18.0 Manufacture and Assembly

18.1 Initial Winding Approaches

Winding Procedure Specification Content:

The seller is responsible for selecting the winding process that will best achieve the required coil geometry, insulation configuration, and impregnation quality. A possible winding method is described here. The bidder shall describe his proposed winding procedure, and any change to the purchaser's suggested procedure as a part of bid proposal. The Seller's winding procedure shall be submitted to the purchaser for review and approval. Prior to purchase of the conductor, the Seller shall perform a test bend of a sample length of conductor, over a mandrel or bend fixture which has minimum radius required for winding the coil segment. The conductor sample shall have the same physical properties, yield strength ultimate and % elongation, as the specified conductor. The test sample of the conductor shall be wrapped with glass tape, and the mandrel surface shall have a Kapton sheet applied. Cuts in the Kapton, or tears in the fiberglass tape shall be reported to Purchaser for resolution.

Options for “Resolution”:

- Relax cold work
- Increase corner radius
- Pre bend over shaping rollers

Assembly and Manufacture

The Coil is layer wound
The Coil is made in three segments. Phased manufacture is allowed
Three separate mandrels are planned.
Mandrels maintain a precise bore geometry
Ribs are applied to outer surface of the wound and impregnated coil
Ribs are machined to match the ID of the next coil segment
Coils are slipped on to one another. – with a temperature difference if needed
Phased fabrication of the coil segments is the motivation for the mechanical head closure.

The joint flanges are loosened, bellows compressed, and ceramaseal penetration set screws are loosened.
The insulating penetration connections are removed.
Head lip seal welds (if used) are cut.
The closure head is removed. Internal support straps hold the coil weight.
The assembly shell is installed, bolted to the inner head bolt circle. Temporary supports/cribbing support the shell and coil weight. The internal support straps are removed.
The coolant shroud (red) is removed swapping inner and outer temporary supports.
The third coil segment is then slipped into place.
The internal support straps are replaced. The assembly shell is removed.
The head is replaced, and bolts torqued. The lip seal welds (if used) are made. The ceramaseal connections are re-made.
18.2 Initial Vessel Assemble Approaches

This was an MIT proposal. CVIP used a modified approach.
18.3 Magnet Manufacturing Experience

Trial Bending

This was a test winding done by Everson before material purchase, and before the final pricing proposal to CVIP
Damaged insulation from pinched rollers during the test winding.
Braze Joint Qualification

BNL Pulsed Magnet Manufacturing Status Sept 8 2004
Faint indication of silver soldered scarf joint
Load Displacement plot of Silver Solder Joint.
Winding Process

Segment #1 being wound. Photo taken by Dave Rakos at Everson 09-08-04. Kapton layer spaced at every eighth turn relieves axial tension in the layers near the cooling channels. First Layer, Coil Segment#2

Kapton arc sections inserted between every eighth turn on those layers that face the cooling channels.

Winding Segment #2
Segment #2 on the Winding Machine

Segment #3 has been wound and the outer “waffle” pattern has been applied. This is scheduled for impregnation Feb 2 to 4.
Impregnation Process

Segment 1 showing formed leads and portions of the mold

Glass Tube Surrounding the Joint Brea-Out, Coil number one. This is used as a sight glass to watch for bubbles during the vacuum application of the VPI process
A vacuum is maintained on the mold (inside the autoclave box) with a vacuum pump (not shown) to the right of the autoclave. The epoxy tank is at an atmosphere gage. Ron adjusts epoxy flow manually. After the mold is filled, pressure is cycled to drive off bubbles. The mold is under pressure during the cure cycle to minimize the remaining bubbles.
There was a leak in the longitudinal seam weld. This required application of RTV caulk and additional time to wait for the cure. This was to be held at 2 atm for 12 hrs prior to impregnation.
Impregnated Coils

