SSC-MAG-121
SSC-N-295
LBID-1264
2/3/87

COIL PRESTRESS MEASUREMENTS FOR NINETEEN 1-M COLLARED DIPOLE MODELS CONSTRUCTED AT LBL

C. Peters

During the past two years, nineteen SSC type collared 1-M dipole models have been constructed and tested at LBL. Three major types of collars were used; 25mm AL. (2 models), 15mm S.S. (10 models), 15mm AL. (7 models). Each of these models contained 4 gages (2 inner and 2 outer, except where noted in Table I) to measure coil pressure in the azimuthal direction at the pole of each layer. Each gage consists of a temperature compensated full bridge strain gage circuit. Warm and cold calibrations are performed on each gage before and after installation in its collar lamination assembly to produce coil pressure versus gage output calibration curves for 300K, 80K, and 4K. The detail design, construction, and calibration procedures are given in Ref. 1.

Table I is a compilation of all measured prestress data available on the 19 models constructed and tested. Absence of data means gages were not installed (note 15,13), were not read for that item (note 8), or some specific gage error or failure occured (note 11). In the author's opinion, the coil prestress measurements are accurate. The exception is the outer layer data for models D12C-1 through D12C-6, which may be 15% high due to radial load from the inner layer.

In some cases magnet constuction procedures created coil pressures aberrant to the norm (note 3,4,6,7,12,14). Care must be taken in characterizing magnet prestress behavior to account for these factors.

(1) C. Peters, "Coil Stress Meassurements on Five 1-M SSC Model Dipoles," SSC-MAG-57 (10/17/85).

TABLE I
SUMMARY OF COIL PRESTRESS DATA FROM ALL COLLARED DIPOLE MODELS

MODEL NUMBER	COLLAR TYPE	NOTES	ASSEMBLY (INNER/OUTER) (Kpsi)	AFTER COLLARING (Kpsi)	IN YOKE (Kpsi)	BEFORE CRYOSTAT (Kpsi)	WARM IN CRYOSTAT (Kpsi)	4K BEFORE CONDITIONING (Kpsi)	4K AFTER CONDITIONING (Kpsi)	CURRENT TO UNLOAD (KA)
D12C-1	25mm AL	2	16.3	9.9	8.3 (11d.)	-	7.7(18d.)	9.8	6.2	>7.5
		1 5	21.0	14.7	12.3	-	12.0	14.4	10.8	-
D12C-2	15mm S.S.	2	19.0	9.5	-	7.2(12d.)	7.3	1.8	2.6	5.0
		5	18.3	8.1	-	7.3	7.0	5.9	2.0	-
D12C-3	25mm AL		16.0	8.7	-	7.9(43d.)	7.9	9.8	7.9	7.5
		5	25.5	9.6	-	8.2	8.2	10.0	6.9	-
D12C-4	15mm S.S.	3	22.3	11.1	10.1(1d.)	-	9.5	4.3	5.0	>6.0
		5	16.2	6.1	5.1	-	5.8	3.8	3.3	-
D12C-5	15mm S.S.		21.7	6.8	-	5.6(5d.)	5.3(11d.)	1.5	2.1	6.0
		5	13.8	5.8	-	3.8	4.2	3.0	1.5	-
D12C-6	15mm S.S.	4	22.3	10.9	11.5(9d.)	11.9(11d.)	11.2	3.2	4.0	6.5
		1 5	14.7	5.2	7.3	6.9	6.7	4.0	2.8	-
D12C-7	15mm S.S.	4 6 7	18.4	5.0/3.2	-	-	5.0	1.2	1.3	4.0
			22.8	10.3/6.7	-	-	9.0	6.2	4.7	-
D12C-8	15mm S.S.	1 4	23.9	10.5	10.2	-	-	2.5	2.5	6.0
		1	24.9	10.3	9.2	-	-	-	-	-
MD-1	15mm S.S.	3 4 8	25.9	9.6	11.1(7d.)	-	-	-	-	-
			5.3	0.7	1.4	-	-	-	-	-
MD-2	15mm S.S.	4	20.2	9.8	-	9.6(21d.)	9.5	-	-	-
			13.2	6.5	-	6.2	4.9	-	-	-
MD-3	15mm S.S.	1	22.1	9.3	-	-	-	-	-	-
		1	9.0	7.4	-	-	-	-	-	-
D14B-1	15mm AL.	9 10	23.2	5.9	6.8	-	6.2(12d.)	5.6	-	7.0
		15	-	-	-	-	-	-	-	-
D14B-2	15mm AL	9 11	11.8	3.3	-	3.1(14d.)	2.7(18d.)	-	-	5.0
		15	-	-	-	-	-	-	-	-
D14B-3	15mm S.S.	9 11 12	7.6	3.0	-	2.6	2.7	-	-	5.0
		15	-	-	-	-	-	-	-	-
D14B-4	15mm AL.	13	15.8	5.7	-	-	-	-	-	-
		15	-	-	-	-	-	-	-	-
D14B-5	15mm AL	11	16.3	4.7	-	3.5	-	-	3.7	6.5
		15	-	-	-	-	-	-	-	-
D14B-6	15mm AL.	9	21.7	8.0	-	-	7.5	7.4	8.3	9.0
		15	-	-	-	-	-	-	-	-
D14B-7	15mm AL	9	19.8	7.8	-	-	7.7	6.4	8.9	9.0
		15	-	-	-	-	-	-	-	-
D14B-8	15mm AL	9 14	17.1	5.8	-	-	5.9	5.2	-	-
		15	-	-	-	-	-	-	-	-
D14B-9	15mm AL	9	16.3	5.5	-	-	5.4	4.0	6.2	8.0
			18.3	4.9	-	-	4.9	4.3	4.6	-

