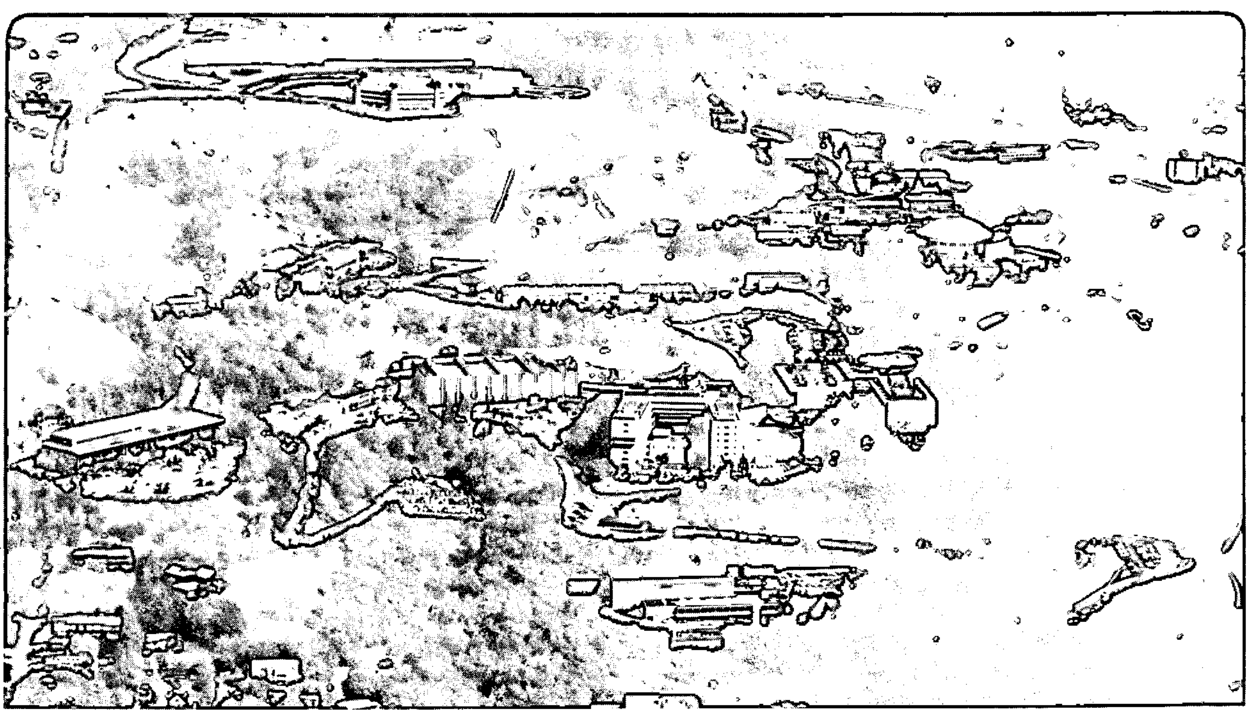
Title
CYLINDER ASSY, LARGE RADIUS COARSE FIELD CAGE

Author
Nesbitt, Dale.

Publication Date
1981-06-01

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Engineering & Technical Services Division



LBID 607

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA ENGINEERING NOTE		CODE P40406	SERIAL M5664	PAGE 1 OF 6
AUTHOR Dale Nesbitt	DEPARTMENT Mechanical Engineering	LOCATION Berkeley	DATE 24 June 1981	
PROGRAM — PROJECT — JOB PEP-4				
FIELD CAGES (TPC)				
TITLE CYLINDER ASSY, LARGE RADIUS COARSE FIELD CAGE				

The purpose of this note is to record pertinent information concerning the assembly work done at LBL on the L.R.C.F.C.which is specified on Drawing Nos. 19Q2746, 20C1486 and 19Q2736.

This note will be some what historical in nature and will spell out some of our failures and frustrations as well as the successes. Most of this work was done with NO drawings or procedures worked out a head of time. Rough notes were kept as well as time permitted by Fred Perry and Dale Nesbitt and many pictures taken. These are in two large looseleaf note book which will be kept by D. Nesbitt or in the print room. Most of the people who worked on the assembly are shown in one of the photos.

