Fuji Film Tests on DSA322
End Clamp Pressure

TS-SSC 91-135
S. Delchamps
July 2, 1991

Abstract: Preliminary results are given from installations of Fuji Prescale pressure-sensitive films [1,2] at the midplane and pole surfaces of the DSA322 coils inside an aluminum end clamp with G10CR insulators. Pressures at these surfaces are measured and related to various externally measureable quantities, such as end clamp outer diameter deflection on loading and the hydraulic pressure necessary to push the end clamp into place.

A return end clamp was installed on the coils from magnet DSA322 five times. Before each installation, Fuji Prescale pressure sensitive film was placed on the inner and outer coil midplane surfaces, and on the outer coil key surfaces[1], in the region of the coils covered by the end clamp. The external dimensions of the end clamp can were measured before and after installation, and the hydraulic pressure necessary to bring the end can all the way on was recorded for each installation[2].

Table 1 gives a summary of the five installations performed. The last column of the table shows where strips of Prescale film were attached. Only in the first installation was film applied to the inner coil key surfaces. There is no kapton insulation at this surface which can be removed to compensate for the extra thickness of the Fuji film.

MS type film was used in the second installation; in all other cases, HS type film was used.

In the last two installations, 5 mils of extra kapton insulation was attached to the inner surfaces of the G10CR insulators. This is expected to raise the pressure at all coil surfaces.

Installation #	Date	Film Type	Extra Insulation (mils)	Film Locations
1	June 18, 1991	HS	0	O,I Key; O,I Mid
2	June 20, 1991	MS	0	O Key, O, I Mid
3	June 22, 1991	HS	0	Same as 2
4	June 24, 1991	HS	5	Same as 2
5	June 26, 1991	HS	5	Same as 2

Table 1. Summary of First Five Installations of End Clamp with Fuji Prescale Pressure Sensitive Film

[1]In the case of the first installation, Fuji Prescale film was placed on the inner coil key surfaces.

[2]Raw data may be obtained from S. Delchamps.

Distribution: R. Bossert, W. Koska, J. Strait, M. Wake

Figures 1a and 1b are sketches of what the pieces of film placed at the midplane and pole surfaces look like upon removal of the end clamp. It is seen that the distribution of pressures across the midplane is not uniform, and the midplane pressure decreases rapidly about three inches into the end clamp. This is expected since the coils are beginning to turn up and in at this point.

The pressure appears to be fairly uniform along and across the outer pole turn (key) surfaces. Both the pole surfaces and the midplane surfaces show the marks from the insulating glass tape wrap, however.

The Fuji Prescale densitometer FPD301 makes it possible to do some averaging over pressure non-unifomities by "sliding" the instrument across a surface to be measured. During the slide, the 0.6 second exposure takes four readings, and averages them. Sets of up to five slides may then be averaged automatically by the FPD303 printer.

For this analysis, three sets of five slides were made along each film strip. For example, to measure the average pressure at the outer coil midplane between quadrants 1 and 3, five slides were first made along the left side of the film as shown in Figure 2. This produced a printed pressure value from the FPD303. Five slides were then made down the center of the strip, producing another printed number. Five slides down the right side of the strip produced a third printed number, which when averaged with the first two numbers gave the average pressure on the midplane.

Table 2 shows the measured average pressures for midplane and pole surfaces for each of the five installations. Also shown are the vertical and horizontal deflections of the end clamp 1.5" away from the end of the collar laminations, the overall diameter change as measured by a "pi-tape", and the hydraulic pressure required to install the end clamp.

In Table 2, "O Key" stands for outer coil key surface, "I Key" for inner key (installation #1 only), "O Mid" and "I Mid" for outer and inner midplane surface (the numbers give the quadrants bounded by the midplane surface in question.) All pressures are in kpsi, including the last row, which shows the hydraulic pressure needed to install the end clamp.

