# LHC Enhanced Quench Protection System Review

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# Enhanced QPS Review Panel

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# Enhanced QPS Review

- We wish to thank the LHC management for inviting us to serve on this review committee and giving us the opportunity to make a small contribution towards the success of this great endeavor.

# Enhanced QPS Review

- We wish to thank the Machine Protection staff for the unstinting granting of their time, for their candor and for engaging with us in the spirit of collegiality and common effort as we have tried to understand the issues related to the upgrade of the Quench Protection System.

- The level of understanding and development since 19 September has been very impressive.

# Review Charge

1. Review in terms of completeness, the functional specifications of the proposed new system, in particular, the strategy for the proposed new scheme to detect (and protect against) abnormally high resistance “splices” and the detection of a symmetric quench.

1. Review and analyze the technical details of the proposed implementation of the new enhanced Quench Detection and Protection system paying particular attention to the critical nature of the system with respect to LHC operation.

1. Examine all operational issues associated with the new system in particular the two extremes of failing to trigger when necessary and spuriously triggering unnecessarily and thereby causing down time of the LHC.

1. Review the planning schedule foreseen for the completion of the new Enhanced QPS system and define priorities (high resistance splice detection vs symmetric quench).

1. Review the robustness of the new system which should operate reliably during many years in a hostile environment (including radiation) of the LHC tunnel.

# Functional Specifications

Recommendation

- Write a formal overall project specification for the design of the splice protection system

Recommendation

- Write a formal overall project specification for the design of the symmetric quench protection system

# Functional Specifications

Recommendation

- Collect and review existing Miits limit calculation documentations for all components in all circuits and generate a summary document for design and reference. Use it to verify existing circuit protection designs.

# Technical Details

Finding - High Resistance Splice Detection

- The Machine Protection staff has demonstrated a deep understanding of the issues involved in the design of this system: noise levels, filtering, choice of electronics, radiation sensitivity, etc.

- We have full confidence that their new system will have the ability to detect and interlock errors on the level of 0.3 mv and to give early warnings for suspicious splices measured at the level of 1 nohm.

- With this system in place, they will be able to detect resistive splices.

# Technical Details

Recommendation – High Resistance Splice Protection System

- We strongly recommend that the Machine Protection staff develop techniques to put at least 1 kA through the splices in a non-superconducting state so that they can then measure voltages across the buses and uncover any splices that have good superconducting joints but poor electrical contact through the copper stabilizer in the main bus joint.
- Any such splice, if present, would be undetectable by the High Resistance Splice Detection system. It would lurk like a “Silent Killer”, with the potential for a bus failure whenever it quenched at operational current levels.

# Technical Details

Recommendation – Existing QPS

- We strongly recommend that the existing magnet coil quench protection system be modified to include the single joint within each magnet that is presently not included in the system that measures magnet resistances at the 10 nohm level. Accomplish this through modification of the “IFS box”.

- With three known bad internal splices already identified, we feel that these joints cannot be left unmonitored.

- Although a failure of this joint will not be as harmful as that of a bus joint, the failure will destroy the individual magnet and will have the capability of burning holes within the magnet cryostat.

# Technical Details

Findings – Symmetric Quench Protection System

- The machine Protection staff has grasped the opportunity provided by the installation of the splice detection system to design an excellent Symmetric Quench detection system, making good use of the new cables to minimize the effort required and selecting the system with the best features of all of the considered alternatives (the 3+1 system in the case of dipoles).

- We have confidence that this system, once its design is complete, will be able to detect quenches at the 200mv level [twice the normal detection level] and will provide an important redundant back-up to the existing magnet coil quench protection system.

# Technical Details

## Recommendation – Symmetrical Quench Protection System

- None

# Operational Issues

Recommendation

- Power the accelerator only after the splice protection, symmetric quench protection and redundant UPS systems have been installed and commissioned.

- Prior to superconducting operation, either experimentally verify that all main bus copper stabilizers exhibit adequate longitudinal conductance or set appropriate operational limits

- Prior to physics operation, measure all splice resistances (bus and magnet) using developed techniques.

# Operational Issues

Recommendation

- Define a dedicated operational procedure for taking, analyzing and responding to joint resistance measurement data.

# Planning Schedule

Comments

- The scope of the Enhanced QPS system required for operation in fall was considerably increased at the Chamonix Workshop without a change in schedule.

- We are encouraged that overall Enhanced QPS project management is being developed.

# Planning Schedule

Recommendation

- Laboratory management should ensure that proper resources required from outside the MPE group be made available.
- Review the resource assignments to confirm resource requirements and availability for the critical tasks.
- Develop workflow plans  for production and installation of the Enhanced QPS. This should include process flow diagrams and layouts of testing, staging and work centers.
- Quality assurance and maintaining functional requirements must take priority over schedule.

# Robustness

Recommendation

- Ensure timely procurement and testing of spare components (such as cold diodes).
- Monitor the radiation exposure at each Enhanced QPS system crate and develop a maintenance plan.
- Ensure tunnel dehumidification and temperature control in order to maintain electronics and connector reliability.

We look forward to celebrating your accomplishments this fall and the coming years.