Electrical testing IS NOT covered in this note. This was specified by and the results given to the physicists.

* All dimensions in inches unless noted

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Due to lack of time the following will only be a very brief mention of some of the more important problem areas and of the solutions (if any). There is much more information in the note books and photos but it would be difficult for anyone to decipher (including me):

1) Demandreling: The force required to pull the wedges was excessive. We finally had to cut the mandrel apart.

2) The end of the insulation was not cut square by Sheldal, we made a special setup and cut it square.

3) The cylinder was not to print, either in length or I.D. It shrank approximately .043 on the diameter upon being removed from the mandrel.

4) The end rings were badly out of spec., especially on flatness which made it very difficult to flaten during assembly and epoxying. Apparently the epoxy didn't hold them flat.

5) The drilling fixture and dummy sectors did not match up well. Finally we decided to use the drilling fixture and force the dummy sectors to fit.

6) We found that the line up and drilling for the sectors did not work well as designed so we revised the procedures and designed several new fixtures.

7) The entire cylinder is skewed - which may have been caused or aggravated by pulling the wedges out. In the end this made it necessary to do the line up for the center supports etc. horizontally.

8) The cylinder is very weak, it sags almost 1/2" under its own weight.

9) There were a number of voids between the G - 10 boards used to build up the inner cylinder, they were filled at the cost of lots of time.

10) There were many small voids under the Kapton, all of them over about .100 were filled. After the initial electrical test (Building 6) under pressure and vacuum it was found that a large number of bubbles had formed. After testing of samples (report part of this Engineering Note) it was decided to pierce the Kapton.

11) Soldering of the sockets into the ferrules was a very difficult task. There should be a better way.

12) Measurements was however probably the biggest problem. First how to make them and then whether to believe them or not. This is to be covered in more detail in the next section.

Measurements:

The original concept was that most of the measurements and assembly of the end rings, supports etc would be done with the cylinder vertically on a flat table (A 8' x 8' table was purchased). There had been holes drilled in 6 places in the center groove (Drawing No. 198854) which would define the center plane. Then the end rings would be placed on equal distance from and parallel to these. The center supports were to be positioned in line with these holes. However, it did not work out that way or easy. First the cylinder was neither the correct I.D., length nor round. The height of the six holes (pins installed) were measured from the flat table and 3 selected to define a plane (total variation between all 6 was .007 - remember the desired maximum error is ±.004). The end planes were positioned, held flat as well as possible and epoxied. (See notes from 7-2 to 7-21 1980)

Measurements taken shortly afterwards indicated all was well. But later while trying to line up the location of the holes for the sectors from end to end it was observed that the cylinder was not perpendicular to the end rings. It was skewed about .030. An attempt was made to compensate for this and all the holes drilled. Due to this and to the out of tolerance cylinder it was decided that measurements of the I.D. and center supports and sector mounting surfaces had to be made with the cylinder in its normal horizontal position with sectors in place. This required more fixtures. The measurements were made using a indicator or depth mike mounted on arm(s) that divoted around a tube which was held in the center of the small radius end rings (which were not on the S.R.C.F.C.) which were held by the dummy sectors. There are sketches and photos of this.

Based on these measurements all the supports were reworked or remade and installed. See 19Q2736. However, the problem was always one of (a) being able to repeat a measurement - especially longitudinly and (b) even if it repeated there was no way to check the absolute accuracy.

The entire Field Cage assembly was completed after the L.R.C.F.C. (19Q2736) assy. was done using dummy end rings for the S.R.F.C. and with out trying to precisely align the L.R.F.F.Cs or check for axial line up of the large and small radius end rings. After the entire assembly was successfully tested (in Building 6) up to 100,000 volts it was taken back to Building 77 for the final precision lineup.

The items covered in this Engineering Note took from 6-10-80 to 12-19-80 with 2 to 5 assembly technicians so obviously this only covers it very lightly.