	1	2	3	4	5
O Key 1	10.22	4.75	8.25	8.63	10.78
O Key 2	9.03	4.82	8.28	8.93	11.43
O Key 3	9.29	4.45	8.32	9.95	10.49
O Key 4	8.11	5.21	7.51	9.29	10.58
I Key 1	12.22	-	-	-	-
I Key 2	11.46	-	-	-	-
I Key 3	10.49	-	-	-	-
I Key 4	11.50	-	-	-	-
O Mid 1/3	8.58	5.29	7.91	10.54	12.14
O Mid 2/4	8.36	4.18	7.58	9.36	10.85
I Mid 1/3	8.58	4.28	7.91	9.13	10.30
I Mid 2/4	8.36	4.38	8.01	8.79	10.58
dVert (mils)	+2	+6	+3	+6	+7
dHoriz (mils)	-2	-3	+1	-1	0
dpi-tape (mils)	+3	+5	+2	+3	+4
Hydraulic Pressure to install	5.0	5.5	4.5	8.5	9.0

Table 2. Results for the First Five Installations of End Clamp with Fuji Prescale Pressure Sensitive Film

We know from calibration work done with the HS type Prescale film [2] that the measured pressure is systematically higher than the average pressure for this film, so that the measured pressures for installations 1, 3, 4, and 5 are probably inflated by several kpsi. Furthermore, some of the measured pressures fall within a pressure range (6 - 8 kpsi) in which neither MS nor HS films give well-defined pressures [2].

It is somewhat disturbing that the measured pressures for installations 2 and 3 are quite different. These installations were done with the same insulator conditions. Yet the Fuji film measured pressures differ by nearly a factor of 2. However, these pressures are close to the upper reliable limit for the MS type of film used in installation 2 [2].

Figure 3 shows the uncorrected Fuji pressure averaged over outer coil key surfaces and inner and outer midplane surfaces plotted against installation number. The first installation shows somewhat higher pressures than the third, perhaps because of the perturbation of adding Fuji film to the inner coil key surfaces (not contained in the pressure average.) The second installation shows low average pressure, but MS type film was used in this installation. The fourth and fifth installations had 5 mils of extra kapton insulator inside the end clamp, so that a somewhat higher average pressure is expected.

Figure 4 shows the uncorrected Fuji pressure plotted against the increase in the diameter of the end can along the vertical axis 1.5" away from the end of the collar laminations. Figure 5 shows the same quantity plotted against the increase in a pi-tape reading of the end can diameter at the same location. Finally, Figure 6 shows the uncorrected pressure plotted against the hydraulic pump pressure required to install the end clamp[3]. Only weak dependence of the average end clamp pressure on any of the observables is seen.

References

1. TS-SSC 91-133, "Instruction Manual for Fuji Film Densitometer FPD301 and Printer FPD303."

2. TS-SSC 91-134, "Calibration of Fuji Prescale Pressure Sensitive Film."

[3]The hydraulic pressures needed to install the end clamp in these tests were typically higher than the pressures seen in ICB on magnets DCA310 and DCA311, even though on these latter magnets up to two layers of 5 mil kapton have been added to the inner surfaces of the end clamp insulators. This is not understood.

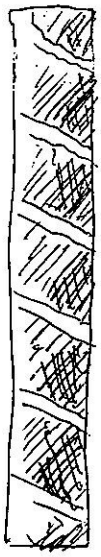

Figure 1a. Fuji Film Placed at Pole Surface (Key)

