MICE Magnetic Field Safety Review

28/04/2015

The Mars Room, Electron Building, STFC, RAL

Review Panel:

Martin Hughes – STFC (Chair)
John Thomason – STFC
Jim Clarke – STFC
Felix Bergsma – CERN
Duncan Francis – STFC
M'Hamed Lakrimi – Siemens Magnet Technology
Xavier Queralt – STFC
Steve Harrison - STFC

MICE attendees:

Andy Nichols
Craig Macwaters
Ken Long
Jason Tarrant
Jaroslaw Pasternak – to present
Holger Witte – by telephone to present

Review charge:

To review the commissioning plan and operational methodology for the MICE step IV cooling channel magnets to ensure personnel and equipment safety when energising the beamline.

The panel will also review the implementation to date of the magnet partial return yoke, the south side of which should be installed by the time of the review.

Review format:

The review consisted of a series of presentations by MICE engineers and scientists detailing the design and implementation of the partial return yoke (PRY) for the cooling channel magnets, as well as the plans for commissioning of the magnets. The review panel were taken on a guided tour of the MICE Hall to view the magnets and the completed south side of the PRY *in-situ*.

The review panel met in a closed session to discuss their findings, after which verbal feedback was given to the MICE team.

Presentation summary:

Introduction and background – Andy Nichols

> Background on the MICE project was presented, as well as basic information on the superconducting magnets to be used to contain the muon beam. 3D models of the beamline and the MICE Hall were shown.

PRY Implementation – Jason Tarrant

> Difficulties in the design of the PRY were discussed – uneven floor level, trenches *etc.* and the engineering solutions were presented in the design of the PRY base and supports.

Several modifications have taken place to the PRY design as a result of the recommendations made in the 2013 review. The design is now more symmetrical, and a central access panel has been added to provide quicker access to the focus coil and absorbers.

The south side of the PRY has been installed, and photographs were shown. The steel for the north side is due in the UK on the 29th April.

Following the presentation, discussions centred on whether the forces on the magnets caused by any asymmetry in the PRY installation had been considered as this would not have been taken into account when the magnet stands were designed. It was decided that Holger Witte would be the best person to give detail on this.

Magnet Commissioning Plans – Jaroslaw Pasternak

An introduction to the MICE project aims was given, and details of what is expected at step IV. A team has been working to define the magnet commissioning procedure – the MICE Magnets Integration Task Force (MMITF).

The cooling channel magnets consist of 12 coils, 11 of which can be powered independently. There are various configurations which will require different current values in some of the coils, thus requiring knowledge of how to tune between the different settings.

In magnet training that has been carried out so far, the Spectrometer Solenoid (SS) magnets do not remember their training, and ~15 quenches are required to reach nominal current. The Focus Coil (FC) magnets do remember their training and will only need 1-2 quenches.

Several commissioning scenarios were presented which have been considered by the MMITF, of which scenario 5 was chosen as the favourite. Scenario 5 is independent training of each magnet at first, followed by setting nominal currents in the SS magnets and then increasing current in the FC.

Simulated quench scenarios were presented, which led to discussions with the review panel on the likelihood of quench propagation through the channel, and on the quench detection electronics.

Following the presentation discussions were held about stray field mapping in the hall, which has not yet been fully planned, and also whether any review of cryogenic safety has been carried out.

Magnetic Field Sensitive Equipment in the MICE Hall – Craig Macwaters

An overview of the MICE Hall Vector Fields stray field model prior to the introduction of the PRY was shown, and information on the original attempts to find all field sensitive equipment and design local shielding for this equipment was given.

The COMSOL model of the cooling channel incorporating the PRY was then shown, and the substantial reductions in stray field level were highlighted.

The locations of the cryostats and the LH_2 gas panels were shown both with and without the PRY. With the PRY in the model, this equipment sits in field regions low enough to not be of concern. Some further areas which were of concern without the PRY were listed, all of which are no longer a concern with the PRY.

A brief overview of the PPS system and its implications for running the magnets and gaining access to the hall during magnet running was given.

PRY Simulation Overview – Holger Witte

An overview of the PRY design principle was shown. Simulations showed that PRY geometry did not have a big impact on performance, so the final design was mostly engineering driven.

Various plots were shown, showing the COMSOL simulated reduction in stray field due to the PRY, in particular in the region of the field tracker cryostat.

Horizontal gaps in the PRY structure do not dramatically decrease its effectiveness, however vertical gaps do. This problem is resolved by sealing vertical joints between two overlapping pieces of steel, providing a continuous path.

The risks identified with the design were presented, as well as the steps taken to mitigate them. Two separate FEA codes (Vector Fields OPERA and COMSOL) have been used to produce models, the results of which are very similar. The material properties were identified as a risk, as different 1010 steels can have quite different magnetic characteristics. Due to this, high quality steel with very repeatable magnetic properties has been sourced from a company in Japan. Testing and measurement of the steel has shown that there is still a difference between real values and targeted values, but not enough of a difference at the MICE operating point to cause problems.

Further simulations were shown covering potential designs for the future development of the PRY in preparation for the next stage of the MICE project.

Discussion following the presentation went back to the subject of forces acting on coils due to the presence of the PRY. Holger stated that simulations had been done in the past on this subject and the results were deemed acceptable, but could not provide further details at the time.

MICE Hall tour:

The review panel were given a tour of the MICE hall, and given the chance to inspect the completed installation of the south side of the PRY as well as looking at the magnets themselves. MICE engineers were available to answer any questions raised by panel members.

Review panel comments and recommendations:

Following a review panel closed session discussion; verbal feedback was given to MICE covering the following points:

Comments

- The review panel would like to thank the MICE speakers for a series of interesting talks, and while some of the conversation may have strayed away from the safety aspect, it is hoped that the points raised will be considered useful by MICE.
- The review panel were impressed with the completed installation work for the south side of the PRY.
- The review panel approve the choice of commissioning scenario 5 as presented.

Recommendations

- It was felt that the various quench scenarios were unclear, particularly over whether there are any safety implications of one magnet quenching without the others. It was felt that quench-back should not be relied on to quench the whole channel, and there were remaining questions over the reliability of the electronics in the quench detection system and its ability to avoid false quenching. This should be clarified.
- A cryogenic safety analysis including a loss of vacuum should be in place. This should be made available for the ISIS-MICE Safety Committee.
- A plan for the stray field mapping around the PRY during commissioning should be completed and presented for review to the ISIS-MICE Safety Committee.
- Training should be put in place to establish competence of anybody having controlled access to the hall with the magnets energized, for compliance with STFC safety code 39. A list of competent people should be kept and checked before granting entry.
- There were concerns that in the event of a full quench during a controlled entry, visibility in the hall would be low and that therefore consideration should be given to putting high visibility emergency exit signs on the floor.
- There remained some concern over the effect of forces acting on the coils due to the presence of the shielding. It is recommended that MICE look at the simulation work that has been done in order to quantify the forces, and to ensure that the coil supports will be strong enough in the direction that the forces will be acting.