Chapter 11. Prototype Cold Mass

Prototype Goals

The goal of the prototype program is to demonstrate the extension of the conclusions of the model magnet program to the full length, MQXB design. At the end of the prototype program, the Fermilab – LHC effort will be on line for a production readiness review, the last step before initiation of the production of deliverable magnets to CERN for installation in LHC.

The prototype program is built in two steps: the production and assembly of a first full length cold mass, which is cryostatted and tested singly (Q2P1), and the production of a second cold mass, identical to the first, which is then assembled with the first cold mass and a prototype MCBX corrector from CERN into a single helium vessel. This vessel is then assembled into a full length Q2 cryostat, and the complete assembly (Q2P2) again tested at the Magnet test facility.

The first step in the program provides initial verification of the extrapolation of the cold mass design from the 1.8m models to the 5.8m MQXB and verification of the Q1/Q3 cryostat design and assembly procedure. The second step provides a confirmation of the cold mass performance, and a verification of the complete Q2 assembly and test procedures.

From a cold mass centric view, the goals of the prototype program are to verify the same items as the model program:

- Quench Performance – using the production quench performance program as in HGQ08/09, verify the adequate quench performance of the full-length magnet.
- Field Quality – show that the measured field quality is consistent with that predicted in the latest version of the reference table
- Quench Protection – demonstrate the magnet can be adequately protected within the limits of the LHC Quench Protection system
- Alignment – demonstrate that the alignment of the production cold mass is consistent with that seen in the model program.

To complete the prototype program, new winding, curing, and collaring tooling is required, as the IB3 tooling is limited to coils of 2m and less. The yoke and skinning press currently in use can handle magnets of this length and no modifications are needed. In addition, the Vertical Magnet Test Facility is limited to lengths of 4m or less, so a Horizontal Test Stand is required in the Magnet Test Facility, which means the cryostat and production measurement equipment must also be available to complete the program. The schedule described later for test of the prototype magnets is current and reflects these other necessary inputs.

Prototype Design

The prototype magnet follows directly from the model magnet program, building on the best practices from magnets HGQ05-09. A brief description of the design,shown in Figure 1, is as follows.

