September 20, 2011

MAP INTERNAL REVIEW REPORT

MICE Spectrometer Solenoid Repair Plan

Review date: Tuesday, September 13th 2011

Reviewers: Alan Bross, Richard Fernow, Don Hartill, Daniel Kaplan, Derun Li, Kirk McDonald, Robert B Palmer, John Tompkins

The MAP Interim Director would like to thank the MICE Spectrometer Solenoid repair team for their well prepared presentations to the MAP Technical Board. The charge and the individual reports from the committee members are appended to this report.

In general, the MAP TB was impressed by the work done by the Spectrometer Solenoid team. The TB has advised the MAP Director to accept the plan after taking into account the following:

1. There appeared to be some inconsistencies in the schedule as presented, which suggested that the delivery date of the first SS at RAL was over optimistic, by perhaps a month. The schedule should be checked in detail and revised.

2. Measurement of the field along the axis with sufficient accuracy (3-D Hall probe?) to detect any substantial deviation from the nominal field direction should be considered. This would be worthwhile if it introduced no more than a short delay (e.g. a week?) in the delivery schedule.

3. To validate that the assumed "quench back" will happen, a calculation should be performed of the radial tension or compression on the interfaces between the inside of the coils and outside of the mandrel.

4. Triggering the "HTS lead protection" to draw down coil currents in the event of any indication of a quench should be considered.

I am pleased to accept the recommendations from MAP TB, and adopt the plan prepared by the Spectrometer Solenoid team as the proposed MAP plan once the schedule has been revised (item 1 above), and a suitable document describing the plan has been prepared to transmit to the DOE. Item 2

above should become part of the plan provided it does not introduce a significant delay in delivering the magnets. Items 3 and 4 should receive serious consideration.

Finally some comments on schedule and resources. The TB noted that, even after the requested revision, the proposed schedule is very aggressive. The TB was not asked to review, and did not review, the resource requirements to implement the plan. The list of required resources, provided by Steve Gourlay to the MAP Director, are consistent with the MAP FY12 plan based on the present funding guidelines.

Steve Geer

(MAP Interim Director)

APPENDIX 1: The Charge

A timely repair of the MICE Spectrometer Solenoids is crucial for both MAP and MICE. We must ensure that the plan is both adequate and, since it will require a significant fraction of MAP FY12 funding, is also fiscally responsible.

Review and comment on the following:

1. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?
2. Does the repair plan adequately address the known past problems with the spectrometer solenoids?
3. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?
4. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?
5. Is the schedule credible? Are the schedule risks acceptable?

APPENDIX 2: Reviewer Reports

Alan Bross

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Review and comment on the following:

6. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?
    a. To a large degree yes. However, there is a great deal of uncertainty due to the lack of instrumentation (voltage tap readout and vacuum) in previous tests that makes interpretation of the collected data difficult and in some cases ambiguous. There is not much else to do at this point other than to apply the known "best-practices".
7. Does the repair plan adequately address the known past problems with the spectrometer solenoids?
    a. Yes, to the level that they are understood and with the application of the known best-practices as applied to superconducting magnet fabrication.
8. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?
    a. Yes.
9. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?
    a. Yes, but I feel that some additional B mapping is in order.
10. Is the schedule credible? Are the schedule risks acceptable?

a. There are problems with the schedule as shown which need to be addressed. In addition, I think that the roughly 4 weeks for training, testing and evaluation of the first spectrometer solenoid is too short. I would add 2 weeks

Bob Palmer response to

MICE Spectrometer Solenoid Repair Plan Review

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1. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?

A qualified yes. See note 1

2. Does the repair plan adequately address the known past problems with the spectrometer solenoids?

A qualified yes. See note 2

3. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?

A qualified yes. See notes

4. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?

Yes

5. Is the schedule credible? Are the schedule risks acceptable?

Yes

Notes:

1) I have some reservations about the simulations assumption of "quench back" that is dependent on good thermal contact between coils and mandrel. I would like to see a calculation of the radial tension or compression on the interfaces between the inside of the coils and outside of the mandrel. The aluminum over-wrap would provide compression, but the electromagnetic forces are trying to pull the coil off the mandrel – i.e. tension on the interface. It is important

that the overwrap be sufficient to avoid such tension that could cause separation and reduction of the thermal contact needed for “quench back”.

2) It seems like a good idea to trigger the “HTS lead protection”, and thus draw down of coil currents, in the event of any indication of a quench. This would provide a level of “active quench protection” that has been recommended by one of the earlier reviews. This option was discussed, but not definitively agreed to.

John Tompkins

1. ***Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?***

   Yes. Detailed analyses and simulations have provided results which are consistent with the observed problem. Overheating of the bypass/protection resistors was noted and analyzed but there were no failures; improvements have been planned to make this area more robust; the HTS leads configuration has also been revised.

2. ***Does the repair plan adequately address the known past problems with the spectrometer solenoids?***

   Yes. A number of improvements to the system have been planned but there are no changes of sufficient complexity or change in approach which would compromise success.