NOTES:
(XYd.) Indicates elapsed days since assembly
1. Single gage
2. Mechanically loose ends
3. Recollared 4 times
4. Coil partially prestressed by yoke (warm only).
5. Outer gage data subject to +15% error due to radial pressure from layer 1.
6. Assembly mandrel interference with coil.
7. Heat soaked coil to get mandrel out.
8. Warm model only.
9. 0.008-0.016 in. interference between yoke and collars on horizontal diameter.
10. Cold data at 80K.
11. Data subject to error due to axial magnet strain during cooldown and operation.
12. Recollared 2 times.
13. Gage pack removed after assembly for use in model B-5.
14. Magnet heated to 80K during magnetic measurements.
15. No pressure gages in outer layer.

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SPRINGBACK, CREEP, AND COOLDOWN PRESTRESS LOSSES IN NINETEEN COLLARED 1-M DIPOLE MODELS CONSTRUCTED AT LBL

C. Peters

During the past two years, nineteen SSC type collared 1-M dipole models have been constructed and tested at LBL. Three major types of collars were used; 25mm AL. (2 models), 15mm S.S. (10 models), 15mm AL. (7 models). Coil prestress measurements were made during assembly and testing of each model and are presented in Ref. 1. The assembly, residual, and before and after cooldown prestresses are extracted from Ref. 1 and presented here by collar type in Tables I, II, and III. Springback, creep, and cooldown losses are then calculated. Finally, for each collar type the average pecentage losses and a normalized prestress profile (based on 18 Kpsi assembly starting prestress) are calculated. Table IV and Fig. 1 are a summary of the average pecentage losses and normalized prestress profiles for each collar type.

(1) C. Peters, "Coil Prestress Measurements for Nineteen 1-M Collared Dipole Models Constructed at LBL," LBID-1264 , SSC-MAG-121, SSC-N-295 (2/3/887).

TABLE I

COIL PRESTRESS DATA FROM ALL MODELS CONSTRUCTED WITH 15mm S.S. COLLARS AT LBL

MODEL NUMBER	ASSEMBLY INNER/OUTER	RESIDUAL	SPRINGBACK LOSS		BEFORE COOLDOWN	CREEP LOSS		AFTER COOLDOWN	COOLDOWN LOSS	
	(Kpsi)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)
D12C-2	19.0	9.5	9.5	50	7.3	2.2	23	1.8	5.5	75
	18.3	8.1	10.2	56	7.0	1.1	14	5.9	1.1	16
C-4	22.3	11.1	11.2	50	9.5	1.6	14	4.3	5.2	55
	16.2	6.1	10.1	62	5.8	0.3	5	3.8	2.0	34
C-5	21.7	6.8	14.9	69	5.3	1.5	22	1.5	3.8	72
	13.8	5.6	8.2	59	4.2	1.4	25	3.0	1.2	29
C-6	22.3	10.9	11.4	51	-	-	-	3.2	-	-
	14.7	5.2	9.5	65	-	-	-	4.0	-	-
C-7	18.4	-	-	-	-	-	-	1.2	-	-
	22.8	-	-	-	-	-	-	6.2	-	-
C-8	23.9	10.5	13.4	56	-	-	-	2.5	-	-
	24.9	10.3	14.6	59	-	-	-	-	-	-
MD-1	25.9	9.6	16.3	63	-	-	-	-	-	-
	5.3	0.7	4.6	87	-	-	-	-	-	-
MD-2	20.2	9.8	10.4	51	9.5	0.3	3	-	-	-
	13.2	6.5	6.7	51	4.9	1.6	25	-	-	-
MD-3	22.1	9.3	12.8	58	-	-	-	-	-	-
	9.0	7.4	1.6	18	-	-	-	-	-	-
D14B-3	7.6	3.0	4.6	61	2.7	0.3	10	-	-	-
	-	-	-	-	-	-	-	-	-	-
AVERAGE % LOSS				57			15			67
				57			17			26
NORMALIZ PROFILE	18.0	7.8			6.7			2.2		
	18.0	7.7			6.4			4.7		

