from H4639A to zone E6 or E7. See page 15 of notes.

E) ***Cooldown*** of the ***"first" loop***(1/2 ring).

F) ***Cooldown*** of the entire machine.

G) ***Recool*** the ***5:00*** sextant with all others cold.

The following analysis work sheets cover the valve boxes and magnet strings for the modes of operation referenced above.

5.0 Results

The Project policy for the safety review of cryogenic systems is contained in RHIC SEAPPM 5.2.1. The P&IDs and the Active Components List, mentioned above in Chapter 3, Section Q.5., were the basis for two Failure Modes and Effects Analysis (FMEA) which were done for this system (see Attachments 1 and 2). The first analysis was conducted for the Normal Operating Condition, when the rings were cooled to 4K for steady-state operation. The second analysis was conducted for a single sextant warm-up, where one or more magnets required removal and replacement. In this case, RHIC operations would prefer to maintain the remainder of the machine at 4K to save energy and reduce recooling time. A warm-up of the 3 o'clock sextant was analyzed, but is representative of a warm-up of any other sextant. These analyses list the identified hazards which may result from the failure of each item of equipment in the system and assesses the risk of that event. Where this analysis resulted in action items recommended to eliminate or control the hazard, these actions have been incorporated into the design.

The Normal Operations FMEA was performed in conjunction with the design effort for the Cryogenic System Valve Boxes. The Cryogenic System Valve Boxes are the centralized controls for the distribution of cryogen at the end of each sextant. At the 6 o'clock junction, the Cryogenic System Valve Box functions were expanded to include the interface between the RHIC Refrigerator and the Collider Ring and to include the ring helium circulators. The system makes extensive use of remotely operated valves which may be controlled from the Cryogenic System Main Control Room. These valves are air-operated via solenoid controls, with the de-energized state relying upon spring force for motive power. Thus, an initial de-energized state must be assigned in order to conduct the analysis. Once RHIC commences operation, the Cryogenic System should operate in the cold state for a majority of the year, with, at most, annual shut-downs for maintenance. The initial valve state was chosen such that failures of the valves will not cause an interruption of Collider operations. The FMEA also considered isolation and warm-up of a single sextant while the rest of the system remained cold.

The analytical effort of Normal Operations was especially successful in discovering some initial design flaws which would have prevented intended operation of the Cryogenic System. These flaws were corrected prior to valve box construction, with negligible impact on system cost or schedule. The FMEA worksheets provide details regarding the failure modes and failure effects for each Cryogenic System Valve Box component. Also included in the FMEA was an analysis to determine the means by which the failure could be detected.

There were 83 functionally-distinct categories for 1880 components that were analyzed. There are no single-point failures which would result in personal injury or major system damage.

There were 27 functional categories of components which would restrict or inhibit cryogen flow to a degree that, for a worst case situation, the magnets would be insufficiently cooled and might quench. However, all magnets will have a quench protection system which will de-energize power supplies and activate an energy absorbing system, and the RHIC magnets all are capable of absorbing their own energy without the potential for damage. Pressure transducers for the Cryogenic System have a capacity at least equal to the Cryogenic System design pressure of 275 psi. Nine functional categories of components have the potential for loss of helium gas inventory. The worst case assumes no intervention. However, a sizable gas leak would be readily detected by Cryogenic System operators, and there would be sufficient instrumentation/controls; i.e., pressure transducers, temperature sensors, remote valve operation, etc., remaining intact to prevent a significant loss of inventory. One fault would result in a relatively minor leak of inventory to atmosphere.

Four functional categories of components may affect the speed control for the cryogenic circulators. Two would cause the speed to decrease, with a potential for reduced cooling capability. Two could command speeds excessive for the circulator, leading to an overspeed. To prevent electrical overspeed of the circulator, a design criterion was established to incorporate a separate overspeed protection circuit. Two faults could cause magnets to de-energize due to loss of lead cooling. One of those faults is a manual valve, which would be detected on start-up. Six faults could cause an imbalance of the refrigerator. A significant imbalance in the refrigerator would cause the refrigerator to be shut off from the rings in order to maintain refrigerator operation. This is not hazardous, because the rings would act like a large dewar, taking several hours to warm sufficiently that the pressure would reach relief valve settings. Two faults could cause valves to not seat entirely, permitting leakage of gas. However, this would have no impact on Normal Operations. Finally, a single category of component, a relief valve, could result in a failure of piping or adjacent components which may contain cryogen. The relief valve protects the volume between two valves which interconnect adjacent process lines. However, one of the valve pairs is normally open, thereby venting the volume to a process line. The volume also includes pressure sensors. Finally, an overpressure can only occur when the volume is filled with cryogen, then warmed. Again, the volume will normally be open during warm-up to release this gas. The valves and the volume reside inside the valve box vacuum tank which will provide containment. There is no hazard from helium release because of the small volume involved.

Similarly, a FMEA was conducted for a single sextant warm-up. The analysis considered both rings warming in the affected sextant, although it likely that only one ring would require warming. Because the rings are mirrored configurations, there is no fault that could impact the other. Warming the sextant is a transient operation lasting less than 24 hours which did not warrant evaluation. However, once warmed, operations will be conducted to maintain the remainder of the sextants at about 4K. This consists of two modes for operation – one to maintain the heat shield, and the second to circulate 4K gas to keep the magnets cold. The two operations are mutually exclusive. The FMEA considers both modes in a single tabulation, where those components would have an impact on one or the other mode. A majority of the components are not involved in the warm-up operation or do not interface with the warmed-up sextant, thus have no impact on the operating state.

There were 93 functionally-distinct categories for 1880 components that were analyzed. There are no single-point failures which would result in personal injury or major system damage. There were 30 functional categories of components which would restrict or inhibit cryogen flow

to a degree that, for a worst case situation, the magnets would be insufficiently cooled. The consequence is that the temperature rise will be accompanied by a pressure rise and the need to store helium inventory. This can be accomplished safely in the liquid storage area or in the gaseous storage tanks. Nine functional categories of components have the potential for loss of helium gas inventory, with three additional categories posing a potential thermal and/or Oxygen Deficiency hazard to personnel as well as the loss of inventory. The worst case gas leak assumes no intervention. However, a sizable gas leak would be readily detected by Cryogenic System operators, and there would be sufficient instrumentation/controls; i.e., pressure transducers, temperature sensors, remote valve operation, etc., remaining intact to prevent a significant loss of inventory. The three faults which could result in the potential for personnel hazard are the process isolation valves between the warm and cold sextants. The fault assumes the valves are open. This is unlikely, as the valves are lockable, and were originally designed as such because this failure mode was obvious for this scenario.

Seven faults could cause an imbalance of the refrigerator. A significant imbalance in the refrigerator would cause the refrigerator to be shut off from the rings in order to maintain refrigerator operation. This is not hazardous, because the rings would act like a large dewar, taking several hours to warm sufficiently that the pressure would reach relief valve settings. Finally, a single category of component, a relief valve, could result in a failure of piping or adjacent components which may contain cryogen. The relief valve protects the volume between two valves which interconnect adjacent process lines. However, one of the valve pairs is normally open, thereby venting the volume to a process line. The volume also includes pressure sensors. Finally, an overpressure can only occur when the volume is filled with cryogen, then warmed. Again, the volume will normally be open during warm-up to release this gas. The valves and the volume reside inside the valve box vacuum tank which will provide containment. There is no hazard from helium release because of the small volume involved.

ATTACHMENT 1

FAILURE MODES EFFECTS ANALYSIS
FOR
NORMAL OPERATING MODE

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 19-Nov-98

Operation Mode: Full Ring Normal Operations

Item: 1

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	No flow. Heat shield temperature increase with magnet temperature rise and subsequent magnet quench. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
F4251H	B	2	FILTER H 4
F4256H	B	2	FILTER H 12
F6256H	Y	2	FILTER H 4
F6261H	Y	2	FILTER H 12
F4469H	B	4	FILTER H 6
F4474H	B	4	FILTER H 2
F6425H	Y	4	FILTER H 6
F6430H	Y	4	FILTER H 2
F4611H	B	6	FILTER H 8
F4616H	B	6	FILTER H 4
F6748H	Y	6	FILTER H 8
F6753H	Y	6	FILTER H 4
F4862H	B	8	FILTER H 10
F4867H	B	8	FILTER H 6
F6851H	Y	8	FILTER H 10
F6856H	Y	8	FILTER H 6
F5051H	B	10	FILTER H 12
F5056H	B	10	FILTER H 8
F7051H	Y	10	FILTER H 12
F7056H	Y	10	FILTER H 8
F4029H	B	12	FILTER H 2
F4035H	B	12	FILTER H 10
F6054H	Y	12	FILTER H 2
F6059H	Y	12	FILTER H 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 2

Item: 2

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak. Short/open on Magnet electrical circuits. Circulator failure.	Minor helium leak. Minor increase in refrigerator output.
Clogged	No flow. Magnet temperature rise and subsequent magnet quench. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
F4249H	B	2	FILTER M 4
F6254H	Y	2	FILTER M 4
F4467H	B	4	FILTER M 6
F6423H	Y	4	FILTER M 6
F4609H	B	6	FILTER M 8
F4614H	B	6	FILTER M 4
F6746H	Y	6	FILTER M 8
F6751H	Y	6	FILTER M 4
F4860H	B	8	FILTER M 10
F6849H	Y	8	FILTER M 10
F5049H	B	10	FILTER M 12
F7049H	Y	10	FILTER M 12
F4027H	B	12	FILTER M 2
F6052H	Y	12	FILTER M 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 3

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	Increased pressure drop may reduce flow. Utility Line provides alternate path. Recooler temperature increase with Magnet temperature rise and magnet quench. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
F4253H	B	2	FILTER R 4
F4258H	B	2	FILTER R 12
F6258H	Y	2	FILTER R 4
F6263H	Y	2	FILTER R 12
F4471H	B	4	FILTER R 6
F4476H	B	4	FILTER R 2
F6427H	Y	4	FILTER R 6
F6432H	Y	4	FILTER R 2
F4613H	B	6	FILTER R 8
F4618H	B	6	FILTER R 4
F6750H	Y	6	FILTER R 8
F6755H	Y	6	FILTER R 4
F4864H	B	8	FILTER R 10
F4869H	B	8	FILTER R 6
F6853H	Y	8	FILTER R 10
F6858H	Y	8	FILTER R 6
F5053H	B	10	FILTER R 12
F5058H	B	10	FILTER R 8
F7053H	Y	10	FILTER R 12
F7058H	Y	10	FILTER R 8
F4032H	B	12	FILTER R 2
F4037H	B	12	FILTER R 10
F6056H	Y	12	FILTER R 2
F6061H	Y	12	FILTER R 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 4

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	No impact. Supply gas provided by flow from opposite direction. Filter will collapse and fail at low Delta P. See Open.	Possible pressure differential.

Affected Components:

Component #	Ring	Box	Nomenclature
F4250H	B	2	FILTER S 4
F4255H	B	2	FILTER S 12
F6255H	Y	2	FILTER S 4
F6260H	Y	2	FILTER S 12
F4468H	B	4	FILTER S 6
F4473H	B	4	FILTER S 2
F6424H	Y	4	FILTER S 6
F6429H	Y	4	FILTER S 2
F4610H	B	6	FILTER S 8
F4615H	B	6	FILTER S 4
F6747H	Y	6	FILTER S 8
F6752H	Y	6	FILTER S 4
F4861H	B	8	FILTER S 10
F4866H	B	8	FILTER S 6
F6850H	Y	8	FILTER S 10
F6855H	Y	8	FILTER S 6
F5050H	B	10	FILTER S 12
F5055H	B	10	FILTER S 8
F7050H	Y	10	FILTER S 12
F7055H	Y	10	FILTER S 8
F4028H	B	12	FILTER S 2
F4034H	B	12	FILTER S 10
F6053H	Y	12	FILTER S 2
F6058H	Y	12	FILTER S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 5

Item: 5

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	Increased pressure drop may reduce flow. Return Line provides alternate path. Recooler temperature increase with Magnet temperature rise and magnet quench. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators and Magnet quench. Minor increase in refrigerator output.

Affected Components:

Component #	Ring	Box	Nomenclature
F4252H	B	2	FILTER U 4
F4257H	B	2	FILTER U 12
F6257H	Y	2	FILTER U 4
F6262H	Y	2	FILTER U 12
F4470H	B	4	FILTER U 6
F4475H	B	4	FILTER U 2
F6426H	Y	4	FILTER U 6
F6431H	Y	4	FILTER U 2
F4612H	B	6	FILTER U 8
F4617H	B	6	FILTER U 4
F6749H	Y	6	FILTER U 8
F6754H	Y	6	FILTER U 4
F4863H	B	8	FILTER U 10
F4868H	B	8	FILTER U 6
F6852H	Y	8	FILTER U 10
F6857H	Y	8	FILTER U 6
F5052H	B	10	FILTER U 12
F5057H	B	10	FILTER U 8
F7052H	Y	10	FILTER U 12
F7057H	Y	10	FILTER U 8
F4031H	B	12	FILTER U 2
F4036H	B	12	FILTER U 10
F6055H	Y	12	FILTER U 2
F6060H	Y	12	FILTER U 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 6

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Little to no impact. Supply gas provided by flow in opposite direction. Possible pressure drop. Possible minor increase in heat load in valve box, minor increase in refrigerator load.	Normally open valve. Visual detection. Low level indication. Pressure Differential..

Affected Components:

Component #	Ring	Box	Nomenclature
H4201A L	B	2	ISOLATION S
H6201A L	Y	2	ISOLATION S
H4401A L	B	4	ISOLATION S
H6401A L	Y	4	ISOLATION S
H4501A L	B	6	ISOLATION S 4
H4601A	B	6	ISOLATION S 8
H6601A L	Y	6	ISOLATION S 4
H6701A	Y	6	ISOLATION S 8
H4801A L	B	8	ISOLATION S
H6801A L	Y	8	ISOLATION S
H5001A L	B	10	ISOLATION S
H7001A L	Y	10	ISOLATION S
H4001A L	B	12	ISOLATION S
H6001A L	Y	12	ISOLATION S

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 7

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Increased pressure drop may reduce flow. Return line provides alternate path. Recooler temperature increase with magnet temperature rise and magnet quench.	Normally open valve. Visual detection. Decreasing liquid level indication. Elevated temperature/pressure indication. Pressure differential. Minor increase in refrigerator load.

Affected Components:

Component #	Ring	Box	Nomenclature
H4203A L	B	2	ISOLATION U
H6203A L	Y	2	ISOLATION U
H4403A L	B	4	ISOLATION U
H6403A L	Y	4	ISOLATION U
H4503A L	B	6	ISOLATION U 4
H4603A	B	6	ISOLATION U 8
H6603A L	Y	6	ISOLATION U 4
H6703A	Y	6	ISOLATION U 8
H4803A L	B	8	ISOLATION U
H6803A L	Y	8	ISOLATION U
H5003A L	B	10	ISOLATION U
H7003A L	Y	10	ISOLATION U
H4003A L	B	12	ISOLATION U
H6003A L	Y	12	ISOLATION U

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 8

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Large quantity of cold gas flows to refrigerator causing severe imbalance. Magnet temperature rises with subsequent magnet quench. Circulator overspeed shutdown.	Manual valve. Visual detection. Elevated pressure/ temperature. Temperature & pressure indicators. Magnet quench. Refrigerator alarms.
Closed	No impact. Normal Operating position.	None. Manual valve. Normal operation.

Affected Components:

Component #	Ring	Box	Nomenclature
H6823M	B	6	CIRC C3019 WARMUP SUPPLY
H6894M	Y	6	CIRC C3018 WARMUP SUPPLY

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 9

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Increased pressure drop may reduce flow. Utility line provides alternate path. Recooler temperature increase with magnet temperature rise and magnet quench.	Normally open valve. Visual detection. Decreasing liquid level indication. Elevated temperature/pressure indication. Pressure differential. Minor increase in refrigerator load.

Affected Components:

Component #	Ring	Box	Nomenclature
H4204A L	B	2	ISOLATION R
H6204A L	Y	2	ISOLATION R
H4404A L	B	4	ISOLATION R
H6404A L	Y	4	ISOLATION R
H4504A L	B	6	ISOLATION R 4
H4604A	B	6	ISOLATION R 8
H6604A L	Y	6	ISOLATION R 4
H6704A	Y	6	ISOLATION R 8
H4804A L	B	8	ISOLATION R
H6804A L	Y	8	ISOLATION R
H5004A L	B	10	ISOLATION R
H7004A L	Y	10	ISOLATION R
H4004A L	B	12	ISOLATION R
H6004A L	Y	12	ISOLATION R

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 10

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Increased refrigerator demand. Refrigerator imbalance caused by unmodulated Supply gas going into Return. Refrigerator shutoff from ring.	Normally closed valve. Increasing liquid level. Increased refrigerator load.
Closed	Possible minor increase in heat load in valve box, minor increase in refrigerator load.	Normally closed valve. Low level indication. Elevated temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
H4209A	B	2	J T 225watt RECOOLER
H6224A	Y	2	J T 225watt RECOOLER
H4409A	B	4	J T 225watt RECOOLER
H6451A	Y	4	J T 225watt RECOOLER
H4558A	B	6	J T 225watt RECOOLER
H6605A	Y	6	J T 225watt RECOOLER
H4809A	B	8	J T 225watt RECOOLER
H6809A	Y	8	J T 225watt RECOOLER
H5009A	B	10	J T 225watt RECOOLER
H7009A	Y	10	J T 225watt RECOOLER
H4073A	B	12	J T 225watt RECOOLER
H6009A	Y	12	J T 225watt RECOOLER

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 11

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
N/A	No longer a separate component. Integrated with lead control.	

Affected Components:

Component #	Ring	Box	Nomenclature
FE4260H	B	2	FLOW CONTROL ELEMENT 10
FE4261H	B	2	FLOW CONTROL ELEMENT 9
FE4262H	B	2	FLOW CONTROL ELEMENT 8
FE4263H	B	2	FLOW CONTROL ELEMENT 7
FE4264H	B	2	FLOW CONTROL ELEMENT 12
FE4265H	B	2	FLOW CONTROL ELEMENT 5
FE4266H	B	2	FLOW CONTROL ELEMENT 4
FE4267H	B	2	FLOW CONTROL ELEMENT 3
FE4268H	B	2	FLOW CONTROL ELEMENT 2
FE4269H	B	2	FLOW CONTROL ELEMENT 1
FE6254H	Y	2	FLOW CONTROL ELEMENT 9
FE6255H	Y	2	FLOW CONTROL ELEMENT 8
FE6256H	Y	2	FLOW CONTROL ELEMENT 7
FE6257H	Y	2	FLOW CONTROL ELEMENT 5
FE6258H	Y	2	FLOW CONTROL ELEMENT 4
FE6259H	Y	2	FLOW CONTROL ELEMENT 2
FE6260H	Y	2	FLOW CONTROL ELEMENT 1
FE6261H	Y	2	FLOW CONTROL ELEMENT 10
FE6262H	Y	2	FLOW CONTROL ELEMENT 11
FE6263H	Y	2	FLOW CONTROL ELEMENT 3
FE4465H	B	4	FLOW CONTROL ELEMENT B10
FE4466H	B	4	FLOW CONTROL ELEMENT B9
FE4467H	B	4	FLOW CONTROL ELEMENT B8
FE4468H	B	4	FLOW CONTROL ELEMENT B7
FE4469H	B	4	FLOW CONTROL ELEMENT B6
FE4470H	B	4	FLOW CONTROL ELEMENT A11
FE4471H	B	4	FLOW CONTROL ELEMENT A9
FE4472H	B	4	FLOW CONTROL ELEMENT A8
FE4473H	B	4	FLOW CONTROL ELEMENT A6
FE4474H	B	4	FLOW CONTROL ELEMENT A5
FE4475H	B	4	FLOW CONTROL ELEMENT A4
FE4476H	B	4	FLOW CONTROL ELEMENT A2
FE4477H	B	4	FLOW CONTROL ELEMENT A1
FE6465H	Y	4	FLOW CONTROL ELEMENT 10
FE6466H	Y	4	FLOW CONTROL ELEMENT 9
FE6467H	Y	4	FLOW CONTROL ELEMENT 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 12

Component #	Ring	Box	Nomenclature
FE6468H	Y	4	FLOW CONTROL ELEMENT 7
FE6469H	Y	4	FLOW CONTROL ELEMENT 6
FE6470H	Y	4	FLOW CONTROL ELEMENT 5
FE6471H	Y	4	FLOW CONTROL ELEMENT 4
FE6472H	Y	4	FLOW CONTROL ELEMENT 3
FE6473H	Y	4	FLOW CONTROL ELEMENT 2
FE6474H	Y	4	FLOW CONTROL ELEMENT 1
FE6475H	Y	4	FLOW CONTROL ELEMENT 11
FE4005H	B	6	FLOW CONTROL ELEMENT 11
FE4006H	B	6	FLOW CONTROL ELEMENT 10
FE4007H	B	6	FLOW CONTROL ELEMENT 9
FE4008H	B	6	FLOW CONTROL ELEMENT 8
FE4009H	B	6	FLOW CONTROL ELEMENT 7
FE4080H	B	6	FLOW CONTROL ELEMENT 5
FE4081H	B	6	FLOW CONTROL ELEMENT 4
FE4082H	B	6	FLOW CONTROL ELEMENT 2
FE4083H	B	6	FLOW CONTROL ELEMENT 1
FE4096H	B	6	FLOW CONTROL ELEMENT 3
FE4000H	Y	6	FLOW CONTROL ELEMENT 9
FE4001H	Y	6	FLOW CONTROL ELEMENT 8
FE4002H	Y	6	FLOW CONTROL ELEMENT 7
FE4013H	Y	6	FLOW CONTROL ELEMENT 4
FE4014H	Y	6	FLOW CONTROL ELEMENT 2
FE4015H	Y	6	FLOW CONTROL ELEMENT 10
FE4016H	Y	6	FLOW CONTROL ELEMENT 1
FE4017H	Y	6	FLOW CONTROL ELEMENT 5
FE4018H	Y	6	FLOW CONTROL ELEMENT 11
FE6869H	Y	6	FLOW CONTROL ELEMENT 11
FE4860H	B	8	FLOW CONTROL ELEMENT 11
FE4861H	B	8	FLOW CONTROL ELEMENT 10
FE4862H	B	8	FLOW CONTROL ELEMENT 9
FE4863H	B	8	FLOW CONTROL ELEMENT 8
FE4864H	B	8	FLOW CONTROL ELEMENT 7
FE4865H	B	8	FLOW CONTROL ELEMENT 5
FE4866H	B	8	FLOW CONTROL ELEMENT 4
FE4867H	B	8	FLOW CONTROL ELEMENT 2
FE4868H	B	8	FLOW CONTROL ELEMENT 1
FE4869H	B	8	FLOW CONTROL ELEMENT 3
FE6860H	Y	8	FLOW CONTROL ELEMENT 9
FE6861H	Y	8	FLOW CONTROL ELEMENT 8
FE6862H	Y	8	FLOW CONTROL ELEMENT 7
FE6863H	Y	8	FLOW CONTROL ELEMENT 6
FE6864H	Y	8	FLOW CONTROL ELEMENT 4
FE6865H	Y	8	FLOW CONTROL ELEMENT 2
FE6866H	Y	8	FLOW CONTROL ELEMENT 10
FE6867H	Y	8	FLOW CONTROL ELEMENT 1
FE6868H	Y	8	FLOW CONTROL ELEMENT 5
FE5160H	B	10	FLOW CONTROL ELEMENT B11

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 13

Component #	Ring	Box	Nomenclature
FE5161H	B	10	FLOW CONTROL ELEMENT B10
FE5162H	B	10	FLOW CONTROL ELEMENT B9
FE5163H	B	10	FLOW CONTROL ELEMENT B2
FE5164H	B	10	FLOW CONTROL ELEMENT B4
FE5165H	B	10	FLOW CONTROL ELEMENT B7
FE5166H	B	10	FLOW CONTROL ELEMENT A11
FE5167H	B	10	FLOW CONTROL ELEMENT A9
FE5168H	B	10	FLOW CONTROL ELEMENT A8
FE5169H	B	10	FLOW CONTROL ELEMENT A6
FE5170H	B	10	FLOW CONTROL ELEMENT A5
FE5171H	B	10	FLOW CONTROL ELEMENT A4
FE5172H	B	10	FLOW CONTROL ELEMENT A2
FE5173H	B	10	FLOW CONTROL ELEMENT A1
FE5174H	B	10	FLOW CONTROL ELEMENT B7
FE5175H	B	10	FLOW CONTROL ELEMENT A10
FE5200H	B	10	FLOW CONTROL ELEMENT B8
FE7060H	Y	10	FLOW CONTROL ELEMENT B10
FE7061H	Y	10	FLOW CONTROL ELEMENT B9
FE7062H	Y	10	FLOW CONTROL ELEMENT B8
FE7063H	Y	10	FLOW CONTROL ELEMENT B7
FE7064H	Y	10	FLOW CONTROL ELEMENT B6
FE7065H	Y	10	FLOW CONTROL ELEMENT B11
FE7066H	Y	10	FLOW CONTROL ELEMENT A11
FE7067H	Y	10	FLOW CONTROL ELEMENT A9
FE7068H	Y	10	FLOW CONTROL ELEMENT A8
FE7069H	Y	10	FLOW CONTROL ELEMENT A6
FE7070H	Y	10	FLOW CONTROL ELEMENT A5
FE7071H	Y	10	FLOW CONTROL ELEMENT A4
FE7072H	Y	10	FLOW CONTROL ELEMENT A2
FE7073H	Y	10	FLOW CONTROL ELEMENT A1
FE4074H	B	12	FLOW CONTROL ELEMENT 11
FE4075H	B	12	FLOW CONTROL ELEMENT 10
FE4076H	B	12	FLOW CONTROL ELEMENT 9
FE4077H	B	12	FLOW CONTROL ELEMENT 8
FE4078H	B	12	FLOW CONTROL ELEMENT 7
FE4079H	B	12	FLOW CONTROL ELEMENT 5
FE4091H	B	12	FLOW CONTROL ELEMENT 4
FE4092H	B	12	FLOW CONTROL ELEMENT 2
FE4093H	B	12	FLOW CONTROL ELEMENT 1
FE4094H	B	12	FLOW CONTROL ELEMENT 3
FE6059H	Y	12	FLOW CONTROL ELEMENT 9
FE6060H	Y	12	FLOW CONTROL ELEMENT 8
FE6061H	Y	12	FLOW CONTROL ELEMENT 7
FE6062H	Y	12	FLOW CONTROL ELEMENT 6
FE6063H	Y	12	FLOW CONTROL ELEMENT 4
FE6064H	Y	12	FLOW CONTROL ELEMENT 2
FE6065H	Y	12	FLOW CONTROL ELEMENT 10
FE6066H	Y	12	FLOW CONTROL ELEMENT 1

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Component #	Ring	Box	Nomenclature
FE6067H	Y	12	FLOW CONTROL ELEMENT 5
FE6068H	Y	12	FLOW CONTROL ELEMENT 11

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
None	Shaped pipe. Has no normally anticipated failure modes.	

Affected Components:

Component #	Ring	Box	Nomenclature
FE4011H	B	6	VENTURI FLOW 200 g/sec He @ 4k
FE4010H	Y	6	VENTURI FLOW 200 g/sec He @ 4k

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 16

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Continuous lead flow. Increased refrigerator heat load.	Minor helium leak. Minor increase in refrigerator output.
Closed	No lead cooling. Power supply shutdown by voltage monitoring circuit.	Power supply shutdown or elevated lead voltage.

Affected Components:

Component #	Ring	Box	Nomenclature
H4255E	B	2	LEAD CONTROL 11
H4256E	B	2	LEAD CONTROL 10
H4257E	B	2	LEAD CONTROL 9
H4258E	B	2	LEAD CONTROL 8
H4259E	B	2	LEAD CONTROL 7
H4260E	B	2	LEAD CONTROL 12
H4261E	B	2	LEAD CONTROL 5
H4262E	B	2	LEAD CONTROL 4
H4263E	B	2	LEAD CONTROL 3
H4264E	B	2	LEAD CONTROL 2
H4265E	B	2	LEAD CONTROL 1
H6228E	Y	2	LEAD CONTROL 9
H6229E	Y	2	LEAD CONTROL 8
H6231E	Y	2	LEAD CONTROL 7
H6232E	Y	2	LEAD CONTROL 6
H6261E	Y	2	LEAD CONTROL 5
H6262E	Y	2	LEAD CONTROL 4
H6263E	Y	2	LEAD CONTROL 2
H6264E	Y	2	LEAD CONTROL 1
H4455E	B	4	LEAD CONTROL B10
H4456E	B	4	LEAD CONTROL B9
H4457E	B	4	LEAD CONTROL B8
H4458E	B	4	LEAD CONTROL B7
H4459E	B	4	LEAD CONTROL B6
H4460E	B	4	LEAD CONTROL A11
H4461E	B	4	LEAD CONTROL A9
H4462E	B	4	LEAD CONTROL A8
H4465E	B	4	LEAD CONTROL A6
H4466E	B	4	LEAD CONTROL A5
H4467E	B	4	LEAD CONTROL A4

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H4468E	B	4	LEAD CONTROL A2
H4469E	B	4	LEAD CONTROL A1
H6453E	Y	4	LEAD CONTROL 10
H6454E	Y	4	LEAD CONTROL 9
H6455E	Y	4	LEAD CONTROL 8
H6456E	Y	4	LEAD CONTROL 7
H6457E	Y	4	LEAD CONTROL 6
H6458E	Y	4	LEAD CONTROL 5
H6459E	Y	4	LEAD CONTROL 4
H6460E	Y	4	LEAD CONTROL 3
H6472E	Y	4	LEAD CONTROL 2
H6473E	Y	4	LEAD CONTROL 1
H6474E	Y	4	LEAD CONTROL 11
H4513E	B	6	LEAD CONTROL 11
H4514E	B	6	LEAD CONTROL 10
H4518E	B	6	LEAD CONTROL 9
H4519E	B	6	LEAD CONTROL 8
H4523E	B	6	LEAD CONTROL 7
H4547E	B	6	LEAD CONTROL 5
H4548E	B	6	LEAD CONTROL 4
H4549E	B	6	LEAD CONTROL 2
H4550E	B	6	LEAD CONTROL 1
H6613E	Y	6	LEAD CONTROL 9
H6614E	Y	6	LEAD CONTROL 8
H6618E	Y	6	LEAD CONTROL 7
H6627E	Y	6	LEAD CONTROL 2
H6628E	Y	6	LEAD CONTROL 10
H6629E	Y	6	LEAD CONTROL 1
H6632E	Y	6	LEAD CONTROL 11
H4855E	B	8	LEAD CONTROL 11
H4856E	B	8	LEAD CONTROL 10
H4857E	B	8	LEAD CONTROL 9
H4858E	B	8	LEAD CONTROL 8
H4859E	B	8	LEAD CONTROL 7
H4860E	B	8	LEAD CONTROL 5
H4862E	B	8	LEAD CONTROL 4
H4863E	B	8	LEAD CONTROL 2
H4864E	B	8	LEAD CONTROL 1
H6855E	Y	8	LEAD CONTROL 9
H6856E	Y	8	LEAD CONTROL 8
H6857E	Y	8	LEAD CONTROL 7
H6858E	Y	8	LEAD CONTROL 6
H6868E	Y	8	LEAD CONTROL 2
H6869E	Y	8	LEAD CONTROL 10
H6870E	Y	8	LEAD CONTROL 1
H6883E	Y	8	LEAD CONTROL 11
H5049E	B	10	LEAD CONTROL B11
H5050E	B	10	LEAD CONTROL B10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

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Component #	Ring	Box	Nomenclature
H5051E	B	10	LEAD CONTROL B9
H5052E	B	10	LEAD CONTROL B2
H5053E	B	10	LEAD CONTROL B4
H5055E	B	10	LEAD CONTROL B7
H5056E	B	10	LEAD CONTROL A11
H5057E	B	10	LEAD CONTROL A9
H5058E	B	10	LEAD CONTROL A8
H5059E	B	10	LEAD CONTROL A6
H5084E	B	10	LEAD CONTROL A5
H5085E	B	10	LEAD CONTROL A4
H5086E	B	10	LEAD CONTROL A2
H5087E	B	10	LEAD CONTROL A1
H5088E	B	10	LEAD CONTROL A7
H5089E	B	10	LEAD CONTROL A10
H7055E	Y	10	LEAD CONTROL B10
H7056E	Y	10	LEAD CONTROL B9
H7057E	Y	10	LEAD CONTROL B8
H7058E	Y	10	LEAD CONTROL B7
H7059E	Y	10	LEAD CONTROL B6
H7060E	Y	10	LEAD CONTROL B11
H7061E	Y	10	LEAD CONTROL A11
H7063E	Y	10	LEAD CONTROL A9
H7071E	Y	10	LEAD CONTROL A8
H7072E	Y	10	LEAD CONTROL A6
H7073E	Y	10	LEAD CONTROL A5
H7074E	Y	10	LEAD CONTROL A4
H7075E	Y	10	LEAD CONTROL A2
H7087E	Y	10	LEAD CONTROL A1
H4064E	B	12	LEAD CONTROL 11
H4065E	B	12	LEAD CONTROL 10
H4066E	B	12	LEAD CONTROL 9
H4067E	B	12	LEAD CONTROL 8
H4068E	B	12	LEAD CONTROL 7
H4074E	B	12	LEAD CONTROL 5
H4075E	B	12	LEAD CONTROL 4
H4076E	B	12	LEAD CONTROL 2
H4077E	B	12	LEAD CONTROL 1
H6046E	Y	12	LEAD CONTROL 9
H6047E	Y	12	LEAD CONTROL 8
H6048E	Y	12	LEAD CONTROL 7
H6049E	Y	12	LEAD CONTROL 6
H6074E	Y	12	LEAD CONTROL 2
H6075E	Y	12	LEAD CONTROL 10
H6076E	Y	12	LEAD CONTROL 1
H6100E	Y	12	LEAD CONTROL 11

