TS-SSC 91-065

COIL SIZE MEASUREMENTS AND COIL CURING

R.E. Sims

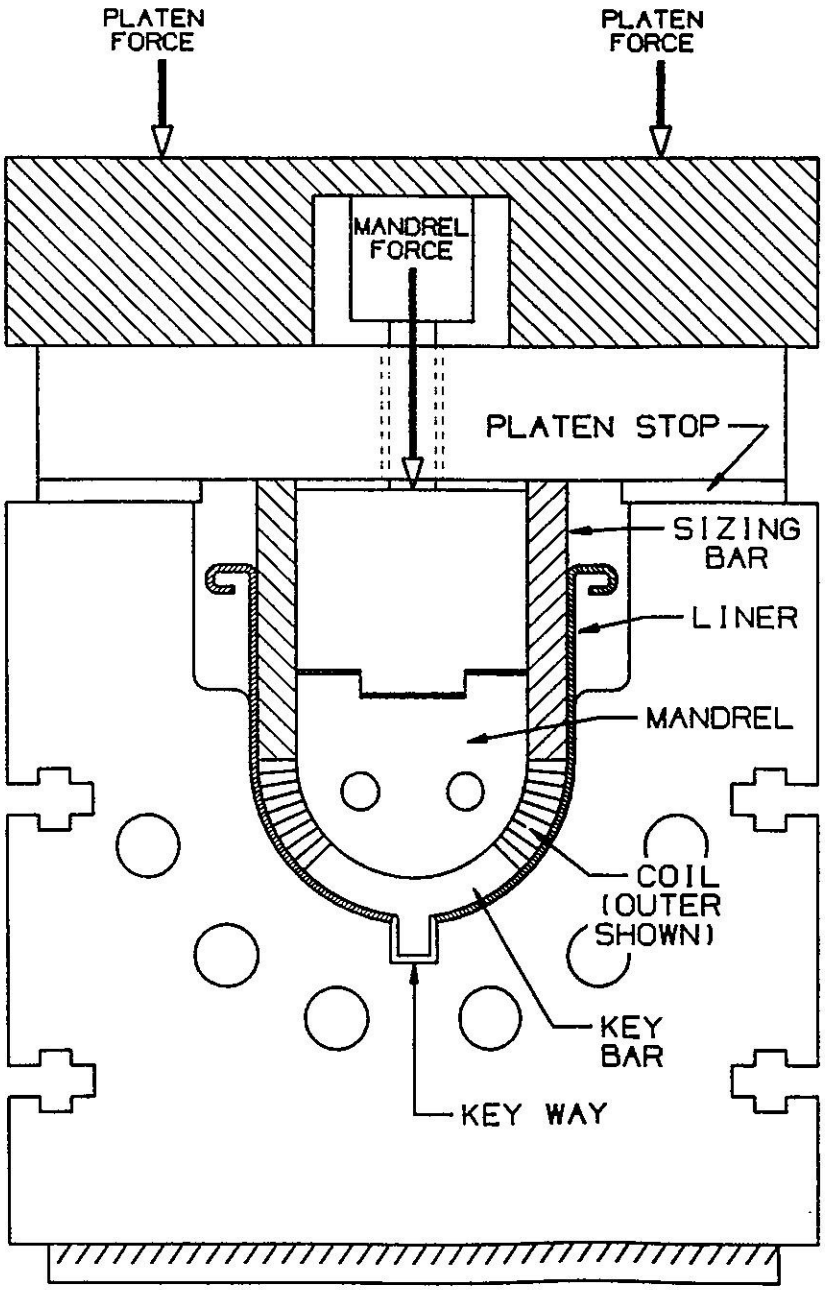
Presented at the Fermilab
Production Readiness Review

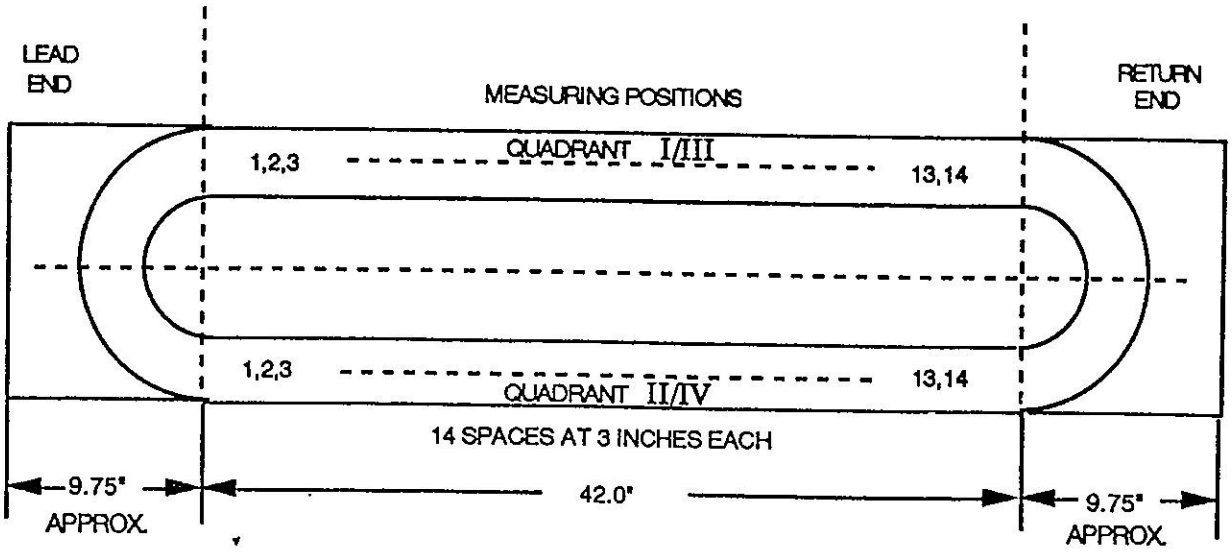
4/4/91

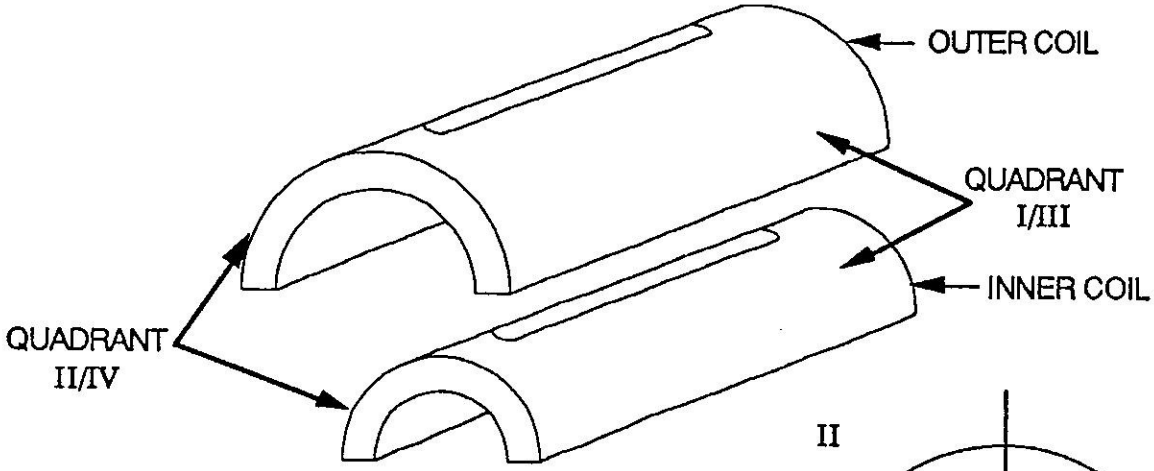
Distribution:
R. Bossert
J. Carson
S. Delchamps
I. Gonczy
S. Gourlay
W. Koska
M. Lamm
D. Smith
M. Wake
W. Zimmerman