TABLE II 15mmAL

COIL PRESTRESS DATA FROM ALL MODELS CONSTRUCTED WITH 15mm AL. COLLARS AT LBL

MODEL NUMBER	ASSEMBLY INNER/OUTER	RESIDUAL	SPRINGBACK LOSS		BEFORE COOLDOWN	CREEP LOSS		AFTER COOLDOWN	COOLDOWN LOSS	
	(Kpsi)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)
D14B-1	23.2	5.9	17.3	75	6.2	-0.3	-5	5.6	0.6	10
	-	-	-	-	-	-	-	-	-	-
B-2	11.8	3.3	8.5	72	2.7	0.6	18	-	-	-
	-	-	-	-	-	-	-	-	-	-
B-4	15.8	5.7	10.1	64	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
B-5	16.3	4.7	11.6	71	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
B-6	21.7	8.0	13.7	63	7.5	0.5	6	7.4	0.1	1
	-	-	-	-	-	-	-	-	-	-
B-7	19.8	7.8	12.0	61	7.7	0.0	0	6.4	1.3	17
	-	-	-	-	-	-	-	-	-	-
B-8	17.1	5.8	11.3	66	5.9	-0.1	-1	5.2	0.7	12
	-	-	-	-	-	-	-	-	-	-
B-9	16.3	5.5	10.7	66	5.4	0.2	3	4.0	1.4	25
	18.3	4.9	13.4	73	4.9	0.0	1	4.3	0.6	11
AVERAGE				67			4			13
% LOSS				73			1			11
NORMALIZ	18.0	5.9			5.7			4.9		
PROFILE	18.0	4.8			4.8			4.3		

TABLE III

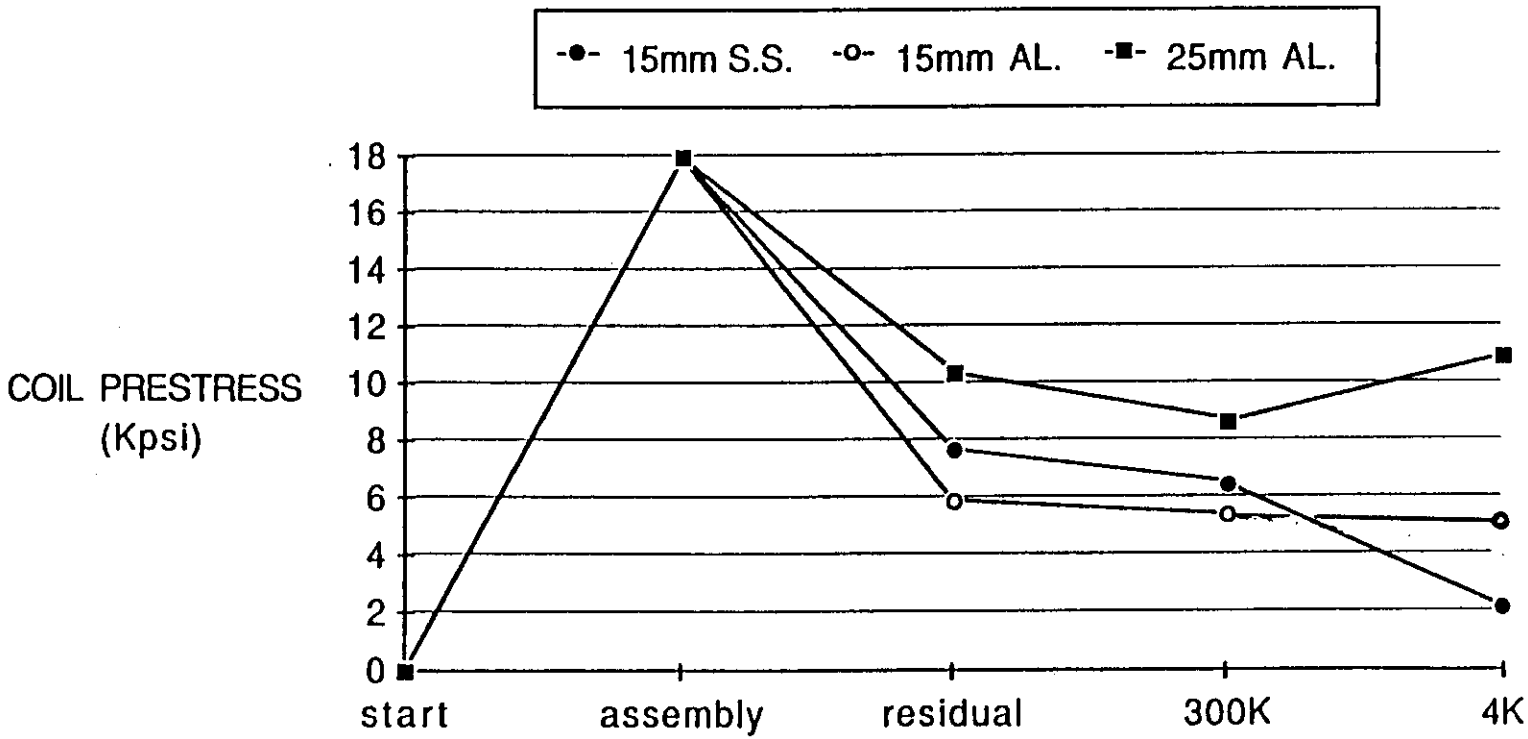
COIL PRESTRESS DATA FROM ALL MODELS CONSTRUCTED WITH 25 mm AL. COLLARS AT LBL