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 14

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Minor increase in refrigerator heat load.	Minor helium leak. Minor increase in refrigerator output.
Closed	Line bursts, with loss of insulating vacuum (internal line) or pressure indicator failure (external line). Internal line burst will cause helium to escape into Power Supply building through vacuum tank relief valve.	Elevated pressure/temperature. Temperature indicators and Magnet quench. Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4207R	B	2	RELIEF H4205M~H4200A
H4246R	B	2	RELIEF H4210A~H4211A
H4247R	B	2	RELIEF H4215A~H4216A
H4248R	B	2	RELIEF H4220A~H4221A
H4249R	B	2	RELIEF H4218M~H4201A
H6246R	Y	2	RELIEF H6215A~H6216A
H6247R	Y	2	RELIEF H6210A~H6211A
H6248R	Y	2	RELIEF H6220A~H6221A
H6255R	Y	2	RELIEF H6254M~H6201A
H6258R	Y	2	RELIEF H6253M~H6200A
H4413R	B	4	RELIEF H4407M~H4400A
H4419R	B	4	RELIEF H4420A~H4421A
H4446R	B	4	RELIEF H4415A~H4416A
H4447R	B	4	RELIEF H4410A~H4411A
H4448R	B	4	RELIEF H4405M~H4401A
H6413R	Y	4	RELIEF H6400A~H6405M
H6423R	Y	4	RELIEF H6420A~H6421A
H6442R	Y	4	RELIEF H6415A~H6416A
H6443R	Y	4	RELIEF H6410A~H6411A
H6444R	Y	4	RELIEF H6401A~H6426M
H3090R	B	6	CIRCULATOR C3019 RELIEF
H3091R	B	6	RELIEF H4602A~H4645A H 8
H3092R	B	6	RELIEF H4641A~H4500A
H3093R	B	6	RELIEF H4516A~H4616A S BYPASS
H3094R	B	6	RELIEF H4534M~H4614M S
H3095R	B	6	RELIEF H4503A~H4603A U
H3096R	B	6	RELIEF H4504A~H4604A R
H3097R	B	6	RELIEF H4502A~H4510A H 4
H3109R	B	6	RELIEF H4620A~H4621A
H3110R	B	6	RELIEF H4510A~H4511A

Failure Mode Effects Analysis

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Operation Mode: Full Ring Normal Operations **Page:** 20

Component #	Ring	Box	Nomenclature
H3111R	B	6	RELIEF H4515A~H4516A
H3112R	B	6	RELIEF H4615A~H4616A
H3113R	B	6	RELIEF H4520A~H4521A
H3231R	B	6	RELIEF H4536A~H4636A R BYPASS
H3232R	B	6	RELIEF H4501A~H4534M
H3235R	B	6	RELIEF H4600A~H4618M
H6471R	B	6	RELIEF H4500A~H6733M
H6813R	B	6	RELIEF H4601A~H4614M
H3076R	Y	6	RELIEF H6702A~H6745A H 8
H3077R	Y	6	RELIEF H6740A~H6600A
H3078R	Y	6	RELIEF H6616A~H6716A S BYPASS
H3079R	Y	6	RELIEF H6609M~H6705M S
H3080R	Y	6	RELIEF H6603A~H6703A U
H3081R	Y	6	RELIEF H6604A~H6704A R
H3082R	Y	6	RELIEF H6602A~H6610A H 4
H3088R	Y	6	CIRCULATOR C3018 RELIEF
H3104R	Y	6	RELIEF H6720A~H6721A
H3105R	Y	6	RELIEF H6610A~H6611A
H3106R	Y	6	RELIEF H6615A~H6616A
H3107R	Y	6	RELIEF H6715A~H6716A
H3108R	Y	6	RELIEF H6620A~H6621A
H3114R	Y	6	RELIEF H6636A~H6736A R BYPASS
H3115R	Y	6	RELIEF H6701A~H6705M
H6642R	Y	6	RELIEF H6600A~H6623M
H6805R	Y	6	RELIEF H6601A~H6609M
H6807R	Y	6	RELIEF H6700A~H6707M
H4807R	B	8	RELIEF H4800A~H4831M
H4832R	B	8	RELIEF H4810A~H4811A
H4846R	B	8	RELIEF H4820A~H4821A
H4847R	B	8	RELIEF H4801A~H4805M
H4848R	B	8	RELIEF H4815A~H4816A
H6846R	Y	8	RELIEF H6820A~H6821A
H6847R	Y	8	RELIEF H6810A~H6811A
H6848R	Y	8	RELIEF H6815A~H6816A
H6863R	Y	8	RELIEF H6800A~H6859M
H6864R	Y	8	RELIEF H6801A~H6860M
H5032R	B	10	RELIEF H5283M~H5001A
H5046R	B	10	RELIEF H5020A~H5021A
H5047R	B	10	RELIEF H5010A~H5011A
H5048R	B	10	RELIEF H5015A~H5016A
H5282R	B	10	RELIEF H5284M~H5000A
H7046R	Y	10	RELIEF H7020A~H7021A
H7047R	Y	10	RELIEF H7010A~H7011A
H7048R	Y	10	RELIEF H7015A~H7016A
H7065R	Y	10	RELIEF H7000A~H7067A
H7068R	Y	10	RELIEF H7001A~H7066M
H4012R	B	12	RELIEF H4000A~H4007A
H4018R	B	12	RELIEF H4005A~H4001A

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H4053R	B	12	RELIEF H4035A~H4039A
H4054R	B	12	RELIEF H4020A~H4021A
H4055R	B	12	RELIEF H4010A~H4011A
H4056R	B	12	RELIEF H4015A~H4016A
H6029R	Y	12	RELIEF H6000A~H6056A
H6044R	Y	12	RELIEF H6015A~H6016A
H6045R	Y	12	RELIEF H6010A~H6011A
H6054R	Y	12	RELIEF H6001A~H6055A
H6058R	Y	12	RELIEF H6020A~H6021A
H6072R	Y	12	RELIEF H6007A~H6070A

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 22

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vent to atmosphere. Unacceptable leak, with depletion of helium inventory.	Elevated temperature/low pressure. Frosted valve.
Closed	No impact. Relief on opposite end of magnet string is adequate	Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4236R	B	2	RELIEF LINE M 4
H4237R	B	2	RELIEF LINE S 4
H4238R	B	2	RELIEF LINE H 4
H4239R	B	2	RELIEF LINE U 4
H4240R	B	2	RELIEF LINE R 4
H4241R	B	2	RELIEF LINE M 12
H4242R	B	2	RELIEF LINE S 12
H4243R	B	2	RELIEF LINE H 12
H4244R	B	2	RELIEF LINE U 12
H4245R	B	2	RELIEF LINE R 12
H6236R	Y	2	RELIEF LINE M 4
H6237R	Y	2	RELIEF LINE S 4
H6238R	Y	2	RELIEF LINE H 4
H6239R	Y	2	RELIEF LINE U 4
H6240R	Y	2	RELIEF LINE R 4
H6241R	Y	2	RELIEF LINE M 12
H6242R	Y	2	RELIEF LINE S 12
H6243R	Y	2	RELIEF LINE H 12
H6244R	Y	2	RELIEF LINE U 12
H6245R	Y	2	RELIEF LINE R 12
H4436R	B	4	RELIEF LINE M 6
H4437R	B	4	RELIEF LINE S 6
H4438R	B	4	RELIEF LINE H 6
H4439R	B	4	RELIEF LINE U 6
H4440R	B	4	RELIEF LINE R 6
H4441R	B	4	RELIEF LINE M 2
H4442R	B	4	RELIEF LINE S 2
H4443R	B	4	RELIEF LINE H 2
H4444R	B	4	RELIEF LINE U 2
H4445R	B	4	RELIEF LINE R 2

Failure Mode Effects Analysis

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Operation Mode: Full Ring Normal Operations

Component #	Ring	Box	Nomenclature
H6432R	Y	4	RELIEF LINE M 6
H6433R	Y	4	RELIEF LINE S 6
H6434R	Y	4	RELIEF LINE H 6
H6435R	Y	4	RELIEF LINE U 6
H6436R	Y	4	RELIEF LINE R 6
H6437R	Y	4	RELIEF LINE M 2
H6438R	Y	4	RELIEF LINE S 2
H6439R	Y	4	RELIEF LINE H 2
H6440R	Y	4	RELIEF LINE U 2
H6441R	Y	4	RELIEF LINE R 2
H3098R	B	6	RELIEF LINE M 4
H3099R	B	6	RELIEF LINE H 4
H3100R	B	6	RELIEF LINE S 4
H3102R	B	6	RELIEF LINE R 4
H3103R	B	6	RELIEF LINE U 4
H4609R	B	6	RELIEF LINE M 8
H4610R	B	6	RELIEF LINE S 8
H4611R	B	6	RELIEF LINE H 8
H4612R	B	6	RELIEF LINE U 8
H4613R	B	6	RELIEF LINE R 8
H3083R	Y	6	RELIEF LINE M 4
H3084R	Y	6	RELIEF LINE S 4
H3085R	Y	6	RELIEF LINE H 4
H3086R	Y	6	RELIEF LINE U 4
H3087R	Y	6	RELIEF LINE R 4
H6746R	Y	6	RELIEF LINE M 8
H6747R	Y	6	RELIEF LINE S 8
H6748R	Y	6	RELIEF LINE H 8
H6749R	Y	6	RELIEF LINE U 8
H6750R	Y	6	RELIEF LINE R 8
H4836R	B	8	RELIEF LINE M 10
H4837R	B	8	RELIEF LINE S 10
H4838R	B	8	RELIEF LINE H 10
H4839R	B	8	RELIEF LINE U 10
H4840R	B	8	RELIEF LINE R 10
H4841R	B	8	RELIEF LINE M 6
H4842R	B	8	RELIEF LINE S 6
H4843R	B	8	RELIEF LINE H 6
H4844R	B	8	RELIEF LINE U 6
H4845R	B	8	RELIEF LINE R 6
H6836R	Y	8	RELIEF LINE M 10
H6837R	Y	8	RELIEF LINE S 10
H6838R	Y	8	RELIEF LINE H 10
H6839R	Y	8	RELIEF LINE U 10
H6840R	Y	8	RELIEF LINE R 10
H6841R	Y	8	RELIEF LINE M 6
H6842R	Y	8	RELIEF LINE S 6
H6843R	Y	8	RELIEF LINE H 6

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Component #	Ring	Box	Nomenclature
H6844R	Y	8	RELIEF LINE U 6
H6845R	Y	8	RELIEF LINE R 6
H5036R	B	10	RELIEF LINE M 12
H5037R	B	10	RELIEF LINE S 12
H5038R	B	10	RELIEF LINE H 12
H5039R	B	10	RELIEF LINE U 12
H5040R	B	10	RELIEF LINE R 12
H5041R	B	10	RELIEF LINE M 8
H5042R	B	10	RELIEF LINE S 8
H5043R	B	10	RELIEF LINE H 8
H5044R	B	10	RELIEF LINE U 8
H5045R	B	10	RELIEF LINE R 8
H7036R	Y	10	RELIEF LINE M 12
H7037R	Y	10	RELIEF LINE S 12
H7038R	Y	10	RELIEF LINE H 12
H7039R	Y	10	RELIEF LINE U 12
H7040R	Y	10	RELIEF LINE R 12
H7041R	Y	10	RELIEF LINE M 8
H7042R	Y	10	RELIEF LINE S 8
H7043R	Y	10	RELIEF LINE H 8
H7044R	Y	10	RELIEF LINE U 8
H7045R	Y	10	RELIEF LINE R 8
H4043R	B	12	RELIEF LINE M 2
H4044R	B	12	RELIEF LINE S 2
H4045R	B	12	RELIEF LINE H 2
H4046R	B	12	RELIEF LINE U 2
H4047R	B	12	RELIEF LINE R 2
H4048R	B	12	RELIEF LINE M 10
H4049R	B	12	RELIEF LINE S 10
H4051R	B	12	RELIEF LINE U 10
H4052R	B	12	RELIEF LINE R 10
H4057R	B	12	RELIEF LINE H 10
H6032R	Y	12	RELIEF LINE M 2
H6033R	Y	12	RELIEF LINE S 2
H6034R	Y	12	RELIEF LINE H 2
H6035R	Y	12	RELIEF LINE U 2
H6038R	Y	12	RELIEF LINE R 2
H6039R	Y	12	RELIEF LINE M 10
H6040R	Y	12	RELIEF LINE S 10
H6041R	Y	12	RELIEF LINE H 10
H6042R	Y	12	RELIEF LINE U 10
H6043R	Y	12	RELIEF LINE R 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 16

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Headers open to warm Return. Vent checkvalve prevents flow.	Detectable only with individual test.
Closed	No impact. Headers open to Return.	Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4227R	B	2	VENT RELIEF 4
H6452R	Y	4	VENT RELIEF 6
H4623R	B	6	VENT RELIEF 8
H6723R	Y	6	VENT RELIEF 8
H4827R	B	8	VENT RELIEF 10
H5027R	B	10	VENT RELIEF 12
H7027R	Y	10	VENT RELIEF 12
H4061R	B	12	VENT RELIEF 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 17

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Instrumentation only with redundant sensors.	Temperature indication unreasonably high.
Full Scale Low	No impact. Instrumentation only with redundant sensors.	Zero temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
TI4253H	B	2	CALIBRATED SNSR RECL IN
TI4254H	B	2	CALIBRATED SNSR RECL OUT
TI4255H	B	2	SNSR RECLR LIQUID LI4252
TI4265H	B	2	CALIBRATED SENSOR S 12
TI4266H	B	2	CALIBRATED SENSOR H 12
TI4267H	B	2	CALIBRATED SENSOR U 12
TI4268H	B	2	CALIBRATED SENSOR R 12
TI4405H	B	2	CALIBRATED SENSOR R 4 IN
TI4406H	B	2	CALIBRATED SENSOR U 4 IN
TI4407H	B	2	CALIBRATED SENSOR H 4 IN
TI4408H	B	2	CALIBRATED SENSOR S 4 IN
TI4409H	B	2	CALIBRATED SENSOR M 4 IN
TI4410H	B	2	CALIBRATED SENSOR R 12 OUT
TI4411H	B	2	CALIBRATED SENSOR U 12 OUT
TI4412H	B	2	CALIBRATED SENSOR H 12 OUT
TI4413H	B	2	CALIBRATED SENSOR S 12 OUT
TI4414H	B	2	CALIBRATED SENSOR M 12 OUT
TI6241H	Y	2	CALIBRATED SENSOR R 4 IN
TI6242H	Y	2	CALIBRATED SENSOR U 4 IN
TI6243H	Y	2	CALIBRATED SENSOR H 4 IN
TI6244H	Y	2	CALIBRATED SENSOR S 4 IN
TI6245H	Y	2	CALIBRATED SENSOR M 4 IN
TI6246H	Y	2	CALIBRATED SENSOR R 12 OUT
TI6247H	Y	2	CALIBRATED SENSOR U 12 OUT
TI6248H	Y	2	CALIBRATED SENSOR H 12 OUT
TI6249H	Y	2	CALIBRATED SENSOR S 12 OUT
TI6250H	Y	2	CALIBRATED SENSOR M 12 OUT
TI6251H	Y	2	CALIBRATED SNSR RECL IN
TI6252H	Y	2	CALIBRATED SNSR RECL OUT
TI6258H	Y	2	SNSR RECLR LIQUID LI6253

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 27

Component #	Ring	Box	Nomenclature
TI6263H	Y	2	CALIBRATED SENSOR S 12
TI6264H	Y	2	CALIBRATED SENSOR H 12
TI6265H	Y	2	CALIBRATED SENSOR U 12
TI6266H	Y	2	CALIBRATED SENSOR R 12
TI4454H	B	4	CALIBRATED SNSR RECL IN
TI4464H	B	4	CALIBRATED SNSR RECL OUT
TI4470H	B	4	SNSR RECLR LIQUID LI4452
TI4479H	B	4	CALIBRATED SENSOR R 6 IN
TI4480H	B	4	CALIBRATED SENSOR U 6 IN
TI4481H	B	4	CALIBRATED SENSOR H 6 IN
TI4482H	B	4	CALIBRATED SENSOR S 6 IN
TI4483H	B	4	CALIBRATED SENSOR M 6 IN
TI4484H	B	4	CALIBRATED SENSOR R 2 OUT
TI4485H	B	4	CALIBRATED SENSOR U 2 OUT
TI4486H	B	4	CALIBRATED SENSOR H 2 OUT
TI4487H	B	4	CALIBRATED SENSOR S 2 OUT
TI4488H	B	4	CALIBRATED SENSOR M 2 OUT
TI6475H	Y	4	CALIBRATED SNSR RECL IN
TI6476H	Y	4	CALIBRATED SNSR RECL OUT
TI6477H	Y	4	SNSR RECLR LIQUID LI6477
TI6491H	Y	4	CALIBRATED SENSOR R 6 IN
TI6492H	Y	4	CALIBRATED SENSOR U 6 IN
TI6493H	Y	4	CALIBRATED SENSOR H 6 IN
TI6494H	Y	4	CALIBRATED SENSOR S 6 IN
TI6495H	Y	4	CALIBRATED SENSOR M 6 IN
TI6496H	Y	4	CALIBRATED SENSOR R 2 OUT
TI6497H	Y	4	CALIBRATED SENSOR U 2 OUT
TI6498H	Y	4	CALIBRATED SENSOR H 2 OUT
TI6499H	Y	4	CALIBRATED SENSOR S 2 OUT
TI6500H	Y	4	CALIBRATED SENSOR M 2 OUT
TI3709H	B	6	CALIBRATED SNSR L. P. OUT
TI3710H	B	6	CALIBRATED SNSR CIRC IN
TI3711H	B	6	CALIBRATED SNSR CIRC OUT
TI3714H	B	6	CALIBRATED SNSR RECL OUT
TI3804H	B	6	CALIBRATED SENSOR CIRC OUTLET
TI4002H	B	6	SNSR RECLR LIQUID LI4001
TI4600H	B	6	CALIBRATED SENSOR S 8
TI4601H	B	6	CALIBRATED SENSOR H 8
TI4602H	B	6	CALIBRATED SENSOR U 8
TI4603H	B	6	CALIBRATED SENSOR R 8
TI4604H	B	6	CALIBRATED SENSOR S 4
TI4605H	B	6	CALIBRATED SENSOR H 4
TI4606H	B	6	CALIBRATED SENSOR U 4
TI4607H	B	6	CALIBRATED SENSOR R 4
TI4608H	B	6	CALIBRATED SENSOR S IN
TI4609H	B	6	CALIBRATED SENSOR R OUT
TI4610H	B	6	CALIBRATED SENSOR CR OUT
TI4611H	B	6	CALIBRATED SENSOR HS IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

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Component #	Ring	Box	Nomenclature
TI4612H	B	6	CALIBRATED SENSOR HR OUT
TI3705H	Y	6	CALIBRATED SNSR L. P. OUT
TI3706H	Y	6	CALIBRATED SNSR CIRC IN
TI3707H	Y	6	CALIBRATED SNSR CIRC OUT
TI3713H	Y	6	CALIBRATED SNSR RECL OUT
TI3806H	Y	6	CALIBRATED SENSOR CIRC OUTLET
TI4805H	Y	6	CALIBRATED SENSOR M 10 IN
TI6605H	Y	6	SNSR RECLR LIQUID LI4000
TI6700H	Y	6	CALIBRATED SENSOR S 8
TI6701H	Y	6	CALIBRATED SENSOR H 8
TI6702H	Y	6	CALIBRATED SENSOR U 8
TI6703H	Y	6	CALIBRATED SENSOR R 8
TI6704H	Y	6	CALIBRATED SENSOR S 4
TI6705H	Y	6	CALIBRATED SENSOR H 4
TI6706H	Y	6	CALIBRATED SENSOR U 4
TI6707H	Y	6	CALIBRATED SENSOR R 4
TI6708H	Y	6	CALIBRATED SENSOR S IN
TI6709H	Y	6	CALIBRATED SENSOR R OUT
TI6710H	Y	6	CALIBRATED SENSOR CR OUT
TI6711H	Y	6	CALIBRATED SENSOR HS IN
TI6712H	Y	6	CALIBRATED SENSOR HR OUT
TI4801H	B	8	CALIBRATED SENSOR R 10
TI4802H	B	8	CALIBRATED SENSOR U 10
TI4803H	B	8	CALIBRATED SENSOR H 10
TI4804H	B	8	CALIBRATED SENSOR S 10
TI4806	B	8	CALIBRATED SENSOR R 6 OUT
TI4807H	B	8	CALIBRATED SENSOR U 6 OUT
TI4808H	B	8	CALIBRATED SENSOR H 6 OUT
TI4809H	B	8	CALIBRATED SENSOR S 6 OUT
TI4810H	B	8	CALIBRATED SENSOR M 6 OUT
TI4853H	B	8	CALIBRATED SNSR RECL IN
TI4854H	B	8	CALIBRATED SNSR RECL OUT
TI4855H	B	8	SNSR RECLR LIQUID LI4852
TI4865H	B	8	CALIBRATED SENSOR S 6
TI4866H	B	8	CALIBRATED SENSOR H 6
TI4867H	B	8	CALIBRATED SENSOR U 6
TI4868H	B	8	CALIBRATED SENSOR R 6
TI6801H	Y	8	CALIBRATED SENSOR R 10
TI6802H	Y	8	CALIBRATED SENSOR U 10
TI6803H	Y	8	CALIBRATED SENSOR H 10
TI6804H	Y	8	CALIBRATED SENSOR S 10
TI6805H	Y	8	CALIBRATED SENSOR M 10 IN
TI6806H	Y	8	CALIBRATED SENSOR R 6 OUT
TI6807H	Y	8	CALIBRATED SENSOR U 6 OUT
TI6808H	Y	8	CALIBRATED SENSOR H 6 OUT
TI6809H	Y	8	CALIBRATED SENSOR S 6 OUT
TI6810H	Y	8	CALIBRATED SENSOR M 6 OUT
TI6853H	Y	8	CALIBRATED SNSR RECL IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Component #	Ring	Box	Nomenclature
TI6854H	Y	8	CALIBRATED SNSR RECL OUT
TI6860H	Y	8	SNSR RECLR LIQUID LI6852
TI6865H	Y	8	CALIBRATED SENSOR S 6
TI6866H	Y	8	CALIBRATED SENSOR H 6
TI6867H	Y	8	CALIBRATED SENSOR U 6
TI6868H	Y	8	CALIBRATED SENSOR R 6
TI5053H	B	10	CALIBRATED SNSR RECL IN
TI5054H	B	10	CALIBRATED SNSR RECL OUT
TI5087H	B	10	SNSR RECLR LIQUID LI5052
TI5097H	B	10	CALIBRATED SENSOR S 8
TI5098H	B	10	CALIBRATED SENSOR H 8
TI5099H	B	10	CALIBRATED SENSOR U 8
TI5100H	B	10	CALIBRATED SENSOR R 8
TI5301H	B	10	CALIBRATED SENSOR R 12
TI5302H	B	10	CALIBRATED SENSOR U 12
TI5303H	B	10	CALIBRATED SENSOR H 12
TI5304H	B	10	CALIBRATED SENSOR S 12
TI5305H	B	10	CALIBRATED SENSOR M 12 IN
TI5306H	B	10	CALIBRATED SENSOR R 8 OUT
TI5307H	B	10	CALIBRATED SENSOR U 8 OUT
TI5308H	B	10	CALIBRATED SENSOR H 8 OUT
TI5309H	B	10	CALIBRATED SENSOR S 8 OUT
TI5310H	B	10	CALIBRATED SENSOR M 8 OUT
TI7001H	Y	10	CALIBRATED SENSOR R 12
TI7002H	Y	10	CALIBRATED SENSOR U 12
TI7003H	Y	10	CALIBRATED SENSOR H 12
TI7004H	Y	10	CALIBRATED SENSOR S 12
TI7005H	Y	10	CALIBRATED SENSOR M 12 IN
TI7006H	Y	10	CALIBRATED SENSOR R 8 OUT
TI7007H	Y	10	CALIBRATED SENSOR U 8 OUT
TI7008H	Y	10	CALIBRATED SENSOR H 8 OUT
TI7009H	Y	10	CALIBRATED SENSOR S 8 OUT
TI7010H	Y	10	CALIBRATED SENSOR M 8 OUT
TI7053H	Y	10	CALIBRATED SNSR RECL IN
TI7054H	Y	10	CALIBRATED SNSR RECL OUT
TI7055H	Y	10	SNSR RECLR LIQUID LI7052
TI7065H	Y	10	CALIBRATED SENSOR S 8
TI7066H	Y	10	CALIBRATED SENSOR H 8
TI7067H	Y	10	CALIBRATED SENSOR U 8
TI7068H	Y	10	CALIBRATED SENSOR R 8
TI4014H	B	12	SNSR RECLR LIQUID LI4079
TI4056H	B	12	CALIBRATED SENSOR S 10
TI4057H	B	12	CALIBRATED SENSOR H 10
TI4058H	B	12	CALIBRATED SENSOR U 10
TI4059H	B	12	CALIBRATED SENSOR R 10
TI4080H	B	12	CALIBRATED SNSR RECL IN
TI4081H	B	12	CALIBRATED SNSR RECL OUT
TI4221H	B	12	CALIBRATED SENSOR R 2 IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 30

Component #	Ring	Box	Nomenclature
TI4222H	B	12	CALIBRATED SENSOR U 2 IN
TI4223H	B	12	CALIBRATED SENSOR H 2 IN
TI4224H	B	12	CALIBRATED SENSOR S 2 IN
TI4225H	B	12	CALIBRATED SENSOR M 2 IN
TI4226H	B	12	CALIBRATED SENSOR R 10 OUT
TI4227H	B	12	CALIBRATED SENSOR U 10 OUT
TI4228H	B	12	CALIBRATED SENSOR H 10 OUT
TI4229H	B	12	CALIBRATED SENSOR S 10 OUT
TI4230H	B	12	CALIBRATED SENSOR M 10 OUT
TI6001H	Y	12	CALIBRATED SENSOR R 2 IN
TI6002H	Y	12	CALIBRATED SENSOR U 2 IN
TI6003H	Y	12	CALIBRATED SENSOR H 2 IN
TI6004H	Y	12	CALIBRATED SENSOR S 2 IN
TI6005H	Y	12	CALIBRATED SENSOR M 2 IN
TI6006H	Y	12	CALIBRATED SENSOR R 2 OUT
TI6007H	Y	12	CALIBRATED SENSOR U 2 OUT
TI6008H	Y	12	CALIBRATED SENSOR H 2 OUT
TI6009H	Y	12	CALIBRATED SENSOR S 2 OUT
TI6010H	Y	12	CALIBRATED SENSOR M 2 OUT
TI6055H	Y	12	CALIBRATED SNSR RECL IN
TI6056H	Y	12	CALIBRATED SNSR RECL OUT
TI6057H	Y	12	SNSR RECLR LIQUID LI6057
TI6067H	Y	12	CALIBRATED SENSOR S 10
TI6068H	Y	12	CALIBRATED SENSOR H 10
TI6069H	Y	12	CALIBRATED SENSOR U 10
TI6070H	Y	12	CALIBRATED SENSOR R 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 18

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Pressure indicator failure. Minor cold gas leak. Minor increase in refrigerator heat load. Can be shut off with manual valve.	Visual detection. Frosted Component. Minor helium leak. Minor increase in refrigerator output.
Closed	No impact. Instrumentation only. Burst pressure over 300 psia.	Static pressure indication, inconsistent with other adjacent pressures.
Full Scale High	No impact. Instrumentation only, with adjacent sensors available.	High/Full scale pressure indication.
Full Scale Low	No impact. Instrumentation only with adjacent sensors available.	Zero/Low pressure indication.

Affected Components:

Component #	Ring	Box	Nomenclature
PI3733H	B	2	PRESSURE TRANSDUCER M 12
PI3734H	B	2	PRESSURE TRANSDUCER S 12
PI3735H	B	2	PRESSURE TRANSDUCER H 12
PI3736H	B	2	PRESSURE TRANSDUCER U 12
PI3737H	B	2	PRESSURE TRANSDUCER R 12
PI4249H	B	2	PRESSURE TRANSDUCER H~U 4
PI4250H	B	2	PRESSURE TRANSDUCER S~H
PI4251H	B	2	PRESSURE TRANSDUCER M 4
PI4252H	B	2	PRESSURE TRANSDUCER H~U 12
PI4253H	B	2	PRESSURE TRANSDUCER S 4
PI3751H	Y	2	PRESSURE TRANSDUCER M 12
PI3752H	Y	2	PRESSURE TRANSDUCER S 12
PI3753H	Y	2	PRESSURE TRANSDUCER H 12
PI3754H	Y	2	PRESSURE TRANSDUCER U 12
PI3755H	Y	2	PRESSURE TRANSDUCER R 12
PI6248H	Y	2	PRESSURE TRANSDUCER S~H
PI6249H	Y	2	PRESSURE TRANSDUCER H~U 4
PI6250H	Y	2	PRESSURE TRANSDUCER M 4
PI6251H	Y	2	PRESSURE TRANSDUCER H~U 12

Failure Mode Effects Analysis

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Operation Mode: Full Ring Normal Operations **Page:** 32

Component #	Ring	Box	Nomenclature
PI6252H	Y	2	PRESSURE TRANSDUCER S 4
PI3723H	B	4	PRESSURE TRANSDUCER M 2
PI3724H	B	4	PRESSURE TRANSDUCER S 2
PI3725H	B	4	PRESSURE TRANSDUCER H 2
PI3726H	B	4	PRESSURE TRANSDUCER U 2
PI3727H	B	4	PRESSURE TRANSDUCER R 2
PI4449H	B	4	PRESSURE TRANSDUCER S~H
PI4450H	B	4	PRESSURE TRANSDUCER H~U 6
PI4451H	B	4	PRESSURE TRANSDUCER M 6
PI4452H	B	4	PRESSURE TRANSDUCER S6
PI4453H	B	4	PRESSURE TRANSDUCER H~U 2
PI6413H	Y	4	PRESSURE TRANSDUCER S~H
PI6418H	Y	4	PRESSURE TRANSDUCER H~U 6
PI6423H	Y	4	PRESSURE TRANSDUCER S 6
PI6424H	Y	4	PRESSURE TRANSDUCER M 6
PI6425H	Y	4	PRESSURE TRANSDUCER H~U 2
PI6426H	Y	4	PRESSURE TRANSDUCER M 2
PI6427H	Y	4	PRESSURE TRANSDUCER S 2
PI6428H	Y	4	PRESSURE TRANSDUCER H 2
PI6429H	Y	4	PRESSURE TRANSDUCER U 2
PI6430H	Y	4	PRESSURE TRANSDUCER R 2
PI3709H	B	6	PRESSURE TRANSDUCER H~U 8
PI3710H	B	6	PRESSURE TRANSDUCER S BYPASS 8
PI3711H	B	6	PRESSURE TRANSDUCER S BYPASS 4
PI3712H	B	6	PRESSURE TRANSDUCER H~U MID
PI3713H	B	6	PRESSURE TRANSDUCER H~U 4
PI3718H	B	6	PRESSURE TRANSDUCER M 4
PI3719H	B	6	PRESSURE TRANSDUCER S 4
PI3720H	B	6	PRESSURE TRANSDUCER H
PI3721H	B	6	PRESSURE TRANSDUCER U
PI3722H	B	6	PRESSURE TRANSDUCER R
PI3742H	B	6	PRESSURE TRANSDUCER M MID
PI3743H	B	6	PRESSURE TRANSDUCER S MID
PI3744H	B	6	PRESSURE TRANSDUCER CIRC BYPASS
PI3745H	B	6	PRESSURE TRANSDUCER S 8
PI3704H	Y	6	PRESSURE TRANSDUCER H~U 8
PI3705H	Y	6	PRESSURE TRANSDUCER S BYPASS 8
PI3706H	Y	6	PRESSURE TRANSDUCER S BYPASS 4
PI3707H	Y	6	PRESSURE TRANSDUCER H~U MID
PI3708H	Y	6	PRESSURE TRANSDUCER H~U 4
PI3738H	Y	6	PRESSURE TRANSDUCER M 4
PI3739H	Y	6	PRESSURE TRANSDUCER S 8
PI3740H	Y	6	PRESSURE TRANSDUCER S MID
PI3741H	Y	6	PRESSURE TRANSDUCER CIRC BYPASS
PI6057H	Y	6	PRESSURE TRANSDUCER M 4
PI6058H	Y	6	PRESSURE TRANSDUCER S 4
PI6059H	Y	6	PRESSURE TRANSDUCER H 4
PI6060H	Y	6	PRESSURE TRANSDUCER U 4

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Component #	Ring	Box	Nomenclature
PI6061H	Y	6	PRESSURE TRANSDUCER R 4
PI3746H	B	8	PRESSURE TRANSDUCER M 6
PI3747H	B	8	PRESSURE TRANSDUCER S 6
PI3748H	B	8	PRESSURE TRANSDUCER H 6
PI3749H	B	8	PRESSURE TRANSDUCER U 6
PI3750H	B	8	PRESSURE TRANSDUCER R 6
PI4849H	B	8	PRESSURE TRANSDUCER H~U 10
PI4850H	B	8	PRESSURE TRANSDUCER M 10
PI4851H	B	8	PRESSURE TRANSDUCER S 10
PI4852H	B	8	PRESSURE TRANSDUCER S~H
PI4853H	B	8	PRESSURE TRANSDUCER H~U 6
PI6849H	Y	8	PRESSURE TRANSDUCER H~U 10
PI6850H	Y	8	PRESSURE TRANSDUCER M 10
PI6851H	Y	8	PRESSURE TRANSDUCER H~U 6
PI6852H	Y	8	PRESSURE TRANSDUCER S~H
PI6853H	Y	8	PRESSURE TRANSDUCER S 10
PI6854H	Y	8	PRESSURE TRANSDUCER M 6
PI6855H	Y	8	PRESSURE TRANSDUCER S 6
PI6856H	Y	8	PRESSURE TRANSDUCER H
PI6857H	Y	8	PRESSURE TRANSDUCER U
PI6858H	Y	8	PRESSURE TRANSDUCER R
PI3728H	B	10	PRESSURE TRANSDUCER M 8
PI3729H	B	10	PRESSURE TRANSDUCER S 8
PI3730H	B	10	PRESSURE TRANSDUCER H
PI3731H	B	10	PRESSURE TRANSDUCER U
PI3732H	B	10	PRESSURE TRANSDUCER R
PI5049H	B	10	PRESSURE TRANSDUCER H~U 12
PI5050H	B	10	PRESSURE TRANSDUCER S 12
PI5051H	B	10	PRESSURE TRANSDUCER M 12
PI5062H	B	10	PRESSURE TRANSDUCER H~U 8
PI5063H	B	10	PRESSURE TRANSDUCER S~H
PI7049H	Y	10	PRESSURE TRANSDUCER H~U 12
PI7050H	Y	10	PRESSURE TRANSDUCER M 12
PI7051H	Y	10	PRESSURE TRANSDUCER H~U 8
PI7052H	Y	10	PRESSURE TRANSDUCER S~H
PI7053H	Y	10	PRESSURE TRANSDUCER S 12
PI7054H	Y	10	PRESSURE TRANSDUCER M 8
PI7055H	Y	10	PRESSURE TRANSDUCER S 8
PI7056H	Y	10	PRESSURE TRANSDUCER H
PI7057H	Y	10	PRESSURE TRANSDUCER U
PI7058H	Y	10	PRESSURE TRANSDUCER R
PI4057H	B	12	PRESSURE TRANSDUCER S~H 2
PI4058H	B	12	PRESSURE TRANSDUCER H~U 2
PI4059H	B	12	PRESSURE TRANSDUCER M 2
PI4060H	B	12	PRESSURE TRANSDUCER H~U 10
PI4061H	B	12	PRESSURE TRANSDUCER S~H 10
PI4062H	B	12	PRESSURE TRANSDUCER S 2
PI4063H	B	12	PRESSURE TRANSDUCER M 10

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
PI4064H	B	12	PRESSURE TRANSDUCER S 10
PI4065H	B	12	PRESSURE TRANSDUCER H
PI4066H	B	12	PRESSURE TRANSDUCER U
PI4067H	B	12	PRESSURE TRANSDUCER R
PI6052H	Y	12	PRESSURE TRANSDUCER S~H 2
PI6053H	Y	12	PRESSURE TRANSDUCER H~U 2
PI6054H	Y	12	PRESSURE TRANSDUCER M 2
PI6055H	Y	12	PRESSURE TRANSDUCER H~U 10
PI6056H	Y	12	PRESSURE TRANSDUCER S~H 10
PI6062H	Y	12	PRESSURE TRANSDUCER M 10
PI6063H	Y	12	PRESSURE TRANSDUCER S 10
PI6064H	Y	12	PRESSURE TRANSDUCER H
PI6065H	Y	12	PRESSURE TRANSDUCER U
PI6066H	Y	12	PRESSURE TRANSDUCER R
PI6073H	Y	12	PRESSURE TRANSDUCER S 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 19

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position. Leakage during Pressure Indicator replacement.	Manual valve. Visual detection. Escaping gas during pressure indicator removal.
Closed	No pressure indication or constant pressure indication. No hazard; relief valves safe system.	No pressure indication or constant pressure indication.

