TS-SSC 90-019

Fermilab

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MEMO TO: Rodger Bossert, John Carson, Wayne Koska, Paul Mantsch, Gale Pewitt

FROM: Jim Strait

SUBJECT: DS0309 Yoking

DS0309 was yoked and skinned twice. On the first attempt the yokes "chevroned" in the press when the second pass weld was about 90% complete. The skin was cut off, and the magnet was reassembled with new yoke packs and the original skin. The second yoking was successful. In this note I summarize the yoke chevroning incident and the modification in procedures for the second attempt, and display and discuss the collar pack strain gage data.

That the yoke laminations are unstable against chevroning (a column buckling type instability) when compressed in the yoking press and by the skin tension is obvious and was demonstrated during test assemblies of DSS012. In the base line design the end yoke blocks are epoxy bonded to stabilize them against chevroning. On the first assembly of DS0309 the end blocks were stabilized by several fusion welds on the outer circumference. This clearly proved inadequate. Epoxy bonded end blocks were used on the second attempt.

At the time the yokes chevroned, the press hydraulic pressure was set at 7000 psi (14000 lb/in or about 50% greater than the clamping force due to skin tension at room temperature). The press pump was valved off and the hydraulic system was closed off. When the yoke chevroned the hydraulic pressure dropped by about 1000 psi. Before completing the weld the press pressure was restored to 7000 psi. From the elastic properties of the press tie rods it was estimated that a 1000 psi pressure loss corresponds to the tie rods shortening by about 10 mils, meaning the press vertical opening decreased by this amount also. This corresponds to a longitudinal motion of the yoke mid-plane relative to the pole of about 200 mils. This was verified by rough measurements. Because the end clamp radius is about one half that of the yoke, if the yoke were tightly packed, the end clamps would be forced apart by about 100 mils. When the yoke was removed it was found that at the lead end there was a gap between the end clamp and the end of the collars that varied from roughly 1/32" on one side to 3/32" on the other side. There is no evidence of a gap between the coil end saddles and the face plate of the end clamp, indicating that most of the motion was the coil being stretched relative to the collars.

The collar pack strain gage data are summarized in Figure 1 and Table I. In the first assembly data were recorded before pressing, at full press load before welding, after the first pass weld, after the second pass weld (after the chevroning incident and the press load was restored to its full value) and after the press load was removed. Data were also recorded after the skin was cut and the old yoke blocks were removed. On the second assembly data were recorded at the same points except none were taken between the two weld passes. As discussed in an earlier note [1] the stress-strain calibrations for these gages are considered to be reliable; a generic calibration of 5.7 psi/$\mu\epsilon$ was used.

It is not understood why the coil stress increase under press load is larger in the second assembly than in the first even though a smaller press pressure (5000 psi vs 7000 psi) was used. In the first assembly coil stress decreased by about 500 psi following the yoke chevroning. This presumably results from the decreased skin tension due to the decreased yoke circumference. On the second assembly there is a net increase of 2.0 and 1.1 kpsi in the inner and outer coil stress due to clamping by the skin.

Between collaring and the first yoking attempt and between the two yoke assemblies are two periods in which short term creep can be observed. The creep rates are summarized in Table II.

[1] "Preliminary Analysis of DS0309 Collaring Data" - April 9, 1990, (TS-SSC 90-008)

GAGENO.	Gage Factor	R0(Ohms)	A0	A1	A2	A3
70	2.02	350.242	0.0	5.70000	0.0	0.0
53	2.02	349.941	0.0	5.70000	0.0	0.0
249	2.02	350.099				
87	2.02	350.627	0.0	5.70000	0.0	0.0
88	2.02	350.351	0.0	5.70000	0.0	0.0
244	2.02	349.948				
71	2.02	350.423	0.0	5.70000	0.0	0.0
76	2.02	350.212	0.0	5.70000	0.0	0.0
248	2.02	350.135				
266	2.02	350.394				
263	2.02	350.489				
262	2.02	350.412				
68	2.02	350.030	0.0	5.70000	0.0	0.0
77	2.02	350.408	0.0	5.70000	0.0	0.0

Seq. No.	Date	Press	Hydraulic Pressure Vertical	Hydraulic Pressure Horizontal	Average Coil Stress Inner	Average Coil Stress Outer	Average Coil Stress All	d(Stress)/dPv Inner	d(Stress)/dPv Outer	d(Stress)/dPv All
1	4/4/90	Bench	0	0	-216	-11	-113			
2	4/5/90	Collaring	0	0	-227	0	-114			
3	4/5/90	Collaring	400	0	150	552	351	0.94	1.38	1.16
4	4/5/90	Collaring	1000	0	606	1563	1085	0.76	1.69	1.22
5	4/5/90	Collaring	2000	0	1366	3440	2403	0.76	1.88	1.32
6	4/5/90	Collaring	3000	0	2070	5122	3596	0.70	1.68	1.19
7	4/5/90	Collaring	4000	0	2897	6557	4727	0.83	1.44	1.13
8	4/5/90	Collaring	5000	0	3438	7972	5705	0.54	1.42	0.98
9	4/5/90	Collaring	6000	0	4218	9052	6635	0.78	1.08	0.93
10	4/5/90	Collaring	7000	0	5018	10420	7719	0.80	1.37	1.08
11	4/5/90	Collaring	8000	0	5812	11421	8617	0.79	1.00	0.90
12	4/5/90	Collaring	9000	0	6472	12332	9402	0.66	0.91	0.79
13	4/5/90	Collaring	9000	1000	6661	12886	9774			
14	4/5/90	Collaring	4000	400	5954	10964	8459			
15	4/5/90	Collaring	0	0	4818	8339	6579			
16	4/17/90	Bench	0	0	4211	7685	5948			
17	4/23/90	Yoking	0	0	4213	7568	5890			
18	4/23/90	Yoking	7000	0	5089	9707	7398			
19	4/23/90	Yoking	7000	0	5156	9835	7496			
20	4/23/90	Yoking	7000	0	4686	9367	7026			
21	4/23/90	Yoking	0	0	4453	7935	6194			
22	4/24/90	Un-yoked	0	0	4290	7596	5943			
23	4/30/90	Yoking	0	0	3964	7519	5741			
24	4/30/90	Yoking	5000	0	6075	10111	8093			
25	4/30/90	Yoking	5000	0	6692	10959	8826			
26	4/30/90	Yoking	0	0	5938	8638	7288			