Factors Contributing to the Finished Coil Size

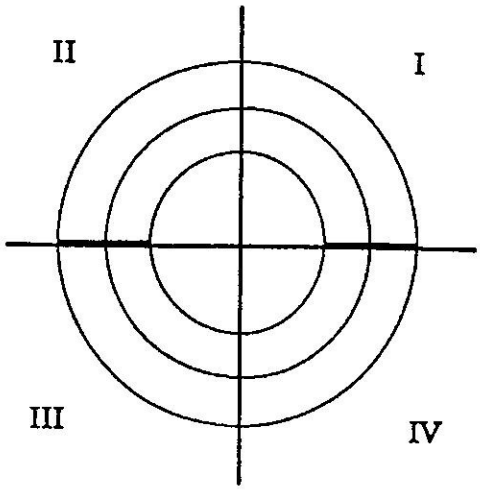
1. Construction Materials
   - A. Cable
   - B. Kapton Film
   - C. Glass Tape
2. Tooling
   - A. Winding Key
   - B. Sizing Bars
   - C. Mandrel
   - D. Liner
   - E. Optional Shims
3. Curing Process Parameters
   - A. Temperature of Cure
   - B. Length of Cure
   - C. Percent of Epoxy in Glass Tape
   - D. Cavity Pressure
   - E. Curing Press Sequence
   - F. Mold Release Compound


PLATEN FORCE
PLATEN FORCE
MANDREL FORCE
PLATEN STOP
SIZING BAR
LINER
MANDREL
COIL (OUTER SHOWN)
KEY BAR
KEY WAY





LOOKING FROM THE LEAD END



SSC 50MM SHORT
OUTER COIL
SIZING POSITIONS

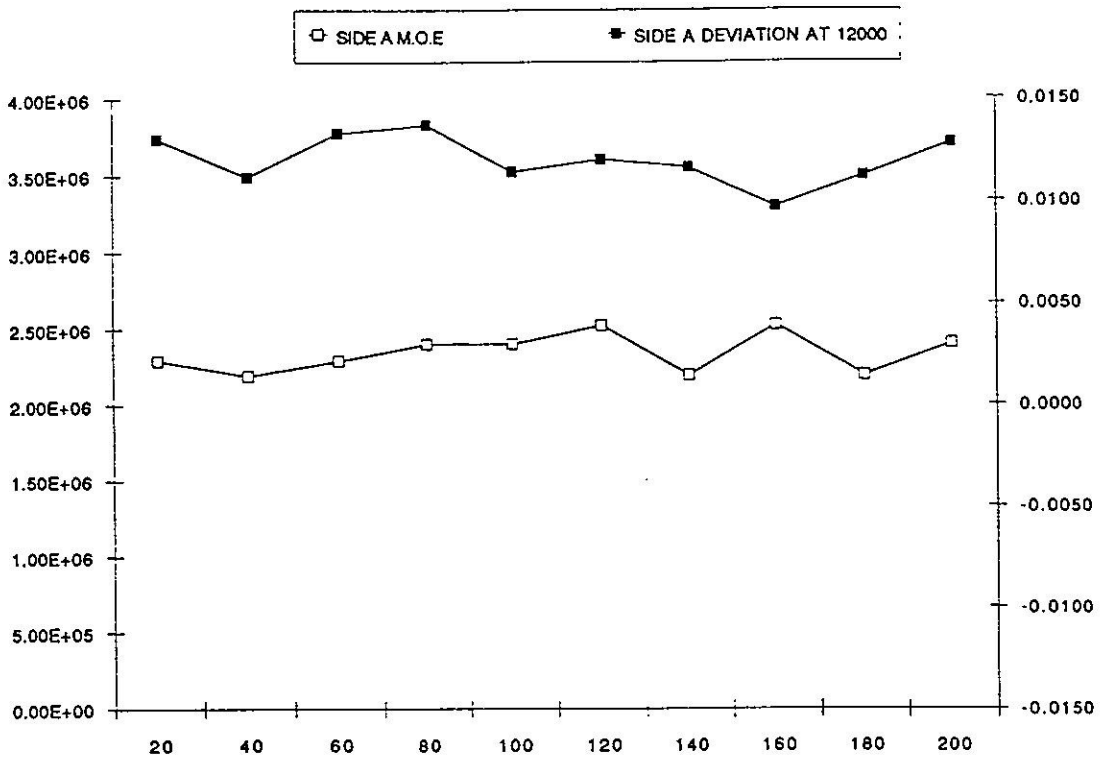
Long SSC Inner Coil # 17M-1016

	SIDE A (1-213)				SIDE B (214-426)				WHOLE COIL		
	8 kpsi	12 kpsi	MOE		8 kpsi	12 kpsi	MOE		8 kpsi	12 kpsi	MOE
AVERAGE	0.0120	0.0100	2338266	AVERAGE	0.0124	0.0108	2419820	AVERAGE	0.0122	0.0104	2379043
STD DEV	0.0012	0.0010	127403	STD DEV	0.0007	0.0012	166824	STD DEV	0.0010	0.0012	150405
RANGE	0.0040	0.0060	327950	RANGE	0.0023	0.0078	607315	RANGE	0.0040	0.0085	607315
MAX	0.0137	0.0127	2518284	MAX	0.0136	0.0152	2797649	MAX	0.0137	0.0152	2797649
MIN	0.0097	0.0067	2190334	MIN	0.0113	0.0074	2190334	MIN	0.0097	0.0067	2190334