LAWRENCE BERKELEY LABORATORY
Bldg.: 50B Room: 6204 Ext.: 6521

May 4, 1981

MEMORANDUM

TO: Distribution

FROM: S. Sherman and D. Nesbitt

SUBJECT: Results of the H.V. Field Cage Bubbling Tests

After the high voltage tests in Bldg. 6 were completed it was observed that the kapton-epoxy laminate on the inside of the coarse field cage had developed bubbles. The bubbles varied in size with the largest being 1" × 1" with a depth of about 0.010/0.015". These bubbles might conceivably grow so large as to disturb the high voltage field.

In an attempt to understand and limit the growth of bubbles on the field cage, several samples of the field cage material were tested in an environment which simulated the pressure and vacuum conditions of the high voltage test. The idea being that bubbles formed as a result of compression and decompression during the H.V. tests.

4" × 4" samples of either 3 mil or 1 mil kapton on 1/8" FR-4 fiberglass were fabricated. Some were deliberately flawed. Some had areas where there was a lack of epoxy; some had small bubbles. The samples were placed in a test vessel and pumped down for 5 min. to 48 hrs., the vacuum reaching 25" Hg and 350 millitorr respectively. Then the vessel was filled to 135 psig with either 100% Argon or 80% Argon-20% Methane. The samples were kept at pressure for times ranging from 4.5 hrs. to 1 week. The vessel was vented to 1 atm. in 2 to 5 minutes, pumped down to 29 in Hg of vacuum and then backfilled with air. The samples were removed and immediately examined. Two samples from each test were kept at air for several days after decompression and checked daily under a microscope for signs of bubble growth. It should be pointed out that the 2-5 min. decompression in the bubbling test was much faster than the 20 hrs. in the high voltage test. Four samples each spent a total of 660 hrs. at pressure. In all there were 14 samples tested.

The samples showed no bubbling on the order that the field cage displayed. The largest bubbles were about 1/4" × 1/4" × 0.010" deep in the 1 mil samples and 1/8" × 1/8" × 0.005" in the 3 mil samples. In no case was there an increase in area, nor did any bubbles form except when there was no epoxy to start with. Bubbles which were lanced returned to their original size. The 3 mil samples in general showed less bubbling than the 1 mil samples. There seemed to be no difference in results produced by the 100% Argon and the mixed gas. Areas lacking epoxy developed small bubbles which, like all other observed bubbles, reached a limit to their growth.

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Our results suggest that there is something peculiar to the laminate in the field cage which allowed the bubbles to form. We were not able to produce bubbles on the order that was seen in the field cage even though our test conditions were more extreme than the H.V. test conditions. In addition, the three sections of the field cage display differing amounts of bubbling. They were fabricated at different times and this suggests that some aspect of the fabrication changed which allowed for greater or lesser susceptibility to bubbling even though care was taken to keep the fabrication consistent.

Whatever the cause, lancing the bubbles will take care of existing bubbles. Bubbles formed in the future will most likely reach a terminal size and in any case may be lanced when the field cage is removed. It is not known, however, if any more bubbles will develop. This is something that should be looked at during the IR-2 tests.

SS/DN:cg

Distribution:
- A. Bross
- L. E. Brown
- O. Chamberlain
- O. Draeger
- R. Madaras
- K. Mirk

AUTHOR	DEPARTMENT	LOCATION	DATE
Dale Nesbitt	Mechanical Engineering	Berkeley	24 June 1981

Conclusions/Recommendations:

1) The basic design concepts of the TPC (which includes the Field Cages) is inappropriate to hold the requested tolerances of ±.004 (1/10 mm).

2) Much more real Engineering needs to go into conceptual design, calculations, pre-planning and prototyping as appropriate before the design is released. Part of this would be to present a reasonable estimate of costs versus precision to physics so that alternate ways to acheive the end goal(s) could be considered. Trying to make it work as we did is the worst way.

3) It would have been a lot worse without the expert assistance of Fred Perry and the willing cooperation and many good suggestions from all the assembly and machine shop people, especially Bill Baldock, Roy Oki, Jon Wirth, Al Barone and Otto Draeger.

/nc

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720