AD/RHIC/RD–73

RHIC PROJECT

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FMEA RHIC Cryogenics

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F.M.E.A.
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 system and all of its subsystems and components.

2.2 SYSTEMS, SUBSYSTEMS, 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 main refrigerator for the RHIC cryogenic system.
2.2.1.2 The compressor system for item 2.1.1.1.
2.2.1.3 All ambient and cryogenic piping associated with items 2.2.1.1 & 2.2.1.2.
2.2.1.4 The cryogenic system control computer.
2.2.1.5 The helium recovery system.
2.2.1.6 The cold helium distribution system associated with the ring magnets (valve boxes, transfer lines, etc.)
2.2.1.7 The effect of the failures of:
A) Global utilities, i.e., electrical and water
B) Local utilities, i.e., electrical, water, LN2, and air.

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.

PROCEDURE FOR ANALYSIS FOR THE VALVE BOXES

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 ***7:00*** sextant including: the same as 5:00

Note: proposed modification to the 8:00 and the 10:00 P&IDs, thus allowing operation the same as 5:00. Relocate the S to M bypass line between the isolation valves in the supply and magnet lines. This allows the reestablishment of the helium coolant (in any direction), via the refrigerator supply directed to the magnet loop, in the counter clockwise direction through the magnet loop. The helium coolant then enters the supply header and feeds the recooler JT valves, with final passage to return.

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.