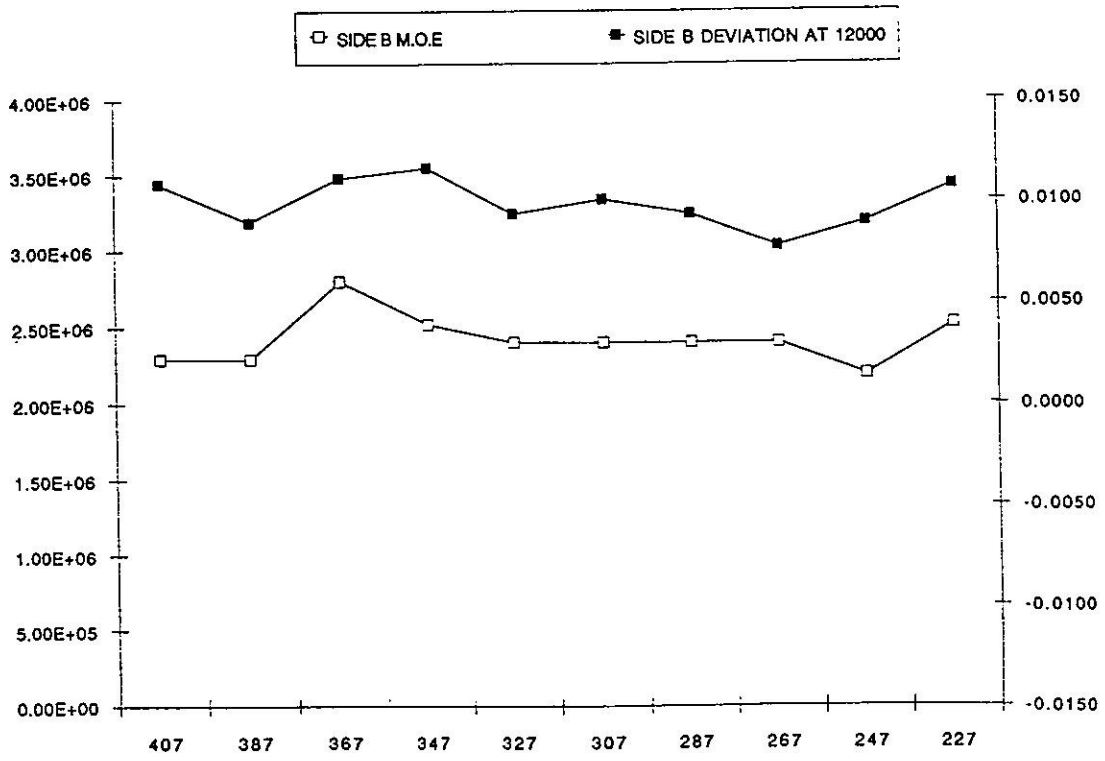
MEASUREMENT DATA

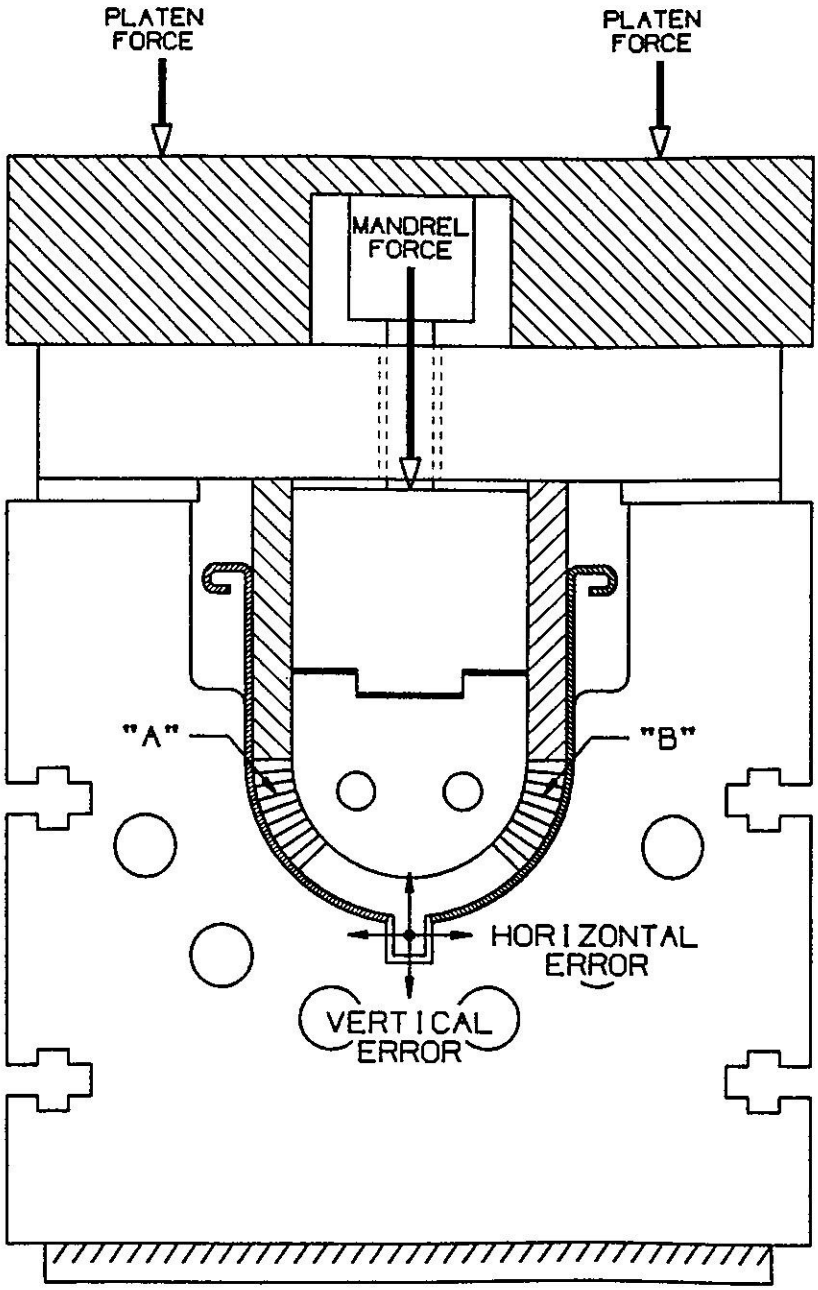
Coil #17M-1016 Coil Type: Inner Date: 1/19/91 MEAS. BY: SANDERS

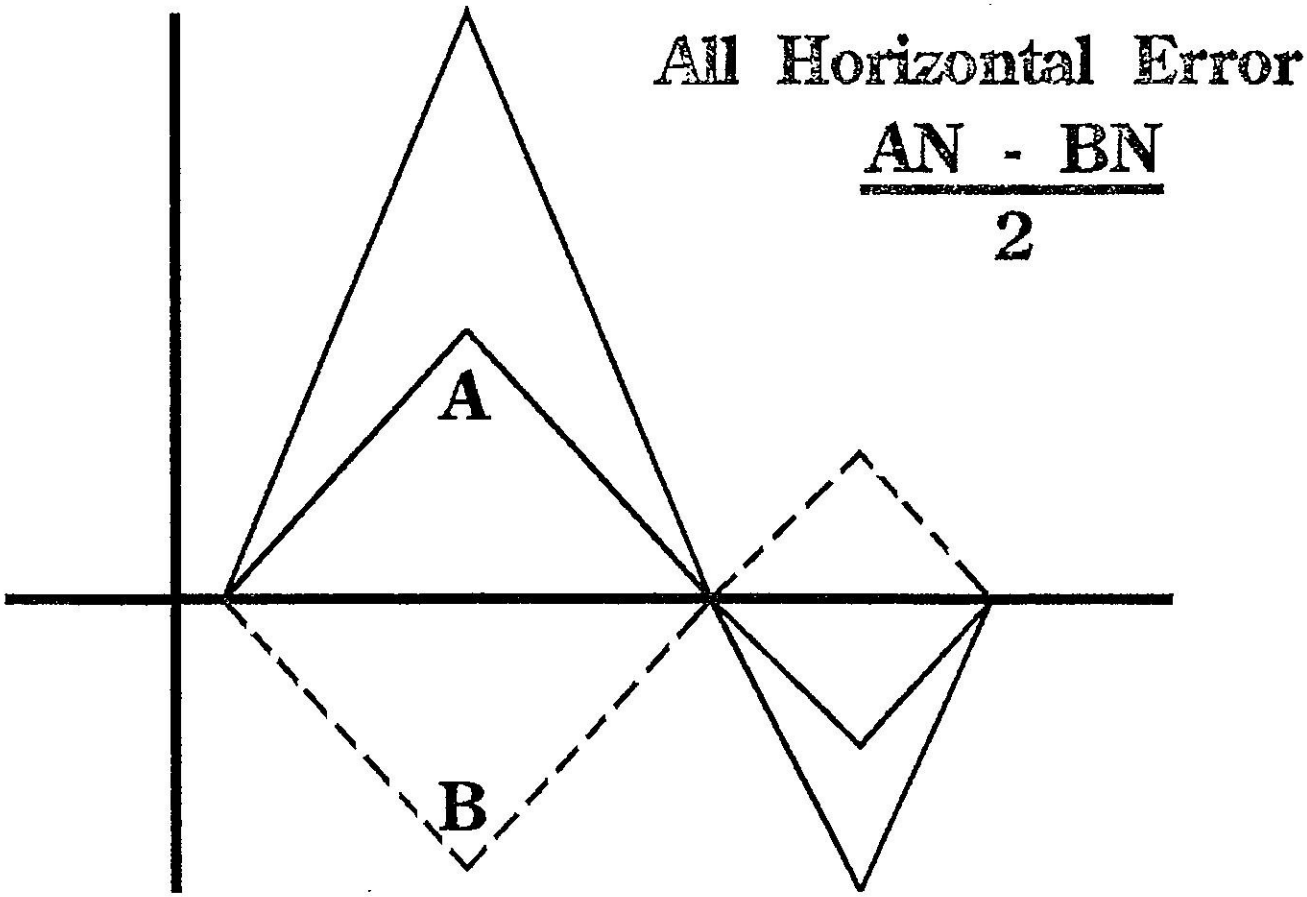
Pos #	Stress: 6000 Coil	6000 Master	8000 Coil	8000 Master	10000 Coil	10000 Master	12000 Coil	12000 Master	COIL SIZE WITH RESPECT TO THE MASTER 8000	12000	DEVIATION FROM THE WHOLE COIL AVERAGE AT 12000	MOE
1							1.0039	0.9950		.0089	-.0015	
2							1.0050	0.9950		.0100	-.0004	
3							1.0050	0.9951		.0099	-.0005	
4							1.0055	0.9951		.0104	.0000	
5							1.0055	0.9951		.0104	.0000	
6							1.0050	0.9951		.0099	-.0005	
7							1.0054	0.9950		.0104	.0000	
8							1.0052	0.9950		.0102	-.0002	
9							1.0054	0.9950		.0104	.0000	
10							1.0055	0.9950		.0105	.0001	
11							1.0060	0.9950		.0110	.0006	
12							1.0057	0.9950		.0107	.0003	
13							1.0059	0.9951		.0108	.0004	
14							1.0058	0.9951		.0107	.0003	
15							1.0051	0.9951		.0100	-.0004	
16							1.0053	0.9950		.0103	-.0001	
17							1.0062	0.9950		.0112	.0008	
18							1.0055	0.9950		.0105	.0001	
19							1.0058	0.9950		.0108	.0004	
20 UP	1.0139	1.0000	1.0115	0.9985	1.0085	0.9970	1.0063	0.9955	.0130	.0108	.0004	2289713
21							1.0064	0.9958		.0106	.0002	
22							1.0067	0.9955		.0112	.0008	
