Fermilab

TS-SSC-91-180

Pressure Gradient and Key-Stone Angle in The Cable [1]

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We had been using "square key" method in the keying of DSA series and DS0 series magnets until recent change to the "intermediate method". This keying technique assumed that the insulation of the conductor should not be damaged until the pressure exceed 30 ksi. The lab test of KAPTON insulation showed the upper limit of the pressure is in this range. Although, we had a serious turn to turn short problems in the last series of long magnets. So far we have managed it by modifying the keying method. But the following question remained unanswered at that time.

- Why the KAPTON insulation fails with much less pressure than the lab test break down pressure?
- Why the short circuit happens always in the midplane?

To study the pressure distribution in the width of the cable, Fuji pressure measuring sheet "prescale" was used in DSA322 and DSA327. DSA322 result is reported in TS-SSC-91-046, where only the results at the end part was presented. Fig.1 and 2 are the results from DSA327 at the streight section. It is clear that there is a very large pressure gradient in the mid plane, while there is not so large pressure gradient in the pole.

The reason for the large gradient is the tolerance in the key-stone angle of the cable. The specification for the inner cable is $1.2° \pm 0.1°$. If the error comes with random fluctuation, the turn number 19 will average the error. But the real distribution of the conductor key-stone angle is shown in Fig.3. The deviation from the specification is fairly stable in the batch. This means the deviation from the designed value is multiplied by the turn number. Another fact is that the key-stone angle has a tendency to have the lower edge value of the specification.

In addition there is a discrepancy between cable specification and the cross section as shown in Fig.4. Actually, the cross section required key-stone angle

[1]Distribution: R.Bossert, J.Carson, S.Delchamps, S.Gourlay, W.Koska, M.Kuchnir, M.Lamm, G.Pewitt, R.Sims, J.Strait

is 1.2151°. Therefore, the midplane coil angles in most of the magnets are more than 1° off from midplane. This can easily make the inner edge pressure very high compared to the outer edge.

If the midplane angle is off by 1°, the pressure distribution in the midplane becomes large but the coil cross section is an arc and, since the force has to be transferred through many layers of conductors, it become diffused by the time transferred to the pole. This explains the lack of the pressure gradient at the pole.

Since the systematic error of the key-stone angle is very large, it might have affected the coil size and the field quality of the magnets. If we correct the key-stone angle deviation, we should not have the insulation damage even if we use "square key method".