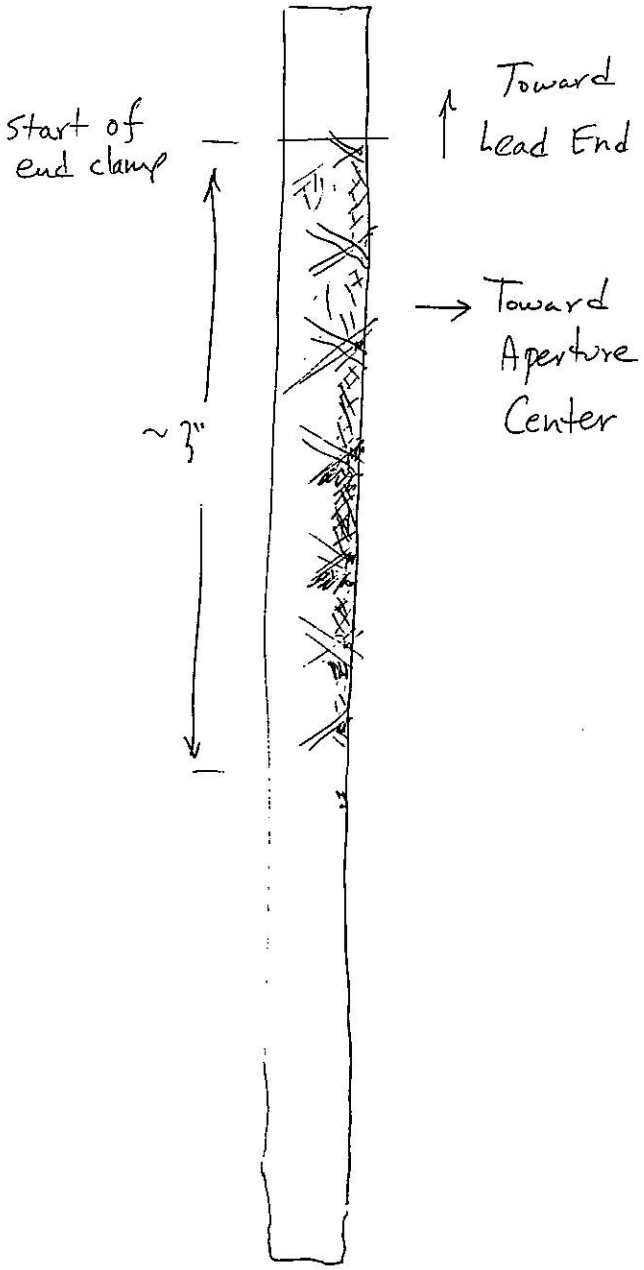

Figure 1b. Fuji Film Placed at Midplane Surface

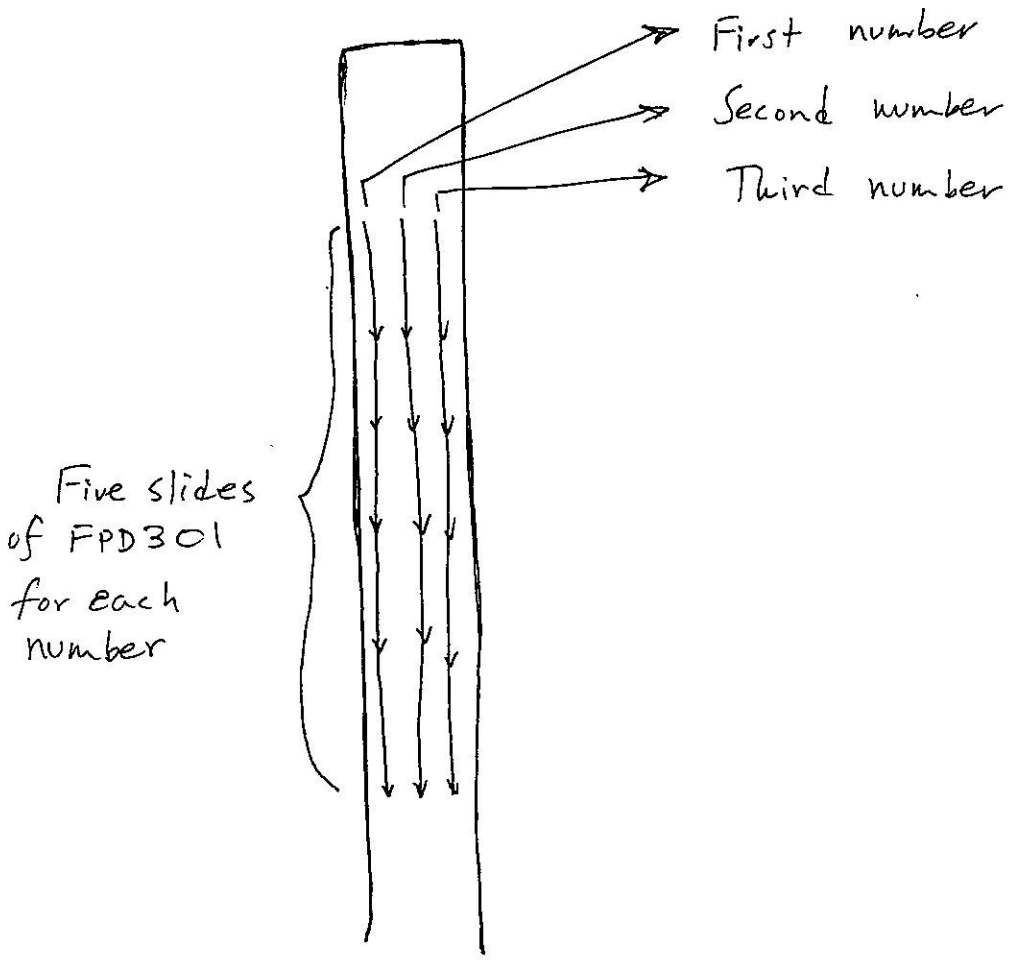

Figure 2. Read-out Pattern

DSA322 Fuji Tape Tests