23							1.0070	0.9958		.0112	.0008	
24							1.0058	0.9954		.0104	.0000	
25							1.0046	0.9955		.0090	-.0014	
26							1.0046	0.9956		.0090	-.0014	
27							1.0055	0.9956		.0099	-.0005	
28							1.0042	0.9956		.0086	-.0018	
29							1.0069	0.9956		.0113	.0009	
30							1.0066	0.9956		.0110	.0006	
31							1.0070	0.9956		.0114	.0010	
32							1.0064	0.9956		.0108	.0004	
33							1.0069	0.9956		.0113	.0009	
34							1.0065	0.9956		.0109	.0005	
35							1.0060	0.9956		.0104	.0000	
36							1.0062	0.9956		.0106	.0002	
37							1.0060	0.9956		.0104	.0000	
38							1.0061	0.9956		.0105	.0001	
39							1.0066	0.9956		.0110	.0006	
40 UP	1.0121	1.0000	1.0094	0.9982	1.0067	0.9969	1.0042	0.9953	.0112	.0089	-.0015	2190334
41							1.0046	0.9952		.0094	-.0010	
42							1.0039	0.9951		.0088	-.0016	
43							1.0046	0.9951		.0095	-.0009	
44							1.0056	0.9951		.0105	.0001	
45							1.0063	0.9952		.0111	.0007	
46							1.0060	0.9952		.0108	.0004	
47							1.0064	0.9952		.0112	.0008	
48							1.0079	0.9952		.0127	.0023	
49							1.0078	0.9952		.0126	.0022	
50							1.0060	0.9952		.0108	.0004	
51							1.0054	0.9952		.0102	-.0002	
52							1.0040	0.9952		.0088	-.0016	
53							1.0038	0.9952		.0086	-.0018	
54							1.0037	0.9952		.0085	-.0019	