MODEL NUMBER	ASSEMBLY INNER/OUTER	RESIDUAL	SPRINGBACK LOSS		BEFORE COOLDOWN	CREEP LOSS		AFTER COOLDOWN	COOLDOWN LOSS	
	(Kpsi)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)
D12C-1	16.3	9.9	6.4	39	7.7	2.2	22	9.8	-2.1	-27
	21.0	14.7	6.3	30	12.0	2.7	18	14.4	-2.4	-20
C-3	16.0	8.7	7.3	46	7.9	0.8	9	9.8	-1.9	-24
	25.5	9.6	15.9	62	8.2	1.4	15	10.0	-1.8	-22
AVERAGE				42			16			-26
% LOSS				46			16			-21
NORMALIZ	18.0	10.4			8.7			11.0		
PROFILE	18.0	9.7			8.1			9.8		

TABLE IV

SUMMARY OF COIL PRESTRESS DATA (NORMALIZED TO 18Kpsi)
FOR ALL 1-M COLLARED DIPOLE MODELS CONSTRUCTED AT LBL

COLLAR TYPE	ASSEMBLY INNER/OUTER	RESIDUAL SPRINGBACK LOSS			BEFORE COOLDOWN	CREEP LOSS		AFTER COOLDOWN	COOLDOWN LOSS	
	(Kpsi)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)	(Kpsi)	(Kpsi)	(%)
MODELS										
15mm S.S.	18.0	7.7	10.3	57	6.6	1.2	15	2.2	4.4	67
	18.0	7.7	10.3	57	6.4	1.3	17	4.8	1.7	26
15mm AL.	18.0	5.9	12.1	67	5.4	0.5	9	4.2	1.2	22
	18.0	-	-	-	-	-	-	-	-	-
25mm AL.	18.0	10.4	7.6	42	8.8	1.7	16	11.0	-2.3	-26
	18.0	9.7	8.3	46	8.2	1.6	16	9.9	-1.7	-21
TESTS										
CCT #1	18.0	8.1	9.9	55	7.6	0.5	6	3.7	3.9	51
	18.0	-	-	-	-	-	-	-	-	-
CCT #2	18.0	8.6	9.4	52	7.7	1.0	11	2.8	4.8	63
	18.0	5.2	12.8	71	4.5	0.7	13	2.1	2.4	53
SPOT WELD	18.0	8.8	9.2	51	8.4	0.4	5	3.9	4.4	53
	18.0	7.2	10.8	60	6.7	0.5	7	3.1	3.5	53
FULL WELD	18.0	12.6	5.4	30	11.0	1.6	13	3.1	7.9	72
	18.0	-	-	-	-	-	-	-	-	-

FIG. 1

AVERAGE INNER LAYER PRESTRESS LOSSES FOR MODELS CONSTRUCTED AT LBL