Table I

Table II

Date	--- σ (psi) --- Inner	Outer	--- $\Delta\sigma$ (psi) --- Inner	Outer	- $\Delta\sigma/\Delta t$(psi/day) - Inner	Outer
4/5	4818	8339				
4/17	4211	7685	-607	-654	- 51	- 55
4/23	4213	7568	+ 2	-117	0	- 20
4/24	4290	7596				
4/30	3964	7519	-326	- 77	- 54	- 13

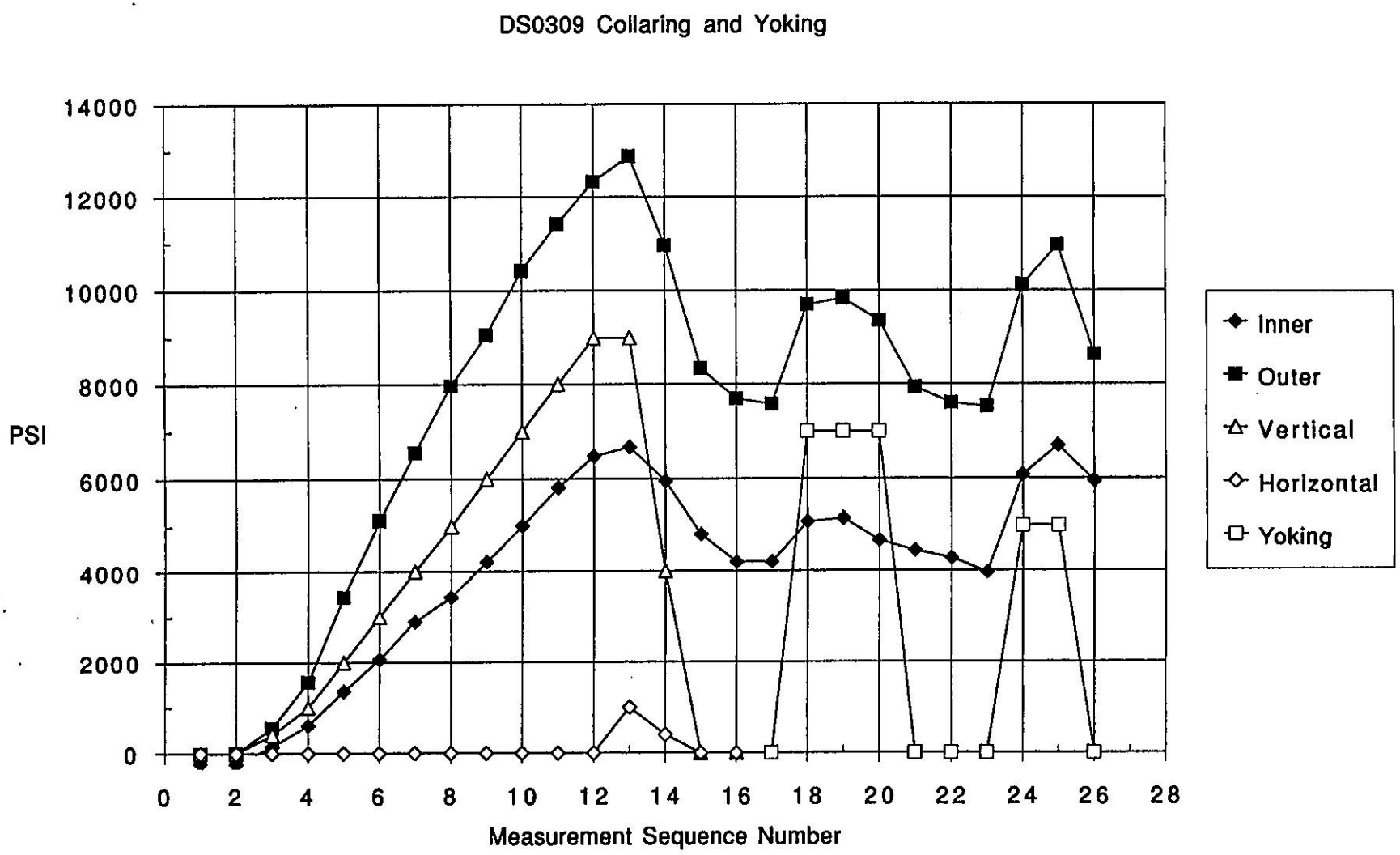
DS0309 Collaring and Yoking
PSI
14000
12000
10000
8000
6000
4000
2000
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Measurement Sequence Number
Inner
Outer
Vertical
Horizontal
Yoking

Figure 1