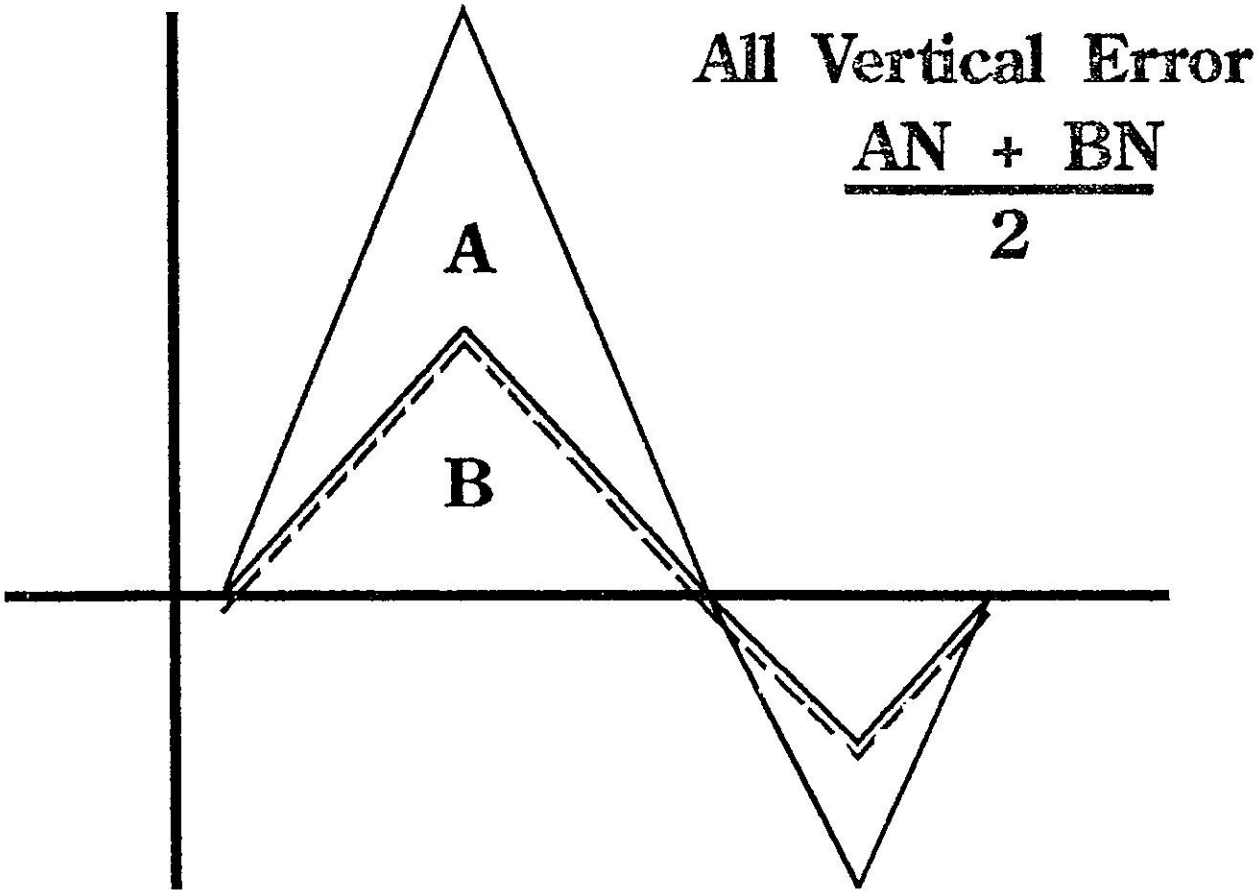


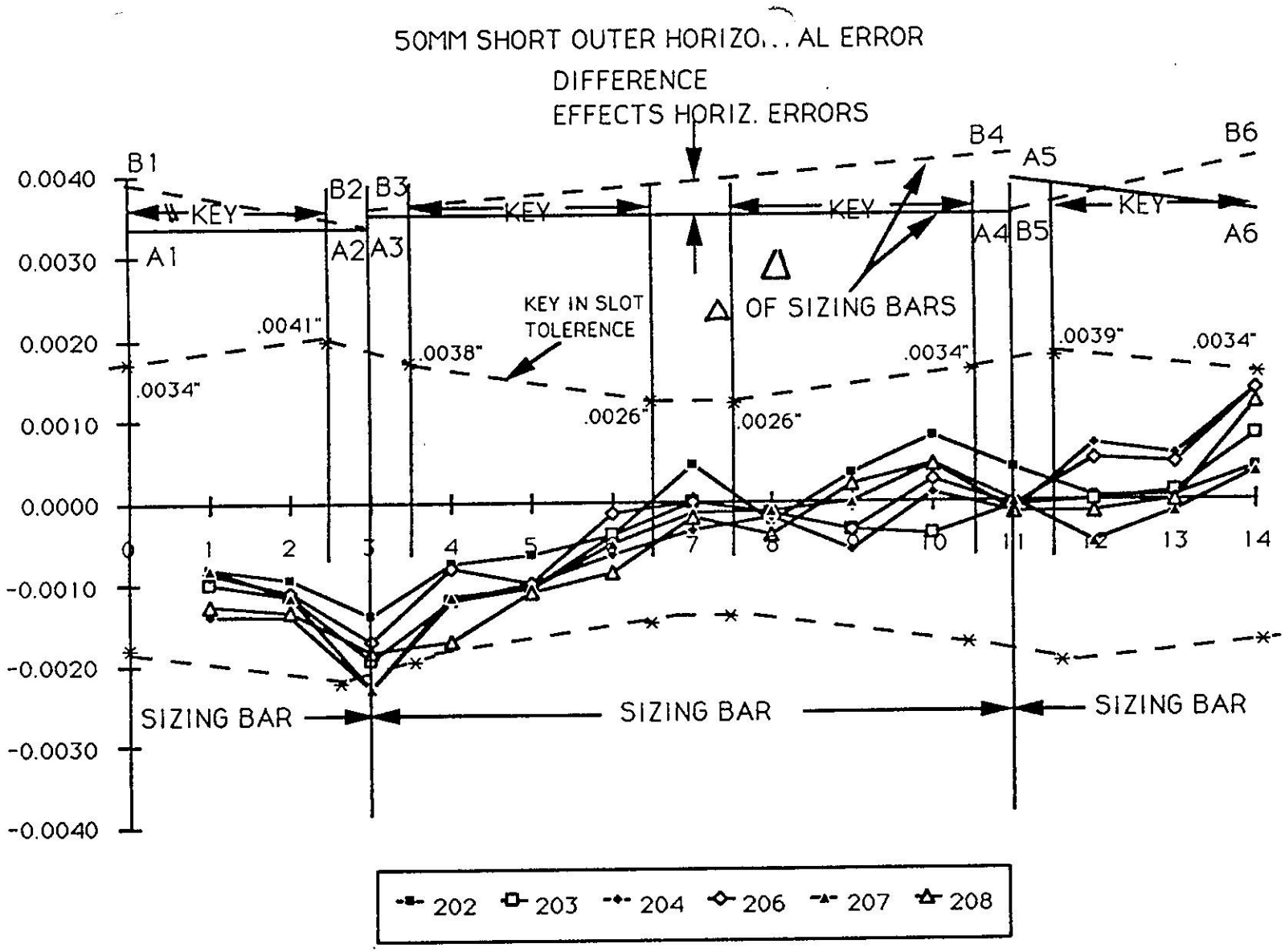
1016 SIDE B MOE TO SIDE B




PLATEN FORCE
PLATEN FORCE
MANDREL FORCE
"A"
"B"
HORIZONTAL ERROR
VERTICAL ERROR


All Horizontal Error
AN - BN
2
A
B


All Vertical Error
AN + BN
2
A
B


50MM SHORT OUTER HORIZO... AL ERROR
DIFFERENCE
EFFECTS HORIZ. ERRORS
B1
B2
B3
B4
B5
B6
A1
A2
A3
A4
A5
A6
KEY
KEY
KEY
KEY
KEY IN SLOT
TOLERENCE
Δ OF SIZING BARS
.0041"
.0038"
.0034"
.0026"
.0026"
.0034"
.0039"
.0034"
SIZING BAR
SIZING BAR
SIZING BAR
0.0040
0.0030
0.0020
0.0010
0.0000
-0.0010
-0.0020
-0.0030
-0.0040
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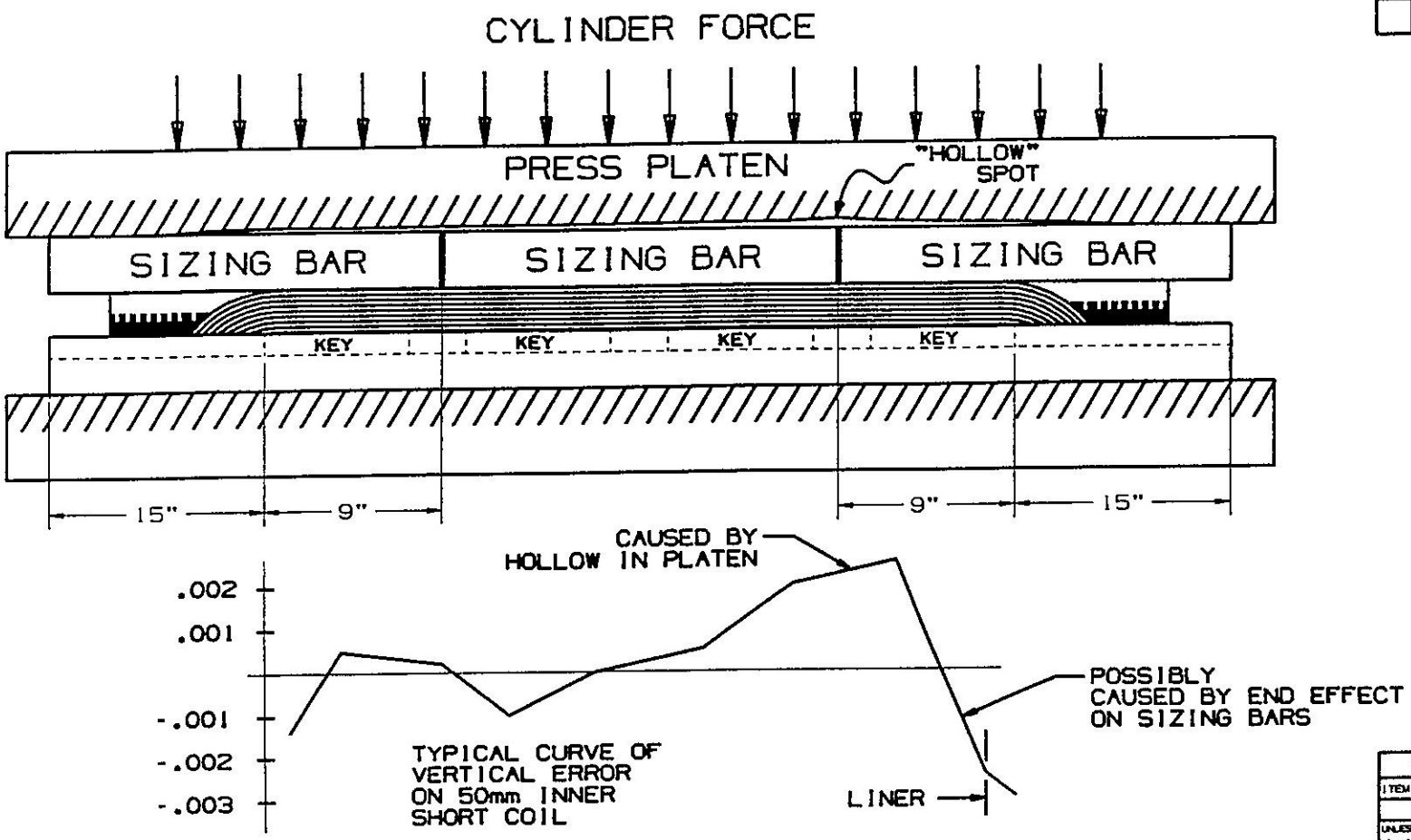


REV.	DESCRIPTION	DRAWN / APPD.

ITEM	PART NO.	DESCRIPTION OR SIZE

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. TOLERANCES: ± 1 mm.
3. DIMENSIONS BASED UPON ANSI Y14.5M-1982.
4. INCH DIMENSIONS ARE FOR REFERENCE ONLY.
5. BREAK ALL SHARP EDGES.
6. DO NOT SCALE DRAWING.
7. MAX. ALL MACH. SURFACES
8. DIMENSION IDENTIFICATION: MILLIMETER (MILLIMETER/INCH)