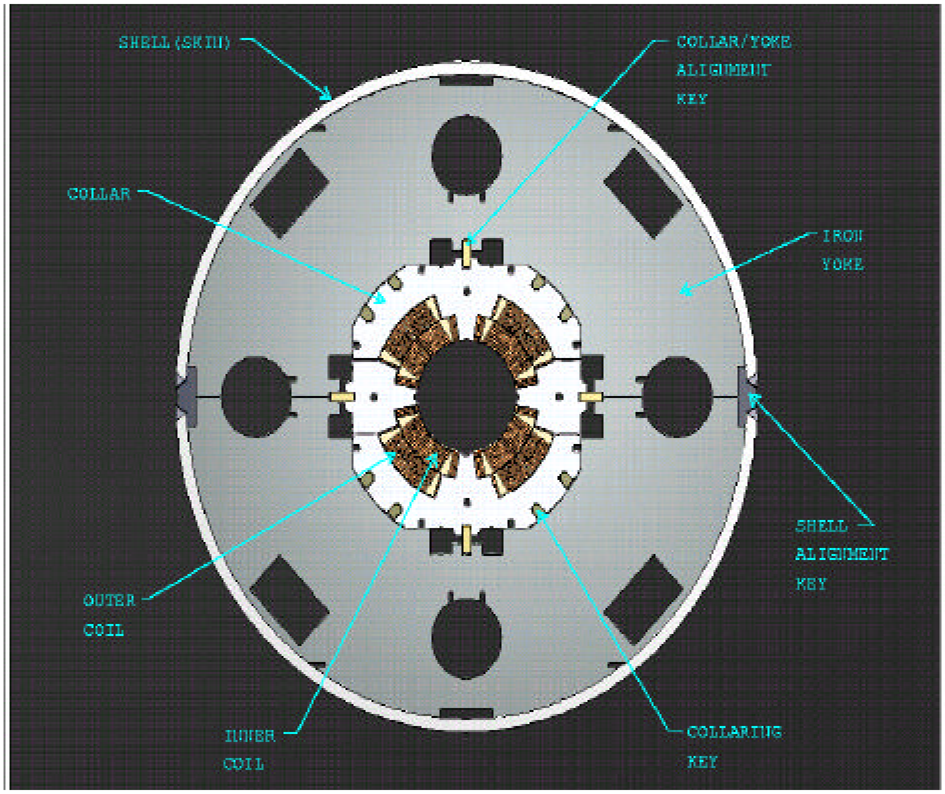

Figure 1. Prototype Cross Section

The cable will be made from SSC type strand, unannealed and without a stabrite coating. The inner cable will be made of 37 strands, have a right lay direction such that it can be wound favorably, with both the nominal strand dimensions and the nominal cable dimensions being the same as that used in the recent models. The outer cable will be made of 46 strands, left lay, with both the strand and cable dimensions being the same as used in the last 5 model magnets. The inner coils will be insulated with an electrical wrap of Kapton HA, 25 microns thick with approximately 50% overlap, followed by a mechanical layer of Kapton LT 50 microns thick, with 2mm edge to edge gaps. The outer surface of this mechanical layer is coated with ZQIX, a modified polyimide adhesive. The outer coils will be insulated with an electrical wrap of Kapton HA identical to the inner coils, but followed with a mechanical wrap of insulation of 25 micron thick Kapton LT, coated with ZQIX, and overlapped approximately 50% as well. The nominal insulation scheme follows directly from the model magnets HGQ06 and beyond, we expect the exact amount of overlap of the insulation will be adjusted after several test coils such that the mechanical properties of the cured coils are within targets. The wedges will be produced to the same dimensions as the model program.

The coils will be cured using a two step cycle, where the coil is first cured at low pressure and 190C, followed by a high pressure, 135C cure. The target size for both the inner and outer coils is +275microns with respect to the master at 83MPa, and the target measured azimuthal modulus of elasticity is 9Gpa for both coils.

The end parts will be G11CR, machined to the 5 block design used in HGQ06-09. Internal splices will be used for the inner to outer coil layer jump, as has been used since HGQ03. The end regions are shimmed to a nominal prestress identical to the body, tapering off to zero at the ends.

The CERN supplied quench protection heater will cover the outer coil only, and be double element with a SS:Cu longitudinal distribution of 2:1 and a steel section length of ~100mm. The ground wrap system is consistent with that used in the model magnets.

Both coils will be preloaded to a target stress of 75MPa by Nitronic 40 collars, assembled in collar packs and without bearing strips, as was done in HGQ08 and HGQ09. The packs will be 38mm long, providing discrete cooling channels with that period along the length. The keys will be at least 75mm long, of phosphor bronze. Collet end clamps, using aluminum exterior cans over G11CR quadrant pieces will support both ends of the coils.

The yoke laminations include modifications introduced with HGQ09, which affect the magnetic and thermal characteristics only. The tuning shims have been deleted from the design, and ½ of the tuning shim slot is now filled with iron as part of the lamination. Also, the cooling holes in every quadrant have been reduced to 50mm diameter, which remains adequate for thermal performance and increases the lamination stability. The yoke continues to have a radial clearance with respect to the collar and does not provide any mechanical support, and alignment between the collar and yoke is provided in the standard way with collar yoke alignment keys in every quadrant. Stainless steel laminations cover the collets, reducing the peak field, and with modifications to the inner radius such that they clear the collet assemblies.

The assembly is completed by the welding of an 8mm thick shell to skin alignment keys in the automatic press in ICB, followed by the circumferential welding of the 35mm end plate to the skin at both ends. On each end the collets will be bolted to the end plates using the tension bolts to control coil contraction, and 2000lbs of force applied through each bullet to the end of each quadrant of coils. Green putty is used to do the fine detail shimming of the inner and outer coil end lengths in each quadrant.

For instrumentation, the prototype magnets will be instrumented much like the HGQ models were. Currently the voltage tap plan remains the same, as does the gauge pack implementation with both beam and capacitor gauges. Spot heaters will be placed on the pole turns of two outer coils.

<u>Prototype Schedule</u>

The target date for start of winding of prototype coils is 3 April 2000, with a projected cold test date for the complete Q2P1 assembly in October of 2000. The production inner cable run started at NEEW 3 March, and break in of the winding and curing tooling starts the week of 6 March. A picture of a long coil on the mandrel after winding is shown in Figure 2. The collaring operation is planned for June, and cryostatting in August and September. After completion of the first test, Q2P1 is disassembled, the P1 and P2 cold masses assembled with the MCBX prototype corrector, and the full cryostat assembly Q2P2 completed and projected for test in April 2001.

Figure 2. Practice Long Coil after Winding