Affected Components:

Component #	Ring	Box	Nomenclature
H4213M	B	2	ISOLATION PI4251H
H4229M	B	2	ISOLATION PI4254H
H4251M	B	2	ISOLATION PI4253H
H6765M	B	2	ISOLATION PI3733H
H6766M	B	2	ISOLATION PI3734H
H6767M	B	2	ISOLATION PI3735H
H6768M	B	2	ISOLATION PI3736H
H6769M	B	2	ISOLATION PI3737H
H6907M	B	2	ISOLATION PI4249H
H6908M	B	2	ISOLATION PI4250H
H6909M	B	2	ISOLATION PI4252H
H3116M	Y	2	ISOLATION PI3751H
H3117M	Y	2	ISOLATION PI3752H
H3118M	Y	2	ISOLATION PI3753H
H3119M	Y	2	ISOLATION PI3754H
H3120M	Y	2	ISOLATION PI3755H
H6250M	Y	2	ISOLATION PI6253H
H6257M	Y	2	ISOLATION PI6252H
H6259M	Y	2	ISOLATION PI6250H
H6790M	Y	2	ISOLATION PI6248H
H6791M	Y	2	ISOLATION PI6249H
H6792M	Y	2	ISOLATION PI6251H
H4414M	B	4	ISOLATION PI4451H
H4423M	B	4	ISOLATION PI4448H
H4429M	B	4	ISOLATION PI4453H
H6770M	B	4	ISOLATION PI3723H
H6771M	B	4	ISOLATION PI3724H
H6772M	B	4	ISOLATION PI3725H
H6773M	B	4	ISOLATION PI3726H
H6774M	B	4	ISOLATION PI3727H

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H6910M	B	4	ISOLATION PI4449H
H6911M	B	4	ISOLATION PI4450H
H6912M	B	4	ISOLATION PI4452H
H6407M	Y	4	ISOLATION PI6424H
H6419M	Y	4	ISOLATION PI6414H
H6425M	Y	4	ISOLATION PI6425H
H6427M	Y	4	ISOLATION PI6426H
H6428M	Y	4	ISOLATION PI6427H
H6429M	Y	4	ISOLATION PI6428H
H6446M	Y	4	ISOLATION PI6429H
H6447M	Y	4	ISOLATION PI6430H
H6793M	Y	4	ISOLATION PI6413H
H6794M	Y	4	ISOLATION PI6418H
H6795M	Y	4	ISOLATION PI6423H
H3234M	B	6	ISOLATION PI3743H
H3236M	B	6	ISOLATION PI3744H
H4657M	B	6	ISOLATION PI6068H
H6734M	B	6	ISOLATION PI3742H
H6754M	B	6	ISOLATION PI3709H
H6755M	B	6	ISOLATION PI3712H
H6756M	B	6	ISOLATION PI3711H
H6757M	B	6	ISOLATION PI3710H
H6758M	B	6	ISOLATION PI3716H
H6760M	B	6	ISOLATION PI3713H
H6775M	B	6	ISOLATION PI3718H
H6776M	B	6	ISOLATION PI3719H
H6777M	B	6	ISOLATION PI3720H
H6778M	B	6	ISOLATION PI3721H
H6779M	B	6	ISOLATION PI3722H
H6814M	B	6	ISOLATION PI3745H
H3075M	Y	6	ISOLATION PI6067H
H6640M	Y	6	ISOLATION PI3738H
H6724M	Y	6	ISOLATION PI6057H
H6725M	Y	6	ISOLATION PI6058H
H6727M	Y	6	ISOLATION PI3740H
H6729M	Y	6	ISOLATION PI3741H
H6741M	Y	6	ISOLATION PI3704H
H6742M	Y	6	ISOLATION PI3707H
H6743M	Y	6	ISOLATION PI3706H
H6744M	Y	6	ISOLATION PI3705H
H6751M	Y	6	ISOLATION PI3714H
H6753M	Y	6	ISOLATION PI3708H
H6763M	Y	6	ISOLATION PI3739H
H6787M	Y	6	ISOLATION PI6059H
H6788M	Y	6	ISOLATION PI6060H
H6789M	Y	6	ISOLATION PI6061H
H4553M	B	8	ISOLATION PI3746H
H4554M	B	8	ISOLATION PI3747H

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H4555M	B	8	ISOLATION PI3748H
H4556M	B	8	ISOLATION PI3749H
H4557M	B	8	ISOLATION PI3750H
H4828M	B	8	ISOLATION PI4850H
H4851M	B	8	ISOLATION PI4854H
H4861M	B	8	ISOLATION PI4853H
H6913M	B	8	ISOLATION PI4849H
H6914M	B	8	ISOLATION PI4851H
H6915M	B	8	ISOLATION PI4852H
H6796M	Y	8	ISOLATION PI6849H
H6797M	Y	8	ISOLATION PI6851H
H6798M	Y	8	ISOLATION PI6852H
H6849M	Y	8	ISOLATION PI6854H
H6850M	Y	8	ISOLATION PI6855H
H6851M	Y	8	ISOLATION PI6856H
H6852M	Y	8	ISOLATION PI6857H
H6853M	Y	8	ISOLATION PI6858H
H6854M	Y	8	ISOLATION PI6859H
H6861M	Y	8	ISOLATION PI6850H
H6866M	Y	8	ISOLATION PI6853H
H3238M	B	10	ISOLATION PI3728H
H3239M	B	10	ISOLATION PI3729H
H3240M	B	10	ISOLATION PI3730H
H3241M	B	10	ISOLATION PI3731H
H3242M	B	10	ISOLATION PI3732H
H5028M	B	10	ISOLATION PI5064H
H5054M	B	10	ISOLATION PI5050H
H5280M	B	10	ISOLATION PI5051H
H6916M	B	10	ISOLATION PI5049H
H6917M	B	10	ISOLATION PI5062H
H6918M	B	10	ISOLATION PI5063H
H6900M	Y	10	ISOLATION PI7049H
H6901M	Y	10	ISOLATION PI7050H
H6902M	Y	10	ISOLATION PI7051H
H7013M	Y	10	ISOLATION PI7054H
H7014M	Y	10	ISOLATION PI7055H
H7019M	Y	10	ISOLATION PI7056H
H7026M	Y	10	ISOLATION PI7057H
H7033M	Y	10	ISOLATION PI7058H
H7049M	Y	10	ISOLATION PI7059H
H7063M	Y	10	ISOLATION PI7052H
H7070M	Y	10	ISOLATION PI7053H
H4013M	B	12	ISOLATION PI4061H
H4028M	B	12	ISOLATION PI4062H
H4059M	B	12	ISOLATION PI4068H
H6694M	B	12	ISOLATION PI4063H
H6695M	B	12	ISOLATION PI4064H
H6696M	B	12	ISOLATION PI4065H

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H6697M	B	12	ISOLATION PI4066H
H6698M	B	12	ISOLATION PI4067H
H6919M	B	12	ISOLATION PI4057H
H6920M	B	12	ISOLATION PI4058H
H6921M	B	12	ISOLATION PI4059H
H6922M	B	12	ISOLATION PI4060H
H6027M	Y	12	ISOLATION PI6056H
H6053M	Y	12	ISOLATION PI6073H
H6091M	Y	12	ISOLATION PI6062H
H6092M	Y	12	ISOLATION PI6063H
H6093M	Y	12	ISOLATION PI6064H
H6094M	Y	12	ISOLATION PI6065H
H6095M	Y	12	ISOLATION PI6066H
H6096M	Y	12	ISOLATION PI6074H
H6903M	Y	12	ISOLATION PI6052H
H6904M	Y	12	ISOLATION PI6053H
H6905M	Y	12	ISOLATION PI6054H
H6906M	Y	12	ISOLATION PI6055H

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 20

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	No circulation. Magnet temperature rises with subsequent magnet quench.	Normally open valve. Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
H4200A L	B	2	ISOLATION M
H6200A L	Y	2	ISOLATION M
H4400A L	B	4	ISOLATION M
H6400A L	Y	4	ISOLATION M
H4500A L	B	6	ISOLATION M 4
H4641A	B	6	ISOLATION CIRCULATOR OUT
H6600A L	Y	6	ISOLATION M 4
H6740A	Y	6	ISOLATION CIRCULATOR OUT
H4800A L	B	8	ISOLATION M
H6800A L	Y	8	ISOLATION M
H5000A L	B	10	ISOLATION M
H7000A L	Y	10	ISOLATION M
H4000A L	B	12	ISOLATION M
H6000A L	Y	12	ISOLATION M

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 21

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Closed	Incorrect flow indication. No impact. Instrumentation only.	Manual valve. No flow indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6759M	B	6	ISOLATION DELTA P IN
H6752M	Y	6	ISOLATION DELTA P IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 22

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Closed	Incorrect flow indication. No impact. Instrumentation only.	Manual valve. High flow indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6731M	B	6	ISOLATION DELTA P OUT
H6761M	Y	6	ISOLATION DELTA P OUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 23

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	No flow. Heat shield temperature increase with Magnet temperature rise and subsequent magnet quench.	Normally open valve. Visual detection. Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
H4202A L	B	2	ISOLATION H
H6202A L	Y	2	ISOLATION H
H4402A L	B	4	ISOLATION H
H6402A L	Y	4	ISOLATION H
H4502A L	B	6	ISOLATION H 4
H4602A	B	6	ISOLATION H 8 Linear Plug
H6602A L	Y	6	ISOLATION H 4
H6702A	Y	6	ISOLATION H 8 Linear Plug
H4802A L	B	8	ISOLATION H
H6802A L	Y	8	ISOLATION H
H5002A L	B	10	ISOLATION H
H7002A L	Y	10	ISOLATION H
H4002A L	B	12	ISOLATION H
H6002A L	Y	12	ISOLATION H

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 24

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.
Closed	No circulation. Magnet temperature rises with subsequent magnet quench.	Normally closed valve. Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
H4642A	B	6	ISOLATION CIRCULATOR IN
H6739A	Y	6	ISOLATION CIRCULATOR IN

Failure Mode Effects Analysis

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Operation Mode: Full Ring Normal Operations **Page:** 44

Item: 25

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection.
Closed	Little to no impact. Supply gas provided by flow in opposite direction. Possible pressure drop. Possible minor increase in heat load in valve box, minor increase in refrigerator load.	Manual valve. Visual detection. Elevated pressure. Pressure differential.

Affected Components:

Component #	Ring	Box	Nomenclature
H4218M L	B	2	MANUAL ISOLATION S
H6254M L	Y	2	MANUAL ISOLATION S
H4405M L	B	4	MANUAL ISOLATION S
H6426M L	Y	4	MANUAL ISOLATION S
H4534M L	B	6	MANUAL ISOLATION S 4
H4614M L	B	6	MANUAL ISOLATION S 8
H6609M L	Y	6	MANUAL ISOLATION S 4
H6705M L	Y	6	MANUAL ISOLATION S 8
H4805M L	B	8	MANUAL ISOLATION S
H6860M L	Y	8	MANUAL ISOLATION S
H5283M L	B	10	MANUAL ISOLATION S
H7066M L	Y	10	MANUAL ISOLATION S
H4005M L	B	12	MANUAL ISOLATION S
H6055M L	Y	12	MANUAL ISOLATION S

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 26

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection.
Closed	No flow. Magnet temperature rises with power supply shutdown possible.	Manual valve. Visual detection. Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
H4205M L	B	2	MANUAL ISOLATION M
H6253M L	Y	2	MANUAL ISOLATION M
H4407M L	B	4	MANUAL ISOLATION M
H6405M L	Y	4	MANUAL ISOLATION M
H6733M L	B	6	MANUAL ISOLATION M
H6623M L	Y	6	MANUAL ISOLATION M
H4831M L	B	8	MANUAL ISOLATION M
H6859M L	Y	8	MANUAL ISOLATION M
H5284M L	B	10	MANUAL ISOLATION M
H7067M L	Y	10	MANUAL ISOLATION M
H4007M L	B	12	MANUAL ISOLATION M
H6056M L	Y	12	MANUAL ISOLATION M

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 27

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Checkvalve. Detectable only with individual test.
Open	No impact. Checkvalve lies between manual and automatic valves which will be closed for Normal Operations.	Checkvalve. Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4541C	B	6	WARM SUPPLY CHECK S 4
H4624C	B	6	WARM SUPPLY CHECK S 8
H6643C	Y	6	WARM SUPPLY CHECK S 8
H6645C	Y	6	WARM SUPPLY CHECK S 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 28

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield to Supply. Recooler empties. Magnet temperature rises with subsequent magnet quench. Can be reconfigured.	Normally closed valve. Elevated pressure/temperature; zero recooler level. Temperature indicators and Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4615A	B	6	CROSSOVER S~B~HS 8
H6715A	Y	6	CROSSOVER S~B~HS 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 29

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Return line opened to Cooldown Return, through Thermax heaters, to Main Compressor Suction. Main Compressor Suction may operate at a higher pressure; needs to be evaluated. If at higher pressure, increased heat load, with magnet quench.	Normally closed valve. Visual detection. Elevated pressure/temperature. Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4536A	B	6	BYPASS R 4
H4636A	B	6	BYPASS R 8
H6636A	Y	6	BYPASS R 4
H6736A	Y	6	BYPASS R 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 30

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Utility line/Return flow opened to Cooldown Return, through Thermax heaters, to Main Compressor Suction. Main Compressor Suction may operate at a higher pressure; needs to be evaluated. If at higher pressure, increased heat load, with magnet quench.	Normally closed valve. Visual detection. Elevated pressure/temperature. Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4508A	B	6	BYPASS U 4
H4608A	B	6	BYPASS U 8
H6608A	Y	6	BYPASS U 4
H6708A	Y	6	BYPASS U 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 31

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Pressure/gas make-up for magnet line.	Normally closed valve. Visual detection. Magnet line same pressure as supply line.
Closed	No magnet line pressure/gas make-up. Possible circulator failure.	Normally closed valve. Low magnet line pressure. Erratic circulator speed. Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
H4524A	B	6	REF SUPPLY M Linear Plug
H6607A	Y	6	REF SUPPLY M Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 32

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Inadequate flow to recoolers. Recooler level declines with possible minor increase in heat load in valve box, minor increase in refrigerator load.	Elevated pressure/temperature; high liquid level indication.
Full Scale Low	Opens recooler J-T valve. Increased refrigerator demand. Refrigerator imbalance caused by unmodulated Supply gas going into Return. Refrigerator shutoff from ring.	Constant low liquid level output. Increase in refrigerator output.

Affected Components:

Component #	Ring	Box	Nomenclature
LI4252H	B	2	SUPERCON LEVEL PROBE
LI6253H	Y	2	SUPERCON LEVEL PROBE
LI4452H	B	4	SUPERCON LEVEL PROBE
LI6477H	Y	4	SUPERCON LEVEL PROBE
LI4001H	B	6	SUPERCON LEVEL PROBE
LI4000H	Y	6	SUPERCON LEVEL PROBE
LI4852H	B	8	SUPERCON LEVEL PROBE
LI6852H	Y	8	SUPERCON LEVEL PROBE
LI5052H	B	10	SUPERCON LEVEL PROBE
LI7052H	Y	10	SUPERCON LEVEL PROBE
LI4079H	B	12	SUPERCON LEVEL PROBE
LI6057H	Y	12	SUPERCON LEVEL PROBE

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 33

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Manual valve in series to prevent warm gas flow into Ring. If manual valve is open, large quantity of cold gas flows to refrigerator causing severe imbalance. Magnet temperature rises with subsequent magnet quench.	Normally closed valve. Visual detection. If manual valve is open, elevated pressure/ temperature. Temperature & pressure indicators. Magnet quench. Refrigerator alarms.
Closed	No impact. Normal Operating position.	None. Normally closed valve. Normal operation.

Affected Components:

Component #	Ring	Box	Nomenclature
H4538A	B	6	WARM SUPPLY TO S 4
H4639A	B	6	WARM SUPPLY TO S 8
H6639A	Y	6	WARM SUPPLY TO S 4
H6738A	Y	6	WARM SUPPLY TO S 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 34

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Visual detection. Normal operations.
Closed/No output	No circulation. Magnet temperature rises with power supply shutdown possible.	Elevated pressure/temperature. Temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
C3019H	B	6	CIRCULATOR @ 5ATM
C3018H	Y	6	CIRCULATOR @ 5ATM

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 35

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	High flow indication may cause operator to lower circulation. Magnet temperature rises with subsequent magnet quench. Is not used to control circulator speed.	Elevated pressure/temperature/speed. Temperature indicators and Magnet quench.
Full Scale Low	No flow indication may cause operator to command maximum circulator speed. Potential for circulator shutdown by overspeed protection system. Is not used to control circulator speed.	No/low flow indication with high circulator speed. Circulator speed alarm and/or shutdown.

Affected Components:

Component #	Ring	Box	Nomenclature
DPT3008H	B	6	DELTA P TRANSDUCER
DPT3007H	Y	6	DELTA P TRANSDUCER

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 36

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Maximum speed output	No impact; instrumentation only. May cause operator to lower circulation. Magnet temperature rises with subsequent magnet quench.	Elevated pressure/temperature/speed with low flow. Temperature indicators and Magnet quench.
Minimum speed output	No impact; instrumentation only. May cause operator to increase circulation. Circulator may shutdown by overspeed protection system.	Constant low speed indication and command mismatch.

Affected Components:

Component #	Ring	Box	Nomenclature
ST4647H	B	6	5k~15kRPM C3019 TRANSDUCER
ST6746H	Y	6	5k~15kRPM C3018 TRANSDUCER

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 37

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Minor heat load increase with Magnet temperature rise.	Manual valve. Visual detection. Elevated magnet temperature. Minor increase in refrigerator output. Frosted valve.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H6826M	B	6	CIRC C3019 WARMUP RETURN
H6895M	Y	6	CIRC C3018 WARMUP RETURN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 38

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
N/A	Spare lead. Lead Control and Lead Isolation manual valve not connected on inlet; no lead to connect gas. Inlet capped. Upstream side connected to warm return. No hazard.	

Affected Components:

Component #	Ring	Box	Nomenclature
H6277E	Y	2	LEAD CONTROL 3
H6289M	Y	2	LEAD ISOLATION 3
H4552E	B	6	LEAD CONTROL 3
H4752M	B	6	LEAD ISOLATION 3
H6626E	Y	6	LEAD CONTROL 4
H6631E	Y	6	LEAD CONTROL 5
H6888M	Y	6	LEAD ISOLATION 4
H6892M	Y	6	LEAD ISOLATION 5
H4865E	B	8	LEAD CONTROL 3
H4889M	B	8	LEAD ISOLATION 3
H6867E	Y	8	LEAD CONTROL 4
H6871E	Y	8	LEAD CONTROL 5
H6927M	Y	8	LEAD ISOLATION 4
H6931M	Y	8	LEAD ISOLATION 5
H4853M	B	10	LEAD ISOLATION B8
H5100E	B	10	LEAD CONTROL B8
H4078E	B	12	LEAD CONTROL 3
H4142M	B	12	LEAD ISOLATION 3
H6065M	Y	12	LEAD ISOLATION 4
H6069M	Y	12	LEAD ISOLATION 5
H6073E	Y	12	LEAD CONTROL 4
H6077E	Y	12	LEAD CONTROL 5

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 39

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Significantly reduced circulation. Magnet temperature rises with subsequent magnet quench.	Normally open valve. Visual detection. Elevated pressure/temperature. Temperature indicators and Magnet quench.
Closed	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4533A	B	6	CIRCULATOR TEST Linear Plug
H6606A	Y	6	CIRCULATOR TEST Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 40

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No flow indication.	Manual valve. Visual detection. Normal operations.
Closed	No impact. Normal operating position.	Manual valve. No flow indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6732M	B	6	DELTA P CROSSOVER
H6762M	Y	6	DELTA P CROSSOVER

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 41

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by manual valve. Possible pipe contamination.	Normally open valve. Erroneous instrumentation. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4600A	B	6	CIRC BYPASS OUT~B~IN
H6700A	Y	6	CIRC BYPASS OUT~B~IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 42

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. No pressure source. Relief valve protects vacuum pump. Spoilation of insulating vacuum if helium leaks into vacuum header faster than turbo pump can evacuate. Magnet temperature rises with subsequent magnet quench.	Manual valve. Visual detection. Vacuum indication. Elevated temperature. Magnet quench.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4277M	B	2	VACUUM ISOLATION 10
H6276M	Y	2	VACUUM ISOLATION 12
H6485M	Y	4	VACUUM ISOLATION 2
H4656M	B	6	VACUUM ISOLATION 4
H6785M	Y	6	VACUUM ISOLATION 4
H6882M	Y	8	VACUUM ISOLATION 6
H7086M	Y	10	VACUUM ISOLATION 8
H6088M	Y	12	VACUUM ISOLATION 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 43

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Vacuum header closed off by manual valves, vented by check valve.	Manual valve. Visual detection.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4279M	B	2	VACUUM~VENT 12
H6278M	Y	2	VACUUM~VENT 12
H4482M	B	4	VACUUM~VENT 2
H6470M	Y	4	VACUUM~VENT 2
H4629M	B	6	VACUUM~VENT 4
H6786M	Y	6	VACUUM~VENT 4
H4879M	B	8	VACUUM~VENT 6
H6893M	Y	8	VACUUM~VENT 6
H5166M	B	10	VACUUM~VENT 8
H7052M	Y	10	VACUUM~VENT 8
H4050M	B	12	VACUUM~VENT 10
H6090M	Y	12	VACUUM~VENT 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 44

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Vent header contaminated by air.	Checkvalve. Detectable only with individual test.
Closed	Loss of emergency venting and relief valve capacity. Adjacent magnet/valvebox relief valves have adequate capacity.	Checkvalve. Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4234C	B	2	VENT CHECK 4
H6234C	Y	2	VENT CHECK 4
H4434C	B	4	VENT CHECK 6
H6445C	Y	4	VENT CHECK 6
H4009C	B	6	VENT CHECK 8
H4029C	Y	6	VENT CHECK 8
H4814C	B	8	VENT CHECK 10
H6834C	Y	8	VENT CHECK 10
H5034C	B	10	VENT CHECK 12
H7034C	Y	10	VENT CHECK 12
H4040C	B	12	VENT CHECK 2
H6064C	Y	12	VENT CHECK 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 45

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Collider magnet loop to Cooldown Return. If magnet loop pressure is higher than Cooldown Return, cold gas flows through Thermax heaters to Main Compressor Suction. If Cooldown Return pressure is higher, increased heat load.	Normally closed valve. Visual detection. Cold gas flow to Cooldown Return will result in frosted components. Warm gas flow to magnet loop will cause minor increase in refrigerator output.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4537A	B	6	CROSSOVER CR~U 4
H4637A	B	6	CROSSOVER CR~U 8
H6637A	Y	6	CROSSOVER CR~U 4
H6737A	Y	6	CROSSOVER CR~U 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 46

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield to Supply. Recooler level declines with Magnet temperature rise and subsequent magnet quench.	Normally closed valve. Elevated pressure/temperature; zero recooler level. Temperature indicators and Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4216A	B	2	CROSSOVER H~B~S 4
H6216A	Y	2	CROSSOVER H~B~S 4
H4416A	B	4	CROSSOVER H~B~S 6
H6416A	Y	4	CROSSOVER H~B~S 6
H4816A	B	8	CROSSOVER H~B~S 6
H6816A	Y	8	CROSSOVER H~B~S 6
H5016A	B	10	CROSSOVER H~B~S 8
H7016A	Y	10	CROSSOVER H~B~S
H4016A	B	12	CROSSOVER H~B~S 10
H4039A	B	12	CROSSOVER H~B~S 2
H6016A	Y	12	CROSSOVER H~B~S 2
H6070A	Y	12	CROSSOVER H~B~S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 47

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Erroneous instrumentation. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4211A	B	2	CROSSOVER U~B~H 4
H4220A	B	2	CROSSOVER H~B~U 12
H6211A	Y	2	CROSSOVER U~B~H 4
H6220A	Y	2	CROSSOVER H~B~U 12
H4411A	B	4	CROSSOVER U~B~H 6
H4420A	B	4	CROSSOVER H~B~U 2
H6411A	Y	4	CROSSOVER U~B~H 6
H6420A	Y	4	CROSSOVER H~B~U 2
H4510A	B	6	CROSSOVER H~B~U MID
H4520A	B	6	CROSSOVER H~B~U 4
H4621A	B	6	CROSSOVER U~B~H 8
H6610A	Y	6	CROSSOVER H~B~U MID
H6620A	Y	6	CROSSOVER H~B~U 4
H6721A	Y	6	CROSSOVER U~B~H 8
H4810A	B	8	CROSSOVER H~B~U 6
H4821A	B	8	CROSSOVER U~B~H 10
H6810A	Y	8	CROSSOVER H~B~U 6
H6821A	Y	8	CROSSOVER U~B~H 10
H5010A	B	10	CROSSOVER H~B~U 8
H5021A	B	10	CROSSOVER U~B~H 12
H7010A	Y	10	CROSSOVER H~B~U 8
H7021A	Y	10	CROSSOVER U~B~H 12
H4010A	B	12	CROSSOVER H~B~U 10
H4021A	B	12	CROSSOVER U~B~H 2
H6010A	Y	12	CROSSOVER H~B~U 10
H6021A	Y	12	CROSSOVER U~B~H 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 48

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Open	No impact. Checkvalve and automatic valve prevent flow.	Manual valve. Visual detection. Possible frosted valve.

Affected Components:

Component #	Ring	Box	Nomenclature
H4542M	B	6	WARM SUPPLY ISOLATION S 4
H4626M	B	6	WARM SUPPLY ISOLATION S 8
H6644M	Y	6	WARM SUPPLY ISOLATION S 8
H6646M	Y	6	WARM SUPPLY ISOLATION S 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 49

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield to Supply. Recooler empties. Magnet temperature rise with eventual magnet quench.	Normally closed valve. Elevated pressure/temperature; zero recooler level. Temperature indicators and Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4516A	B	6	CROSSOVER HS~B~S 4
H6616A	Y	6	CROSSOVER HS~B~S 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 50

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Visual detection. Erroneous instrumentation.

Affected Components:

Component #	Ring	Box	Nomenclature
H4616A	B	6	CROSSOVER HS~B~S 8
H6716A	Y	6	CROSSOVER HS~B~S 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 51

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Magnet pressure & temperature fluctuates.	Normally closed valve. Pressure and temperature fluctuations. Visual detection.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4230A	B	2	CROSSOVER M~S 12
H6230A	Y	2	CROSSOVER M~S 12
H4430A	B	4	CROSSOVER M~S 2
H6430A	Y	4	CROSSOVER M~S 2
H4530A	B	6	CROSSOVER M~S 4
H4630A	B	6	CROSSOVER M~S 8
H6630A	Y	6	CROSSOVER M~S 4
H6730A	Y	6	CROSSOVER M~S 8
H4830A	B	8	CROSSOVER M~S
H6830A	Y	8	CROSSOVER M~S
H5030A	B	10	CROSSOVER M~S
H7030A	Y	10	CROSSOVER M~S
H4030A	B	12	CROSSOVER M~S 10
H4036A	B	12	CROSSOVER M~S 2
H6005A	Y	12	CROSSOVER M~S 2
H6030A	Y	12	CROSSOVER M~S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 52

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Utility & Return line already common at 6 o'clock valve box.	Normally closed valve. Visual detection.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4208A	B	2	CROSSOVER R~U 4
H6208A	Y	2	CROSSOVER R~U 4
H4408A	B	4	CROSSOVER R~U 6
H6408A	Y	4	CROSSOVER R~U 6
H4808A	B	8	CROSSOVER R~U 6
H6808A	Y	8	CROSSOVER R~U 6
H5008A	B	10	CROSSOVER R~U 8
H7008A	Y	10	CROSSOVER R~U 8
H4008A	B	12	CROSSOVER R~U 10
H4038A	B	12	CROSSOVER R~U 2
H6008A	Y	12	CROSSOVER R~U 10
H6037A	Y	12	CROSSOVER R~U 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 53

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position. Bypass dead-headed by second automatic valve.	Normally open valve. Visual detection.
Closed	Loss of instrumentation.	Normally open valve. No pressure indication or constant pressure indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4215A	B	2	CROSSOVER S~B~H 4 Linear Plug
H6215A	Y	2	CROSSOVER S~B~H 4 Linear Plug
H4415A	B	4	CROSSOVER S~B~H 6 Linear Plug
H6415A	Y	4	CROSSOVER S~B~H 6 Linear Plug
H4815A	B	8	CROSSOVER S~B~H 6 Linear Plug
H6815A	Y	8	CROSSOVER S~B~H 6 Linear Plug
H5015A	B	10	CROSSOVER S~B~H 8 Linear Plug
H7015A	Y	10	CROSSOVER S~B~H Linear Plug
H4015A	B	12	CROSSOVER S~B~H 10 Linear Plug
H4035A	B	12	CROSSOVER S~B~H 2 Linear Plug
H6007A	Y	12	CROSSOVER S~B~H 10 Linear Plug
H6015A	Y	12	CROSSOVER S~B~H 2 Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 54

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Visual detection. Erroneous instrumentation.

Affected Components:

Component #	Ring	Box	Nomenclature
H4515A	B	6	CROSSOVER S~B~HS 4
H6615A	Y	6	CROSSOVER S~B~HS 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 74

Item: 55

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield through Utility to cold Return. Increased refrigerator load with consequent increase in Supply temperature. Magnet temperature rise and subsequent magnet quench. Can be reconfigured.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicator or power supply lead monitoring alarms. Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4210A	B	2	CROSSOVER H~B~U 4
H4221A	B	2	CROSSOVER U~B~H 12
H6210A	Y	2	CROSSOVER H~B~U 4
H6221A	Y	2	CROSSOVER U~B~H 12
H4410A	B	4	CROSSOVER H~B~U 6
H4421A	B	4	CROSSOVER U~B~H 2
H6410A	Y	4	CROSSOVER H~B~U 6
H6421A	Y	4	CROSSOVER U~B~H 2
H4511A	B	6	CROSSOVER U~B~H MID
H4521A	B	6	CROSSOVER U~B~H 4
H4620A	B	6	CROSSOVER H~B~U 8
H6611A	Y	6	CROSSOVER U~B~H MID
H6621A	Y	6	CROSSOVER U~B~H 4
H6720A	Y	6	CROSSOVER H~B~U 8
H4811A	B	8	CROSSOVER U~B~H 6
H4820A	B	8	CROSSOVER H~B~U 10
H6811A	Y	8	CROSSOVER U~B~H 6
H6820A	Y	8	CROSSOVER H~B~U 10
H5011A	B	10	CROSSOVER U~B~H 8
H5020A	B	10	CROSSOVER H~B~U 12
H7011A	Y	10	CROSSOVER U~B~H 8
H7020A	Y	10	CROSSOVER H~B~U 12
H4011A	B	12	CROSSOVER U~B~H 10
H4020A	B	12	CROSSOVER H~B~U 2
H6011A	Y	12	CROSSOVER U~B~H 10
H6020A	Y	12	CROSSOVER H~B~U 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 19-Nov-98

Operation Mode: Full Ring Normal Operations

Item: 56

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header checkvalve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Suction pressure drop. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4254M	B	2	PUMPOUT WARM RETURN 2
H6469M	Y	4	PUMPOUT WARM RETURN 4
H4634M	B	6	PUMPOUT WARM RETURN 6
H4850M	B	8	PUMPOUT WARM RETURN 8
H5123M	B	10	PUMPOUT WARM RETURN 10
H4058M	B	12	PUMPOUT WARM RETURN 12

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 57

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No circulation. Magnet temperature rises with power supply shutdown possible.	Manual valve. Visual detection. Elevated pressure/temperature. Temperature indicators and Magnet quench.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4618M L	B	6	CIRC BYPASS IN~B~OUT
H6707M L	Y	6	CIRC BYPASS IN~B~OUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 77

Item: 58

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Closed	No lead cooling. Power supply shutdown by voltage monitoring circuit.	Manual valve. Visual detection. No lead flow indication. Power supply shutdown.