ORIGINATOR
DRAWN
CHECKED
APPROVED
USED ON
MATERIAL

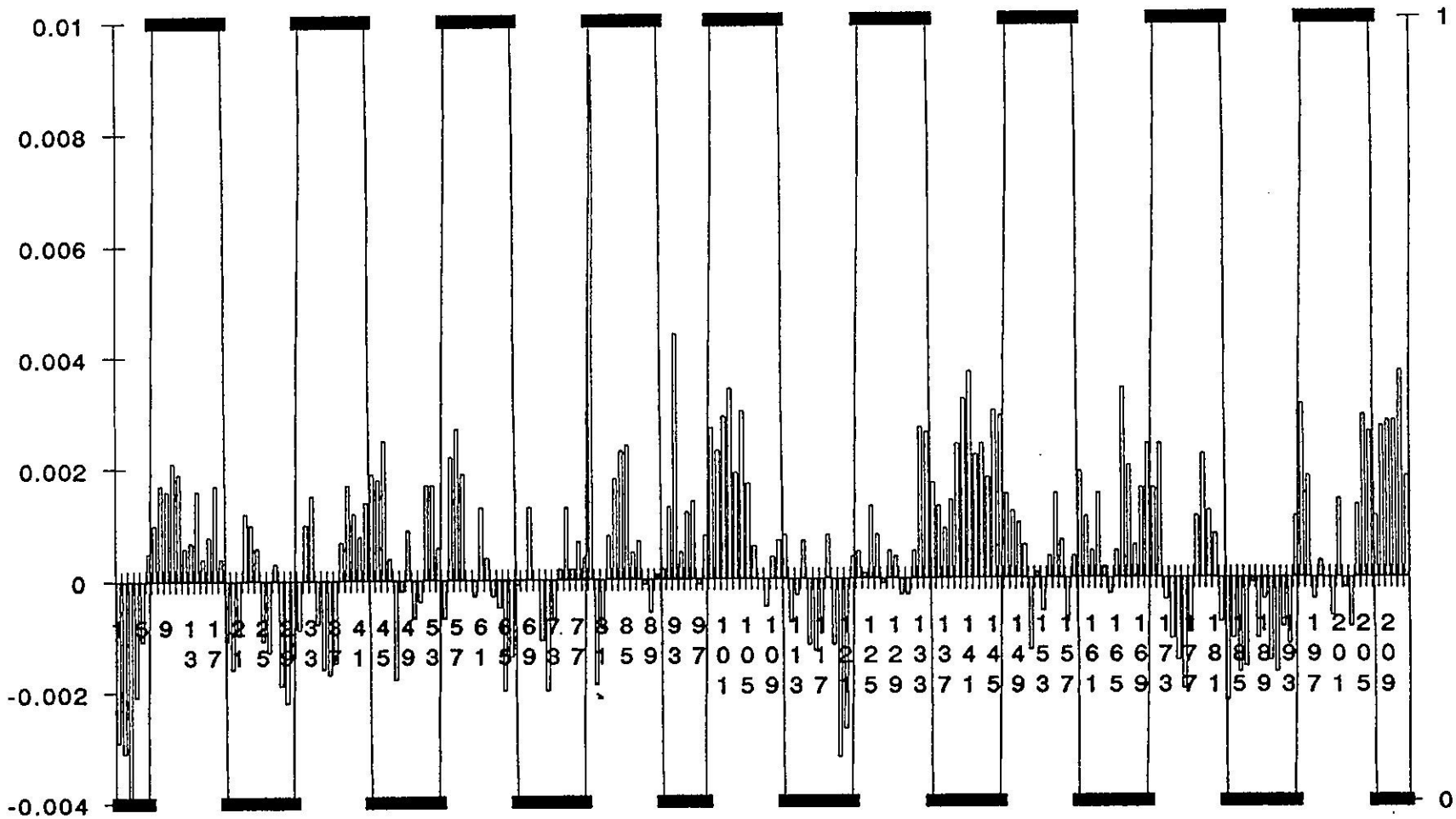
FERMI NATIONAL ACCELERATOR LABORAT
UNITED STATES DEPARTMENT OF ENERGY
SSC

50mm CURING PRESS SIDE VIEW

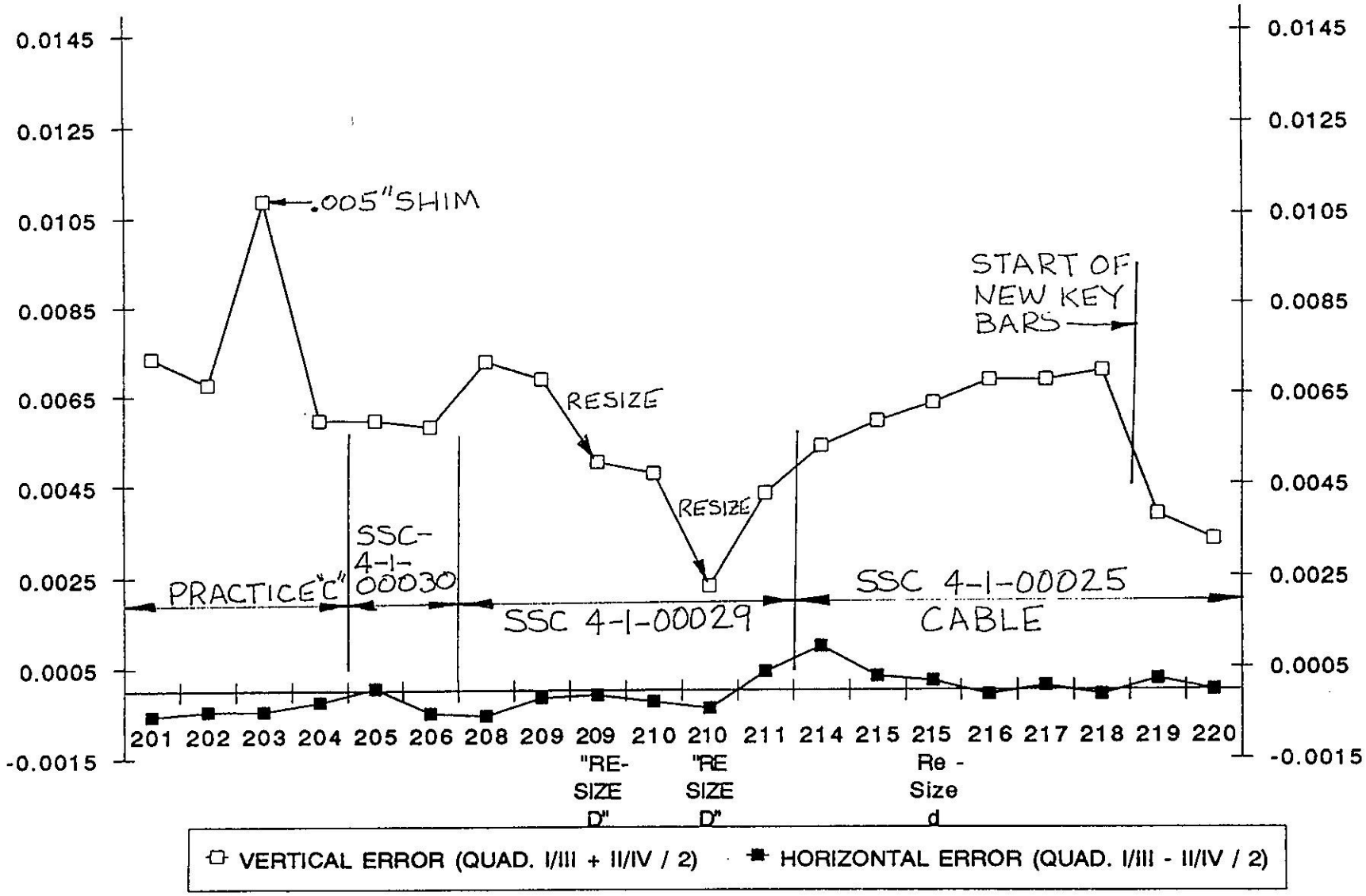