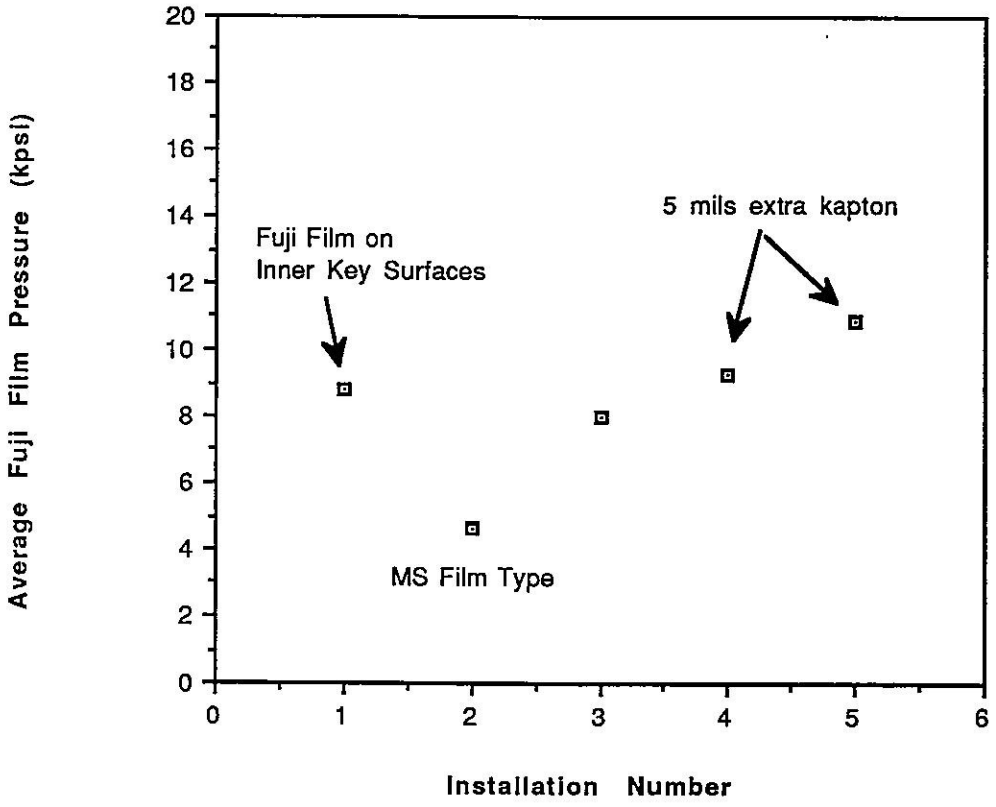

Figure 3

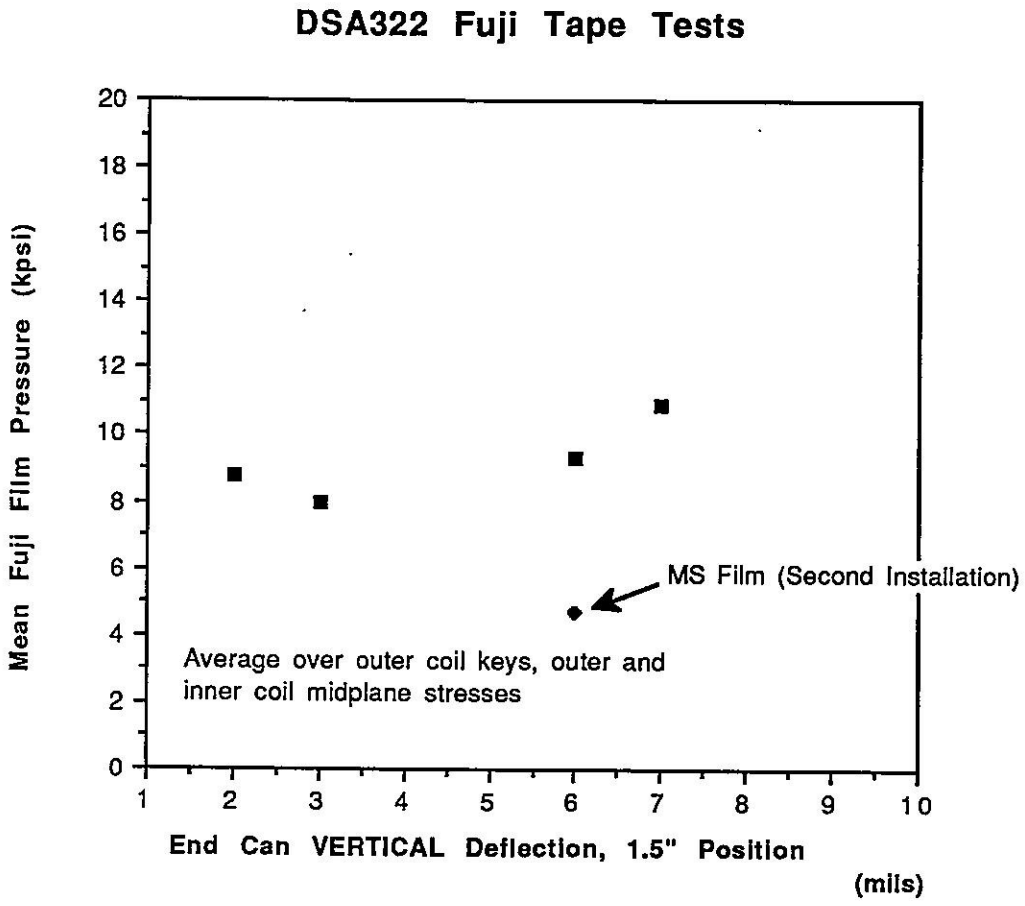
DSA322 Fuji Tape Tests
Mean Fuji Film Pressure (kpsi)
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
MS Film (Second Installation)
Average over outer coil keys, outer and inner coil midplane stresses
End Can VERTICAL Deflection, 1.5" Position
(mils)