Affected Components:

Component #	Ring	Box	Nomenclature
H4280M	B	2	LEAD ISOLATION 11
H4281M	B	2	LEAD ISOLATION 10
H4282M	B	2	LEAD ISOLATION 9
H4283M	B	2	LEAD ISOLATION 8
H4284M	B	2	LEAD ISOLATION 7
H4285M	B	2	LEAD ISOLATION 12
H4286M	B	2	LEAD ISOLATION 5
H4287M	B	2	LEAD ISOLATION 4
H4288M	B	2	LEAD ISOLATION 3
H4289M	B	2	LEAD ISOLATION 2
H4290M	B	2	LEAD ISOLATION 1
H6280M	Y	2	LEAD ISOLATION 9
H6281M	Y	2	LEAD ISOLATION 8
H6282M	Y	2	LEAD ISOLATION 7
H6283M	Y	2	LEAD ISOLATION 5
H6284M	Y	2	LEAD ISOLATION 4
H6285M	Y	2	LEAD ISOLATION 2
H6286M	Y	2	LEAD ISOLATION 1
H6287M	Y	2	LEAD ISOLATION 10
H6288M	Y	2	LEAD ISOLATION 11
H4483M	B	4	LEAD ISOLATION B10
H4484M	B	4	LEAD ISOLATION B9
H4485M	B	4	LEAD ISOLATION B8
H4486M	B	4	LEAD ISOLATION B7
H4487M	B	4	LEAD ISOLATION B6
H4488M	B	4	LEAD ISOLATION A11
H4489M	B	4	LEAD ISOLATION A9
H4490M	B	4	LEAD ISOLATION A8
H4491M	B	4	LEAD ISOLATION A6
H4492M	B	4	LEAD ISOLATION A5

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 78

Component #	Ring	Box	Nomenclature
H4493M	B	4	LEAD ISOLATION A4
H4494M	B	4	LEAD ISOLATION A2
H4495M	B	4	LEAD ISOLATION A1
H6528M	Y	4	LEAD ISOLATION 10
H6529M	Y	4	LEAD ISOLATION 9
H6530M	Y	4	LEAD ISOLATION 8
H6531M	Y	4	LEAD ISOLATION 7
H6532M	Y	4	LEAD ISOLATION 6
H6533M	Y	4	LEAD ISOLATION 5
H6534M	Y	4	LEAD ISOLATION 4
H6535M	Y	4	LEAD ISOLATION 3
H6536M	Y	4	LEAD ISOLATION 2
H6537M	Y	4	LEAD ISOLATION 1
H6538M	Y	4	LEAD ISOLATION 11
H4742M	B	6	LEAD ISOLATION 11
H4743M	B	6	LEAD ISOLATION 10
H4744M	B	6	LEAD ISOLATION 9
H4745M	B	6	LEAD ISOLATION 8
H4746M	B	6	LEAD ISOLATION 7
H4747M	B	6	LEAD ISOLATION 5
H4748M	B	6	LEAD ISOLATION 4
H4749M	B	6	LEAD ISOLATION 2
H4750M	B	6	LEAD ISOLATION 1
H6884M	Y	6	LEAD ISOLATION 9
H6885M	Y	6	LEAD ISOLATION 8
H6886M	Y	6	LEAD ISOLATION 7
H6889M	Y	6	LEAD ISOLATION 2
H6890M	Y	6	LEAD ISOLATION 10
H6891M	Y	6	LEAD ISOLATION 1
H6896M	Y	6	LEAD ISOLATION 11
H4880M	B	8	LEAD ISOLATION 11
H4881M	B	8	LEAD ISOLATION 10
H4882M	B	8	LEAD ISOLATION 9
H4883M	B	8	LEAD ISOLATION 8
H4884M	B	8	LEAD ISOLATION 7
H4885M	B	8	LEAD ISOLATION 5
H4886M	B	8	LEAD ISOLATION 4
H4887M	B	8	LEAD ISOLATION 2
H4888M	B	8	LEAD ISOLATION 1
H6923M	Y	8	LEAD ISOLATION 9
H6924M	Y	8	LEAD ISOLATION 8
H6925M	Y	8	LEAD ISOLATION 7
H6926M	Y	8	LEAD ISOLATION 6
H6928M	Y	8	LEAD ISOLATION 2
H6929M	Y	8	LEAD ISOLATION 10
H6930M	Y	8	LEAD ISOLATION 1
H6932M	Y	8	LEAD ISOLATION 11
H4753M	B	10	LEAD ISOLATION B11

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 79

Component #	Ring	Box	Nomenclature
H4754M	B	10	LEAD ISOLATION B10
H4755M	B	10	LEAD ISOLATION B9
H4756M	B	10	LEAD ISOLATION B2
H4757M	B	10	LEAD ISOLATION B4
H4758M	B	10	LEAD ISOLATION B7
H4759M	B	10	LEAD ISOLATION A11
H4760M	B	10	LEAD ISOLATION A9
H4761M	B	10	LEAD ISOLATION A8
H4762M	B	10	LEAD ISOLATION A6
H4763M	B	10	LEAD ISOLATION A5
H4764M	B	10	LEAD ISOLATION A4
H4765M	B	10	LEAD ISOLATION A2
H4766M	B	10	LEAD ISOLATION A1
H4767M	B	10	LEAD ISOLATION A7
H4854M	B	10	LEAD ISOLATION A10
H7129M	Y	10	LEAD ISOLATION B10
H7130M	Y	10	LEAD ISOLATION B9
H7131M	Y	10	LEAD ISOLATION B8
H7132M	Y	10	LEAD ISOLATION B7
H7133M	Y	10	LEAD ISOLATION B6
H7134M	Y	10	LEAD ISOLATION B11
H7135M	Y	10	LEAD ISOLATION A11
H7137M	Y	10	LEAD ISOLATION A9
H7138M	Y	10	LEAD ISOLATION A8
H7139M	Y	10	LEAD ISOLATION A6
H7140M	Y	10	LEAD ISOLATION A5
H7141M	Y	10	LEAD ISOLATION A4
H7142M	Y	10	LEAD ISOLATION A2
H7143M	Y	10	LEAD ISOLATION A1
H4133M	B	12	LEAD ISOLATION 11
H4134M	B	12	LEAD ISOLATION 10
H4135M	B	12	LEAD ISOLATION 9
H4136M	B	12	LEAD ISOLATION 8
H4137M	B	12	LEAD ISOLATION 7
H4138M	B	12	LEAD ISOLATION 5
H4139M	B	12	LEAD ISOLATION 4
H4140M	B	12	LEAD ISOLATION 2
H4141M	B	12	LEAD ISOLATION 1
H6059M	Y	12	LEAD ISOLATION 9
H6060M	Y	12	LEAD ISOLATION 8
H6061M	Y	12	LEAD ISOLATION 7
H6062M	Y	12	LEAD ISOLATION 6
H6066M	Y	12	LEAD ISOLATION 2
H6067M	Y	12	LEAD ISOLATION 10
H6068M	Y	12	LEAD ISOLATION 1
H6097M	Y	12	LEAD ISOLATION 11

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 59

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow to local Warm Return header. Minor refrigerator heat load increase.	Manual valve. Visual detection. Frosted valve. Minor increase in refrigerator output.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4212M	B	2	MONITOR TUBE H4215A~H4216A
H4214M	B	2	MONITOR TUBE H4205M~H4200A
H4217M	B	2	MONITOR TUBE H4210A~H4211A
H4222M	B	2	MONITOR TUBE H4218M~H4201A
H4250M	B	2	MONITOR TUBE H4220A~H4221A
H6212M	Y	2	MONITOR TUBE H6215A~H6216A
H6217M	Y	2	MONITOR TUBE H6210A~H6211A
H6222M	Y	2	MONITOR TUBE H6220A~H6221A
H6256M	Y	2	MONITOR TUBE H6254M~H6201A
H6260M	Y	2	MONITOR TUBE H6253M~H6200A
H4412M	B	4	MONITOR TUBE H4415A~H4416A
H4417M	B	4	MONITOR TUBE H4410A~H4411A
H4418M	B	4	MONITOR TUBE H4407M~H4400A
H4422M	B	4	MONITOR TUBE H4405M~H4401A
H4428M	B	4	MONITOR TUBE H4420A~H4421A
H6409M	Y	4	MONITOR TUBE H6000A~H6405M
H6412M	Y	4	MONITOR TUBE H6415A~H6416A
H6417M	Y	4	MONITOR TUBE H6410A~H6411A
H6422M	Y	4	MONITOR TUBE H6402A~H6426M
H6424M	Y	4	MONITOR TUBE H6420A~H6421A
H3233M	B	6	MONITOR TUBE H4501A~H4534M
H3237M	B	6	MONITOR TUBE H4600A~H4618M
H4512M	B	6	MONITOR TUBE H4510A~H4511A
H4517M	B	6	MONITOR TUBE H4515A~H4516A
H4522M	B	6	MONITOR TUBE H4520A~H4521A
H4617M	B	6	MONITOR TUBE H4615A~H4616A
H4622M	B	6	MONITOR TUBE H4620A~H4621A
H6735M	B	6	MONITOR TUBE H4500A~H6733M
H6819M	B	6	MONITOR TUBE H4601A~H4614M
H6612M	Y	6	MONITOR TUBE H6610A~H6611A

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 81

Component #	Ring	Box	Nomenclature
H6617M	Y	6	MONITOR TUBE H6615A~H6616A
H6622M	Y	6	MONITOR TUBE H6620A~H6621A
H6641M	Y	6	MONITOR TUBE H6600A~H6623M
H6717M	Y	6	MONITOR TUBE H6715A~H6716A
H6722M	Y	6	MONITOR TUBE H6720A~H6721A
H6726M	Y	6	MONITOR TUBE H6601A~H6609M
H6728M	Y	6	MONITOR TUBE H6700A~H6707M
H6764M	Y	6	MONITOR TUBE H6701A~H6705M
H4812M	B	8	MONITOR TUBE H4801A~H4805M
H4817M	B	8	MONITOR TUBE H4815A~H4816A
H4822M	B	8	MONITOR TUBE H4820A~H4821A
H4829M	B	8	MONITOR TUBE H4800A~H4831M
H4833M	B	8	MONITOR TUBE H4810A~H4811A
H6812M	Y	8	MONITOR TUBE H6810A~H6811A
H6817M	Y	8	MONITOR TUBE H6815A~H6816A
H6822M	Y	8	MONITOR TUBE H6820A~H4821A
H6862M	Y	8	MONITOR TUBE H6800M~H6859M
H6865M	Y	8	MONITOR TUBE H6801A~H6860M
H5012M	B	10	MONITOR TUBE H5010A~H5011A
H5017M	B	10	MONITOR TUBE H5015A~H5016A
H5022M	B	10	MONITOR TUBE H5020A~H5021A
H5033M	B	10	MONITOR TUBE H5283M~H5001A
H5281M	B	10	MONITOR TUBE H5284M~H5000A
H7012M	Y	10	MONITOR TUBE H7010A~H7011A
H7017M	Y	10	MONITOR TUBE H7015A~H7016A
H7022M	Y	10	MONITOR TUBE H7020A~H7021A
H7064M	Y	10	MONITOR TUBE H7000A~H7067A
H7069M	Y	10	MONITOR TUBE H7001A~H7066M
H4017M	B	12	MONITOR TUBE H4000A~H4007A
H4019M	B	12	MONITOR TUBE H4005M~H4001A
H4062M	B	12	MONITOR TUBE H4035A~H4039A
H4063M	B	12	MONITOR TUBE H4020A~H4021A
H4069M	B	12	MONITOR TUBE H4010A~H4011A
H4070M	B	12	MONITOR TUBE H4015A~H4016A
H6012M	Y	12	MONITOR TUBE H6010A~H6011A
H6017M	Y	12	MONITOR TUBE H6020A~H6021A
H6022M	Y	12	MONITOR TUBE H6015A~H6016A
H6028M	Y	12	MONITOR TUBE H6000A~H6056A
H6052M	Y	12	MONITOR TUBE H6001M~H6055A
H6071M	Y	12	MONITOR TUBE H6007A~H6070A

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 82

Item: 60

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure in Heat Shield line. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4269M	B	2	PUMPOUT H 4
H4274M	B	2	PUMPOUT H 12
H6268M	Y	2	PUMPOUT H 4
H6273M	Y	2	PUMPOUT H 12
H4472M	B	4	PUMPOUT H 6
H4477M	B	4	PUMPOUT H 2
H6477M	Y	4	PUMPOUT H 6
H6482M	Y	4	PUMPOUT H 2
H4648M	B	6	PUMPOUT H 8
H4653M	B	6	PUMPOUT H 4
H6711M	Y	6	PUMPOUT H 8
H6782M	Y	6	PUMPOUT H 4
H4869M	B	8	PUMPOUT H 10
H4874M	B	8	PUMPOUT H 6
H6874M	Y	8	PUMPOUT H 10
H6879M	Y	8	PUMPOUT H 6
H5156M	B	10	PUMPOUT H 12
H5161M	B	10	PUMPOUT H 8
H7078M	Y	10	PUMPOUT H 12
H7083M	Y	10	PUMPOUT H 8
H4082M	B	12	PUMPOUT H 2
H4087M	B	12	PUMPOUT H 10
H6080M	Y	12	PUMPOUT H 2
H6085M	Y	12	PUMPOUT H 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 61

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4267M	B	2	PUMPOUT M 4
H4272M	B	2	PUMPOUT M 12
H6266M	Y	2	PUMPOUT M 4
H6271M	Y	2	PUMPOUT M 12
H4470M	B	4	PUMPOUT M 6
H4475M	B	4	PUMPOUT M 2
H6475M	Y	4	PUMPOUT M 6
H6480M	Y	4	PUMPOUT M 2
H4651M	B	6	PUMPOUT M 4
H6709M	Y	6	PUMPOUT M 8
H6780M	Y	6	PUMPOUT M 4
H4867M	B	8	PUMPOUT M 10
H4872M	B	8	PUMPOUT M 6
H6872M	Y	8	PUMPOUT M 10
H6877M	Y	8	PUMPOUT M 6
H5154M	B	10	PUMPOUT M 12
H5159M	B	10	PUMPOUT M 8
H7076M	Y	10	PUMPOUT M 12
H7081M	Y	10	PUMPOUT M 8
H4080M	B	12	PUMPOUT M 2
H4085M	B	12	PUMPOUT M 10
H6078M	Y	12	PUMPOUT M 2
H6083M	Y	12	PUMPOUT M 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 62

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4271M	B	2	PUMPOUT R 4
H4276M	B	2	PUMPOUT R 12
H6270M	Y	2	PUMPOUT R 4
H6275M	Y	2	PUMPOUT R 12
H4474M	B	4	PUMPOUT R 6
H4479M	B	4	PUMPOUT R 2
H6479M	Y	4	PUMPOUT R 6
H6484M	Y	4	PUMPOUT R 2
H4646M	B	6	PUMPOUT M 8
H4650M	B	6	PUMPOUT R 8
H4655M	B	6	PUMPOUT R 4
H6713M	Y	6	PUMPOUT R 8
H6784M	Y	6	PUMPOUT R 4
H4871M	B	8	PUMPOUT R 10
H4876M	B	8	PUMPOUT R 6
H6876M	Y	8	PUMPOUT R 10
H6881M	Y	8	PUMPOUT R 6
H5158M	B	10	PUMPOUT R 12
H5163M	B	10	PUMPOUT R 8
H7080M	Y	10	PUMPOUT R 12
H7085M	Y	10	PUMPOUT R 8
H4084M	B	12	PUMPOUT R 2
H4089M	B	12	PUMPOUT R 10
H6082M	Y	12	PUMPOUT R 2
H6087M	Y	12	PUMPOUT R 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 63

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4268M	B	2	PUMPOUT S 4
H4273M	B	2	PUMPOUT S 12
H6267M	Y	2	PUMPOUT S 4
H6272M	Y	2	PUMPOUT S 12
H4471M	B	4	PUMPOUT S 6
H4476M	B	4	PUMPOUT S 2
H6476M	Y	4	PUMPOUT S 6
H6481M	Y	4	PUMPOUT S 2
H4647M	B	6	PUMPOUT S 8
H4652M	B	6	PUMPOUT S 4
H6710M	Y	6	PUMPOUT S 8
H6781M	Y	6	PUMPOUT S 4
H4868M	B	8	PUMPOUT S 10
H4873M	B	8	PUMPOUT S 6
H6873M	Y	8	PUMPOUT S 10
H6878M	Y	8	PUMPOUT S 6
H5155M	B	10	PUMPOUT S 12
H5160M	B	10	PUMPOUT S 8
H7077M	Y	10	PUMPOUT S 12
H7082M	Y	10	PUMPOUT S 8
H4081M	B	12	PUMPOUT S 2
H4086M	B	12	PUMPOUT S 10
H6079M	Y	12	PUMPOUT S 2
H6084M	Y	12	PUMPOUT S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 86

Item: 64

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4270M	B	2	PUMPOUT U 4
H4275M	B	2	PUMPOUT U 12
H6269M	Y	2	PUMPOUT U 4
H6274M	Y	2	PUMPOUT U 12
H4473M	B	4	PUMPOUT U 6
H4478M	B	4	PUMPOUT U 2
H6478M	Y	4	PUMPOUT U 6
H6483M	Y	4	PUMPOUT U 2
H4649M	B	6	PUMPOUT U 8
H4654M	B	6	PUMPOUT U 4
H6712M	Y	6	PUMPOUT U 8
H6783M	Y	6	PUMPOUT U 4
H4870M	B	8	PUMPOUT U 10
H4875M	B	8	PUMPOUT U 6
H6875M	Y	8	PUMPOUT U 10
H6880M	Y	8	PUMPOUT U 6
H5157M	B	10	PUMPOUT U 12
H5162M	B	10	PUMPOUT U 8
H7079M	Y	10	PUMPOUT U 12
H7084M	Y	10	PUMPOUT U 8
H4083M	B	12	PUMPOUT U 2
H4088M	B	12	PUMPOUT U 10
H6081M	Y	12	PUMPOUT U 2
H6086M	Y	12	PUMPOUT U 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 65

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal Operations.
Closed	Possible increase in pressure drop. Flow permitted in opposite direction. Minor increase in refrigerator load.	Normally open valve. Visual detection. Pressure increase. Decreased lead flow. Decreased suction pressure.

Affected Components:

Component #	Ring	Box	Nomenclature
H6249R	Y	2	VACUUM SKID RELIEF 2
H6414R	Y	4	VACUUM SKID RELIEF 4
H4560R	B	6	VACUUM SKID RELIEF 6
H6714R	Y	6	VACUUM SKID RELIEF 6
H6824R	Y	8	VACUUM SKID RELIEF 8
H7023R	Y	10	VACUUM SKID RELIEF 10
H6050R	Y	12	VACUUM SKID RELIEF 12

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 66

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Vacuum header open to vent header. Lines not used for normal operations.	No detection.
Closed	No impact. Lines not used for normal operations. Low pressure relief for protection of vacuum pump.	No detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6218A	Y	2	WARM RETURN ISOLATION 2
H6418A	Y	4	WARM RETURN ISOLATION 4
H6718A	Y	6	WARM RETURN ISOLATION 6~8
H6719A	Y	6	WARM RETURN ISOLATION 6~4
H6818A	Y	8	WARM RETURN ISOLATION 8
H7018A	Y	10	WARM RETURN ISOLATION 10
H6018A	Y	12	WARM RETURN ISOLATION 12

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 67

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Not in use - Open	No impact. Bayonet capped with relief valve. Normal operating position.	Normally closed valve. Visual detection.
Not in use - Closed	Leakage will be relieved on warming.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4225A	B	2	DETECTOR SUPPLY
H6225A	Y	2	DETECTOR SUPPLY
H4425A	B	4	DETECTOR SUPPLY
H6462A	Y	4	DETECTOR SUPPLY
H4625A	B	6	DETECTOR SUPPLY
H6625A	Y	6	DETECTOR SUPPLY
H4825A	B	8	DETECTOR SUPPLY
H6825A	Y	8	DETECTOR SUPPLY
H5025A	B	10	DETECTOR SUPPLY
H7025A	Y	10	DETECTOR SUPPLY
H4072A	B	12	DETECTOR SUPPLY
H6013A	Y	12	DETECTOR SUPPLY

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 68

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open/ Leaks	Flow of Supply gas to atmosphere. Can be shutoff with valve. Unacceptable leak, with depletion of helium inventory. Increased refrigerator load.	Elevated temperature/low pressure. Frosted fitting. Increased refrigerator output.
Closed	No impact. Normal operating position.	Normally closed. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
U0003H	B	2	1/2 IPS FEMALE BAYONET
U0009H	Y	2	1/2 IPS FEMALE BAYONET
U0004H	B	4	1/2 IPS FEMALE BAYONET
U0010H	Y	4	1/2 IPS FEMALE BAYONET
U0005H	B	6	1/2 IPS FEMALE BAYONET
U0011H	Y	6	1/2 IPS FEMALE BAYONET
U0006H	B	8	1/2 IPS FEMALE BAYONET
U0012H	Y	8	1/2 IPS FEMALE BAYONET
U0001H	B	10	1/2 IPS FEMALE BAYONET
U0007H	Y	10	1/2 IPS FEMALE BAYONET
U0002H	B	12	1/2 IPS FEMALE BAYONET
U0008H	Y	12	1/2 IPS FEMALE BAYONET

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 69

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Increased refrigerator demand. Refrigerator imbalance caused by unmodulated 4K gas going into Return. Refrigerator shutoff from ring.	Normally closed valve. Visual detection. Refrigerator alarms.
Closed	No impact. Normal operating position.	Normally closed. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4206A	B	2	CROSSOVER M~U 4
H6206A	Y	2	CROSSOVER M~U 4
H4406A	B	4	CROSSOVER M~U 6
H6406A	Y	4	CROSSOVER M~U 6
H4506A	B	6	CROSSOVER M~U 4
H4606A	B	6	CROSSOVER M~U 8
H6638A	Y	6	CROSSOVER M~U 4
H6706A	Y	6	CROSSOVER M~U 8
H4806A	B	8	CROSSOVER M~U 6
H6806A	Y	8	CROSSOVER M~U 6
H5006A	B	10	CROSSOVER M~U 8
H7006A	Y	10	CROSSOVER M~U 8
H4006A	B	12	CROSSOVER M~U 10
H4037A	B	12	CROSSOVER M~U 2
H6006A	Y	12	CROSSOVER M~U 10
H6036A	Y	12	CROSSOVER M~U 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 70

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield Supply bypassed to Heat Shield Return. Heat shield temperature increase with magnet temperature rise and subsequent magnet quench.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicators and Magnet quench.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4645A	B	6	ISOLATION H 4 Linear Plug
H6745A	Y	6	ISOLATION H 4 Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 15-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 71

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Leaks	Helium leaks into valve box insulating vacuum. Loss of inventory. Unacceptable heat load. Magnet quench.	Pressure tested pressure vessel. Elevated Pressure/temperature. Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
LP1 C	B	2	LEAD POT 32015127 01
LP5 B	Y	2	LEAD POT 32015127 05
LP2 C	B	4	LEAD POT "a" 32015127 02
LP3 B	B	4	LEAD POT "b" 32015127 03
LP1 A	Y	4	LEAD POT 32015127 01
LP1 E	B	6	LEAD POT 32015127 01
LP5 A	Y	6	LEAD POT 32015127 05
LP1 D	B	8	LEAD POT 32015127 01
LP5 D	Y	8	LEAD POT 32015127 05
LP2 B	B	10	LEAD POT "a" 32015127 02
LP4 A	B	10	LEAD POT "b" 32015127 04
LP2 A	Y	10	LEAD POT "a" 32015127 02
LP3 A	Y	10	LEAD POT "b" 32015127 03
LP1 B	B	12	LEAD POT 32015127 01
LP5 C	Y	12	LEAD POT 32015127 05

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 72

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal Operations.
Closed	Turbo pump cannot evacuate valve box. Spoilation of cryostat insulating vacuum. Magnet temperature rises with subsequent magnet quench.	Normally closed valve. Visual detection. Vacuum indication. Elevated pressure/ temperature. Low vacuum. Temperature/ pressure/vacuum indicators. Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
V4202A	B	2	ISOLATION TURBO B 2
V6202A	Y	2	ISOLATION TURBO
V4402A	B	4	ISOLATION TURBO
V6402A	Y	4	ISOLATION TURBO
V4502A	B	6	ISOLATION TURBO
V6602A	Y	6	ISOLATION TURBO
V4802A	B	8	ISOLATION TURBO
V6802A	Y	8	ISOLATION TURBO
V5002A	B	10	ISOLATION TURBO
V7702A	Y	10	ISOLATION TURBO
V4052A	B	12	ISOLATION TURBO
V6042A	Y	12	ISOLATION TURBO

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 95

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal Operations.
Open	Potential for loss of insulating vacuum and turbo pump failure. Magnet temperature rises with subsequent magnet quench.	Manual valve. Visual detection. Elevated pressure/temperature. Low vacuum. Temperature/pressure/vacuum indicators. Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
V4203M	B	2	CRYOSTAT PUMPOUT
V6203M	Y	2	CRYOSTAT PUMPOUT
V4403M	B	4	CRYOSTAT PUMPOUT
V6403M	Y	4	CRYOSTAT PUMPOUT
V4503M	B	6	CRYOSTAT PUMPOUT
V6603M	Y	6	CRYOSTAT PUMPOUT
V4803M	B	8	CRYOSTAT PUMPOUT
V6803M	Y	8	CRYOSTAT PUMPOUT
V5003M	B	10	CRYOSTAT PUMPOUT
V7703M	Y	10	CRYOSTAT PUMPOUT
V4053M	B	12	CRYOSTAT PUMPOUT
V6043M	Y	12	CRYOSTAT PUMPOUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 74

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Instrumentation only.	High/Full scale pressure indication.
Full Scale Low	No impact. Instrumentation only.	Zero/Low pressure indication.

Affected Components:

Component #	Ring	Box	Nomenclature
PI4254H	B	2	PRESSURE TRANSDUCER VENT
PI6253H	Y	2	PRESSURE TRANSDUCER VENT
PI4448H	B	4	PRESSURE TRANSDUCER VENT
PI6414H	Y	4	PRESSURE TRANSDUCER VENT
PI6068H	B	6	PRESSURE TRANSDUCER VENT
PI6067H	Y	6	PRESSURE TRANSDUCER VENT
PI4854H	B	8	PRESSURE TRANSDUCER VENT
PI6859H	Y	8	PRESSURE TRANSDUCER VENT
PI5064H	B	10	PRESSURE TRANSDUCER VENT
PI7059H	Y	10	PRESSURE TRANSDUCER VENT
PI4068H	B	12	PRESSURE TRANSDUCER VENT
PI6074H	Y	12	PRESSURE TRANSDUCER VENT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 75

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4559M	B	6	CIRC C3019 PUMPOUT
H6799M	Y	6	CIRC C3018 PUMPOUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 76

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Interlock closes circulator isolation valve. No circulation. Also closes Supply make-up. Magnet temperature rises with power supply shutdown possible.	Temperature indication unreasonably high. Elevated pressure/temperature. Other temperature indicators and Magnet quench.
Full Scale Low	Interlock closes circulator isolation valve. No circulation. Also opens Supply make-up to full open. Magnet temperature rises with power supply shutdown possible.	Zero temperature indication. Elevated pressure/temperature. Other temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
PI3717H	B	6	PRESSURE TRANSDUCER CIRC OUT
PI3715H	Y	6	PRESSURE TRANSDUCER CIRC OUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 77

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Interlock closes circulator isolation valve. No circulation. Magnet temperature rises with power supply shutdown possible.	Temperature indication unreasonably high. Elevated pressure/temperature. Other temperature indicators and Magnet quench.
Full Scale Low	Interlock closes circulator isolation valve. No circulation. Magnet temperature rises with power supply shutdown possible.	Zero temperature indication. Elevated pressure/temperature. Other temperature indicators and Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
PI3716H	B	6	PRESSURE TRANSDUCER CIRC IN
PI3714H	Y	6	PRESSURE TRANSDUCER CIRC IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 78

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Interlock turns off heater in valve box. Heater not used for First Sextant Test.	Temperature indication unreasonably high.
Full Scale Low	No impact. Interlock would permit heater operation at elevated temperature or when circulator is turned off. Heater not used for First Sextant Test.	Zero temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
TI3712H	B	6	CALIBRATED SNSR RECL IN
TI3708H	Y	6	CALIBRATED SNSR RECL IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 79

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Circulator speed limited to 5,000 RPM. No impact above 20 K, but limits heat removal capacity below 20 K and may prevent cooling to superconducting temperature.	Temperature indication unreasonably high. Elevated pressure/temperature. Magnet quench.
Full Scale Low	Speed limit for elevated temperature operation disabled. Overspeed protection provided by other interlocks. Cryogen provides lubrication for lower bearing. Speed above 5000 RPM above 20 K will accelerate bearing deterioration.	Zero temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
TI3803H	B	6	CALIBRATED SENSOR CIRC INLET
TI3805H	Y	6	CALIBRATED SENSOR CIRC INLET

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations **Page:** 102

Item: 80

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open- No Pump	Loss of valve box insulating vacuum. Unacceptable heat load. Temperature rise and subsequent quench.	Elevated pressure/temperature. Magnet quench. Visual detection.
Closed- No Pump	No impact. Normal operating position.	Visual detection. Vacuum indication.
Open- Pump Attached	No impact. Normal operating position.	Visual detection. Vacuum indications (Pump and valve box indicators compare).
Closed- Pump Attached	Pump cannot evacuate valve box. Continues spoilation of vacuum. Temperature rise and subsequent magnet quench.	Visual detection. Vacuum indication. Elevated temperature. Magnet quench.

