US LHC IR Quadrupole R&D Program Review
18-19 March 1999
Fermilab

Summary of Recommendations
J. Strait

This summary is based on my notes from Arnaud Devred's presentation in the closeout, and has been checked by him for accuracy. It does not, however, represent the report from the review committee, which is currently in preparation and will be circulated once it is complete and has been approved by the whole committee.

I also attach a copy of the charge and agenda for the review.

1) HGQ05 should be considered as the reference design against which modifications are considered. As such, the test data from this magnet should be fully analyzed and its behavior understood as completely as possible.
2) The committee endorses the change of end part material from Ultem to G10/G11.
3) The results from HGQ05 show that there are no thermondynamic stability problems with the cable, but we may have underestimated the effect of the 135C cure on the HGQ05 performance. Therefore we ought to consider the cure temperature more carefully. The committee recommends that we stay with the epoxy and low cure temperature if we can satisfy the coil cooling requirements either by showing that porosity is not required, or finding a vendor (perhaps that used by KEK) who can put on a thinner coating that will preserve the porosity. If it is necessary to use the 190C cure cycle, then the committee recommends that we follow the CERN specifications for the final treatment of the wire and cable: anneal the strands, coat them with Stabrite. Carefully evaluate the necessity of and parameters for any post-cabling heat treatment.
4) The committee sees no reason to reduce the number of strands in the outer cable from 46 to 45.
5) The committee does see good reasons for the 38->37 strand change for the inner cable. Winding tests of the 37 strand cable should be performed as soon as possible to verify fully it mechanical stability.
6) The committee feels that the decision regarding the inner cable lay direction should be driven by technical considerations and not by the small cost savings from using left lay cable. The committee recommends that we consider the issue of crossing strands in the splices. If the strands do not cross we may need to do some development to ensure low and reproducible splice resistance.

7) Matching coil properties is a good idea. The committee in addition recommends we learn how BNL cures coils, particularly for the high temperature cure cycle, and see if we can learn something useful from them.

8) The collar packs are good, but we should improve their engineering to reduce the high frictional force required to assemble them about the coil.

9) Further optimization of the containment of the forces at the ends is indicated, and the committee recommends considering splitting the large current block in the outer layer.

10) The committee strongly encourages us to keep studying the axial mechanics to gain a detailed understanding.

11) It is not clear if the end preload through the bullets is required, and the committee endorses our plan to pursue tests of this.

12) The committee believes that the collets are a reasonable solution to end clamping, but recommends that we develop a more production oriented procedure for coil end shimming and try to improve the coil end size reproducibility.

13) The effect of bolting the collets to the end plates needs to be understood better by including this in FEA models and in the overall study of axial mechanics, and by the planned tests of HGQ05 with the ends freed.

14) Quench training with full energy deposition in the coil needs to be done to check if there is any detraining that might result, as has been observed in some LHC dipoles.

15) The R&D program plan needs to be revised to capture fully the lessons learned from HGQ05 and from the strand and cable development program.

16) The committee strongly recommends that the revised program still include 2 nominally identical models.

17) The committee recommends that we try to keep to the original schedule for the full-scale prototype, and not allow it to slip based on the extended model magnet program.

18) The committee strongly recommends that the prototype must include the final cable design, and therefore it is very urgent to start and finish the strand and cable development.

Review – Charge
HGQ R&D Program

Background:

The US LHC Accelerator Project is responsible for providing CERN with integrated inner triplet magnet systems for the four interactions regions (IRs) at points 1,2,5, and 8. Fermilab is responsible for the design, development and fabrication of half of the high gradient quadrupoles. While most of the R&D issues have been resolved, the models tested up to now have exhibited unacceptable quench training. The goal of this review is to obtain the advice of the committee concerning the direction and adequacy of our R&D program.

The high gradient quadrupole R&D program includes:

> The design, construction and testing of a series of short (2 m) model magnets in order to develop the design features required to meet the functional requirements (model magnet program phase 1).
> The construction and testing of two nominally identical 2 m models of the "final" design, incorporating all the design features developed during phase 1 (model magnet program phase 2).
> The design, construction and testing of a full-scale prototype magnet in a prototype cryostat.

The review will address the model magnet program, which is currently in its first phase. In particular, the following topics will be presented:

Overview of the mechanical design
Design iterations
Quench performance
Hardware & assembly
Plan for magnet tests and other R&D activities

HGQ Review Committee:

The design review committee members are as follows:

Arnaud Devred, Saclay, Chairman
Pierre Vedrine, Saclay
Ranko Ostojic, CERN
Daniel Leroy, CERN
Mike Anerella, BNL
Bob Schermer, consultant
Akira Yamamoto, KEK (cannot attend, but will receive all review materials)

Review – Charge
HGQ R&D Program

The following questions are posed to the review committee:

1. Has the design team learned all it could from the tests so far?
2. Does the R&D program – model magnets and other tests – address adequately the design questions and weak points identified so far?
3. Are there weak points in the design that have not been identified?
4. Are there additional technical options that should be considered?
5. Are there issues other than quench training that are not being adequately addressed?
6. Have intellectual and material resources that are adequate to solve the quench problems in a timely way been applied to the program?

The design review committee has the usual freedom to investigate other areas of the HGQ R&D program that may provide insight into the quench performance of the magnet.

Results of the Review:

The review will be complete with a summary discussion by reviewers of their observations, conclusions, recommendations, etc. The review committee will provide the Project Manager with a written summary documenting their observations, conclusions and recommendations.

Review – Charge
HGQ R&D Program

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Draft Agenda

Thursday 18 March 1999

9:00 am Introduction – a series of presentations to provide an overview of design features and results of magnet testing to-date
- Focus→Quench Performance
- Overview of Mechanical Design
- Design Iterations
- Quench Performance
- Directions

10:30 am Break & Continuation of Presentations

12:30 pm Lunch

1:30 pm IB3 Tour – a tour of the manufacturing building to provide a hands-on introduction to the parts of the magnet and the assembly process
- Coil Winding
- Curing
- Collaring / Yoking / Skinning
- End Cans

3:30 pm Discussion

4:30 pm Friday Action Item List – development of a list of additional information, calculations, figures, drawings, data, etc. that the reviewers would like to discuss on Friday

6:00 pm Reception

7:00 pm Dinner at Chez Leon

Friday19 March 1999

9:00 am Follow up on Thursday Discussion / Action Items – continued discussion and presentation of topics and action items raised on Thursday

10:30 am Break

12:30 pm Lunch

1:30 pm Discussion – continued discussion

3:00 pm Break

4:30 pm Closeout – summary discussion by reviewers of their observations, conclusions, recommendations, etc.