Fig 1

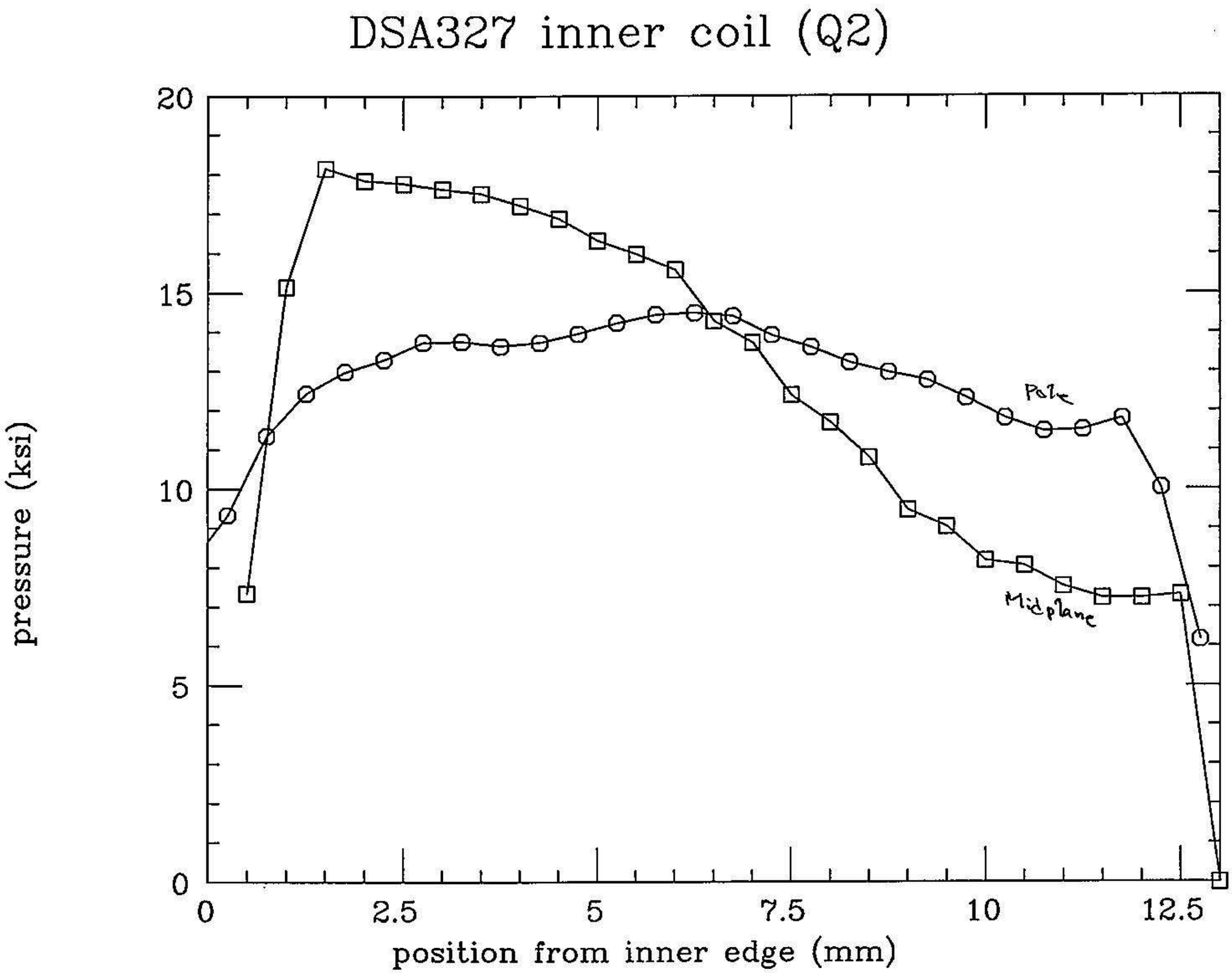

DSA327 inner coil (Q2)
pressure (ksi)
position from inner edge (mm)
0
5
10
15
20
0
2.5
5
7.5
10
12.5
Pole
Midplane