Affected Components:

Component #	Ring	Box	Nomenclature
V4200M	B	2	PUMPOUT VI4200V~VI4201V
V6200M	Y	2	PUMPOUT VI6200V~VI6201V
V4400M	B	4	PUMPOUT VI4400V~VI4401V
V6400M	Y	4	PUMPOUT VI6400V~VI6401V
V4500M	B	6	PUMPOUT VI4500V~VI4501V
V6600M	Y	6	PUMPOUT VI6600V~VI6601V
V4800M	B	8	PUMPOUT VI4800V~VI4801V
V6800M	Y	8	PUMPOUT VI6800V~VI6801V
V5200M	B	10	PUMPOUT VI5200V~VI5201V
V7700M	Y	10	PUMPOUT VI7700V~VI7701V
V4050M	B	12	PUMPOUT VI4050V~VI4051V
V6040M	Y	12	PUMPOUT VI6050V~VI6051V

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 81

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Normal operating position. Leakage during vacuum indicator replacement causing spoilation of vacuum.	Manual valve. Visual detection. In-rushing air during vacuum indicator removal.
Closed	Isolation of vacuum indicators. Erroneous insulating vacuum readings. May mask bad vacuum problem.	Manual valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
V4201M	B	2	ISOLATION VI4200V~VI4201V
V6201M	Y	2	ISOLATION VI6200V~VI6201V
V4401M	B	4	ISOLATION VI4400V~VI4401V
V6401M	Y	4	ISOLATION VI6400V~VI6401V
V4501M	B	6	ISOLATION VI4500V~VI4501V
V6601M	Y	6	ISOLATION VI6600V~VI6601V
V4801M	B	8	ISOLATION VI4800V~VI4801V
V6801M	Y	8	ISOLATION VI6800V~VI6801V
V5201M	B	10	ISOLATION VI5200V~VI5201V
V7701M	Y	10	ISOLATION VI7700V~VI7701V
V4051M	B	12	ISOLATION VI4050V~VI4051V
V6041M	Y	12	ISOLATION VI6050V~VI6051V

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 82

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Indicates poor vacuum. Does not correlate with high vacuum indicator.	Compare with high vacuum indicator.
Full Scale Low	No impact. Normal operations.	Not detectable during normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
VI4201V	B	2	CRYOSTAT LOW VAC TRANSDUCER
VI6201V	Y	2	CRYOSTAT LOW VAC TRANSDUCER
VI4401V	B	4	CRYOSTAT LOW VAC TRANSDUCER
VI6401V	Y	4	CRYOSTAT LOW VAC TRANSDUCER
VI4501V	B	6	CRYOSTAT LOW VAC TRANSDUCER
VI6601V	Y	6	CRYOSTAT LOW VAC TRANSDUCER
VI4801V	B	8	CRYOSTAT LOW VAC TRANSDUCER
VI6801V	Y	8	CRYOSTAT LOW VAC TRANSDUCER
VI5201V	B	10	CRYOSTAT LOW VAC TRANSDUCER
VI7701V	Y	10	CRYOSTAT LOW VAC TRANSDUCER
VI4051V	B	12	CRYOSTAT LOW VAC TRANSDUCER
VI6051V	Y	12	CRYOSTAT LOW VAC TRANSDUCER

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 16-Sep-98

Operation Mode: Full Ring Normal Operations

Item: 83

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Indicates high vacuum. Will mask spoilation of vacuum.	Vacuum higher than possible or initially set, without vacuum pump attached.
Full Scale Low	Indicates poor vacuum, but temperatures remain acceptable and rough vacuum indicator remains full scale.	Mismatch in vacuum indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
VI4200V	B	2	CRYOSTAT HIGH VAC TRANSDUCER
VI6200V	Y	2	CRYOSTAT HIGH VAC TRANSDUCER
VI4400V	B	4	CRYOSTAT HIGH VAC TRANSDUCER
VI6400V	Y	4	CRYOSTAT HIGH VAC TRANSDUCER
VI4500V	B	6	CRYOSTAT HIGH VAC TRANSDUCER
VI6600V	Y	6	CRYOSTAT HIGH VAC TRANSDUCER
VI4800V	B	8	CRYOSTAT HIGH VAC TRANSDUCER
VI6800V	Y	8	CRYOSTAT HIGH VAC TRANSDUCER
VI5200V	B	10	CRYOSTAT HIGH VAC TRANSDUCER
VI7700V	Y	10	CRYOSTAT HIGH VAC TRANSDUCER
VI4050V	B	12	CRYOSTAT HIGH VAC TRANSDUCER
VI6050V	Y	12	CRYOSTAT HIGH VAC TRANSDUCER

ATTACHMENT 2

FAILURE MODES EFFECTS ANALYSIS
FOR
SINGLE SEXTANT WARM-UP

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 1

Item: 1

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	No flow. Heat shield temperature increase with magnet temperature rise. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
F4256H	B	2	FILTER H 12
F6261H	Y	2	FILTER H 12
F4469H	B	4	FILTER H 6
F6425H	Y	4	FILTER H 6
F4611H	B	6	FILTER H 8
F4616H	B	6	FILTER H 4
F6748H	Y	6	FILTER H 8
F6753H	Y	6	FILTER H 4
F4862H	B	8	FILTER H 10
F4867H	B	8	FILTER H 6
F6851H	Y	8	FILTER H 10
F6856H	Y	8	FILTER H 6
F5051H	B	10	FILTER H 12
F5056H	B	10	FILTER H 8
F7051H	Y	10	FILTER H 12
F7056H	Y	10	FILTER H 8
F4029H	B	12	FILTER H 2
F4035H	B	12	FILTER H 10
F6054H	Y	12	FILTER H 2
F6059H	Y	12	FILTER H 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 2

Item: 2

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak. Short/open on Magnet electrical circuits. Circulator failure.	Minor helium leak. Minor increase in refrigerator output.
Clogged	No flow. Magnet temperature rise. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
F4467H	B	4	FILTER M 6
F6423H	Y	4	FILTER M 6
F4609H	B	6	FILTER M 8
F4614H	B	6	FILTER M 4
F6746H	Y	6	FILTER M 8
F6751H	Y	6	FILTER M 4
F4860H	B	8	FILTER M 10
F6849H	Y	8	FILTER M 10
F5049H	B	10	FILTER M 12
F7049H	Y	10	FILTER M 12
F4027H	B	12	FILTER M 2
F6052H	Y	12	FILTER M 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 3

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	Increased pressure drop may reduce flow. Utility Line provides alternate path. Recooler temperature increase with Magnet temperature rise. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
F4258H	B	2	FILTER R 12
F6263H	Y	2	FILTER R 12
F4471H	B	4	FILTER R 6
F6427H	Y	4	FILTER R 6
F4613H	B	6	FILTER R 8
F4618H	B	6	FILTER R 4
F6750H	Y	6	FILTER R 8
F6755H	Y	6	FILTER R 4
F4864H	B	8	FILTER R 10
F4869H	B	8	FILTER R 6
F6853H	Y	8	FILTER R 10
F6858H	Y	8	FILTER R 6
F5053H	B	10	FILTER R 12
F5058H	B	10	FILTER R 8
F7053H	Y	10	FILTER R 12
F7058H	Y	10	FILTER R 8
F4032H	B	12	FILTER R 2
F4037H	B	12	FILTER R 10
F6056H	Y	12	FILTER R 2
F6061H	Y	12	FILTER R 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 4

Item: 4

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	No impact. Supply gas provided by flow from opposite direction. Filter will collapse and fail at low Delta P. See Open.	Possible pressure differential.

Affected Components:

Component #	Ring	Box	Nomenclature
F4255H	B	2	FILTER S 12
F6260H	Y	2	FILTER S 12
F4468H	B	4	FILTER S 6
F6424H	Y	4	FILTER S 6
F4610H	B	6	FILTER S 8
F4615H	B	6	FILTER S 4
F6747H	Y	6	FILTER S 8
F6752H	Y	6	FILTER S 4
F4861H	B	8	FILTER S 10
F4866H	B	8	FILTER S 6
F6850H	Y	8	FILTER S 10
F6855H	Y	8	FILTER S 6
F5050H	B	10	FILTER S 12
F5055H	B	10	FILTER S 8
F7050H	Y	10	FILTER S 12
F7055H	Y	10	FILTER S 8
F4028H	B	12	FILTER S 2
F4034H	B	12	FILTER S 10
F6053H	Y	12	FILTER S 2
F6058H	Y	12	FILTER S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 5

Item: 5

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Contaminants may cause valves downstream of affected filter to leak.	Minor helium leak. Minor increase in refrigerator output.
Clogged	Increased pressure drop may reduce flow. Return Line provides alternate path. Recooler temperature increase with Magnet temperature rise. Filter will collapse and fail at low Delta P. See Open. Pump & Purge will minimize condensables.	Elevated pressure/temperature. Temperature indicators. Minor increase in refrigerator output.

Affected Components:

Component #	Ring	Box	Nomenclature
F4257H	B	2	FILTER U 12
F6262H	Y	2	FILTER U 12
F4470H	B	4	FILTER U 6
F6426H	Y	4	FILTER U 6
F4612H	B	6	FILTER U 8
F4617H	B	6	FILTER U 4
F6749H	Y	6	FILTER U 8
F6754H	Y	6	FILTER U 4
F4863H	B	8	FILTER U 10
F4868H	B	8	FILTER U 6
F6852H	Y	8	FILTER U 10
F6857H	Y	8	FILTER U 6
F5052H	B	10	FILTER U 12
F5057H	B	10	FILTER U 8
F7052H	Y	10	FILTER U 12
F7057H	Y	10	FILTER U 8
F4031H	B	12	FILTER U 2
F4036H	B	12	FILTER U 10
F6055H	Y	12	FILTER U 2
F6060H	Y	12	FILTER U 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 6

Item: 6

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Little to no impact. Supply gas provided by flow in opposite direction. Possible pressure drop. Possible minor increase in heat load in valve box, minor increase in refrigerator load.	Normally open valve. Visual detection. Low level indication. Pressure Differential.

Affected Components:

Component #	Ring	Box	Nomenclature
H4501A L	B	6	ISOLATION S 4
H4601A	B	6	ISOLATION S 8
H6601A L	Y	6	ISOLATION S 4
H6701A	Y	6	ISOLATION S 8
H4801A L	B	8	ISOLATION S
H6801A L	Y	8	ISOLATION S
H5001A L	B	10	ISOLATION S
H7001A L	Y	10	ISOLATION S
H4001A L	B	12	ISOLATION S
H6001A L	Y	12	ISOLATION S

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 7

Item: 7

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open-Magnet Cooling Mode	No impact. Normal operating position.	Normally open valve. Visual detection.
Closed-Magnet Cooling Mode	No flow. Magnet temperature increase. Excess inventory needs to be stored.	Normally open valve. Visual detection. Elevated pressure/temperature. Temperature indicators. Storage capacity.
Open/ Closed-Heat Shield Mode	Increased pressure drop may reduce flow. Utility line provides alternate path. Recooler temperature increase with magnet temperature rise.	Normally open valve. Visual detection. Decreasing liquid level indication. Elevated temperature/pressure indication. Pressure differential. Minor increase in refrigerator load.

Affected Components:

Component #	Ring	Box	Nomenclature
H4504A L	B	6	ISOLATION R 4
H6604A L	Y	6	ISOLATION R 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 8

Item: 8

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Large quantity of cold gas flows to refrigerator causing severe imbalance. Magnet temperature rises. Circulator overspeed shutdown.	Manual valve. Visual detection. Elevated pressure/ temperature. Temperature & pressure indicators. Refrigerator alarms.
Closed	No impact. Normal Operating position.	None. Manual valve. Normal operation.

Affected Components:

Component #	Ring	Box	Nomenclature
H6823M	B	6	CIRC C3019 WARMUP SUPPLY
H6894M	Y	6	CIRC C3018 WARMUP SUPPLY

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 9

Item: 9

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Increased pressure drop may reduce flow. Utility line provides alternate path. Recooler temperature increase with magnet temperature rise.	Normally open valve. Visual detection. Decreasing liquid level indication. Elevated temperature/pressure indication. Pressure differential. Minor increase in refrigerator load.

Affected Components:

Component #	Ring	Box	Nomenclature
H4604A	B	6	ISOLATION R 8
H6704A	Y	6	ISOLATION R 8
H4804A L	B	8	ISOLATION R
H6804A L	Y	8	ISOLATION R
H5004A L	B	10	ISOLATION R
H7004A L	Y	10	ISOLATION R
H4004A L	B	12	ISOLATION R
H6004A L	Y	12	ISOLATION R

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 10

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Increased refrigerator demand. Refrigerator imbalance caused by unmodulated Supply gas going into Return. Refrigerator shutoff from ring.	Normally closed valve. Increasing liquid level. Increased refrigerator load.
Closed	Possible minor increase in heat load in valve box, minor increase in refrigerator load.	Normally closed valve. Low level indication. Elevated temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
H4209A	B	2	J T 225watt RECOOLER
H6224A	Y	2	J T 225watt RECOOLER
H4558A	B	6	J T 225watt RECOOLER
H6605A	Y	6	J T 225watt RECOOLER
H4809A	B	8	J T 225watt RECOOLER
H6809A	Y	8	J T 225watt RECOOLER
H5009A	B	10	J T 225watt RECOOLER
H7009A	Y	10	J T 225watt RECOOLER
H4073A	B	12	J T 225watt RECOOLER
H6009A	Y	12	J T 225watt RECOOLER

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Item: 11

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
N/A	No longer a separate component. Integrated with lead control.	

Affected Components:

Component #	Ring	Box	Nomenclature
FE4260H	B	2	FLOW CONTROL ELEMENT 10
FE4261H	B	2	FLOW CONTROL ELEMENT 9
FE4262H	B	2	FLOW CONTROL ELEMENT 8
FE4263H	B	2	FLOW CONTROL ELEMENT 7
FE4264H	B	2	FLOW CONTROL ELEMENT 12
FE4265H	B	2	FLOW CONTROL ELEMENT 5
FE4266H	B	2	FLOW CONTROL ELEMENT 4
FE4267H	B	2	FLOW CONTROL ELEMENT 3
FE4268H	B	2	FLOW CONTROL ELEMENT 2
FE4269H	B	2	FLOW CONTROL ELEMENT 1
FE6254H	Y	2	FLOW CONTROL ELEMENT 9
FE6255H	Y	2	FLOW CONTROL ELEMENT 8
FE6256H	Y	2	FLOW CONTROL ELEMENT 7
FE6257H	Y	2	FLOW CONTROL ELEMENT 5
FE6258H	Y	2	FLOW CONTROL ELEMENT 4
FE6259H	Y	2	FLOW CONTROL ELEMENT 2
FE6260H	Y	2	FLOW CONTROL ELEMENT 1
FE6261H	Y	2	FLOW CONTROL ELEMENT 10
FE6262H	Y	2	FLOW CONTROL ELEMENT 11
FE6263H	Y	2	FLOW CONTROL ELEMENT 3
FE4465H	B	4	FLOW CONTROL ELEMENT B10
FE4466H	B	4	FLOW CONTROL ELEMENT B9
FE4467H	B	4	FLOW CONTROL ELEMENT B8
FE4468H	B	4	FLOW CONTROL ELEMENT B7
FE4469H	B	4	FLOW CONTROL ELEMENT B6
FE4470H	B	4	FLOW CONTROL ELEMENT A11
FE4471H	B	4	FLOW CONTROL ELEMENT A9
FE4472H	B	4	FLOW CONTROL ELEMENT A8
FE4473H	B	4	FLOW CONTROL ELEMENT A6
FE4474H	B	4	FLOW CONTROL ELEMENT A5
FE4475H	B	4	FLOW CONTROL ELEMENT A4
FE4476H	B	4	FLOW CONTROL ELEMENT A2
FE4477H	B	4	FLOW CONTROL ELEMENT A1
FE6465H	Y	4	FLOW CONTROL ELEMENT 10
FE6466H	Y	4	FLOW CONTROL ELEMENT 9
FE6467H	Y	4	FLOW CONTROL ELEMENT 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 12

Component #	Ring	Box	Nomenclature
FE6468H	Y	4	FLOW CONTROL ELEMENT 7
FE6469H	Y	4	FLOW CONTROL ELEMENT 6
FE6470H	Y	4	FLOW CONTROL ELEMENT 5
FE6471H	Y	4	FLOW CONTROL ELEMENT 4
FE6472H	Y	4	FLOW CONTROL ELEMENT 3
FE6473H	Y	4	FLOW CONTROL ELEMENT 2
FE6474H	Y	4	FLOW CONTROL ELEMENT 1
FE6475H	Y	4	FLOW CONTROL ELEMENT 11
FE4005H	B	6	FLOW CONTROL ELEMENT 11
FE4006H	B	6	FLOW CONTROL ELEMENT 10
FE4007H	B	6	FLOW CONTROL ELEMENT 9
FE4008H	B	6	FLOW CONTROL ELEMENT 8
FE4009H	B	6	FLOW CONTROL ELEMENT 7
FE4080H	B	6	FLOW CONTROL ELEMENT 5
FE4081H	B	6	FLOW CONTROL ELEMENT 4
FE4082H	B	6	FLOW CONTROL ELEMENT 2
FE4083H	B	6	FLOW CONTROL ELEMENT 1
FE4096H	B	6	FLOW CONTROL ELEMENT 3
FE4000H	Y	6	FLOW CONTROL ELEMENT 9
FE4001H	Y	6	FLOW CONTROL ELEMENT 8
FE4002H	Y	6	FLOW CONTROL ELEMENT 7
FE4013H	Y	6	FLOW CONTROL ELEMENT 4
FE4014H	Y	6	FLOW CONTROL ELEMENT 2
FE4015H	Y	6	FLOW CONTROL ELEMENT 10
FE4016H	Y	6	FLOW CONTROL ELEMENT 1
FE4017H	Y	6	FLOW CONTROL ELEMENT 5
FE4018H	Y	6	FLOW CONTROL ELEMENT 11
FE6869H	Y	6	FLOW CONTROL ELEMENT 11
FE4860H	B	8	FLOW CONTROL ELEMENT 11
FE4861H	B	8	FLOW CONTROL ELEMENT 10
FE4862H	B	8	FLOW CONTROL ELEMENT 9
FE4863H	B	8	FLOW CONTROL ELEMENT 8
FE4864H	B	8	FLOW CONTROL ELEMENT 7
FE4865H	B	8	FLOW CONTROL ELEMENT 5
FE4866H	B	8	FLOW CONTROL ELEMENT 4
FE4867H	B	8	FLOW CONTROL ELEMENT 2
FE4868H	B	8	FLOW CONTROL ELEMENT 1
FE4869H	B	8	FLOW CONTROL ELEMENT 3
FE6860H	Y	8	FLOW CONTROL ELEMENT 9
FE6861H	Y	8	FLOW CONTROL ELEMENT 8
FE6862H	Y	8	FLOW CONTROL ELEMENT 7
FE6863H	Y	8	FLOW CONTROL ELEMENT 6
FE6864H	Y	8	FLOW CONTROL ELEMENT 4
FE6865H	Y	8	FLOW CONTROL ELEMENT 2
FE6866H	Y	8	FLOW CONTROL ELEMENT 10
FE6867H	Y	8	FLOW CONTROL ELEMENT 1
FE6868H	Y	8	FLOW CONTROL ELEMENT 5
FE5160H	B	10	FLOW CONTROL ELEMENT B11

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Component #	Ring	Box	Nomenclature
FE5161H	B	10	FLOW CONTROL ELEMENT B10
FE5162H	B	10	FLOW CONTROL ELEMENT B9
FE5163H	B	10	FLOW CONTROL ELEMENT B2
FE5164H	B	10	FLOW CONTROL ELEMENT B4
FE5165H	B	10	FLOW CONTROL ELEMENT B7
FE5166H	B	10	FLOW CONTROL ELEMENT A11
FE5167H	B	10	FLOW CONTROL ELEMENT A9
FE5168H	B	10	FLOW CONTROL ELEMENT A8
FE5169H	B	10	FLOW CONTROL ELEMENT A6
FE5170H	B	10	FLOW CONTROL ELEMENT A5
FE5171H	B	10	FLOW CONTROL ELEMENT A4
FE5172H	B	10	FLOW CONTROL ELEMENT A2
FE5173H	B	10	FLOW CONTROL ELEMENT A1
FE5174H	B	10	FLOW CONTROL ELEMENT B7
FE5175H	B	10	FLOW CONTROL ELEMENT A10
FE5200H	B	10	FLOW CONTROL ELEMENT B8
FE7060H	Y	10	FLOW CONTROL ELEMENT B10
FE7061H	Y	10	FLOW CONTROL ELEMENT B9
FE7062H	Y	10	FLOW CONTROL ELEMENT B8
FE7063H	Y	10	FLOW CONTROL ELEMENT B7
FE7064H	Y	10	FLOW CONTROL ELEMENT B6
FE7065H	Y	10	FLOW CONTROL ELEMENT B11
FE7066H	Y	10	FLOW CONTROL ELEMENT A11
FE7067H	Y	10	FLOW CONTROL ELEMENT A9
FE7068H	Y	10	FLOW CONTROL ELEMENT A8
FE7069H	Y	10	FLOW CONTROL ELEMENT A6
FE7070H	Y	10	FLOW CONTROL ELEMENT A5
FE7071H	Y	10	FLOW CONTROL ELEMENT A4
FE7072H	Y	10	FLOW CONTROL ELEMENT A2
FE7073H	Y	10	FLOW CONTROL ELEMENT A1
FE4074H	B	12	FLOW CONTROL ELEMENT 11
FE4075H	B	12	FLOW CONTROL ELEMENT 10
FE4076H	B	12	FLOW CONTROL ELEMENT 9
FE4077H	B	12	FLOW CONTROL ELEMENT 8
FE4078H	B	12	FLOW CONTROL ELEMENT 7
FE4079H	B	12	FLOW CONTROL ELEMENT 5
FE4091H	B	12	FLOW CONTROL ELEMENT 4
FE4092H	B	12	FLOW CONTROL ELEMENT 2
FE4093H	B	12	FLOW CONTROL ELEMENT 1
FE4094H	B	12	FLOW CONTROL ELEMENT 3
FE6059H	Y	12	FLOW CONTROL ELEMENT 9
FE6060H	Y	12	FLOW CONTROL ELEMENT 8
FE6061H	Y	12	FLOW CONTROL ELEMENT 7
FE6062H	Y	12	FLOW CONTROL ELEMENT 6
FE6063H	Y	12	FLOW CONTROL ELEMENT 4
FE6064H	Y	12	FLOW CONTROL ELEMENT 2
FE6065H	Y	12	FLOW CONTROL ELEMENT 10
FE6066H	Y	12	FLOW CONTROL ELEMENT 1

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Component #	Ring	Box	Nomenclature
FE6067H	Y	12	FLOW CONTROL ELEMENT 5
FE6068H	Y	12	FLOW CONTROL ELEMENT 11

Failure Mode Effects Analysis

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
None	Shaped pipe. Has no normally anticipated failure modes.	

Affected Components:

Component #	Ring	Box	Nomenclature
FE4011H	B	6	VENTURI FLOW 200 g/sec He @ 4k
FE4010H	Y	6	VENTURI FLOW 200 g/sec He @ 4k

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Continuous lead flow. Increased refrigerator heat load.	Minor helium leak. Minor increase in refrigerator output.
Closed	No impact. No lead cooling. Leads not energized.	Electronic output.

Affected Components:

Component #	Ring	Box	Nomenclature
H4455E	B	4	LEAD CONTROL B10
H4456E	B	4	LEAD CONTROL B9
H4457E	B	4	LEAD CONTROL B8
H4458E	B	4	LEAD CONTROL B7
H4459E	B	4	LEAD CONTROL B6
H4460E	B	4	LEAD CONTROL A11
H4461E	B	4	LEAD CONTROL A9
H4462E	B	4	LEAD CONTROL A8
H4465E	B	4	LEAD CONTROL A6
H4466E	B	4	LEAD CONTROL A5
H4467E	B	4	LEAD CONTROL A4
H4468E	B	4	LEAD CONTROL A2
H4469E	B	4	LEAD CONTROL A1
H6453E	Y	4	LEAD CONTROL 10
H6454E	Y	4	LEAD CONTROL 9
H6455E	Y	4	LEAD CONTROL 8
H6456E	Y	4	LEAD CONTROL 7
H6457E	Y	4	LEAD CONTROL 6
H6458E	Y	4	LEAD CONTROL 5
H6459E	Y	4	LEAD CONTROL 4
H6460E	Y	4	LEAD CONTROL 3
H6472E	Y	4	LEAD CONTROL 2
H6473E	Y	4	LEAD CONTROL 1
H6474E	Y	4	LEAD CONTROL 11
H4513E	B	6	LEAD CONTROL 11
H4514E	B	6	LEAD CONTROL 10
H4518E	B	6	LEAD CONTROL 9
H4519E	B	6	LEAD CONTROL 8
H4523E	B	6	LEAD CONTROL 7
H4547E	B	6	LEAD CONTROL 5

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Component #	Ring	Box	Nomenclature
H4548E	B	6	LEAD CONTROL 4
H4549E	B	6	LEAD CONTROL 2
H4550E	B	6	LEAD CONTROL 1
H6613E	Y	6	LEAD CONTROL 9
H6614E	Y	6	LEAD CONTROL 8
H6618E	Y	6	LEAD CONTROL 7
H6627E	Y	6	LEAD CONTROL 2
H6628E	Y	6	LEAD CONTROL 10
H6629E	Y	6	LEAD CONTROL 1
H6632E	Y	6	LEAD CONTROL 11
H4855E	B	8	LEAD CONTROL 11
H4856E	B	8	LEAD CONTROL 10
H4857E	B	8	LEAD CONTROL 9
H4858E	B	8	LEAD CONTROL 8
H4859E	B	8	LEAD CONTROL 7
H4860E	B	8	LEAD CONTROL 5
H4862E	B	8	LEAD CONTROL 4
H4863E	B	8	LEAD CONTROL 2
H4864E	B	8	LEAD CONTROL 1
H6855E	Y	8	LEAD CONTROL 9
H6856E	Y	8	LEAD CONTROL 8
H6857E	Y	8	LEAD CONTROL 7
H6858E	Y	8	LEAD CONTROL 6
H6868E	Y	8	LEAD CONTROL 2
H6869E	Y	8	LEAD CONTROL 10
H6870E	Y	8	LEAD CONTROL 1
H6883E	Y	8	LEAD CONTROL 11
H5049E	B	10	LEAD CONTROL B11
H5050E	B	10	LEAD CONTROL B10
H5051E	B	10	LEAD CONTROL B9
H5052E	B	10	LEAD CONTROL B2
H5053E	B	10	LEAD CONTROL B4
H5055E	B	10	LEAD CONTROL B7
H5056E	B	10	LEAD CONTROL A11
H5057E	B	10	LEAD CONTROL A9
H5058E	B	10	LEAD CONTROL A8
H5059E	B	10	LEAD CONTROL A6
H5084E	B	10	LEAD CONTROL A5
H5085E	B	10	LEAD CONTROL A4
H5086E	B	10	LEAD CONTROL A2
H5087E	B	10	LEAD CONTROL A1
H5088E	B	10	LEAD CONTROL A7
H5089E	B	10	LEAD CONTROL A10
H7055E	Y	10	LEAD CONTROL B10
H7056E	Y	10	LEAD CONTROL B9
H7057E	Y	10	LEAD CONTROL B8
H7058E	Y	10	LEAD CONTROL B7
H7059E	Y	10	LEAD CONTROL B6

Failure Mode Effects Analysis

System: RHIC Cryogenic System

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Component #	Ring	Box	Nomenclature
H7060E	Y	10	LEAD CONTROL B11
H7061E	Y	10	LEAD CONTROL A11
H7063E	Y	10	LEAD CONTROL A9
H7071E	Y	10	LEAD CONTROL A8
H7072E	Y	10	LEAD CONTROL A6
H7073E	Y	10	LEAD CONTROL A5
H7074E	Y	10	LEAD CONTROL A4
H7075E	Y	10	LEAD CONTROL A2
H7087E	Y	10	LEAD CONTROL A1
H4064E	B	12	LEAD CONTROL 11
H4065E	B	12	LEAD CONTROL 10
H4066E	B	12	LEAD CONTROL 9
H4067E	B	12	LEAD CONTROL 8
H4068E	B	12.	LEAD CONTROL 7
H4074E	B	12	LEAD CONTROL 5
H4075E	B	12	LEAD CONTROL 4
H4076E	B	12	LEAD CONTROL 2
H4077E	B	12	LEAD CONTROL 1
H6046E	Y	12	LEAD CONTROL 9
H6047E	Y	12	LEAD CONTROL 8
H6048E	Y	12	LEAD CONTROL 7
H6049E	Y	12	LEAD CONTROL 6
H6074E	Y	12	LEAD CONTROL 2
H6075E	Y	12	LEAD CONTROL 10
H6076E	Y	12	LEAD CONTROL 1
H6100E	Y	12	LEAD CONTROL 11

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Minor increase in refrigerator heat load.	Minor helium leak. Minor increase in refrigerator output.
Closed	Line bursts, with loss of insulating vacuum (internal line) or pressure indicator failure (external line). Internal line burst will cause helium to escape into Power Supply building through vacuum tank relief valve.	Elevated pressure/temperature. Temperature indicators. Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4207R	B	2	RELIEF H4205M~H4200A
H4248R	B	2	RELIEF H4220A~H4221A
H4249R	B	2	RELIEF H4218M~H4201A
H6248R	Y	2	RELIEF H6220A~H6221A
H6255R	Y	2	RELIEF H6254M~H6201A
H6258R	Y	2	RELIEF H6253M~H6200A
H4413R	B	4	RELIEF H4407M~H4400A
H4446R	B	4	RELIEF H4415A~H4416A
H4447R	B	4	RELIEF H4410A~H4411A
H6413R	Y	4	RELIEF H6400A~H6405M
H6442R	Y	4	RELIEF H6415A~H6416A
H6443R	Y	4	RELIEF H6410A~H6411A
H3090R	B	6	CIRCULATOR C3019 RELIEF
H3091R	B	6	RELIEF H4602A~H4645A H 8
H3092R	B	6	RELIEF H4641A~H4500A
H3093R	B	6	RELIEF H4516A~H4616A S BYPASS
H3094R	B	6	RELIEF H4534M~H4614M S
H3095R	B	6	RELIEF H4503A~H4603A U
H3096R	B	6	RELIEF H4504A~H4604A R
H3097R	B	6	RELIEF H4502A~H4510A H 4
H3109R	B	6	RELIEF H4620A~H4621A
H3110R	B	6	RELIEF H4510A~H4511A
H3111R	B	6	RELIEF H4515A~H4516A
H3112R	B	6	RELIEF H4615A~H4616A
H3113R	B	6	RELIEF H4520A~H4521A
H3231R	B	6	RELIEF H4536A~H4636A R BYPASS
H3232R	B	6	RELIEF H4501A~H4534M
H3235R	B	6	RELIEF H4600A~H4618M
H6471R	B	6	RELIEF H4500A~H6733M
H6813R	B	6	RELIEF H4601A~H4614M

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Component #	Ring	Box	Nomenclature
H3076R	Y	6	RELIEF H6702A~H6745A H 8
H3077R	Y	6	RELIEF H6740A~H6600A
H3078R	Y	6	RELIEF H6616A~H6716A S BYPASS
H3079R	Y	6	RELIEF H6609M~H6705M S
H3080R	Y	6	RELIEF H6603A~H6703A U
H3081R	Y	6	RELIEF H6604A~H6704A R
H3082R	Y	6	RELIEF H6602A~H6610A H 4
H3088R	Y	6	CIRCULATOR C3018 RELIEF
H3104R	Y	6	RELIEF H6720A~H6721A
H3105R	Y	6	RELIEF H6610A~H6611A
H3106R	Y	6	RELIEF H6615A~H6616A
H3107R	Y	6	RELIEF H6715A~H6716A
H3108R	Y	6	RELIEF H6620A~H6621A
H3114R	Y	6	RELIEF H6636A~H6736A R BYPASS
H3115R	Y	6	RELIEF H6701A~H6705M
H6642R	Y	6	RELIEF H6600A~H6623M
H6805R	Y	6	RELIEF H6601A~H6609M
H6807R	Y	6	RELIEF H6700A~H6707M
H4807R	B	8	RELIEF H4800A~H4831M
H4832R	B	8	RELIEF H4810A~H4811A
H4846R	B	8	RELIEF H4820A~H4821A
H4847R	B	8	RELIEF H4801A~H4805M
H4848R	B	8	RELIEF H4815A~H4816A
H6846R	Y	8	RELIEF H6820A~H6821A
H6847R	Y	8	RELIEF H6810A~H6811A
H6848R	Y	8	RELIEF H6815A~H6816A
H6863R	Y	8	RELIEF H6800A~H6859M
H6864R	Y	8	RELIEF H6801A~H6860M
H5032R	B	10	RELIEF H5283M~H5001A
H5046R	B	10	RELIEF H5020A~H5021A
H5047R	B	10	RELIEF H5010A~H5011A
H5048R	B	10	RELIEF H5015A~H5016A
H5282R	B	10	RELIEF H5284M~H5000A
H7046R	Y	10	RELIEF H7020A~H7021A
H7047R	Y	10	RELIEF H7010A~H7011A
H7048R	Y	10	RELIEF H7015A~H7016A
H7065R	Y	10	RELIEF H7000A~H7067A
H7068R	Y	10	RELIEF H7001A~H7066M
H4012R	B	12	RELIEF H4000A~H4007A
H4018R	B	12	RELIEF H4005A~H4001A
H4053R	B	12	RELIEF H4035A~H4039A
H4054R	B	12	RELIEF H4020A~H4021A
H4055R	B	12	RELIEF H4010A~H4011A
H4056R	B	12	RELIEF H4015A~H4016A
H6029R	Y	12	RELIEF H6000A~H6056A
H6044R	Y	12	RELIEF H6015A~H6016A
H6045R	Y	12	RELIEF H6010A~H6011A
H6054R	Y	12	RELIEF H6001A~H6055A

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Component #	Ring	Box	Nomenclature
H6058R	Y	12	RELIEF H6020A~H6021A
H6072R	Y	12	RELIEF H6007A~H6070A

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vent to atmosphere. Unacceptable leak, with depletion of helium inventory.	Elevated temperature/low pressure. Frosted valve.
Closed	No impact. Relief on opposite end of magnet string is adequate	Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4241R	B	2	RELIEF LINE M 12
H4242R	B	2	RELIEF LINE S 12
H4243R	B	2	RELIEF LINE H 12
H4244R	B	2	RELIEF LINE U 12
H4245R	B	2	RELIEF LINE R 12
H6241R	Y	2	RELIEF LINE M 12
H6242R	Y	2	RELIEF LINE S 12
H6243R	Y	2	RELIEF LINE H 12
H6244R	Y	2	RELIEF LINE U 12
H6245R	Y	2	RELIEF LINE R 12
H4436R	B	4	RELIEF LINE M 6
H4437R	B	4	RELIEF LINE S 6
H4438R	B	4	RELIEF LINE H 6
H4439R	B	4	RELIEF LINE U 6
H4440R	B	4	RELIEF LINE R 6
H6432R	Y	4	RELIEF LINE M 6
H6433R	Y	4	RELIEF LINE S 6
H6434R	Y	4	RELIEF LINE H 6
H6435R	Y	4	RELIEF LINE U 6
H6436R	Y	4	RELIEF LINE R 6
H3098R	B	6	RELIEF LINE M 4
H3099R	B	6	RELIEF LINE H 4
H3100R	B	6	RELIEF LINE S 4
H3102R	B	6	RELIEF LINE R 4
H3103R	B	6	RELIEF LINE U 4
H4609R	B	6	RELIEF LINE M 8
H4610R	B	6	RELIEF LINE S 8
H4611R	B	6	RELIEF LINE H 8
H4612R	B	6	RELIEF LINE U 8
H4613R	B	6	RELIEF LINE R 8

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Component #	Ring	Box	Nomenclature
H3083R	Y	6	RELIEF LINE M 4
H3084R	Y	6	RELIEF LINE S 4
H3085R	Y	6	RELIEF LINE H 4
H3086R	Y	6	RELIEF LINE U 4
H3087R	Y	6	RELIEF LINE R 4
H6746R	Y	6	RELIEF LINE M 8
H6747R	Y	6	RELIEF LINE S 8
H6748R	Y	6	RELIEF LINE H 8
H6749R	Y	6	RELIEF LINE U 8
H6750R	Y	6	RELIEF LINE R 8
H4836R	B	8	RELIEF LINE M 10
H4837R	B	8	RELIEF LINE S 10
H4838R	B	8	RELIEF LINE H 10
H4839R	B	8	RELIEF LINE U 10
H4840R	B	8	RELIEF LINE R 10
H4841R	B	8	RELIEF LINE M 6
H4842R	B	8	RELIEF LINE S 6
H4843R	B	8	RELIEF LINE H 6
H4844R	B	8	RELIEF LINE U 6
H4845R	B	8	RELIEF LINE R 6
H6836R	Y	8	RELIEF LINE M 10
H6837R	Y	8	RELIEF LINE S 10
H6838R	Y	8	RELIEF LINE H 10
H6839R	Y	8	RELIEF LINE U 10
H6840R	Y	8	RELIEF LINE R 10
H6841R	Y	8	RELIEF LINE M 6
H6842R	Y	8	RELIEF LINE S 6
H6843R	Y	8	RELIEF LINE H 6
H6844R	Y	8	RELIEF LINE U 6
H6845R	Y	8	RELIEF LINE R 6
H5036R	B	10	RELIEF LINE M 12
H5037R	B	10	RELIEF LINE S 12
H5038R	B	10	RELIEF LINE H 12
H5039R	B	10	RELIEF LINE U 12
H5040R	B	10	RELIEF LINE R 12
H5041R	B	10	RELIEF LINE M 8
H5042R	B	10	RELIEF LINE S 8
H5043R	B	10	RELIEF LINE H 8
H5044R	B	10	RELIEF LINE U 8
H5045R	B	10	RELIEF LINE R 8
H7036R	Y	10	RELIEF LINE M 12
H7037R	Y	10	RELIEF LINE S 12
H7038R	Y	10	RELIEF LINE H 12
H7039R	Y	10	RELIEF LINE U 12
H7040R	Y	10	RELIEF LINE R 12
H7041R	Y	10	RELIEF LINE M 8
H7042R	Y	10	RELIEF LINE S 8
H7043R	Y	10	RELIEF LINE H 8

