RAMI document

Preliminary RAMI considerations concerning the dipole D1, the quadrupole Q8 and the corrector C8

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1. Introduction

1.1. Purpose of the document

This document provides brief considerations for a RAMI (Reliability, Availability, Maintainability, and Inspectability) analysis concerning the dipole D1, quadrupole Q8 and corrector C8 magnets which will be built and installed in the ESS Linac Warm Unit.

2. Magnets characteristics

The magnets shall be designed, built and put into operation having the following statements in mind:

- Stability: during the operation the magnets shall not deviate or depart from the initial parameter setup, providing that the environment and cooling conditions are kept constant.
- Reproducibility: for the same operating input setup (i.e. cycling procedure, setup current, etc.) the magnets shall deliver the same output values (i.e. the required magnetic field)
- Reliability: the magnets shall work 24/7 according to the operating mode of the relevant power converter.

The magnets shall operate protected by the ESS Machine Protection System which will receive appropriate inputs both from the magnets and the relevant power converters.

Each magnet is a mechanical assembly which is composed by:

- A magnetic core.
- Several excitation coils (the exact number depends on the magnet type) cooled by demineralized water (air cooled in the case of C8 corrector).
- Mechanical components dedicated to the installation (supports) and the magnet alignment.
- Mechanical components dedicated to the distribution of the cooling water.
- Protection devices (thermal switches).

The magnets will be outsourced. The Supplier will develop the engineering of the magnets based on the conceptual models.

3. Reliability

The magnets design, the selection of the materials for the construction and the quality control of the manufacturing process shall guarantee a reliable operation period of at least 20 years. However during each shutdown several actions must be taken in order to monitor the conditions of the magnets. Among these there are:

- Monitoring of the general condition of the magnet (visual inspection).

- Monitoring of the status and efficiency of the cooling distribution circuit (manifolds, connectors, etc).
- Monitoring of the status and efficiency of the thermal protections.
- Monitoring of the status and efficiency of all the electrical connections, both to the power converter and to the interlock system.

Typical faults, especially during the first periods of operations, could be related to defective protection devices (the thermal switches) even though the initial selection of such components should minimize the problem; furthermore such faults will act not directly on the magnet but on the relevant power converter, shutting it off. Typical period of time for fixing these events is about 0.5 hours.

Each 10 – 15 years (or even earlier, depending on the results from the periodic visual inspection) the hoses of the cooling distribution should be replaced. A suitable period of time (about 2 men-months, but this is just an estimation) should be scheduled for the replacement.

4. Availability

No spare parts have been considered as deliverables. A suggested list of components to keep ready in case of intervention will be provided with the magnets delivery.

Concerning spare components it is a good practice to have ready the following.

- Several complete set of excitation coils for each type of magnet; the exact number should be evaluated according to the total number of the magnets for each family.
- A number of protection devices (thermal switches) for rapid replacement in case of faults.
- Several complete sets of hoses for rapid replacement in case of failure.
- Electro-technical components (connection blocks in particular) for replacement of defective ones.

Purchasing the components described above will be guaranteed by the information included in the maintenance plan related to each magnet i.e. technical specifications and drawings of the excitation coils and data sheets of the protection devices.

5. Maintenability and Inspectability

The magnets design has been performed taking into account the inspection and maintenance easiness. Furthermore the maintenance in general, thus thinking not only to the magnet alone, but keeping in mind possible actions involving the magnets, has been considered.

For these reasons the magnets can be easily inspected and easily accessible.

The quadrupoles and the correctors can be opened both for installation issues or maintenance easiness; maintenance not only concerning the magnets themselves,

but concerning the surrounding equipment as well (vacuum chamber, diagnostics, etc.).

6. References

N.	Title	Code number	Rev. n.
2	Magnet Design Report – Quadrupole magnet Q8	E-ST ESS MGN DRD 003	1
3	Magnet Design Report – Dipole magnet D1	E-ST ESS MGN DRD 004	1
4	Magnet Design Report – Corrector magnet C8	E-ST ESS MGN DRD 005	1

7. Revision history

Rev. n.	Changes from previous revision	Author	Date
0	First issue	R. Fabris	20-06-2017