SCALE | FINISH | DRAWING NUMBER

1011RLI KLC

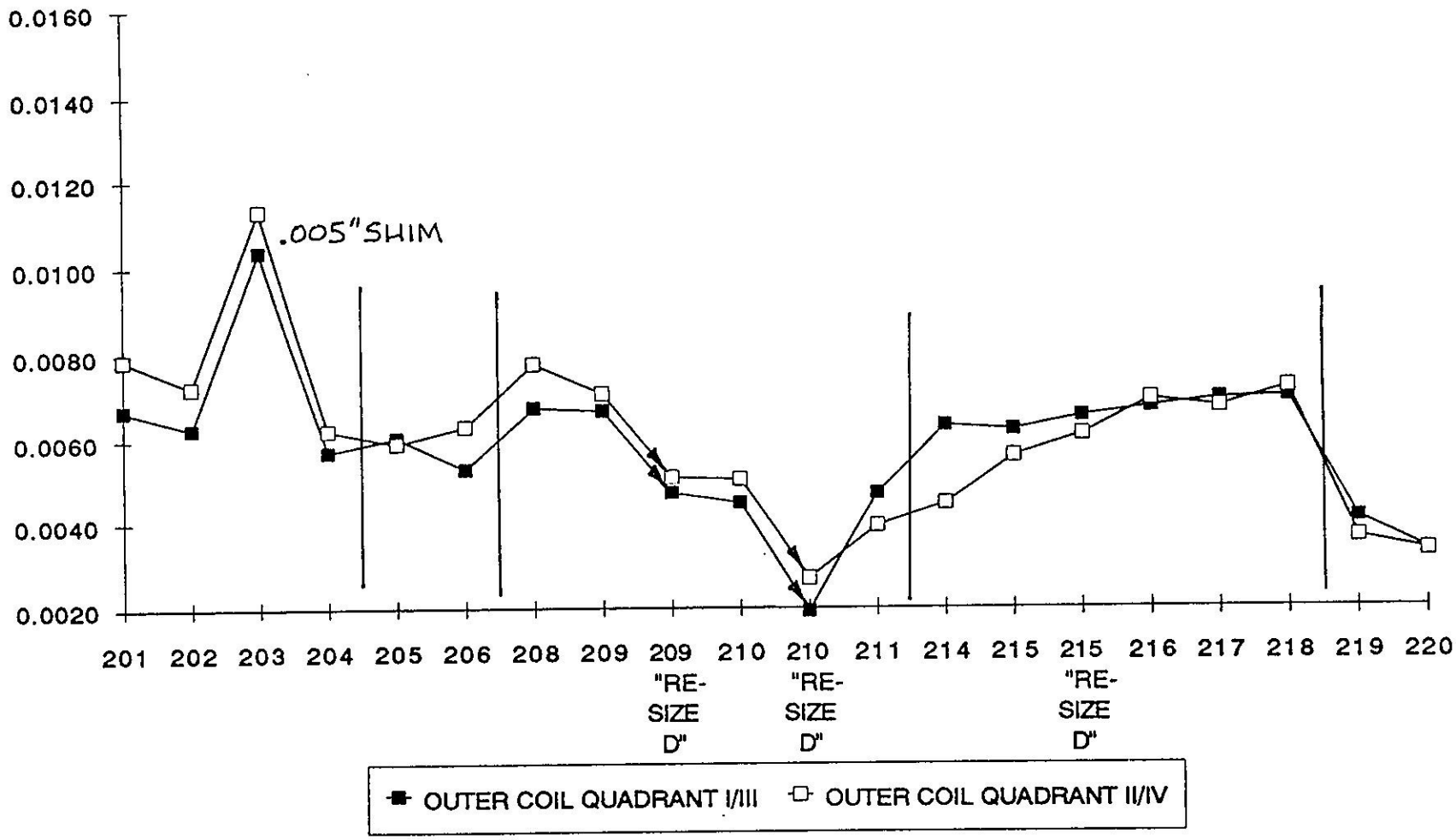
LINER AND A-B



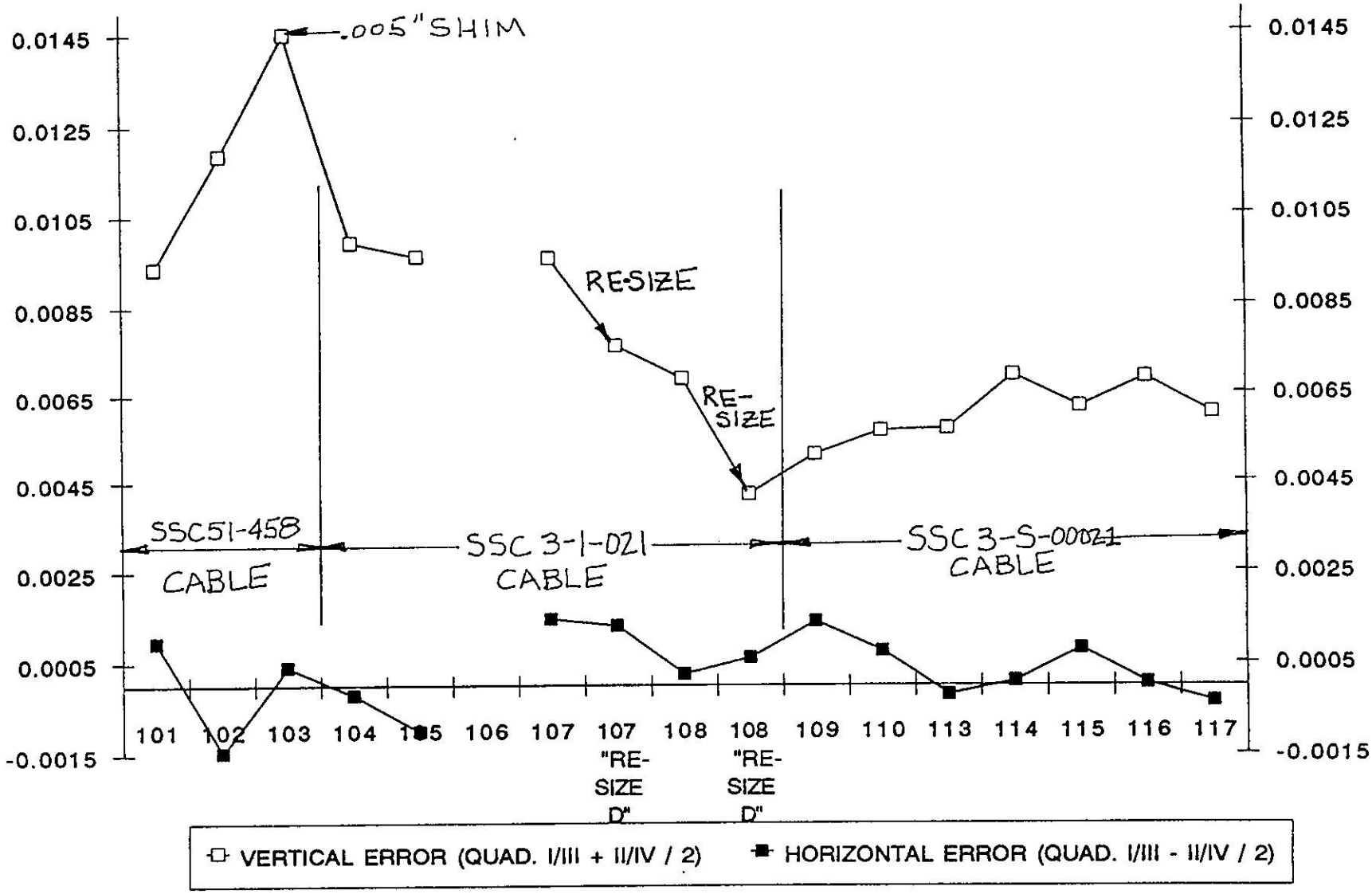
50MM SHORT OUTER COIL VE `CAL AND HORIZONTAL ERROR