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Component #	Ring	Box	Nomenclature
H7044R	Y	10	RELIEF LINE U 8
H7045R	Y	10	RELIEF LINE R 8
H4043R	B	12	RELIEF LINE M 2
H4044R	B	12	RELIEF LINE S 2
H4045R	B	12	RELIEF LINE H 2
H4046R	B	12	RELIEF LINE U 2
H4047R	B	12	RELIEF LINE R 2
H4048R	B	12	RELIEF LINE M 10
H4049R	B	12	RELIEF LINE S 10
H4051R	B	12	RELIEF LINE U 10
H4052R	B	12	RELIEF LINE R 10
H4057R	B	12	RELIEF LINE H 10
H6032R	Y	12	RELIEF LINE M 2
H6033R	Y	12	RELIEF LINE S 2
H6034R	Y	12	RELIEF LINE H 2
H6035R	Y	12	RELIEF LINE U 2
H6038R	Y	12	RELIEF LINE R 2
H6039R	Y	12	RELIEF LINE M 10
H6040R	Y	12	RELIEF LINE S 10
H6041R	Y	12	RELIEF LINE H 10
H6042R	Y	12	RELIEF LINE U 10
H6043R	Y	12	RELIEF LINE R 10

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Headers open to warm Return. Vent checkvalve prevents flow.	Detectable only with individual test.
Closed	No impact. Headers open to Return.	Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4227R	B	2	VENT RELIEF 4
H6452R	Y	4	VENT RELIEF 6
H4623R	B	6	VENT RELIEF 8
H6723R	Y	6	VENT RELIEF 8
H4827R	B	8	VENT RELIEF 10
H5027R	B	10	VENT RELIEF 12
H7027R	Y	10	VENT RELIEF 12
H4061R	B	12	VENT RELIEF 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Instrumentation only with redundant sensors.	Temperature indication unreasonably high.
Full Scale Low	No impact. Instrumentation only with redundant sensors.	Zero temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
TI4253H	B	2	CALIBRATED SNSR RECL IN
TI4254H	B	2	CALIBRATED SNSR RECL OUT
TI4255H	B	2	SNSR RECLR LIQUID LI4252
TI4265H	B	2	CALIBRATED SENSOR S 12
TI4266H	B	2	CALIBRATED SENSOR H 12
TI4267H	B	2	CALIBRATED SENSOR U 12
TI4268H	B	2	CALIBRATED SENSOR R 12
TI4410H	B	2	CALIBRATED SENSOR R 12 OUT
TI4411H	B	2	CALIBRATED SENSOR U 12 OUT
TI4412H	B	2	CALIBRATED SENSOR H 12 OUT
TI4413H	B	2	CALIBRATED SENSOR S 12 OUT
TI4414H	B	2	CALIBRATED SENSOR M 12 OUT
TI6246H	Y	2	CALIBRATED SENSOR R 12 OUT
TI6247H	Y	2	CALIBRATED SENSOR U 12 OUT
TI6248H	Y	2	CALIBRATED SENSOR H 12 OUT
TI6249H	Y	2	CALIBRATED SENSOR S 12 OUT
TI6250H	Y	2	CALIBRATED SENSOR M 12 OUT
TI6251H	Y	2	CALIBRATED SNSR RECL IN
TI6252H	Y	2	CALIBRATED SNSR RECL OUT
TI6258H	Y	2	SNSR RECLR LIQUID LI6253
TI6263H	Y	2	CALIBRATED SENSOR S 12
TI6264H	Y	2	CALIBRATED SENSOR H 12
TI6265H	Y	2	CALIBRATED SENSOR U 12
TI6266H	Y	2	CALIBRATED SENSOR R 12
TI4479H	B	4	CALIBRATED SENSOR R 6 IN
TI4480H	B	4	CALIBRATED SENSOR U 6 IN
TI4481H	B	4	CALIBRATED SENSOR H 6 IN
TI4482H	B	4	CALIBRATED SENSOR S 6 IN
TI4483H	B	4	CALIBRATED SENSOR M 6 IN
TI6491H	Y	4	CALIBRATED SENSOR R 6 IN

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 27

Component #	Ring	Box	Nomenclature
TI6492H	Y	4	CALIBRATED SENSOR U 6 IN
TI6493H	Y	4	CALIBRATED SENSOR H 6 IN
TI6494H	Y	4	CALIBRATED SENSOR S 6 IN
TI6495H	Y	4	CALIBRATED SENSOR M 6 IN
TI3709H	B	6	CALIBRATED SNSR L. P. OUT
TI3710H	B	6	CALIBRATED SNSR CIRC IN
TI3711H	B	6	CALIBRATED SNSR CIRC OUT
TI3714H	B	6	CALIBRATED SNSR RECL OUT
TI3804H	B	6	CALIBRATED SENSOR CIRC OUTLET
TI4002H	B	6	SNSR RECLR LIQUID LI4001
TI4600H	B	6	CALIBRATED SENSOR S 8
TI4601H	B	6	CALIBRATED SENSOR H 8
TI4602H	B	6	CALIBRATED SENSOR U 8
TI4603H	B	6	CALIBRATED SENSOR R 8
TI4604H	B	6	CALIBRATED SENSOR S 4
TI4605H	B	6	CALIBRATED SENSOR H 4
TI4606H	B	6	CALIBRATED SENSOR U 4
TI4607H	B	6	CALIBRATED SENSOR R 4
TI4608H	B	6	CALIBRATED SENSOR S IN
TI4609H	B	6	CALIBRATED SENSOR R OUT
TI4610H	B	6	CALIBRATED SENSOR CR OUT
TI4611H	B	6	CALIBRATED SENSOR HS IN
TI4612H	B	6	CALIBRATED SENSOR HR OUT
TI3705H	Y	6	CALIBRATED SNSR L. P. OUT
TI3706H	Y	6	CALIBRATED SNSR CIRC IN
TI3707H	Y	6	CALIBRATED SNSR CIRC OUT
TI3713H	Y	6	CALIBRATED SNSR RECL OUT
TI3806H	Y	6	CALIBRATED SENSOR CIRC OUTLET
TI4805H	Y	6	CALIBRATED SENSOR M 10 IN
TI6605H	Y	6	SNSR RECLR LIQUID LI4000
TI6700H	Y	6	CALIBRATED SENSOR S 8
TI6701H	Y	6	CALIBRATED SENSOR H 8
TI6702H	Y	6	CALIBRATED SENSOR U 8
TI6703H	Y	6	CALIBRATED SENSOR R 8
TI6704H	Y	6	CALIBRATED SENSOR S 4
TI6705H	Y	6	CALIBRATED SENSOR H 4
TI6706H	Y	6	CALIBRATED SENSOR U 4
TI6707H	Y	6	CALIBRATED SENSOR R 4
TI6708H	Y	6	CALIBRATED SENSOR S IN
TI6709H	Y	6	CALIBRATED SENSOR R OUT
TI6710H	Y	6	CALIBRATED SENSOR CR OUT
TI6711H	Y	6	CALIBRATED SENSOR HS IN
TI6712H	Y	6	CALIBRATED SENSOR HR OUT
TI4801H	B	8	CALIBRATED SENSOR R 10
TI4802H	B	8	CALIBRATED SENSOR U 10
TI4803H	B	8	CALIBRATED SENSOR H 10
TI4804H	B	8	CALIBRATED SENSOR S 10
TI4806	B	8	CALIBRATED SENSOR R 6 OUT

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Component #	Ring	Box	Nomenclature
TI4807H	B	8	CALIBRATED SENSOR U 6 OUT
TI4808H	B	8	CALIBRATED SENSOR H 6 OUT
TI4809H	B	8	CALIBRATED SENSOR S 6 OUT
TI4810H	B	8	CALIBRATED SENSOR M 6 OUT
TI4853H	B	8	CALIBRATED SNSR RECL IN
TI4854H	B	8	CALIBRATED SNSR RECL OUT
TI4855H	B	8	SNSR RECLR LIQUID LI4852
TI4865H	B	8	CALIBRATED SENSOR S 6
TI4866H	B	8	CALIBRATED SENSOR H 6
TI4867H	B	8	CALIBRATED SENSOR U 6
TI4868H	B	8	CALIBRATED SENSOR R 6
TI6801H	Y	8	CALIBRATED SENSOR R 10
TI6802H	Y	8	CALIBRATED SENSOR U 10
TI6803H	Y	8	CALIBRATED SENSOR H 10
TI6804H	Y	8	CALIBRATED SENSOR S 10
TI6805H	Y	8	CALIBRATED SENSOR M 10 IN
TI6806H	Y	8	CALIBRATED SENSOR R 6 OUT
TI6807H	Y	8	CALIBRATED SENSOR U 6 OUT
TI6808H	Y	8	CALIBRATED SENSOR H 6 OUT
TI6809H	Y	8	CALIBRATED SENSOR S 6 OUT
TI6810H	Y	8	CALIBRATED SENSOR M 6 OUT
TI6853H	Y	8	CALIBRATED SNSR RECL IN
TI6854H	Y	8	CALIBRATED SNSR RECL OUT
TI6860H	Y	8	SNSR RECLR LIQUID LI6852
TI6865H	Y	8	CALIBRATED SENSOR S 6
TI6866H	Y	8	CALIBRATED SENSOR H 6
TI6867H	Y	8	CALIBRATED SENSOR U 6
TI6868H	Y	8	CALIBRATED SENSOR R 6
TI5053H	B	10	CALIBRATED SNSR RECL IN
TI5054H	B	10	CALIBRATED SNSR RECL OUT
TI5087H	B	10	SNSR RECLR LIQUID LI5052
TI5097H	B	10	CALIBRATED SENSOR S 8
TI5098H	B	10	CALIBRATED SENSOR H 8
TI5099H	B	10	CALIBRATED SENSOR U 8
TI5100H	B	10	CALIBRATED SENSOR R 8
TI5301H	B	10	CALIBRATED SENSOR R 12
TI5302H	B	10	CALIBRATED SENSOR U 12
TI5303H	B	10	CALIBRATED SENSOR H 12
TI5304H	B	10	CALIBRATED SENSOR S 12
TI5305H	B	10	CALIBRATED SENSOR M 12 IN
TI5306H	B	10	CALIBRATED SENSOR R 8 OUT
TI5307H	B	10	CALIBRATED SENSOR U 8 OUT
TI5308H	B	10	CALIBRATED SENSOR H 8 OUT
TI5309H	B	10	CALIBRATED SENSOR S 8 OUT
TI5310H	B	10	CALIBRATED SENSOR M 8 OUT
TI7001H	Y	10	CALIBRATED SENSOR R 12
TI7002H	Y	10	CALIBRATED SENSOR U 12
TI7003H	Y	10	CALIBRATED SENSOR H 12

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Component #	Ring	Box	Nomenclature
TI7004H	Y	10	CALIBRATED SENSOR S 12
TI7005H	Y	10	CALIBRATED SENSOR M 12 IN
TI7006H	Y	10	CALIBRATED SENSOR R 8 OUT
TI7007H	Y	10	CALIBRATED SENSOR U 8 OUT
TI7008H	Y	10	CALIBRATED SENSOR H 8 OUT
TI7009H	Y	10	CALIBRATED SENSOR S 8 OUT
TI7010H	Y	10	CALIBRATED SENSOR M 8 OUT
TI7053H	Y	10	CALIBRATED SNSR RECL IN
TI7054H	Y	10	CALIBRATED SNSR RECL OUT
TI7055H	Y	10	SNSR RECLR LIQUID LI7052
TI7065H	Y	10	CALIBRATED SENSOR S 8
TI7066H	Y	10	CALIBRATED SENSOR H 8
TI7067H	Y	10	CALIBRATED SENSOR U 8
TI7068H	Y	10	CALIBRATED SENSOR R 8
TI4014H	B	12	SNSR RECLR LIQUID LI4079
TI4056H	B	12	CALIBRATED SENSOR S 10
TI4057H	B	12	CALIBRATED SENSOR H 10
TI4058H	B	12	CALIBRATED SENSOR U 10
TI4059H	B	12	CALIBRATED SENSOR R 10
TI4080H	B	12	CALIBRATED SNSR RECL IN
TI4081H	B	12	CALIBRATED SNSR RECL OUT
TI4221H	B	12	CALIBRATED SENSOR R 2 IN
TI4222H	B	12	CALIBRATED SENSOR U 2 IN
TI4223H	B	12	CALIBRATED SENSOR H 2 IN
TI4224H	B	12	CALIBRATED SENSOR S 2 IN
TI4225H	B	12	CALIBRATED SENSOR M 2 IN
TI4226H	B	12	CALIBRATED SENSOR R 10 OUT
TI4227H	B	12	CALIBRATED SENSOR U 10 OUT
TI4228H	B	12	CALIBRATED SENSOR H 10 OUT
TI4229H	B	12	CALIBRATED SENSOR S 10 OUT
TI4230H	B	12	CALIBRATED SENSOR M 10 OUT
TI6001H	Y	12	CALIBRATED SENSOR R 2 IN
TI6002H	Y	12	CALIBRATED SENSOR U 2 IN
TI6003H	Y	12	CALIBRATED SENSOR H 2 IN
TI6004H	Y	12	CALIBRATED SENSOR S 2 IN
TI6005H	Y	12	CALIBRATED SENSOR M 2 IN
TI6006H	Y	12	CALIBRATED SENSOR R 2 OUT
TI6007H	Y	12	CALIBRATED SENSOR U 2 OUT
TI6008H	Y	12	CALIBRATED SENSOR H 2 OUT
TI6009H	Y	12	CALIBRATED SENSOR S 2 OUT
TI6010H	Y	12	CALIBRATED SENSOR M 2 OUT
TI6055H	Y	12	CALIBRATED SNSR RECL IN
TI6056H	Y	12	CALIBRATED SNSR RECL OUT
TI6057H	Y	12	SNSR RECLR LIQUID LI6057
TI6067H	Y	12	CALIBRATED SENSOR S 10
TI6068H	Y	12	CALIBRATED SENSOR H 10
TI6069H	Y	12	CALIBRATED SENSOR U 10
TI6070H	Y	12	CALIBRATED SENSOR R 10

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Pressure indicator failure. Minor cold gas leak. Minor increase in refrigerator heat load. Can be shut off with manual valve.	Visual detection. Frosted Component. Minor helium leak. Minor increase in refrigerator output.
Closed	No impact. Instrumentation only. Burst pressure over 300 psia.	Static pressure indication, inconsistent with other adjacent pressures.
Full Scale High	No impact. Instrumentation only, with adjacent sensors available.	High/Full scale pressure indication.
Full Scale Low	No impact. Instrumentation only with adjacent sensors available.	Zero/Low pressure indication.

Affected Components:

Component #	Ring	Box	Nomenclature
PI3733H	B	2	PRESSURE TRANSDUCER M 12
PI3734H	B	2	PRESSURE TRANSDUCER S 12
PI3735H	B	2	PRESSURE TRANSDUCER H 12
PI3736H	B	2	PRESSURE TRANSDUCER U 12
PI3737H	B	2	PRESSURE TRANSDUCER R 12
PI4251H	B	2	PRESSURE TRANSDUCER M 4
PI4252H	B	2	PRESSURE TRANSDUCER H~U 12
PI4253H	B	2	PRESSURE TRANSDUCER S 4
PI3751H	Y	2	PRESSURE TRANSDUCER M 12
PI3752H	Y	2	PRESSURE TRANSDUCER S 12
PI3753H	Y	2	PRESSURE TRANSDUCER H 12
PI3754H	Y	2	PRESSURE TRANSDUCER U 12
PI3755H	Y	2	PRESSURE TRANSDUCER R 12
PI6250H	Y	2	PRESSURE TRANSDUCER M 4
PI6251H	Y	2	PRESSURE TRANSDUCER H~U 12
PI6252H	Y	2	PRESSURE TRANSDUCER S 4
PI4449H	B	4	PRESSURE TRANSDUCER S~H
PI4450H	B	4	PRESSURE TRANSDUCER H~U 6
PI4451H	B	4	PRESSURE TRANSDUCER M 6

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Component #	Ring	Box	Nomenclature
PI6413H	Y	4	PRESSURE TRANSDUCER S~H
PI6418H	Y	4	PRESSURE TRANSDUCER H~U 6
PI6424H	Y	4	PRESSURE TRANSDUCER M 6
PI3709H	B	6	PRESSURE TRANSDUCER H~U 8
PI3710H	B	6	PRESSURE TRANSDUCER S BYPASS 8
PI3711H	B	6	PRESSURE TRANSDUCER S BYPASS 4
PI3712H	B	6	PRESSURE TRANSDUCER H~U MID
PI3713H	B	6	PRESSURE TRANSDUCER H~U 4
PI3718H	B	6	PRESSURE TRANSDUCER M 4
PI3719H	B	6	PRESSURE TRANSDUCER S 4
PI3720H	B	6	PRESSURE TRANSDUCER H
PI3721H	B	6	PRESSURE TRANSDUCER U
PI3722H	B	6	PRESSURE TRANSDUCER R
PI3742H	B	6	PRESSURE TRANSDUCER M MID
PI3743H	B	6	PRESSURE TRANSDUCER S MID
PI3744H	B	6	PRESSURE TRANSDUCER CIRC BYPASS
PI3745H	B	6	PRESSURE TRANSDUCER S 8
PI3704H	Y	6	PRESSURE TRANSDUCER H~U 8
PI3705H	Y	6	PRESSURE TRANSDUCER S BYPASS 8
PI3706H	Y	6	PRESSURE TRANSDUCER S BYPASS 4
PI3707H	Y	6	PRESSURE TRANSDUCER H~U MID
PI3708H	Y	6	PRESSURE TRANSDUCER H~U 4
PI3738H	Y	6	PRESSURE TRANSDUCER M 4
PI3739H	Y	6	PRESSURE TRANSDUCER S 8
PI3740H	Y	6	PRESSURE TRANSDUCER S MID
PI3741H	Y	6	PRESSURE TRANSDUCER CIRC BYPASS
PI6057H	Y	6	PRESSURE TRANSDUCER M 4
PI6058H	Y	6	PRESSURE TRANSDUCER S 4
PI6059H	Y	6	PRESSURE TRANSDUCER H 4
PI6060H	Y	6	PRESSURE TRANSDUCER U 4
PI6061H	Y	6	PRESSURE TRANSDUCER R 4
PI3746H	B	8	PRESSURE TRANSDUCER M 6
PI3747H	B	8	PRESSURE TRANSDUCER S 6
PI3748H	B	8	PRESSURE TRANSDUCER H 6
PI3749H	B	8	PRESSURE TRANSDUCER U 6
PI3750H	B	8	PRESSURE TRANSDUCER R 6
PI4849H	B	8	PRESSURE TRANSDUCER H~U 10
PI4850H	B	8	PRESSURE TRANSDUCER M 10
PI4851H	B	8	PRESSURE TRANSDUCER S 10
PI4852H	B	8	PRESSURE TRANSDUCER S~H
PI4853H	B	8	PRESSURE TRANSDUCER H~U 6
PI6849H	Y	8	PRESSURE TRANSDUCER H~U 10
PI6850H	Y	8	PRESSURE TRANSDUCER M 10
PI6851H	Y	8	PRESSURE TRANSDUCER H~U 6
PI6852H	Y	8	PRESSURE TRANSDUCER S~H
PI6853H	Y	8	PRESSURE TRANSDUCER S 10
PI6854H	Y	8	PRESSURE TRANSDUCER M 6
PI6855H	Y	8	PRESSURE TRANSDUCER S 6

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Component #	Ring	Box	Nomenclature
PI6856H	Y	8	PRESSURE TRANSDUCER H
PI6857H	Y	8	PRESSURE TRANSDUCER U
PI6858H	Y	8	PRESSURE TRANSDUCER R
PI3728H	B	10	PRESSURE TRANSDUCER M 8
PI3729H	B	10	PRESSURE TRANSDUCER S 8
PI3730H	B	10	PRESSURE TRANSDUCER H
PI3731H	B	10	PRESSURE TRANSDUCER U
PI3732H	B	10	PRESSURE TRANSDUCER R
PI5049H	B	10	PRESSURE TRANSDUCER H~U 12
PI5050H	B	10	PRESSURE TRANSDUCER S 12
PI5051H	B	10	PRESSURE TRANSDUCER M 12
PI5062H	B	10	PRESSURE TRANSDUCER H~U 8
PI5063H	B	10	PRESSURE TRANSDUCER S~H
PI7049H	Y	10	PRESSURE TRANSDUCER H~U 12
PI7050H	Y	10	PRESSURE TRANSDUCER M 12
PI7051H	Y	10	PRESSURE TRANSDUCER H~U 8
PI7052H	Y	10	PRESSURE TRANSDUCER S~H
PI7053H	Y	10	PRESSURE TRANSDUCER S 12
PI7054H	Y	10	PRESSURE TRANSDUCER M 8
PI7055H	Y	10	PRESSURE TRANSDUCER S 8
PI7056H	Y	10	PRESSURE TRANSDUCER H
PI7057H	Y	10	PRESSURE TRANSDUCER U
PI7058H	Y	10	PRESSURE TRANSDUCER R
PI4057H	B	12	PRESSURE TRANSDUCER S~H 2
PI4058H	B	12	PRESSURE TRANSDUCER H~U 2
PI4059H	B	12	PRESSURE TRANSDUCER M 2
PI4060H	B	12	PRESSURE TRANSDUCER H~U 10
PI4061H	B	12	PRESSURE TRANSDUCER S~H 10
PI4062H	B	12	PRESSURE TRANSDUCER S 2
PI4063H	B	12	PRESSURE TRANSDUCER M 10
PI4064H	B	12	PRESSURE TRANSDUCER S 10
PI4065H	B	12	PRESSURE TRANSDUCER H
PI4066H	B	12	PRESSURE TRANSDUCER U
PI4067H	B	12	PRESSURE TRANSDUCER R
PI6052H	Y	12	PRESSURE TRANSDUCER S~H 2
PI6053H	Y	12	PRESSURE TRANSDUCER H~U 2
PI6054H	Y	12	PRESSURE TRANSDUCER M 2
PI6055H	Y	12	PRESSURE TRANSDUCER H~U 10
PI6056H	Y	12	PRESSURE TRANSDUCER S~H 10
PI6062H	Y	12	PRESSURE TRANSDUCER M 10
PI6063H	Y	12	PRESSURE TRANSDUCER S 10
PI6064H	Y	12	PRESSURE TRANSDUCER H
PI6065H	Y	12	PRESSURE TRANSDUCER U
PI6066H	Y	12	PRESSURE TRANSDUCER R
PI6073H	Y	12	PRESSURE TRANSDUCER S 2

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position. Leakage during Pressure Indicator replacement.	Manual valve. Visual detection. Escaping gas during pressure indicator removal.
Closed	No pressure indication or constant pressure indication. No hazard; relief valves safe system.	No pressure indication or constant pressure indication.

Affected Components:

Component #	Ring	Box	Nomenclature
H4213M	B	2	ISOLATION PI4251H
H4229M	B	2	ISOLATION PI4254H
H4251M	B	2	ISOLATION PI4253H
H6765M	B	2	ISOLATION PI3733H
H6766M	B	2	ISOLATION PI3734H
H6767M	B	2	ISOLATION PI3735H
H6768M	B	2	ISOLATION PI3736H
H6769M	B	2	ISOLATION PI3737H
H6909M	B	2	ISOLATION PI4252H
H3116M	Y	2	ISOLATION PI3751H
H3117M	Y	2	ISOLATION PI3752H
H3118M	Y	2	ISOLATION PI3753H
H3119M	Y	2	ISOLATION PI3754H
H3120M	Y	2	ISOLATION PI3755H
H6250M	Y	2	ISOLATION PI6253H
H6257M	Y	2	ISOLATION PI6252H
H6259M	Y	2	ISOLATION PI6250H
H6792M	Y	2	ISOLATION PI6251H
H4414M	B	4	ISOLATION PI4451H
H4423M	B	4	ISOLATION PI4448H
H6910M	B	4	ISOLATION PI4449H
H6911M	B	4	ISOLATION PI4450H
H6407M	Y	4	ISOLATION PI6424H
H6419M	Y	4	ISOLATION PI6414H
H6793M	Y	4	ISOLATION PI6413H
H6794M	Y	4	ISOLATION PI6418H
H3234M	B	6	ISOLATION PI3743H
H3236M	B	6	ISOLATION PI3744H
H4657M	B	6	ISOLATION PI6068H
H6734M	B	6	ISOLATION PI3742H

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Component #	Ring	Box	Nomenclature
H6754M	B	6	ISOLATION PI3709H
H6755M	B	6	ISOLATION PI3712H
H6756M	B	6	ISOLATION PI3711H
H6757M	B	6	ISOLATION PI3710H
H6758M	B	6	ISOLATION PI3716H
H6760M	B	6	ISOLATION PI3713H
H6775M	B	6	ISOLATION PI3718H
H6776M	B	6	ISOLATION PI3719H
H6777M	B	6	ISOLATION PI3720H
H6778M	B	6	ISOLATION PI3721H
H6779M	B	6	ISOLATION PI3722H
H6814M	B	6	ISOLATION PI3745H
H3075M	Y	6	ISOLATION PI6067H
H6640M	Y	6	ISOLATION PI3738H
H6724M	Y	6	ISOLATION PI6057H
H6725M	Y	6	ISOLATION PI6058H
H6727M	Y	6	ISOLATION PI3740H
H6729M	Y	6	ISOLATION PI3741H
H6741M	Y	6	ISOLATION PI3704H
H6742M	Y	6	ISOLATION PI3707H
H6743M	Y	6	ISOLATION PI3706H
H6744M	Y	6	ISOLATION PI3705H
H6751M	Y	6	ISOLATION PI3714H
H6753M	Y	6	ISOLATION PI3708H
H6763M	Y	6	ISOLATION PI3739H
H6787M	Y	6	ISOLATION PI6059H
H6788M	Y	6	ISOLATION PI6060H
H6789M	Y	6	ISOLATION PI6061H
H4553M	B	8	ISOLATION PI3746H
H4554M	B	8	ISOLATION PI3747H
H4555M	B	8	ISOLATION PI3748H
H4556M	B	8	ISOLATION PI3749H
H4557M	B	8	ISOLATION PI3750H
H4828M	B	8	ISOLATION PI4850H
H4851M	B	8	ISOLATION PI4854H
H4861M	B	8	ISOLATION PI4853H
H6913M	B	8	ISOLATION PI4849H
H6914M	B	8	ISOLATION PI4851H
H6915M	B	8	ISOLATION PI4852H
H6796M	Y	8	ISOLATION PI6849H
H6797M	Y	8	ISOLATION PI6851H
H6798M	Y	8	ISOLATION PI6852H
H6849M	Y	8	ISOLATION PI6854H
H6850M	Y	8	ISOLATION PI6855H
H6851M	Y	8	ISOLATION PI6856H
H6852M	Y	8	ISOLATION PI6857H
H6853M	Y	8	ISOLATION PI6858H
H6854M	Y	8	ISOLATION PI6859H

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Component #	Ring	Box	Nomenclature
H6861M	Y	8	ISOLATION PI6850H
H6866M	Y	8	ISOLATION PI6853H
H3238M	B	10	ISOLATION PI3728H
H3239M	B	10	ISOLATION PI3729H
H3240M	B	10	ISOLATION PI3730H
H3241M	B	10	ISOLATION PI3731H
H3242M	B	10	ISOLATION PI3732H
H5028M	B	10	ISOLATION PI5064H
H5054M	B	10	ISOLATION PI5050H
H5280M	B	10	ISOLATION PI5051H
H6916M	B	10	ISOLATION PI5049H
H6917M	B	10	ISOLATION PI5062H
H6918M	B	10	ISOLATION PI5063H
H6900M	Y	10	ISOLATION PI7049H
H6901M	Y	10	ISOLATION PI7050H
H6902M	Y	10	ISOLATION PI7051H
H7013M	Y	10	ISOLATION PI7054H
H7014M	Y	10	ISOLATION PI7055H
H7019M	Y	10	ISOLATION PI7056H
H7026M	Y	10	ISOLATION PI7057H
H7033M	Y	10	ISOLATION PI7058H
H7049M	Y	10	ISOLATION PI7059H
H7063M	Y	10	ISOLATION PI7052H
H7070M	Y	10	ISOLATION PI7053H
H4013M	B	12	ISOLATION PI4061H
H4028M	B	12	ISOLATION PI4062H
H4059M	B	12	ISOLATION PI4068H
H6694M	B	12	ISOLATION PI4063H
H6695M	B	12	ISOLATION PI4064H
H6696M	B	12	ISOLATION PI4065H
H6697M	B	12	ISOLATION PI4066H
H6698M	B	12	ISOLATION PI4067H
H6919M	B	12	ISOLATION PI4057H
H6920M	B	12	ISOLATION PI4058H
H6921M	B	12	ISOLATION PI4059H
H6922M	B	12	ISOLATION PI4060H
H6027M	Y	12	ISOLATION PI6056H
H6053M	Y	12	ISOLATION PI6073H
H6091M	Y	12	ISOLATION PI6062H
H6092M	Y	12	ISOLATION PI6063H
H6093M	Y	12	ISOLATION PI6064H
H6094M	Y	12	ISOLATION PI6065H
H6095M	Y	12	ISOLATION PI6066H
H6096M	Y	12	ISOLATION PI6074H
H6903M	Y	12	ISOLATION PI6052H
H6904M	Y	12	ISOLATION PI6053H
H6905M	Y	12	ISOLATION PI6054H
H6906M	Y	12	ISOLATION PI6055H

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 20

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	No circulation. Magnet temperature rises.	Normally open valve. Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
H4500A L	B	6	ISOLATION M 4
H4641A	B	6	ISOLATION CIRCULATOR OUT
H6600A L	Y	6	ISOLATION M 4
H6740A	Y	6	ISOLATION CIRCULATOR OUT
H4800A L	B	8	ISOLATION M
H6800A L	Y	8	ISOLATION M
H5000A L	B	10	ISOLATION M
H7000A L	Y	10	ISOLATION M
H4000A L	B	12	ISOLATION M
H6000A L	Y	12	ISOLATION M

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 21

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Closed	Incorrect flow indication. No impact. Instrumentation only.	Manual valve. No flow indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6759M	B	6	ISOLATION DELTA P IN
H6752M	Y	6	ISOLATION DELTA P IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 22

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Closed	Incorrect flow indication. No impact. Instrumentation only.	Manual valve. High flow indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6731M	B	6	ISOLATION DELTA P OUT
H6761M	Y	6	ISOLATION DELTA P OUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 39

Item: 23

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	No flow. Heat shield temperature increase with Magnet temperature rise.	Normally open valve. Visual detection. Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
H4502A L	B	6	ISOLATION H 4
H4602A	B	6	ISOLATION H 8 Linear Plug
H6602A L	Y	6	ISOLATION H 4
H6702A	Y	6	ISOLATION H 8 Linear Plug
H4802A L	B	8	ISOLATION H
H6802A L	Y	8	ISOLATION H
H5002A L	B	10	ISOLATION H
H7002A L	Y	10	ISOLATION H
H4002A L	B	12	ISOLATION H
H6002A L	Y	12	ISOLATION H

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Date: 27-Jan-99

Item: 24

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.
Closed	No circulation. Magnet temperature rises.	Normally closed valve. Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
H4642A	B	6	ISOLATION CIRCULATOR IN
H6739A	Y	6	ISOLATION CIRCULATOR IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 41

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection.
Closed	Little to no impact. Supply gas provided by flow in opposite direction. Possible pressure drop. Possible minor increase in heat load in valve box, minor increase in refrigerator load.	Manual valve. Visual detection. Elevated pressure. Pressure differential.