Figure 4

DSA322 Fuji Tape Tests

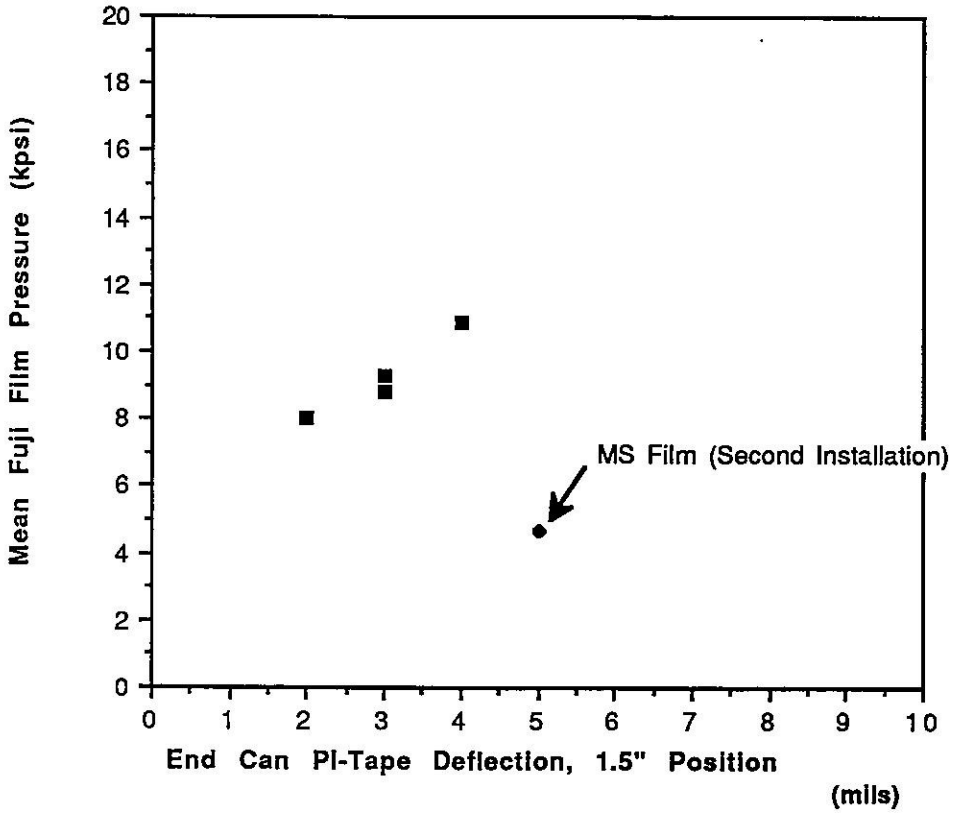

Figure 5

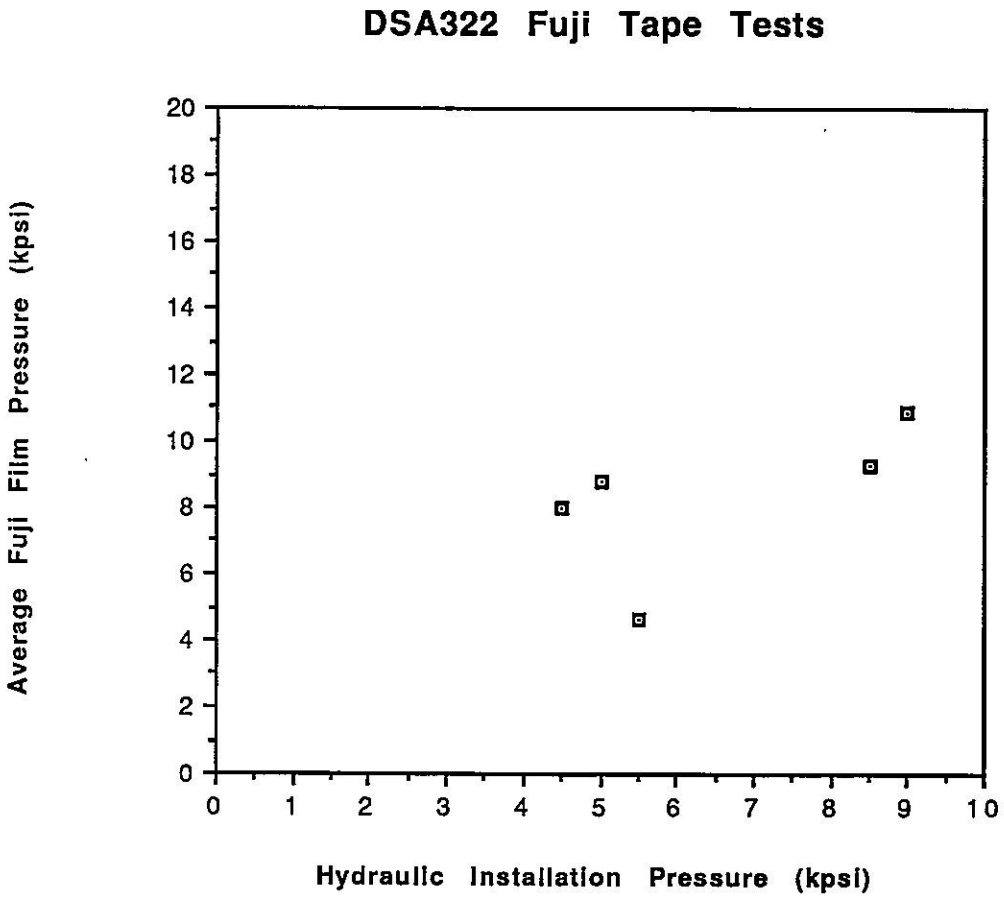
DSA322 Fuji Tape Tests
Average Fuji Film Pressure (kpsi)
20
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
10
Hydraulic Installation Pressure (kpsi)

Figure 6