3. ***Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?***

   Yes. The improvements planned/underway will provide additional system robustness and protection. And, as noted in 1.), the results of detailed analyses and simulations of failure modes support the approach taken.

4. ***Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?***

   Yes. A full cryogenic test and measurement of the field are sufficient. I agree with comments made at the review that a measurement of the field along the axis should be of sufficient accuracy (3-D Hall probe?) to detect any substantial deviation from the nominal field strength and direction.

5. ***Is the schedule credible? Are the schedule risks acceptable?***

   Yes. The schedule is aggressive (and has one or two details to be resolved) but it is not unrealistic.

Unsolicited comment: The MICE spectrometer group, and specifically, the LBNL group, should be commended for the very substantial and thorough analysis of the failure, the modeling of system improvements, and investigation of other possible failure modes.

Kirk McDonald

My overall view is that we should proceed with the repair, but I feel it likely that there will be further troubles with the magnets.

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A timely repair of the MICE Spectrometer Solenoids is crucial for both MAP and MICE. We must ensure that the plan is both adequate and, since it will require a significant fraction of MAP FY12 funding, is also fiscally responsible.

Review and comment on the following:

Comments by K.T. McDonald

1. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?

I was not convinced of this. It seemed more that the present team proceeded in its own style, rather than critically understanding the shortcomings of the early design.

2. Does the repair plan adequately address the known past problems with the spectrometer solenoids?

It probably addresses the known past problem, but there may well remain unknown past problems.

3. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?

The term “acceptable level” seems not to be defined. So far, we have “accepted” the many failures in the spectrometer solenoids. In any case, it seemed that several aspects of the repair plan were tentative, pending further tests. I interpret this as implying the answer is NO to item 3.

4. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?

I defer to others who have commented on how the test plan should be revised/augmented.

5. Is the schedule credible? Are the schedule risks acceptable?

Since no estimate was given of the dollars/resources needed to maintain the repair schedule, I would characterize it as not credible. Others have commented that the schedule is aggressive, and likely will not be met. Is this “acceptable”? Again, I note that in the past we have “accepted” the vast schedule overruns, so I presume we will do so in the future if they recur.

Derun Li

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Review and comment on the following:

1. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?
   Yes, there have been many reviews by experts. Quench protection analysis is in particular received more attention and lots have been done. The updated design and repair plan has addressed all areas and should work.
2. Does the repair plan adequately address the known past problems with the spectrometer solenoids?
   Yes, to the best knowledge that we have learned and experienced so far.
3. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?
   Yes.
4. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?
   Yes in general, but the testing plan details need to be further finalized with inputs from MICE collaboration. In particular to decide where, when and how to address the on-axis B fields measurement and alignment issue.
5. Is the schedule credible? Are the schedule risks acceptable?
   The schedule presented seems to be success-oriented. It may need a few extra weeks in consideration of Thanksgiving, Christmas and New Year holidays. Resources are a concern, can we get adequate and qualified man power support at the right time?

Coordination of man-power needs and schedule is critical to the success, in particular during assembly and integration phases.

Rick Fernow

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Review and comment on the following:

1. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?

Part of the problem seems to be a lack of instrumentation in the original magnet design. This has made it very difficult to understand with certainty the cause of the failures.

2. Does the repair plan adequately address the known past problems with the spectrometer solenoids?

Probably. The amount of instrumentation will be greatly increased. In addition, the design safety margins are much larger.

3. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?

Probably. At least if something goes wrong they should know why in much better detail. I am familiar with Tapio Niinikowski from many years ago. His analysis of the cryogenic heat loads is probably as good as you can get.

4. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?

I agree with the comments from Alan about the magnetic measurements. They should at least follow Bob's suggestion and measure the transverse fields on-axis.

5. Is the schedule credible? Are the schedule risks acceptable?

The schedule seems very tight. Hopefully there is enough slack built in to allow for a few setbacks along the way. From a political point of view it would be much better to deliver the magnets ahead of the official schedule and not be late yet again.

Dan Kaplan

My brief answers:

1. Are the past problems with the spectrometer solenoid sufficiently well understood so as to have confidence in the repair plan?

Not possible to tell with certainty, but it seems plausible that they may be. Weaknesses in our understanding will be much alleviated as the repair progresses and additional data are obtained.

2. Does the repair plan adequately address the known past problems with the spectrometer solenoids?

See answer to 1.

3. Is the repair plan sufficiently conservative so as to limit the risk of another failure to an acceptable level?

I believe so. (Further group discussion of this might be useful.)

4. Is the test plan appropriate? Is it sufficiently detailed in order to guarantee successful operation of the spectrometer solenoids in MICE, if the magnets pass test at the vendor?

The limitation to one training quench per day may be needlessly conservative. As touched on during the meeting, more thought should go into possible magnet flaws that could be turned up with somewhat more detailed field measurements than are currently planned. The acceptance-test field-measurement plan should be specified in more detail.

5. Is the schedule credible? Are the schedule risks acceptable?

We turned up some apparent flaws which Steve will look into. We'll need to see the revised plans in order to judge.