Affected Components:

Component #	Ring	Box	Nomenclature
H4405M L	B	4	MANUAL ISOLATION S
H6426M L	Y	4	MANUAL ISOLATION S
H4534M L	B	6	MANUAL ISOLATION S 4
H4614M L	B	6	MANUAL ISOLATION S 8
H6609M L	Y	6	MANUAL ISOLATION S 4
H6705M L	Y	6	MANUAL ISOLATION S 8
H4805M L	B	8	MANUAL ISOLATION S
H6860M L	Y	8	MANUAL ISOLATION S
H5283M L	B	10	MANUAL ISOLATION S
H7066M L	Y	10	MANUAL ISOLATION S
H4005M L	B	12	MANUAL ISOLATION S
H6055M L	Y	12	MANUAL ISOLATION S

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Date: 27-Jan-99

Item: 26

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection.
Closed	No flow. Magnet temperature rises.	Manual valve. Visual detection. Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
H4407M L	B	4	MANUAL ISOLATION M
H6405M L	Y	4	MANUAL ISOLATION M
H6733M L	B	6	MANUAL ISOLATION M
H6623M L	Y	6	MANUAL ISOLATION M
H4831M L	B	8	MANUAL ISOLATION M
H6859M L	Y	8	MANUAL ISOLATION M
H5284M L	B	10	MANUAL ISOLATION M
H7067M L	Y	10	MANUAL ISOLATION M
H4007M L	B	12	MANUAL ISOLATION M
H6056M L	Y	12	MANUAL ISOLATION M

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 27

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Checkvalve. Detectable only with individual test.
Open	No impact. Checkvalve lies between manual and automatic valves which will be closed for Normal Operations.	Checkvalve. Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4541C	B	6	WARM SUPPLY CHECK S 4
H4624C	B	6	WARM SUPPLY CHECK S 8
H6643C	Y	6	WARM SUPPLY CHECK S 8
H6645C	Y	6	WARM SUPPLY CHECK S 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 28

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield to Supply. Recooler empties. Magnet temperature rises. Can be reconfigured.	Normally closed valve. Elevated pressure/temperature; zero recooler level. Temperature indicators.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4615A	B	6	CROSSOVER S~B~HS 8
H6715A	Y	6	CROSSOVER S~B~HS 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 29

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Return line opened to Cooldown Return, through Thermax heaters, to Main Compressor Suction. Main Compressor Suction may operate at a higher pressure; needs to be evaluated. If at higher pressure, increased heat load.	Normally closed valve. Visual detection. Elevated pressure/temperature.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4536A	B	6	BYPASS R 4
H4636A	B	6	BYPASS R 8
H6636A	Y	6	BYPASS R 4
H6736A	Y	6	BYPASS R 8

Failure Mode Effects Analysis

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 46

Item: 30

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Utility line/Return flow opened to Cooldown Return, through Thermax heaters, to Main Compressor Suction. Main Compressor Suction may operate at a higher pressure; needs to be evaluated. If at higher pressure, increased heat load, with	Normally closed valve. Visual detection. Elevated pressure/temperature.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4503A L	B	6	ISOLATION U 4
H4603A	B	6	ISOLATION U 8
H6603A L	Y	6	ISOLATION U 4
H6703A	Y	6	ISOLATION U 8
H4803A L	B	8	ISOLATION U
H6803A L	Y	8	ISOLATION U
H5003A L	B	10	ISOLATION U
H7003A L	Y	10	ISOLATION U
H4003A L	B	12	ISOLATION U
H6003A L	Y	12	ISOLATION U

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 47

Item: 31

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Pressure/gas make-up for magnet line.	Normally closed valve. Visual detection. Magnet line same pressure as supply line.
Closed	No magnet line pressure/gas make-up. Possible circulator failure.	Normally closed valve. Low magnet line pressure. Erratic circulator speed. Elevated pressure/temperature. Temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
H4524A	B	6	'REF SUPPLY M Linear Plug
H6607A	Y	6	'REF SUPPLY M Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 48

Item: 32

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Inadequate flow to recoolers. Recooler level declines with possible minor increase in heat load in valve box, minor increase in refrigerator load.	Elevated pressure/temperature; high liquid level indication.
Full Scale Low	Opens recooler J-T valve. Increased refrigerator demand. Refrigerator imbalance caused by unmodulated Supply gas going into Return. Refrigerator shutoff from ring.	Constant low liquid level output. Increase in refrigerator output.

Affected Components:

Component #	Ring	Box	Nomenclature
LI6253H	Y	2	SUPERCON LEVEL PROBE
LI4452H	B	4	SUPERCON LEVEL PROBE
LI4001H	B	6	SUPERCON LEVEL PROBE
LI4000H	Y	6	SUPERCON LEVEL PROBE
LI4852H	B	8	SUPERCON LEVEL PROBE
LI6852H	Y	8	SUPERCON LEVEL PROBE
LI5052H	B	10	SUPERCON LEVEL PROBE
LI7052H	Y	10	SUPERCON LEVEL PROBE
LI4079H	B	12	SUPERCON LEVEL PROBE
LI6057H	Y	12	SUPERCON LEVEL PROBE

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 33

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Manual valve in series to prevent warm gas flow into Ring. If manual valve is open, large quantity of cold gas flows to refrigerator causing severe imbalance. Magnet temperature rises.	Normally closed valve. Visual detection. If manual valve is open, elevated pressure/ temperature. Temperature & pressure indicators. Refrigerator alarms.
Closed	No impact. Normal Operating position.	None. Normally closed valve. Normal operation.

Affected Components:

Component #	Ring	Box	Nomenclature
H4538A	B	6	WARM SUPPLY TO S 4
H4639A	B	6	WARM SUPPLY TO S 8
H6639A	Y	6	WARM SUPPLY TO S 4
H6738A	Y	6	WARM SUPPLY TO S 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 34

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Off	No impact. Normal operating condition.	Visual detection. Normal operations.
On	No impact. Inlet valve closed.	Visual indication.

Affected Components:

Component #	Ring	Box	Nomenclature
C3019H	B	6	CIRCULATOR @ 5ATM
C3018H	Y	6	CIRCULATOR @ 5ATM

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Circulator shut down.	Electronic output.
Full Scale Low	No impact. Circulator shut down.	Electronic output.

Affected Components:

Component #	Ring	Box	Nomenclature
DPT3008H	B	6	DELTA P TRANSDUCER
DPT3007H	Y	6	DELTA P TRANSDUCER

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 52

Item: 36

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Maximum speed output	No impact; instrumentation only. May cause operator to lower circulation. Magnet temperature rises.	Elevated pressure/temperature/speed with low flow. Temperature indicators.
Minimum speed output	No impact; instrumentation only. May cause operator to increase circulation. Circulator may shutdown by overspeed protection system.	Constant low speed indication and command mismatch.

Affected Components:

Component #	Ring	Box	Nomenclature
ST4647H	B	6	5k~15kRPM C3019 TRANSDUCER
ST6746H	Y	6	5k~15kRPM C3018 TRANSDUCER

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 37

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Minor heat load increase with Magnet temperature rise.	Manual valve. Visual detection. Elevated magnet temperature. Minor increase in refrigerator output. Frosted valve.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H6826M	B	6	CIRC C3019 WARMUP RETURN
H6895M	Y	6	CIRC C3018 WARMUP RETURN

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 54

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
N/A	Spare lead. Lead Control and Lead Isolation manual valve not connected on inlet; no lead to connect gas. Inlet capped. Upstream side connected to warm return. No hazard.	

Affected Components:

Component #	Ring	Box	Nomenclature
H6289M	Y	2	LEAD ISOLATION 3
H4552E	B	6	LEAD CONTROL 3
H4752M	B	6	LEAD ISOLATION 3
H6626E	Y	6	LEAD CONTROL 4
H6631E	Y	6	LEAD CONTROL 5
H6888M	Y	6	LEAD ISOLATION 4
H6892M	Y	6	LEAD ISOLATION 5
H4865E	B	8	LEAD CONTROL 3
H4889M	B	8	LEAD ISOLATION 3
H6867E	Y	8	LEAD CONTROL 4
H6871E	Y	8	LEAD CONTROL 5
H6927M	Y	8	LEAD ISOLATION 4
H6931M	Y	8	LEAD ISOLATION 5
H4853M	B	10	LEAD ISOLATION B8
H5100E	B	10	LEAD CONTROL B8
H4078E	B	12	LEAD CONTROL 3
H4142M	B	12	LEAD ISOLATION 3
H6065M	Y	12	LEAD ISOLATION 4
H6069M	Y	12	LEAD ISOLATION 5
H6073E	Y	12	LEAD CONTROL 4
H6077E	Y	12	LEAD CONTROL 5

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 39

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Significantly reduced circulation. Magnet temperature rises.	Normally open valve. Visual detection. Elevated pressure/temperature. Temperature indicators.
Closed	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4533A	B	6	CIRCULATOR TEST Linear Plug
H6606A	Y	6	CIRCULATOR TEST Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 56

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No flow indication.	Manual valve. Visual detection. Normal operations.
Closed	No impact. Normal operating position.	Manual valve. No flow indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6732M	B	6	DELTA P CROSSOVER
H6762M	Y	6	DELTA P CROSSOVER

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 41

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by manual valve. Possible pipe contamination.	Normally open valve. Erroneous instrumentation. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4600A	B	6	CIRC BYPASS OUT~B~IN
H6700A	Y	6	CIRC BYPASS OUT~B~IN

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Date: 27-Jan-99

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. No pressure source. Relief valve protects vacuum pump. Spoilation of insulating vacuum if helium leaks into vacuum header faster than turbo pump can evacuate. Magnet temperature rises.	Manual valve. Visual detection. Vacuum indication. Elevated temperature.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4277M	B	2	VACUUM ISOLATION 10
H6276M	Y	2	VACUUM ISOLATION 12
H6485M	Y	4	VACUUM ISOLATION 2
H4656M	B	6	VACUUM ISOLATION 4
H6785M	Y	6	VACUUM ISOLATION 4
H6882M	Y	8	VACUUM ISOLATION 6
H7086M	Y	10	VACUUM ISOLATION 8
H6088M	Y	12	VACUUM ISOLATION 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 43

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Vacuum header closed off by manual valves, vented by check valve.	Manual valve. Visual detection.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4279M	B	2	VACUUM~VENT 12
H6278M	Y	2	VACUUM~VENT 12
H4482M	B	4	VACUUM~VENT 2
H6470M	Y	4	VACUUM~VENT 2
H4629M	B	6	VACUUM~VENT 4
H6786M	Y	6	VACUUM~VENT 4
H4879M	B	8	VACUUM~VENT 6
H6893M	Y	8	VACUUM~VENT 6
H5166M	B	10	VACUUM~VENT 8
H7052M	Y	10	VACUUM~VENT 8
H4050M	B	12	VACUUM~VENT 10
H6090M	Y	12	VACUUM~VENT 10

Failure Mode Effects Analysis

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Vent header contaminated by air.	Checkvalve. Detectable only with individual test.
Closed	Loss of emergency venting and relief valve capacity. Adjacent magnet/valvebox relief valves have adequate capacity.	Checkvalve. Detectable only with individual test.

Affected Components:

Component #	Ring	Box	Nomenclature
H4234C	B	2	VENT CHECK 4
H6234C	Y	2	VENT CHECK 4
H4434C	B	4	VENT CHECK 6
H6445C	Y	4	VENT CHECK 6
H4009C	B	6	VENT CHECK 8
H4029C	Y	6	VENT CHECK 8
H4814C	B	8	VENT CHECK 10
H6834C	Y	8	VENT CHECK 10
H5034C	B	10	VENT CHECK 12
H7034C	Y	10	VENT CHECK 12
H4040C	B	12	VENT CHECK 2
H6064C	Y	12	VENT CHECK 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 45

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Collider magnet loop to Cooldown Return. If magnet loop pressure is higher than Cooldown Return, cold gas flows through Thermax heaters to Main Compressor Suction. If Cooldown Return pressure is higher, increased heat load.	Normally closed valve. Visual detection. Cold gas flow to Cooldown Return will result in frosted components. Warm gas flow to magnet loop will cause minor increase in refrigerator output.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4537A	B	6	CROSSOVER CR~U 4
H4637A	B	6	CROSSOVER CR~U 8
H6637A	Y	6	CROSSOVER CR~U 4
H6737A	Y	6	CROSSOVER CR~U 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Date: 27-Jan-99

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield to Supply. Recooler level declines with Magnet temperature rise.	Normally closed valve. Elevated pressure/temperature; zero recooler level. Temperature indicators.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4416A	B	4	CROSSOVER H~B~S 6
H6416A	Y	4	CROSSOVER H~B~S 6
H4816A	B	8	CROSSOVER H~B~S 6
H6816A	Y	8	CROSSOVER H~B~S 6
H5016A	B	10	CROSSOVER H~B~S 8
H7016A	Y	10	CROSSOVER H~B~S
H4016A	B	12	CROSSOVER H~B~S 10
H4039A	B	12	CROSSOVER H~B~S 2
H6016A	Y	12	CROSSOVER H~B~S 2
H6070A	Y	12	CROSSOVER H~B~S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Erroneous instrumentation. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4510A	B	6	CROSSOVER H~B~U MID
H4520A	B	6	CROSSOVER H~B~U 4
H4621A	B	6	CROSSOVER U~B~H 8
H6610A	Y	6	CROSSOVER H~B~U MID
H6620A	Y	6	CROSSOVER H~B~U 4
H6721A	Y	6	CROSSOVER U~B~H 8
H4810A	B	8	CROSSOVER H~B~U 6
H4821A	B	8	CROSSOVER U~B~H 10
H6810A	Y	8	CROSSOVER H~B~U 6
H6821A	Y	8	CROSSOVER U~B~H 10
H5010A	B	10	CROSSOVER H~B~U 8
H5021A	B	10	CROSSOVER U~B~H 12
H7010A	Y	10	CROSSOVER H~B~U 8
H7021A	Y	10	CROSSOVER U~B~H 12
H4010A	B	12	CROSSOVER H~B~U 10
H4021A	B	12	CROSSOVER U~B~H 2
H6010A	Y	12	CROSSOVER H~B~U 10
H6021A	Y	12	CROSSOVER U~B~H 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 64

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Open	No impact. Checkvalve and automatic valve prevent flow.	Manual valve. Visual detection. Possible frosted valve.

Affected Components:

Component #	Ring	Box	Nomenclature
H4542M	B	6	WARM SUPPLY ISOLATION S 4
H4626M	B	6	WARM SUPPLY ISOLATION S 8
H6644M	Y	6	WARM SUPPLY ISOLATION S 8
H6646M	Y	6	WARM SUPPLY ISOLATION S 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 49

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield to Supply. Recooler empties. Magnet temperature rise with eventual	Normally closed valve. Elevated pressure/temperature; zero recooler level. Temperature indicators.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4516A	B	6	CROSSOVER HS~B~S 4
H6616A	Y	6	CROSSOVER HS~B~S 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 50

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Visual detection. Erroneous instrumentation.

Affected Components:

Component #	Ring	Box	Nomenclature
H4616A	B	6	CROSSOVER HS~B~S 8
H6716A	Y	6	CROSSOVER HS~B~S 8

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 51

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Magnet pressure & temperature fluctuates.	Normally closed valve. Pressure and temperature fluctuations. Visual detection.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4230A	B	2	CROSSOVER M~S 12
H6230A	Y	2	CROSSOVER M~S 12
H4430A	B	4	CROSSOVER M~S 2
H6430A	Y	4	CROSSOVER M~S 2
H4530A	B	6	CROSSOVER M~S 4
H4630A	B	6	CROSSOVER M~S 8
H6630A	Y	6	CROSSOVER M~S 4
H6730A	Y	6	CROSSOVER M~S 8
H4830A	B	8	CROSSOVER M~S
H6830A	Y	8	CROSSOVER M~S
H5030A	B	10	CROSSOVER M~S
H7030A	Y	10	CROSSOVER M~S
H4030A	B	12	CROSSOVER M~S 10
H4036A	B	12	CROSSOVER M~S 2
H6005A	Y	12	CROSSOVER M~S 2
H6030A	Y	12	CROSSOVER M~S 10

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 52

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield through Utility to cold Return. Increased refrigerator load with consequent increase in Supply temperature. Magnet temperature rise. Can be reconfigured.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicator or power supply lead monitoring alarms.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.
Open-Heat Shield Mode	Flow from Heat Shield to cold Return. Increased refrigerator load with consequent increase in Supply temperature. Magnet temperature rise. Can be reconfigured.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicator alarms.
Closed-Heat Shield Mode	No impact. Normal operating position.	Normally closed valve. Visual detection.
Open/ Closed-Magnet Cooling Mode	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4508A	B	6	BYPASS U 4
H4608A	B	6	BYPASS U 8
H6608A	Y	6	BYPASS U 4
H6708A	Y	6	BYPASS U 8
H4808A	B	8	CROSSOVER R~U 6
H6808A	Y	8	CROSSOVER R~U 6
H5008A	B	10	CROSSOVER R~U 8
H7008A	Y	10	CROSSOVER R~U 8
H4008A	B	12	CROSSOVER R~U 10
H4038A	B	12	CROSSOVER R~U 2
H6008A	Y	12	CROSSOVER R~U 10
H6037A	Y	12	CROSSOVER R~U 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 53

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position. Bypass dead-headed by second automatic valve.	Normally open valve. Visual detection.
Closed	Loss of instrumentation.	Normally open valve. No pressure indication or constant pressure indication. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4415A	B	4	CROSSOVER S~B~H 6 Linear Plug
H6415A	Y	4	CROSSOVER S~B~H 6 Linear Plug
H4815A	B	8	CROSSOVER S~B~H 6 Linear Plug
H6815A	Y	8	CROSSOVER S~B~H 6 Linear Plug
H5015A	B	10	CROSSOVER S~B~H 8 Linear Plug
H7015A	Y	10	CROSSOVER S~B~H Linear Plug
H4015A	B	12	CROSSOVER S~B~H 10 Linear Plug
H4035A	B	12	CROSSOVER S~B~H 2 Linear Plug
H6007A	Y	12	CROSSOVER S~B~H 10 Linear Plug
H6015A	Y	12	CROSSOVER S~B~H 2 Linear Plug

Failure Mode Effects Analysis

System: RHIC Cryogenic System **Date:** 27-Jan-99

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Item: 54

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal operations.
Closed	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Visual detection. Erroneous instrumentation.

Affected Components:

Component #	Ring	Box	Nomenclature
H4515A	B	6	CROSSOVER S~B~HS 4
H6615A	Y	6	CROSSOVER S~B~HS 4

Failure Mode Effects Analysis

System: RHIC Cryogenic System

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Item: 55

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield through Utility to cold Return. Increased refrigerator load with consequent increase in Supply temperature. Magnet temperature rise. Can be reconfigured.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicator or power supply lead monitoring alarms.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4511A	B	6	CROSSOVER U~B~H MID
H4521A	B	6	CROSSOVER U~B~H 4
H4620A	B	6	CROSSOVER H~B~U 8
H6611A	Y	6	CROSSOVER U~B~H MID
H6621A	Y	6	CROSSOVER U~B~H 4
H6720A	Y	6	CROSSOVER H~B~U 8
H4811A	B	8	CROSSOVER U~B~H 6
H4820A	B	8	CROSSOVER H~B~U 10
H6811A	Y	8	CROSSOVER U~B~H 6
H6820A	Y	8	CROSSOVER H~B~U 10
H5011A	B	10	CROSSOVER U~B~H 8
H5020A	B	10	CROSSOVER H~B~U 12
H7011A	Y	10	CROSSOVER U~B~H 8
H7020A	Y	10	CROSSOVER H~B~U 12
H4011A	B	12	CROSSOVER U~B~H 10
H4020A	B	12	CROSSOVER H~B~U 2
H6011A	Y	12	CROSSOVER U~B~H 10
H6020A	Y	12	CROSSOVER H~B~U 2

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Date: 27-Jan-99

Item: 56

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header checkvalve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Suction pressure drop. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H6469M	Y	4	PUMPOUT WARM RETURN 4
H4634M	B	6	PUMPOUT WARM RETURN 6
H4850M	B	8	PUMPOUT WARM RETURN 8
H5123M	B	10	PUMPOUT WARM RETURN 10
H4058M	B	12	PUMPOUT WARM RETURN 12

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 57

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No circulation. Magnet temperature rises.	Manual valve. Visual detection. Elevated pressure/temperature. Temperature indicators.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4618M L	B	6	CIRC BYPASS IN~B~OUT
H6707M L	Y	6	CIRC BYPASS IN~B~OUT

Failure Mode Effects Analysis

System: RHIC Cryogenic System

Date: 27-Jan-99

Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Item: 58

Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.
Closed	No impact. No lead cooling. Leads not energized	Manual valve. Visual detection. No lead flow indication.

Affected Components:

Component #	Ring	Box	Nomenclature
H4483M	B	4	LEAD ISOLATION B10
H4484M	B	4	LEAD ISOLATION B9
H4485M	B	4	LEAD ISOLATION B8
H4486M	B	4	LEAD ISOLATION B7
H4487M	B	4	LEAD ISOLATION B6
H4488M	B	4	LEAD ISOLATION A11
H4489M	B	4	LEAD ISOLATION A9
H4490M	B	4	LEAD ISOLATION A8
H4491M	B	4	LEAD ISOLATION A6
H4492M	B	4	LEAD ISOLATION A5
H4493M	B	4	LEAD ISOLATION A4
H4494M	B	4	LEAD ISOLATION A2
H4495M	B	4	LEAD ISOLATION A1
H6528M	Y	4	LEAD ISOLATION 10
H6529M	Y	4	LEAD ISOLATION 9
H6530M	Y	4	LEAD ISOLATION 8
H6531M	Y	4	LEAD ISOLATION 7
H6532M	Y	4	LEAD ISOLATION 6
H6533M	Y	4	LEAD ISOLATION 5
H6534M	Y	4	LEAD ISOLATION 4
H6535M	Y	4	LEAD ISOLATION 3
H6536M	Y	4	LEAD ISOLATION 2
H6537M	Y	4	LEAD ISOLATION 1
H6538M	Y	4	LEAD ISOLATION 11
H4742M	B	6	LEAD ISOLATION 11
H4743M	B	6	LEAD ISOLATION 10
H4744M	B	6	LEAD ISOLATION 9
H4745M	B	6	LEAD ISOLATION 8
H4746M	B	6	LEAD ISOLATION 7
H4747M	B	6	LEAD ISOLATION 5

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H4748M	B	6	LEAD ISOLATION 4
H4749M	B	6	LEAD ISOLATION 2
H4750M	B	6	LEAD ISOLATION 1
H6884M	Y	6	LEAD ISOLATION 9
H6885M	Y	6	LEAD ISOLATION 8
H6886M	Y	6	LEAD ISOLATION 7
H6889M	Y	6	LEAD ISOLATION 2
H6890M	Y	6	LEAD ISOLATION 10
H6891M	Y	6	LEAD ISOLATION 1
H6896M	Y	6	LEAD ISOLATION 11
H4880M	B	8	LEAD ISOLATION 11
H4881M	B	8	LEAD ISOLATION 10
H4882M	B	8	LEAD ISOLATION 9
H4883M	B	8	LEAD ISOLATION 8
H4884M	B	8	LEAD ISOLATION 7
H4885M	B	8	LEAD ISOLATION 5
H4886M	B	8	LEAD ISOLATION 4
H4887M	B	8	LEAD ISOLATION 2
H4888M	B	8	LEAD ISOLATION 1
H6923M	Y	8	LEAD ISOLATION 9
H6924M	Y	8	LEAD ISOLATION 8
H6925M	Y	8	LEAD ISOLATION 7
H6926M	Y	8	LEAD ISOLATION 6
H6928M	Y	8	LEAD ISOLATION 2
H6929M	Y	8	LEAD ISOLATION 10
H6930M	Y	8	LEAD ISOLATION 1
H6932M	Y	8	LEAD ISOLATION 11
H4753M	B	10	LEAD ISOLATION B11
H4754M	B	10	LEAD ISOLATION B10
H4755M	B	10	LEAD ISOLATION B9
H4756M	B	10	LEAD ISOLATION B2
H4757M	B	10	LEAD ISOLATION B4
H4758M	B	10	LEAD ISOLATION B7
H4759M	B	10	LEAD ISOLATION A11
H4760M	B	10	LEAD ISOLATION A9
H4761M	B	10	LEAD ISOLATION A8
H4762M	B	10	LEAD ISOLATION A6
H4763M	B	10	LEAD ISOLATION A5
H4764M	B	10	LEAD ISOLATION A4
H4765M	B	10	LEAD ISOLATION A2
H4766M	B	10	LEAD ISOLATION A1
H4767M	B	10	LEAD ISOLATION A7
H4854M	B	10	LEAD ISOLATION A10
H7129M	Y	10	LEAD ISOLATION B10
H7130M	Y	10	LEAD ISOLATION B9
H7131M	Y	10	LEAD ISOLATION B8
H7132M	Y	10	LEAD ISOLATION B7
H7133M	Y	10	LEAD ISOLATION B6

Failure Mode Effects Analysis

System: RHIC Cryogenic System

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

Component #	Ring	Box	Nomenclature
H7134M	Y	10	LEAD ISOLATION B11
H7135M	Y	10	LEAD ISOLATION A11
H7137M	Y	10	LEAD ISOLATION A9
H7138M	Y	10	LEAD ISOLATION A8
H7139M	Y	10	LEAD ISOLATION A6
H7140M	Y	10	LEAD ISOLATION A5
H7141M	Y	10	LEAD ISOLATION A4
H7142M	Y	10	LEAD ISOLATION A2
H7143M	Y	10	LEAD ISOLATION A1
H6059M	Y	12	LEAD ISOLATION 9
H6060M	Y	12	LEAD ISOLATION 8
H6061M	Y	12	LEAD ISOLATION 7
H6062M	Y	12	LEAD ISOLATION 6
H6066M	Y	12	LEAD ISOLATION 2
H6067M	Y	12	LEAD ISOLATION 10
H6068M	Y	12	LEAD ISOLATION 1
H6097M	Y	12	LEAD ISOLATION 11

Failure Mode Effects Analysis

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 77

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow to local Warm Return header. Minor refrigerator heat load increase.	Manual valve. Visual detection. Frosted valve. Minor increase in refrigerator output.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4214M	B	2	MONITOR TUBE H4205M~H4200A
H4222M	B	2	MONITOR TUBE H4218M~H4201A
H4250M	B	2	MONITOR TUBE H4220A~H4221A
H6222M	Y	2	MONITOR TUBE H6220A~H6221A
H6256M	Y	2	MONITOR TUBE H6254M~H6201A
H6260M	Y	2	MONITOR TUBE H6253M~H6200A
H4412M	B	4	MONITOR TUBE H4415A~H4416A
H4417M	B	4	MONITOR TUBE H4410A~H4411A
H4418M	B	4	MONITOR TUBE H4407M~H4400A
H6409M	Y	4	MONITOR TUBE H6000A~H6405M
H6412M	Y	4	MONITOR TUBE H6415A~H6416A
H6417M	Y	4	MONITOR TUBE H6410A~H6411A
H3233M	B	6	MONITOR TUBE H4501A~H4534M
H3237M	B	6	MONITOR TUBE H4600A~H4618M
H4512M	B	6	MONITOR TUBE H4510A~H4511A
H4517M	B	6	MONITOR TUBE H4515A~H4516A
H4522M	B	6	MONITOR TUBE H4520A~H4521A
H4617M	B	6	MONITOR TUBE H4615A~H4616A
H4622M	B	6	MONITOR TUBE H4620A~H4621A
H6735M	B	6	MONITOR TUBE H4500A~H6733M
H6819M	B	6	MONITOR TUBE H4601A~H4614M
H6612M	Y	6	MONITOR TUBE H6610A~H6611A
H6617M	Y	6	MONITOR TUBE H6615A~H6616A
H6622M	Y	6	MONITOR TUBE H6620A~H6621A
H6641M	Y	6	MONITOR TUBE H6600A~H6623M
H6717M	Y	6	MONITOR TUBE H6715A~H6716A
H6722M	Y	6	MONITOR TUBE H6720A~H6721A
H6726M	Y	6	MONITOR TUBE H6601A~H6609M
H6728M	Y	6	MONITOR TUBE H6700A~H6707M
H6764M	Y	6	MONITOR TUBE H6701A~H6705M

Failure Mode Effects Analysis

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Component #	Ring	Box	Nomenclature
H4812M	B	8	MONITOR TUBE H4801A~H4805M
H4817M	B	8	MONITOR TUBE H4815A~H4816A
H4822M	B	8	MONITOR TUBE H4820A~H4821A
H4829M	B	8	MONITOR TUBE H4800A~H4831M
H4833M	B	8	MONITOR TUBE H4810A~H4811A
H6812M	Y	8	MONITOR TUBE H6810A~H6811A
H6817M	Y	8	MONITOR TUBE H6815A~H6816A
H6822M	Y	8	MONITOR TUBE H6820A~H4821A
H6862M	Y	8	MONITOR TUBE H6800M~H6859M
H6865M	Y	8	MONITOR TUBE H6801A~H6860M
H5012M	B	10	MONITOR TUBE H5010A~H5011A
H5017M	B	10	MONITOR TUBE H5015A~H5016A
H5022M	B	10	MONITOR TUBE H5020A~H5021A
H5033M	B	10	MONITOR TUBE H5283M~H5001A
H5281M	B	10	MONITOR TUBE H5284M~H5000A
H7012M	Y	10	MONITOR TUBE H7010A~H7011A
H7017M	Y	10	MONITOR TUBE H7015A~H7016A
H7022M	Y	10	MONITOR TUBE H7020A~H7021A
H7064M	Y	10	MONITOR TUBE H7000A~H7067A
H7069M	Y	10	MONITOR TUBE H7001A~H7066M
H4017M	B	12	MONITOR TUBE H4000A~H4007A
H4019M	B	12	MONITOR TUBE H4005M~H4001A
H4062M	B	12	MONITOR TUBE H4035A~H4039A
H4063M	B	12	MONITOR TUBE H4020A~H4021A
H4069M	B	12	MONITOR TUBE H4010A~H4011A
H4070M	B	12	MONITOR TUBE H4015A~H4016A
H6012M	Y	12	MONITOR TUBE H6010A~H6011A
H6017M	Y	12	MONITOR TUBE H6020A~H6021A
H6022M	Y	12	MONITOR TUBE H6015A~H6016A
H6028M	Y	12	MONITOR TUBE H6000A~H6056A
H6052M	Y	12	MONITOR TUBE H6001M~H6055A
H6071M	Y	12	MONITOR TUBE H6007A~H6070A

Failure Mode Effects Analysis

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant **Page:** 79

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure in Heat Shield line. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4274M	B	2	PUMPOUT H 12
H6273M	Y	2	PUMPOUT H 12
H4472M	B	4	PUMPOUT H 6
H6477M	Y	4	PUMPOUT H 6
H4648M	B	6	PUMPOUT H 8
H4653M	B	6	PUMPOUT H 4
H6711M	Y	6	PUMPOUT H 8
H6782M	Y	6	PUMPOUT H 4
H4869M	B	8	PUMPOUT H 10
H4874M	B	8	PUMPOUT H 6
H6874M	Y	8	PUMPOUT H 10
H6879M	Y	8	PUMPOUT H 6
H5156M	B	10	PUMPOUT H 12
H5161M	B	10	PUMPOUT H 8
H7078M	Y	10	PUMPOUT H 12
H7083M	Y	10	PUMPOUT H 8
H4082M	B	12	PUMPOUT H 2
H4087M	B	12	PUMPOUT H 10
H6080M	Y	12	PUMPOUT H 2
H6085M	Y	12	PUMPOUT H 10

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4272M	B	2	PUMPOUT M 12
H6271M	Y	2	PUMPOUT M 12
H4470M	B	4	PUMPOUT M 6
H6475M	Y	4	PUMPOUT M 6
H4651M	B	6	PUMPOUT M 4
H6709M	Y	6	PUMPOUT M 8
H6780M	Y	6	PUMPOUT M 4
H4867M	B	8	PUMPOUT M 10
H4872M	B	8	PUMPOUT M 6
H6872M	Y	8	PUMPOUT M 10
H6877M	Y	8	PUMPOUT M 6
H5154M	B	10	PUMPOUT M 12
H5159M	B	10	PUMPOUT M 8
H7076M	Y	10	PUMPOUT M 12
H7081M	Y	10	PUMPOUT M 8
H4080M	B	12	PUMPOUT M 2
H4085M	B	12	PUMPOUT M 10
H6078M	Y	12	PUMPOUT M 2
H6083M	Y	12	PUMPOUT M 10

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Operation Mode: Single Sextant Warm-up - 3 O'Clock Sextant

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4276M	B	2	PUMPOUT R 12
H6275M	Y	2	PUMPOUT R 12
H4474M	B	4	PUMPOUT R 6
H6479M	Y	4	PUMPOUT R 6
H4646M	B	6	PUMPOUT M 8
H4650M	B	6	PUMPOUT R 8
H4655M	B	6	PUMPOUT R 4
H6713M	Y	6	PUMPOUT R 8
H6784M	Y	6	PUMPOUT R 4
H4871M	B	8	PUMPOUT R 10
H4876M	B	8	PUMPOUT R 6
H6876M	Y	8	PUMPOUT R 10
H6881M	Y	8	PUMPOUT R 6
H5158M	B	10	PUMPOUT R 12
H5163M	B	10	PUMPOUT R 8
H7080M	Y	10	PUMPOUT R 12
H7085M	Y	10	PUMPOUT R 8
H4084M	B	12	PUMPOUT R 2
H4089M	B	12	PUMPOUT R 10
H6082M	Y	12	PUMPOUT R 2
H6087M	Y	12	PUMPOUT R 10

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4273M	B	2	PUMPOUT S 12
H6272M	Y	2	PUMPOUT S 12
H4471M	B	4	PUMPOUT S 6
H6476M	Y	4	PUMPOUT S 6
H4647M	B	6	PUMPOUT S 8
H4652M	B	6	PUMPOUT S 4
H6710M	Y	6	PUMPOUT S 8
H6781M	Y	6	PUMPOUT S 4
H4868M	B	8	PUMPOUT S 10
H4873M	B	8	PUMPOUT S 6
H6873M	Y	8	PUMPOUT S 10
H6878M	Y	8	PUMPOUT S 6
H5155M	B	10	PUMPOUT S 12
H5160M	B	10	PUMPOUT S 8
H7077M	Y	10	PUMPOUT S 12
H7082M	Y	10	PUMPOUT S 8
H4081M	B	12	PUMPOUT S 2
H4086M	B	12	PUMPOUT S 10
H6079M	Y	12	PUMPOUT S 2
H6084M	Y	12	PUMPOUT S 10

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4275M	B	2	PUMPOUT U 12
H6274M	Y	2	PUMPOUT U 12
H4473M	B	4	PUMPOUT U 6
H6478M	Y	4	PUMPOUT U 6
H4649M	B	6	PUMPOUT U 8
H4654M	B	6	PUMPOUT U 4
H6712M	Y	6	PUMPOUT U 8
H6783M	Y	6	PUMPOUT U 4
H4870M	B	8	PUMPOUT U 10
H4875M	B	8	PUMPOUT U 6
H6875M	Y	8	PUMPOUT U 10
H6880M	Y	8	PUMPOUT U 6
H5157M	B	10	PUMPOUT U 12
H5162M	B	10	PUMPOUT U 8
H7079M	Y	10	PUMPOUT U 12
H7084M	Y	10	PUMPOUT U 8
H4083M	B	12	PUMPOUT U 2
H4088M	B	12	PUMPOUT U 10
H6081M	Y	12	PUMPOUT U 2
H6086M	Y	12	PUMPOUT U 10

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally open valve. Visual detection. Normal Operations.
Closed	Possible increase in pressure drop. Flow permitted in opposite direction. Minor increase in refrigerator load.	Normally open valve. Visual detection. Pressure increase. Decreased lead flow. Decreased suction pressure.