Fig 2

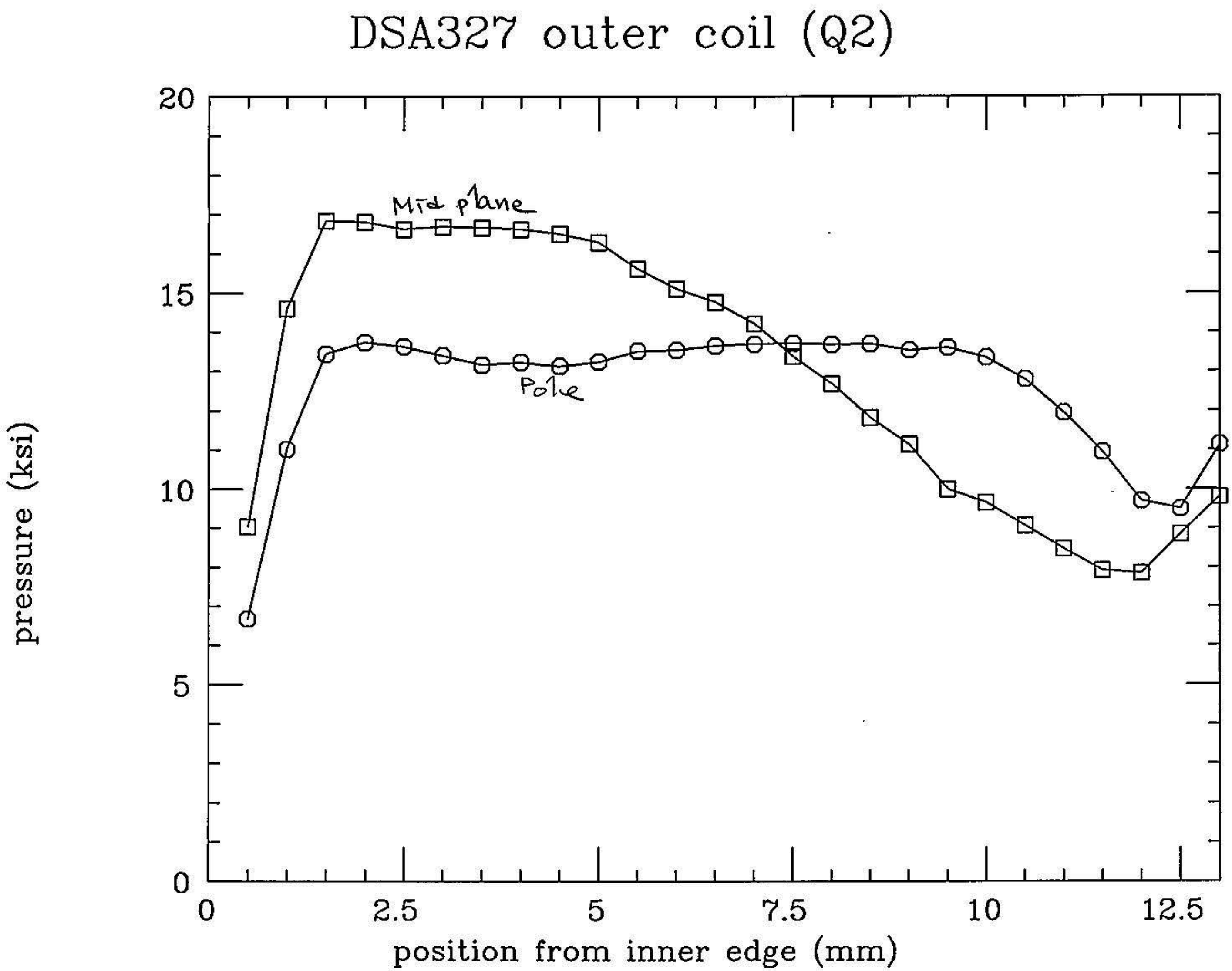
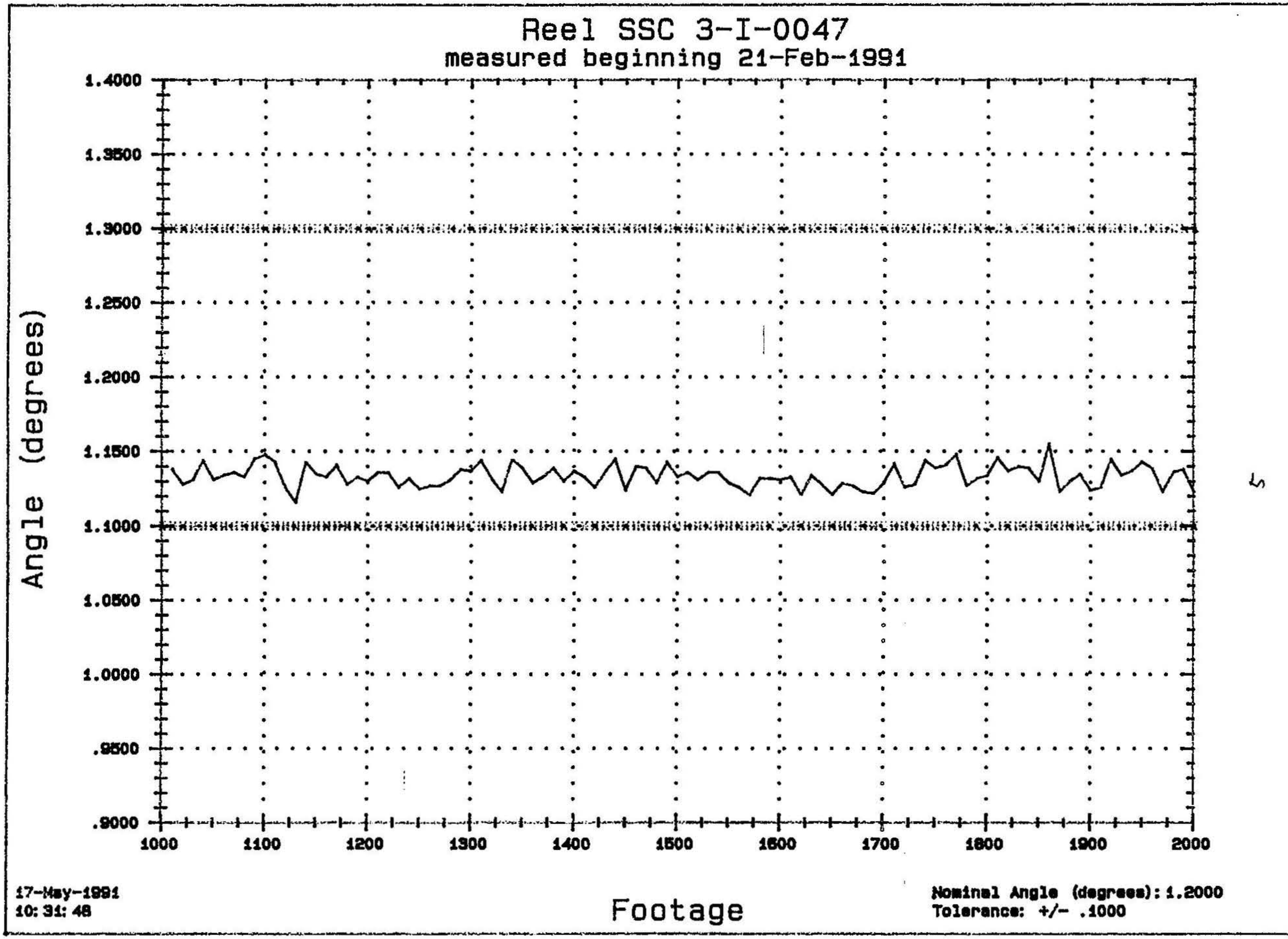
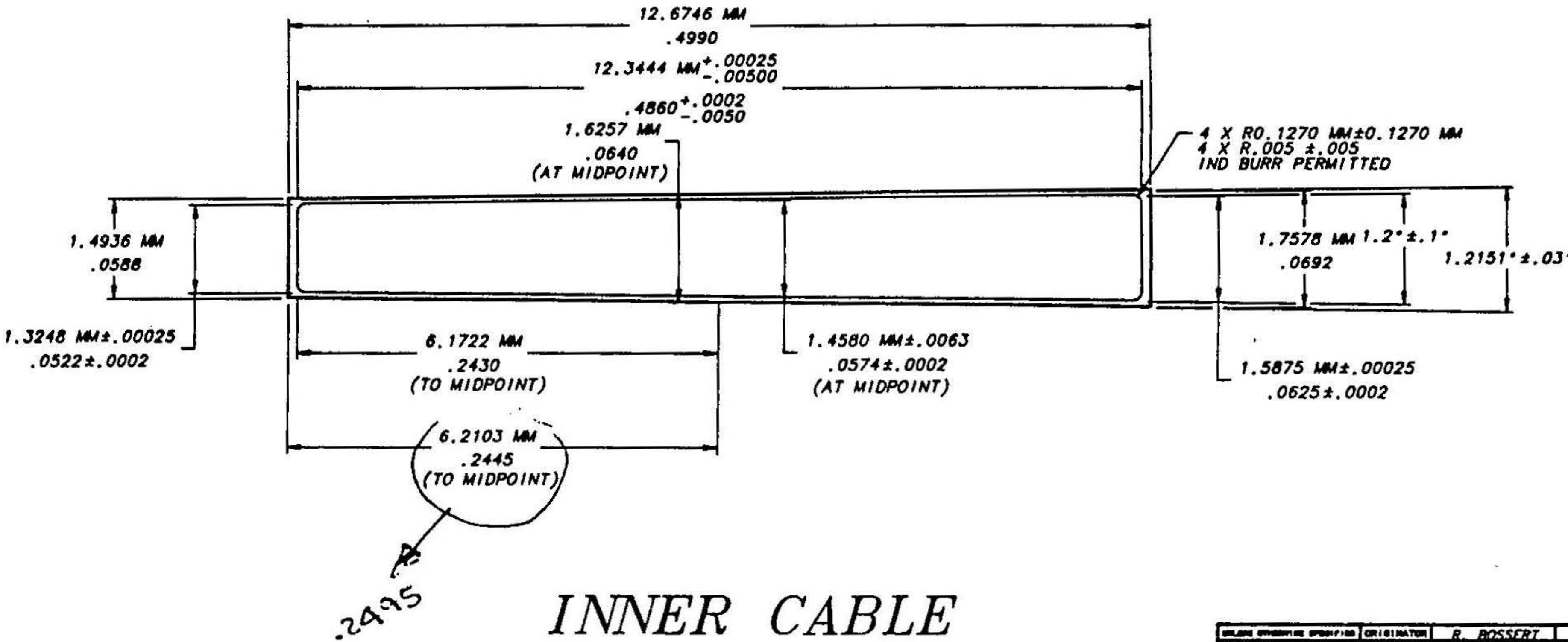

DSA327 outer coil (Q2)
pressure (ksi)
position from inner edge (mm)
Mid plane
Pole
0
5
10
15
20
0
2.5
5
7.5
10
12.5

Fig 3



Reel SSC 3-I-0047
measured beginning 21-Feb-1991
Angle (degrees)
1.4000
1.3500
1.3000
1.2500
1.2000
1.1500
1.1000
1.0500
1.0000
.9500
.9000
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Footage
17-May-1991
10:31:48
Nominal Angle (degrees): 1.2000
Tolerance: +/- .1000

Fig 2.



INNER CABLE

ORIGINATOR	R. BOSSERT
DRAWN	M.BARTLETT 4/2
CHECKED	
APPROVED	
USED ON	
MATERIAL	

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

DSX201 DIPOLE MAGNET
CABLE PARAMETERS
INNER KEYSTONED CABLE & INSULATIO

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