Segment #1 out of the mold. External Silicon fillers that form the “waffle” pattern have not yet been removed.
Segment #1 Bore – Will be fitted to CVIP’s Bore tube
OD Machining Operations

The initial OD Machining operation used by Everson was to turn the coil on a lathe. The impacts of tool against the ribs knocked off some of the ribs. The machining operation was changed to a vertical mill. This made the ribs actually flats but the chord error was small.
Damaged Turn

Notch cut in epoxy to view room around conductor for repair

This turn "popped up" after winding and encroaches on the cooling channel volume

Segment 1 repair of notch
Failed Impregnation and Repair

Two Sheets of .003 inch Glass

Feathered Edge of Impregnated Insulation

1/4 to 1/2 inch

Bare Spot

1/4 to 1/2 inch

Feathered Edge of Impregnated Insulation
Nesting

Successfully nested coils – Segment 1 in Segment 2
Three Nested Coils with Instrumentation
File these corners so that the lead extension doesn't bottom out here, and the taper jams into the female thread of the extension.
Leads threaded with the coils being prepared for shipping
17.4 Vessel Manufacturing Experience

The Inner Cold Vessel at CVIP

Status of Vessel Drawing Submittal by CVIP

Inner Vessel drawings complete and nearly all approved.
Outer vessel drawings under review
Final manufacturing procedure is approved, but there are some final additions.

Segment of Vacuum Jacket Drawing under Review
Metallic seals for the cover flange
OK - The only problem with deleting the glass bead is that the contraction of the epoxy is about twice that of steel. With the glass bead, the contraction is close to steel. As long as the fillers are not bonded to the steel it will be OK, otherwise we will have some scary noises when we cool down for the first time. In our larger experiment across the street they use quartz sand for filler, and haven’t had problems with fouling valves, but they do have screens in the sump. Even pure epoxy has flakes and chips that can clog valves – especially when it cracks on cooldown. I think these should be flushed out during the tests at MIT.

Eliminating the glass filler eliminates a concern that I didn’t talk to you about: activation of any boron containing glass. So leaving out the filler eliminates one more type of material that might activate. “Epoxy only” filler in the dished head will shrink about 3 mm on the diameter with respect to the steel. You had talked about welding some studs or tabs to the head to hold the epoxy block to the head. The contraction could shear off studs. If they are closer to the ID they would probably just bend.

Attached are pictures of Epikure 3140 + Epon 815C epoxy sample.
We did not use glass bead as filler because we think it may come loose and damage the valve sit of N2 flow control.
It’s also not recommend by the manufacture.
We are in process of filling the inner vessel head and forming the strips for filling void area between the cooling shroud and inner vessel wall,
Casting the fillers
OK  We will solder the connections. Please make sure they are bundled carefully, with the labeling tags intact. Tape them to the inside wall of the triport well enough so they don’t shift when the magnet is shipped.

For documentation/contractual reasons, let me add some reasons why it is not as appropriate for CVIP to do the soldering:

The CERNOX sensors have 4 leads each. Two are to apply a current, and two are to measure a voltage. The CERNOX sensor current leads could be wired in series. However, we are not sure we have a current source that can supply the series voltage. We may have to apply current in groups of two or four. The pin count assumed two pins for all the current leads and then two pins for each CERNOX voltage tap. – However we would have instructed CVIP at this point, we might have had to redo the connections during the final configuration of the instrumentation. The discrete sensor was wired without a single lead for the common ground. Each diode has two leads. The common ground will have to be connected inside the instrumentation port to meet the pin count. This was my mistake. Friedrich has sent us the electronics, and we are going to test our understanding with the extra diodes and then wire the diode leads here.

I talked to Jim Zapp when I was at CVIP and he indicated that he hadn’t bought the second 20 pin connector. CVIP should be supplying the second 20 pin connector. – This was in the change order. CVIP can test and ship with a blind flange for the second instrumentation port, but we will need the connector. Shipped with the final shipment or later.