Affected Components:

Component #	Ring	Box	Nomenclature
H6249R	Y	2	VACUUM SKID RELIEF 2
H6414R	Y	4	VACUUM SKID RELIEF 4
H4560R	B	6	VACUUM SKID RELIEF 6
H6714R	Y	6	VACUUM SKID RELIEF 6
H6824R	Y	8	VACUUM SKID RELIEF 8
H7023R	Y	10	VACUUM SKID RELIEF 10
H6050R	Y	12	VACUUM SKID RELIEF 12

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Vacuum header open to vent header. Lines not used for normal operations.	No detection.
Closed	No impact. Lines not used for normal operations. Low pressure relief for protection of vacuum pump.	No detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H6218A	Y	2	WARM RETURN ISOLATION 2
H6418A	Y	4	WARM RETURN ISOLATION 4
H6718A	Y	6	WARM RETURN ISOLATION 6~8
H6719A	Y	6	WARM RETURN ISOLATION 6~4
H6818A	Y	8	WARM RETURN ISOLATION 8
H7018A	Y	10	WARM RETURN ISOLATION 10
H6018A	Y	12	WARM RETURN ISOLATION 12

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Not in use - Open	No impact. Bayonet capped with relief valve. Normal operating position.	Normally closed valve. Visual detection.
Not in use - Closed	Leakage will be relieved on warming.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4225A	B	2	DETECTOR SUPPLY
H6225A	Y	2	DETECTOR SUPPLY
H4625A	B	6	DETECTOR SUPPLY
H6625A	Y	6	DETECTOR SUPPLY
H4825A	B	8	DETECTOR SUPPLY
H6825A	Y	8	DETECTOR SUPPLY
H5025A	B	10	DETECTOR SUPPLY
H7025A	Y	10	DETECTOR SUPPLY
H4072A	B	12	DETECTOR SUPPLY
H6013A	Y	12	DETECTOR SUPPLY

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open/ Leaks	Flow of Supply gas to atmosphere. Can be shutoff with valve. Unacceptable leak, with depletion of helium inventory. Increased refrigerator load.	Elevated temperature/low pressure. Frosted fitting. Increased refrigerator output.
Closed	No impact. Normal operating position.	Normally closed. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
U0003H	B	2	1/2 IPS FEMALE BAYONET
U0009H	Y	2	1/2 IPS FEMALE BAYONET
U0005H	B	6	1/2 IPS FEMALE BAYONET
U0011H	Y	6	1/2 IPS FEMALE BAYONET
U0006H	B	8	1/2 IPS FEMALE BAYONET
U0012H	Y	8	1/2 IPS FEMALE BAYONET
U0001H	B	10	1/2 IPS FEMALE BAYONET
U0007H	Y	10	1/2 IPS FEMALE BAYONET
U0002H	B	12	1/2 IPS FEMALE BAYONET
U0008H	Y	12	1/2 IPS FEMALE BAYONET

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Increased refrigerator demand. Refrigerator imbalance caused by unmodulated 4K gas going into Return. Refrigerator shutoff from ring.	Normally closed valve. Visual detection. Refrigerator alarms.
Closed	No impact. Normal operating position.	Normally closed. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4506A	B	6	CROSSOVER M~U 4
H4606A	B	6	CROSSOVER M~U 8
H6638A	Y	6	CROSSOVER M~U 4
H6706A	Y	6	CROSSOVER M~U 8
H4806A	B	8	CROSSOVER M~U 6
H6806A	Y	8	CROSSOVER M~U 6
H5006A	B	10	CROSSOVER M~U 8
H7006A	Y	10	CROSSOVER M~U 8
H4006A	B	12	CROSSOVER M~U 10
H4037A	B	12	CROSSOVER M~U 2
H6006A	Y	12	CROSSOVER M~U 10
H6036A	Y	12	CROSSOVER M~U 2

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow from Heat Shield Supply bypassed to Heat Shield Return. Heat shield temperature increase with magnet temperature rise.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicators.
Closed	No impact. Normal operating position.	Normally closed valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4645A	B	6	ISOLATION H 4 Linear Plug
H6745A	Y	6	ISOLATION H 4 Linear Plug

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Leaks	Helium leaks into valve box insulating vacuum. Loss of inventory. Unacceptable heat load.	Pressure tested pressure vessel. Elevated Pressure/temperature.

Affected Components:

Component #	Ring	Box	Nomenclature
LP2 C	B	4	LEAD POT "a" 32015127 02
LP3 B	B	4	LEAD POT "b" 32015127 03
LP1 A	Y	4	LEAD POT 32015127 01
LP1 E	B	6	LEAD POT 32015127 01
LP5 A	Y	6	LEAD POT 32015127 05
LP1 D	B	8	LEAD POT 32015127 01
LP5 D	Y	8	LEAD POT 32015127 05
LP2 B	B	10	LEAD POT "a" 32015127 02
LP4 A	B	10	LEAD POT "b" 32015127 04
LP2 A	Y	10	LEAD POT "a" 32015127 02
LP3 A	Y	10	LEAD POT "b" 32015127 03
LP1 B	B	12	LEAD POT 32015127 01
LP5 C	Y	12	LEAD POT 32015127 05

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position.	Normally closed valve. Visual detection. Normal Operations.
Closed	Turbo pump cannot evacuate valve box. Spoilation of cryostat insulating vacuum. Magnet temperature rises.	Normally closed valve. Visual detection. Vacuum indication. Elevated pressure/ temperature. Low vacuum. Temperature/ pressure/vacuum indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
V4202A	B	2	ISOLATION TURBO B 2
V6202A	Y	2	ISOLATION TURBO
V4402A	B	4	ISOLATION TURBO
V6402A	Y	4	ISOLATION TURBO
V4502A	B	6	ISOLATION TURBO
V6602A	Y	6	ISOLATION TURBO
V4802A	B	8	ISOLATION TURBO
V6802A	Y	8	ISOLATION TURBO
V5002A	B	10	ISOLATION TURBO
V7702A	Y	10	ISOLATION TURBO
V4052A	B	12	ISOLATION TURBO
V6042A	Y	12	ISOLATION TURBO

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal Operations.
Open	Potential for loss of insulating vacuum and turbo pump failure. Magnet temperature rises.	Manual valve. Visual detection. Elevated pressure/temperature. Low vacuum. Temperature/pressure/vacuum indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
V4203M	B	2	CRYOSTAT PUMPOUT
V6203M	Y	2	CRYOSTAT PUMPOUT
V4403M	B	4	CRYOSTAT PUMPOUT
V6403M	Y	4	CRYOSTAT PUMPOUT
V4503M	B	6	CRYOSTAT PUMPOUT
V6603M	Y	6	CRYOSTAT PUMPOUT
V4803M	B	8	CRYOSTAT PUMPOUT
V6803M	Y	8	CRYOSTAT PUMPOUT
V5003M	B	10	CRYOSTAT PUMPOUT
V7703M	Y	10	CRYOSTAT PUMPOUT
V4053M	B	12	CRYOSTAT PUMPOUT
V6043M	Y	12	CRYOSTAT PUMPOUT

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Instrumentation only.	High/Full scale pressure indication.
Full Scale Low	No impact. Instrumentation only.	Zero/Low pressure indication.

Affected Components:

Component #	Ring	Box	Nomenclature
PI4254H	B	2	PRESSURE TRANSDUCER VENT
PI6253H	Y	2	PRESSURE TRANSDUCER VENT
PI4448H	B	4	PRESSURE TRANSDUCER VENT
PI6414H	Y	4	PRESSURE TRANSDUCER VENT
PI6068H	B	6	PRESSURE TRANSDUCER VENT
PI6067H	Y	6	PRESSURE TRANSDUCER VENT
PI4854H	B	8	PRESSURE TRANSDUCER VENT
PI6859H	Y	8	PRESSURE TRANSDUCER VENT
PI5064H	B	10	PRESSURE TRANSDUCER VENT
PI7059H	Y	10	PRESSURE TRANSDUCER VENT
PI4068H	B	12	PRESSURE TRANSDUCER VENT
PI6074H	Y	12	PRESSURE TRANSDUCER VENT

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Flow through Vacuum header relief valve to atmosphere. Unacceptable leak, with depletion of helium inventory.	Manual valve. Visual detection. Elevated temperature/low pressure. Frosted valve. Refrigerator gas management alarms.
Closed	No impact. Normal operating position.	Manual valve. Visual detection. Normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4559M	B	6	CIRC C3019 PUMPOUT
H6799M	Y	6	CIRC C3018 PUMPOUT

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Interlock closes circulator isolation valve. No circulation. Also closes Supply make-up. Magnet temperature rises.	Temperature indication unreasonably high. Elevated pressure/temperature. Other temperature indicators.
Full Scale Low	Interlock closes circulator isolation valve. No circulation. Also opens Supply make-up to full open. Magnet temperature rises.	Zero temperature indication. Elevated pressure/temperature. Other temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
PI3717H	B	6	PRESSURE TRANSDUCER CIRC OUT
PI3715H	Y	6	PRESSURE TRANSDUCER CIRC OUT

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Interlock closes circulator isolation valve. No circulation. Magnet temperature rises.	Temperature indication unreasonably high. Elevated pressure/temperature. Other temperature indicators.
Full Scale Low	Interlock closes circulator isolation valve. No circulation. Magnet temperature rises.	Zero temperature indication. Elevated pressure/temperature. Other temperature indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
PI3716H	B	6	PRESSURE TRANSDUCER CIRC IN
PI3714H	Y	6	PRESSURE TRANSDUCER CIRC IN

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Interlock turns off heater in valve box.	Temperature indication unreasonably high.
Full Scale Low	No impact. Interlock would permit heater operation at elevated temperature or when circulator is turned off.	Zero temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
TI3712H	B	6	CALIBRATED SNSR RECL IN
TI3708H	Y	6	CALIBRATED SNSR RECL IN

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Circulator speed limited to 5,000 RPM. No impact above 20 K, but limits heat removal capacity below 20 K and may prevent cooling to superconducting temperature.	Temperature indication unreasonably high. Elevated pressure/temperature.
Full Scale Low	Speed limit for elevated temperature operation disabled. Overspeed protection provided by other interlocks. Cryogen provides lubrication for lower bearing. Speed above 5000 RPM above 20 K will accelerate bearing deterioration.	Zero temperature indication.

Affected Components:

Component #	Ring	Box	Nomenclature
TI3803H	B	6	CALIBRATED SENSOR CIRC INLET
TI3805H	Y	6	CALIBRATED SENSOR CIRC INLET

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open- No Pump	Loss of valve box insulating vacuum. Unacceptable heat load. Temperature rise.	Elevated pressure/temperature. Visual detection.
Closed- No Pump	No impact. Normal operating position.	Visual detection. Vacuum indication.
Open- Pump Attached	No impact. Normal operating position.	Visual detection. Vacuum indications (Pump and valve box indicators compare).
Closed- Pump Attached	Pump cannot evacuate valve box. Continues spoilation of vacuum. Temperature rise.	Visual detection. Vacuum indication. Elevated temperature.

Affected Components:

Component #	Ring	Box	Nomenclature
V4200M	B	2	PUMPOUT VI4200V~VI4201V
V6200M	Y	2	PUMPOUT VI6200V~VI6201V
V4400M	B	4	PUMPOUT VI4400V~VI4401V
V6400M	Y	4	PUMPOUT VI6400V~VI6401V
V4500M	B	6	PUMPOUT VI4500V~VI4501V
V6600M	Y	6	PUMPOUT VI6600V~VI6601V
V4800M	B	8	PUMPOUT VI4800V~VI4801V
V6800M	Y	8	PUMPOUT VI6800V~VI6801V
V5200M	B	10	PUMPOUT VI5200V~VI5201V
V7700M	Y	10	PUMPOUT VI7700V~VI7701V
V4050M	B	12	PUMPOUT VI4050V~VI4051V
V6040M	Y	12	PUMPOUT VI6050V~VI6051V

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	Normal operating position. Leakage during vacuum indicator replacement causing spoilation of vacuum.	Manual valve. Visual detection. In-rushing air during vacuum indicator removal.
Closed	Isolation of vacuum indicators. Erroneous insulating vacuum readings. May mask bad vacuum problem.	Manual valve. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
V4201M	B	2	ISOLATION VI4200V~VI4201V
V6201M	Y	2	ISOLATION VI6200V~VI6201V
V4401M	B	4	ISOLATION VI4400V~VI4401V
V6401M	Y	4	ISOLATION VI6400V~VI6401V
V4501M	B	6	ISOLATION VI4500V~VI4501V
V6601M	Y	6	ISOLATION VI6600V~VI6601V
V4801M	B	8	ISOLATION VI4800V~VI4801V
V6801M	Y	8	ISOLATION VI6800V~VI6801V
V5201M	B	10	ISOLATION VI5200V~VI5201V
V7701M	Y	10	ISOLATION VI7700V~VI7701V
V4051M	B	12	ISOLATION VI4050V~VI4051V
V6041M	Y	12	ISOLATION VI6050V~VI6051V

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	No impact. Indicates poor vacuum. Does not correlate with high vacuum indicator.	Compare with high vacuum indicator.
Full Scale Low	No impact. Normal operations.	Not detectable during normal operations.

Affected Components:

Component #	Ring	Box	Nomenclature
VI4201V	B	2	CRYOSTAT LOW VAC TRANSDUCER
VI6201V	Y	2	CRYOSTAT LOW VAC TRANSDUCER
VI4401V	B	4	CRYOSTAT LOW VAC TRANSDUCER
VI6401V	Y	4	CRYOSTAT LOW VAC TRANSDUCER
VI4501V	B	6	CRYOSTAT LOW VAC TRANSDUCER
VI6601V	Y	6	CRYOSTAT LOW VAC TRANSDUCER
VI4801V	B	8	CRYOSTAT LOW VAC TRANSDUCER
VI6801V	Y	8	CRYOSTAT LOW VAC TRANSDUCER
VI5201V	B	10	CRYOSTAT LOW VAC TRANSDUCER
VI7701V	Y	10	CRYOSTAT LOW VAC TRANSDUCER
VI4051V	B	12	CRYOSTAT LOW VAC TRANSDUCER
VI6051V	Y	12	CRYOSTAT LOW VAC TRANSDUCER

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Full Scale High	Indicates high vacuum. Will mask spoilation of vacuum.	Vacuum higher than possible or initially set, without vacuum pump attached.
Full Scale Low	Indicates poor vacuum, but temperatures remain acceptable and rough vacuum indicator remains full scale.	Mismatch in vacuum indicators.

Affected Components:

Component #	Ring	Box	Nomenclature
VI4200V	B	2	CRYOSTAT HIGH VAC TRANSDUCER
VI6200V	Y	2	CRYOSTAT HIGH VAC TRANSDUCER
VI4400V	B	4	CRYOSTAT HIGH VAC TRANSDUCER
VI6400V	Y	4	CRYOSTAT HIGH VAC TRANSDUCER
VI4500V	B	6	CRYOSTAT HIGH VAC TRANSDUCER
VI6600V	Y	6	CRYOSTAT HIGH VAC TRANSDUCER
VI4800V	B	8	CRYOSTAT HIGH VAC TRANSDUCER
VI6800V	Y	8	CRYOSTAT HIGH VAC TRANSDUCER
VI5200V	B	10	CRYOSTAT HIGH VAC TRANSDUCER
VI7700V	Y	10	CRYOSTAT HIGH VAC TRANSDUCER
VI4050V	B	12	CRYOSTAT HIGH VAC TRANSDUCER
VI6050V	Y	12	CRYOSTAT HIGH VAC TRANSDUCER

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal operating position.	Visual detection. Normal Operations.
Open	Potential for Oxygen Deficiency/thermal Hazard. Valves are lockable.	Aural/visual detection. ODH alarms. Alternate valving available to isolate sector.

Affected Components:

Component #	Ring	Box	Nomenclature
H4202A L	B	2	ISOLATION H
H4203A L	B	2	ISOLATION U
H4204A L	B	2	ISOLATION R
H4205M L	B	2	MANUAL ISOLATION M
H4218M L	B	2	MANUAL ISOLATION S
H6202A L	Y	2	ISOLATION H
H6203A L	Y	2	ISOLATION U
H6204A L	Y	2	ISOLATION R
H6253M L	Y	2	MANUAL ISOLATION M
H6254M L	Y	2	MANUAL ISOLATION S
H4400A L	B	4	ISOLATION M
H4401A L	B	4	ISOLATION S
H4402A L	B	4	ISOLATION H
H4403A L	B	4	ISOLATION U
H4404A L	B	4	ISOLATION R
H6400A L	Y	4	ISOLATION M
H6401A L	Y	4	ISOLATION S
H6402A L	Y	4	ISOLATION H
H6403A L	Y	4	ISOLATION U
H6404A L	Y	4	ISOLATION R

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open-Heat Shield Mode	No impact. Normal operating position.	Visual detection. Normal Operations.
Closed-Heat Shield Mode	No impact.	Visual detection. Normal Operations.
Closed-Magnet Cooling Mode	No 4K flow. Increase in temperature/pressure. Increase of helium in storage.	Visual detection. Temperature/pressure indicators. Storage capacity.

Affected Components:

Component #	Ring	Box	Nomenclature
H4200A L	B	2	ISOLATION M
H4201A L	B	2	ISOLATION S
H6200A L	Y	2	ISOLATION M
H6201A L	Y	2	ISOLATION S

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
All Modes	No impact. Element is in warmed sextant.	Detection is the same as for element in cold regions.

Affected Components:

Component #	Ring	Box	Nomenclature
F4249H	B	2	FILTER M 4
F4250H	B	2	FILTER S 4
F4251H	B	2	FILTER H 4
F4252H	B	2	FILTER U 4
F4253H	B	2	FILTER R 4
H4206A	B	2	CROSSOVER M~U 4
H4208A	B	2	CROSSOVER R~U 4
H4210A	B	2	CROSSOVER H~B~U 4
H4211A	B	2	CROSSOVER U~B~H 4
H4215A	B	2	CROSSOVER S~B~H 4 Linear Plug
H4216A	B	2	CROSSOVER H~B~S 4
H4236R	B	2	RELIEF LINE M 4
H4237R	B	2	RELIEF LINE S 4
H4238R	B	2	RELIEF LINE H 4
H4239R	B	2	RELIEF LINE U 4
H4240R	B	2	RELIEF LINE R 4
H4254M	B	2	PUMPOUT WARM RETURN 2
H4267M	B	2	PUMPOUT M 4
H4268M	B	2	PUMPOUT S 4
H4269M	B	2	PUMPOUT H 4
H4270M	B	2	PUMPOUT U 4
H4271M	B	2	PUMPOUT R 4
H6907M	B	2	ISOLATION PI4249H
H6908M	B	2	ISOLATION PI4250H
LI4252H	B	2	SUPERCON LEVEL PROBE
LP1 C	B	2	LEAD POT 32015127 01
PI4249H	B	2	PRESSURE TRANSDUCER H~U 4
PI4250H	B	2	PRESSURE TRANSDUCER S~H
TI4405H	B	2	CALIBRATED SENSOR R 4 IN
TI4406H	B	2	CALIBRATED SENSOR U 4 IN
TI4407H	B	2	CALIBRATED SENSOR H 4 IN
TI4408H	B	2	CALIBRATED SENSOR S 4 IN
TI4409H	B	2	CALIBRATED SENSOR M 4 IN
F6254H	Y	2	FILTER M 4
F6255H	Y	2	FILTER S 4
F6256H	Y	2	FILTER H 4

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Component #	Ring	Box	Nomenclature
F6257H	Y	2	FILTER U 4
F6258H	Y	2	FILTER R 4
H6206A	Y	2	CROSSOVER M~U 4
H6208A	Y	2	CROSSOVER R~U 4
H6210A	Y	2	CROSSOVER H~B~U 4
H6211A	Y	2	CROSSOVER U~B~H 4
H6215A	Y	2	CROSSOVER S~B~H 4 Linear Plug
H6216A	Y	2	CROSSOVER H~B~S 4
H6236R	Y	2	RELIEF LINE M 4
H6237R	Y	2	RELIEF LINE S 4
H6238R	Y	2	RELIEF LINE H 4
H6239R	Y	2	RELIEF LINE U 4
H6240R	Y	2	RELIEF LINE R 4
H6266M	Y	2	PUMPOUT M 4
H6267M	Y	2	PUMPOUT S 4
H6268M	Y	2	PUMPOUT H 4
H6269M	Y	2	PUMPOUT U 4
H6270M	Y	2	PUMPOUT R 4
H6790M	Y	2	ISOLATION PI6248H
H6791M	Y	2	ISOLATION PI6249H
LP5 B	Y	2	LEAD POT 32015127 05
PI6248H	Y	2	PRESSURE TRANSDUCER S~H
PI6249H	Y	2	PRESSURE TRANSDUCER H~U 4
TI6241H	Y	2	CALIBRATED SENSOR R 4 IN
TI6242H	Y	2	CALIBRATED SENSOR U 4 IN
TI6243H	Y	2	CALIBRATED SENSOR H 4 IN
TI6244H	Y	2	CALIBRATED SENSOR S 4 IN
TI6245H	Y	2	CALIBRATED SENSOR M 4 IN
F4473H	B	4	FILTER S 2
F4474H	B	4	FILTER H 2
F4475H	B	4	FILTER U 2
F4476H	B	4	FILTER R 2
H4409A	B	4	J T 225watt RECOOLER
H4420A	B	4	CROSSOVER H~B~U 2
H4421A	B	4	CROSSOVER U~B~H 2
H4425A	B	4	DETECTOR SUPPLY
H4429M	B	4	ISOLATION PI4453H
H4441R	B	4	RELIEF LINE M 2
H4442R	B	4	RELIEF LINE S 2
H4443R	B	4	RELIEF LINE H 2
H4444R	B	4	RELIEF LINE U 2
H4445R	B	4	RELIEF LINE R 2
H4475M	B	4	PUMPOUT M 2
H4476M	B	4	PUMPOUT S 2
H4477M	B	4	PUMPOUT H 2
H4478M	B	4	PUMPOUT U 2
H4479M	B	4	PUMPOUT R 2
H6770M	B	4	ISOLATION PI3723H

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Component #	Ring	Box	Nomenclature
H6771M	B	4	ISOLATION PI3724H
H6772M	B	4	ISOLATION PI3725H
H6773M	B	4	ISOLATION PI3726H
H6774M	B	4	ISOLATION PI3727H
H6912M	B	4	ISOLATION PI4452H
PI3723H	B	4	PRESSURE TRANSDUCER M 2
PI3724H	B	4	PRESSURE TRANSDUCER S 2
PI3725H	B	4	PRESSURE TRANSDUCER H 2
PI3726H	B	4	PRESSURE TRANSDUCER U 2
PI3727H	B	4	PRESSURE TRANSDUCER R 2
PI4452H	B	4	PRESSURE TRANSDUCER S6
PI4453H	B	4	PRESSURE TRANSDUCER H~U 2
TI4454H	B	4	CALIBRATED SNSR RECL IN
TI4464H	B	4	CALIBRATED SNSR RECL OUT
TI4470H	B	4	SNSR RECLR LIQUID LI4452
TI4484H	B	4	CALIBRATED SENSOR R 2 OUT
TI4485H	B	4	CALIBRATED SENSOR U 2 OUT
TI4486H	B	4	CALIBRATED SENSOR H 2 OUT
TI4487H	B	4	CALIBRATED SENSOR S 2 OUT
TI4488H	B	4	CALIBRATED SENSOR M 2 OUT
U0004H	B	4	1/2 IPS FEMALE BAYONET
F6429H	Y	4	FILTER S 2
F6430H	Y	4	FILTER H 2
F6431H	Y	4	FILTER U 2
F6432H	Y	4	FILTER R 2
H6420A	Y	4	CROSSOVER H~B~U 2
H6421A	Y	4	CROSSOVER U~B~H 2
H6425M	Y	4	ISOLATION PI6425H
H6427M	Y	4	ISOLATION PI6426H
H6428M	Y	4	ISOLATION PI6427H
H6429M	Y	4	ISOLATION PI6428H
H6437R	Y	4	RELIEF LINE M 2
H6438R	Y	4	RELIEF LINE S 2
H6439R	Y	4	RELIEF LINE H 2
H6440R	Y	4	RELIEF LINE U 2
H6441R	Y	4	RELIEF LINE R 2
H6446M	Y	4	ISOLATION PI6429H
H6447M	Y	4	ISOLATION PI6430H
H6451A	Y	4	J T 225watt RECOOLER
H6462A	Y	4	DETECTOR SUPPLY
H6480M	Y	4	PUMPOUT M 2
H6481M	Y	4	PUMPOUT S 2
H6482M	Y	4	PUMPOUT H 2
H6483M	Y	4	PUMPOUT U 2
H6484M	Y	4	PUMPOUT R 2
H6795M	Y	4	ISOLATION PI6423H
LI6477H	Y	4	SUPERCON LEVEL PROBE
PI6423H	Y	4	PRESSURE TRANSDUCER S 6

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Component #	Ring	Box	Nomenclature
PI6425H	Y	4	PRESSURE TRANSDUCER H~U 2
PI6426H	Y	4	PRESSURE TRANSDUCER M 2
PI6427H	Y	4	PRESSURE TRANSDUCER S 2
PI6428H	Y	4	PRESSURE TRANSDUCER H 2
PI6429H	Y	4	PRESSURE TRANSDUCER U 2
PI6430H	Y	4	PRESSURE TRANSDUCER R 2
TI6475H	Y	4	CALIBRATED SNSR RECL IN
TI6476H	Y	4	CALIBRATED SNSR RECL OUT
TI6477H	Y	4	SNSR RECLR LIQUID LI6477
TI6496H	Y	4	CALIBRATED SENSOR R 2 OUT
TI6497H	Y	4	CALIBRATED SENSOR U 2 OUT
TI6498H	Y	4	CALIBRATED SENSOR H 2 OUT
TI6499H	Y	4	CALIBRATED SENSOR S 2 OUT
TI6500H	Y	4	CALIBRATED SENSOR M 2 OUT
U0010H	Y	4	1/2 IPS FEMALE BAYONET

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Manual valves isolate warm sextant from warm return.	Electronic output.
Closed	No impact. Normal position.	Electronic output.

Affected Components:

Component #	Ring	Box	Nomenclature
H4255E	B	2	LEAD CONTROL 11
H4256E	B	2	LEAD CONTROL 10
H4257E	B	2	LEAD CONTROL 9
H4258E	B	2	LEAD CONTROL 8
H4259E	B	2	LEAD CONTROL 7
H4260E	B	2	LEAD CONTROL 12
H4261E	B	2	LEAD CONTROL 5
H4262E	B	2	LEAD CONTROL 4
H4263E	B	2	LEAD CONTROL 3
H4264E	B	2	LEAD CONTROL 2
H4265E	B	2	LEAD CONTROL 1
H6228E	Y	2	LEAD CONTROL 9
H6229E	Y	2	LEAD CONTROL 8
H6231E	Y	2	LEAD CONTROL 7
H6232E	Y	2	LEAD CONTROL 6
H6261E	Y	2	LEAD CONTROL 5
H6262E	Y	2	LEAD CONTROL 4
H6263E	Y	2	LEAD CONTROL 2
H6264E	Y	2	LEAD CONTROL 1
H6277E	Y	2	LEAD CONTROL 3

Failure Mode Effects Analysis

System: RHIC Cryogenic System

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal position. Manual valve.	Visual detection.
Open	No impact. Lead control is normally closed.	Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4280M	B	2	LEAD ISOLATION 11
H4281M	B	2	LEAD ISOLATION 10
H4282M	B	2	LEAD ISOLATION 9
H4283M	B	2	LEAD ISOLATION 8
H4284M	B	2	LEAD ISOLATION 7
H4285M	B	2	LEAD ISOLATION 12
H4286M	B	2	LEAD ISOLATION 5
H4287M	B	2	LEAD ISOLATION 4
H4288M	B	2	LEAD ISOLATION 3
H4289M	B	2	LEAD ISOLATION 2
H4290M	B	2	LEAD ISOLATION 1
H6280M	Y	2	LEAD ISOLATION 9
H6281M	Y	2	LEAD ISOLATION 8
H6282M	Y	2	LEAD ISOLATION 7
H6283M	Y	2	LEAD ISOLATION 5
H6284M	Y	2	LEAD ISOLATION 4
H6285M	Y	2	LEAD ISOLATION 2
H6286M	Y	2	LEAD ISOLATION 1
H6287M	Y	2	LEAD ISOLATION 10
H6288M	Y	2	LEAD ISOLATION 11
H4133M	B	12	LEAD ISOLATION 11
H4134M	B	12	LEAD ISOLATION 10
H4135M	B	12	LEAD ISOLATION 9
H4136M	B	12	LEAD ISOLATION 8
H4137M	B	12	LEAD ISOLATION 7
H4138M	B	12	LEAD ISOLATION 5
H4139M	B	12	LEAD ISOLATION 4
H4140M	B	12	LEAD ISOLATION 2
H4141M	B	12	LEAD ISOLATION 1

Failure Mode Effects Analysis

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	No impact. Normal position.	Visual detection. Manual valve.
Open	Potential for Oxygen Deficiency Hazard. Limited flow.	Aural/visual detection. ODH alarms.

Affected Components:

Component #	Ring	Box	Nomenclature
H4212M	B	2	MONITOR TUBE H4215A~H4216A
H4217M	B	2	MONITOR TUBE H4210A~H4211A
H6212M	Y	2	MONITOR TUBE H6215A~H6216A
H6217M	Y	2	MONITOR TUBE H6210A~H6211A
H4422M	B	4	MONITOR TUBE H4405M~H4401A
H4428M	B	4	MONITOR TUBE H4420A~H4421A
H6422M	Y	4	MONITOR TUBE H6402A~H6426M
H6424M	Y	4	MONITOR TUBE H6420A~H6421A

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed	Line bursts, with loss of insulating vacuum (internal line) or pressure indicator failure (external line). Internal line burst will cause helium to escape into Power Supply building through vacuum tank relief valve.	Elevated pressure/temperature. Temperature indicators. Detectable only with individual test.
Open	Potential for Oxygen Deficiency Hazard. Limited flow.	Aural/visual detection. ODH alarms.

Affected Components:

Component #	Ring	Box	Nomenclature
H4246R	B	2	RELIEF H4210A~H4211A
H4247R	B	2	RELIEF H4215A~H4216A
H6246R	Y	2	RELIEF H6215A~H6216A
H6247R	Y	2	RELIEF H6210A~H6211A
H4419R	B	4	RELIEF H4420A~H4421A
H4448R	B	4	RELIEF H4405M~H4401A
H6423R	Y	4	RELIEF H6420A~H6421A
H6444R	Y	4	RELIEF H6401A~H6426M

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed-Heat Shield Mode	No impact. Normal operating position.	Visual detection. Normal Operations.
Open-Magnet Cooling Mode	No impact. Normal operating position.	Visual detection. Normal Operations.
Open-Heat Shield Mode	Flow from Heat Shield through Utility to Magnet line. Refrigerator imbalance. Increase in Supply and Magnet temperature.	Visual detection. Temperature/pressure indicators. Refrigerator alarms.
Closed-Magnet Cooling Mode	No magnet cooling flow. Increasing temperature/pressure. Excess inventory needs to be stored.	Visual detection. Temperature/pressure indicators. Storage capacity.

Affected Components:

Component #	Ring	Box	Nomenclature
H4406A	B	4	CROSSOVER M~U 6
H4408A	B	4	CROSSOVER R~U 6
H6406A	Y	4	CROSSOVER M~U 6
H6408A	Y	4	CROSSOVER R~U 6

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Closed-Heat Shield Mode	No flow. Heat shield temperature increase with Magnet temperature rise. Excess inventory needs to be stored.	Normally closed valve. Visual detection. Elevated pressure/temperature. Temperature indicators. Storage capacity.
Open-Magnet Cooling Mode	Flow from Heat Shield through Utility to Magnet line. Refrigerator imbalance. Increase in Supply and Magnet temperature.	Visual detection. Temperature/pressure indicators. Refrigerator alarms.
Open-Heat Shield Mode	No impact. Normal operating position.	Visual detection. Normal Operations.
Closed-Magnet Cooling Mode	No impact. Normal operating position. Normally closed valve.	Visual detection. Normal Operations.

Affected Components:

Component #	Ring	Box	Nomenclature
H4221A	B	2	CROSSOVER U~B~H 12
H6221A	Y	2	CROSSOVER U~B~H 12
H4410A	B	4	CROSSOVER H~B~U 6
H6410A	Y	4	CROSSOVER H~B~U 6

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Failure Modes and Effects:

Failure:	Failure Effect:	Failure Detection:
Open	No impact. Normal operating position. Normally open valve.	Visual detection. Normal Operations.
Closed-Heat Shield Mode	No flow. Heat shield temperature increase with Magnet temperature rise. Excess inventory needs to be stored.	Normally open valve. Visual detection. Elevated pressure/temperature. Temperature indicators. Storage capacity.
Closed-Magnet Cooling Mode	Loss of instrumentation. Bypass dead-headed by automatic valve. Possible pipe contamination.	Normally open valve. Erroneous instrumentation. Visual detection.

Affected Components:

Component #	Ring	Box	Nomenclature
H4220A	B	2	CROSSOVER H~B~U 12
H6220A	Y	2	CROSSOVER H~B~U 12
H4411A	B	4	CROSSOVER U~B~H 6
H6411A	Y	4	CROSSOVER U~B~H 6