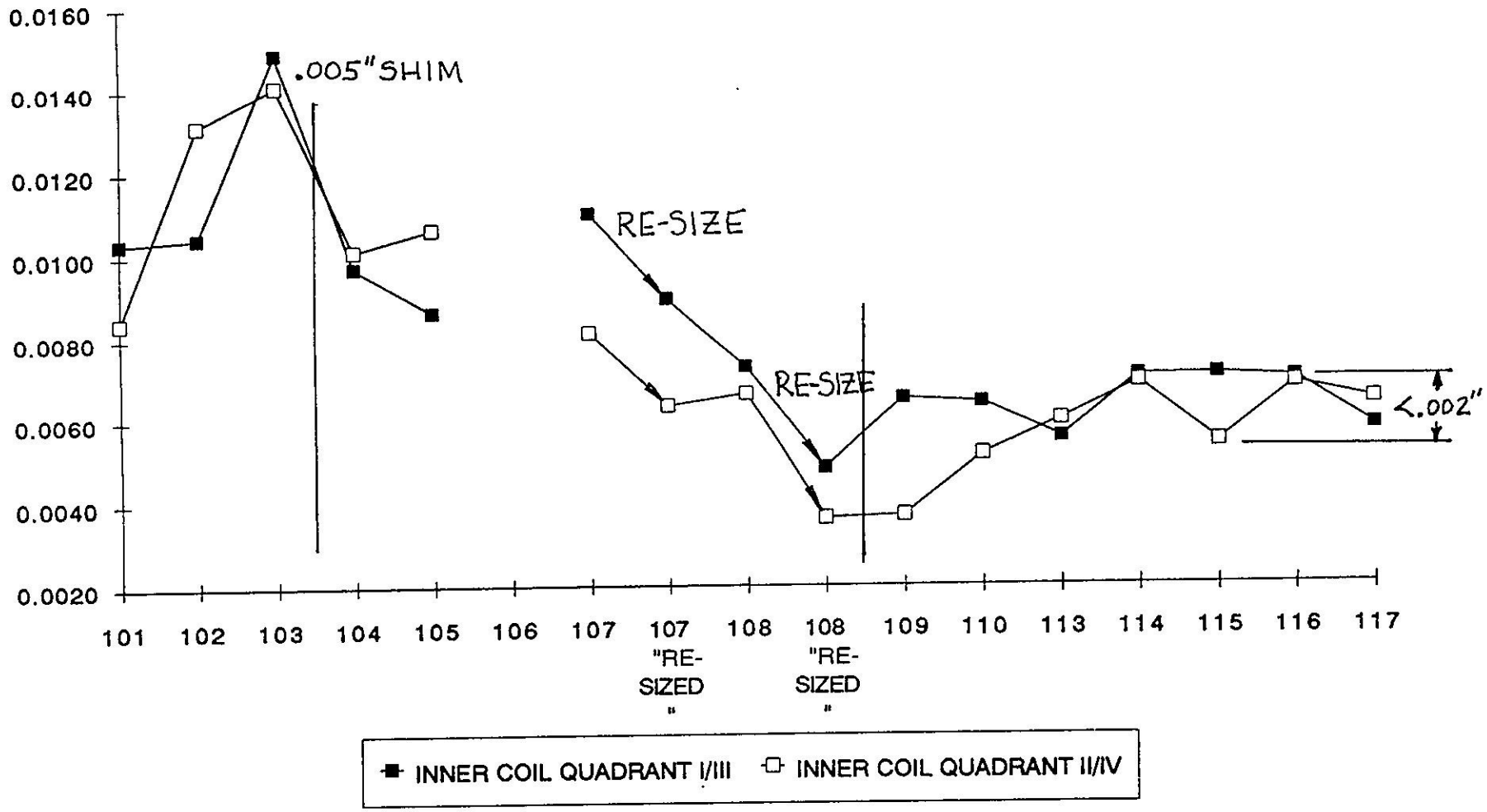
OUTER COIL AVERAGES OF THE COIL DEVIATION FROM THE MASTER AT 12,000 COIL PSI BY COIL NUMBER



50MM SHORT INNER COIL VE. .CAL AND HORIZONTAL ERROR



INNER COIL AVERAGES OF THE COIL DEVIATION FROM THE MASTER AT 12,000 COIL PSI BY COIL NUMBER



TOTALS FOR A MM SHORT COILS

OUTER COIL DATA	SIZE AVERAGE QUAD. I/III	SIZE AVERAGE QUAD. II/IV	SIZE AVERAGE WHOLE COIL	SIZE RANGE	M.O.E. AVERAGE	WHOLE COIL STD. DEV.	VERTICAL ERROR	HORIZONTAL ERROR
AVERAGE	0.0067	0.0075	0.0071	0.0046	1.85E+06	0.0010	0.0071	-0.0004
STD DEV	0.0017	0.0018	0.0017	0.0002	9.77E+04	0.0001	0.0018	0.0002
RANGE	0.0051	0.0054	0.0050	0.0007	2.40E+05	0.0003	0.0051	0.0006
MIN	0.0053	0.0059	0.0058	0.0043	1.75E+06	0.0009	0.0058	-0.0006
MAX	0.0104	0.0113	0.0108	0.0050	1.99E+06	0.0012	0.0109	0.0001

OUTER 50MM COIL # 1M-50-	SHIM USED	SIZE AVERAGE QUAD. I/III	SIZE AVERAGE QUAD. II/IV	SIZE AVERAGE WHOLE COIL	SIZE RANGE	M.O.E. AVERAGE	WHOLE COIL STD. DEV.	VERTICAL ERROR	HORIZONTAL ERROR	REEL SERIAL NUMBER
201	NONE	0.0068	0.0079	0.0074	0.0045	1.75E+06	0.0009	0.0074	-0.0006	PRCT "C"
202	NONE	0.0063	0.0072	0.0067	0.0046	1.94E+06	0.0010	0.0068	-0.0005	PRCT "C"
203	5 MIL.	0.0104	0.0113	0.0108	0.0050	1.79E+06	0.0012	0.0109	-0.0005	PRCT "C"
204	NONE	0.0057	0.0062	0.0060	0.0045	1.99E+06	0.0010	0.0060	-0.0003	PRCT "C"
205	NONE	0.0060	0.0059	0.0060	0.0043	1.77E+06	0.0010	0.0060	0.0001	SSC 4-I-00030
206	NONE	0.0053	0.0063	0.0058	0.0046	1.85E+06	0.0011	0.0058	-0.0005	SSC 4-I-00030
208	NONE	0.0067	0.0078	0.0072	0.0044		0.0011	0.0073	-0.0006	SSC 4-I-00029
209	NONE	0.0067	0.0070	0.0068	0.0036	1.76E+06	0.0008	0.0069	-0.0002	SSC 4-I-00029
209 "RE-SIZED"	NONE	0.0049	0.0051	0.0050	0.0036	2.07E+06	0.0010	0.0050	-0.0001	SSC 4-I-00029
210	NONE	0.0045	0.0050	0.0048	0.0037	1.75E+06	0.0010	0.0048	-0.0003	SSC 4-I-00029
210 "RESIZED"	NONE	0.0019	0.0027	0.0023	0.0031	2.04E+06	0.0007	0.0023	-0.0004	SSC 4-I-00029
211	NONE	0.0047	0.0039	0.0043	0.0039	1.72E+06	0.0010	0.0043	0.0004	SSC 4-I-00029
214	NONE	0.0063	0.0044	0.0054	0.0048	1.83E+06	0.0013	0.0054	0.0010	SSC 4-I-00025
215	NONE	0.0062	0.0056	0.0059	0.0051	1.81E+06	0.0011	0.0059	0.0003	SSC 4-I-00025
215 "RE-SIZED"	NONE	0.0065	0.0061	0.0063	0.0042	2.27E+06	0.0009	0.0063	0.0002	SSC 4-I-00025
216	NONE	0.0067	0.0069	0.0068	0.0040	1.72E+06	0.0010	0.0068	-0.0001	SSC 4-I-00025
217	NONE	0.0069	0.0067	0.0068	0.0035	1.65E+06	0.0009	0.0068	0.0001	SSC 4-I-00025
218	NONE	0.0069	0.0071	0.0070	0.0053	1.78E+06	0.0012	0.0070	-0.0001	SSC 4-I-00025
219	NONE	0.0041	0.0036	0.0038	0.0058	1.94E+06	0.0014	0.0039	0.0003	SSC 4-I-00025
220	NONE	0.0033	0.0033	0.0033	0.0032	1.82E+06	0.0008	0.0033	0.0000	SSC 4-I-00025

NOTE:

1M-50-201 MEASURING PRESSURE WAS 12,484 PSI

1M-50-204 WAS COOLED TO 210 DEG. F THEN LET TO COOL BY RADIATION OVERNIGHT

1M-50-208 WAS CURED 10 DEG. F LOWER BUT ALLOWED TO COOL NATURALLY OVERNIGHT

1M-50-208 WAS MEASURED AT 12,000 COIL PSI ONLY ie NO MODULUS OF ELASTICITY READING

VERTICAL ERROR (QUAD. I/III + II/IV)/2

HORIZONTAL ERROR (QUAD. I/III - II/IV)/2

UPDATED 3/27/91

TOTALS FOR / MM SHORT COILS

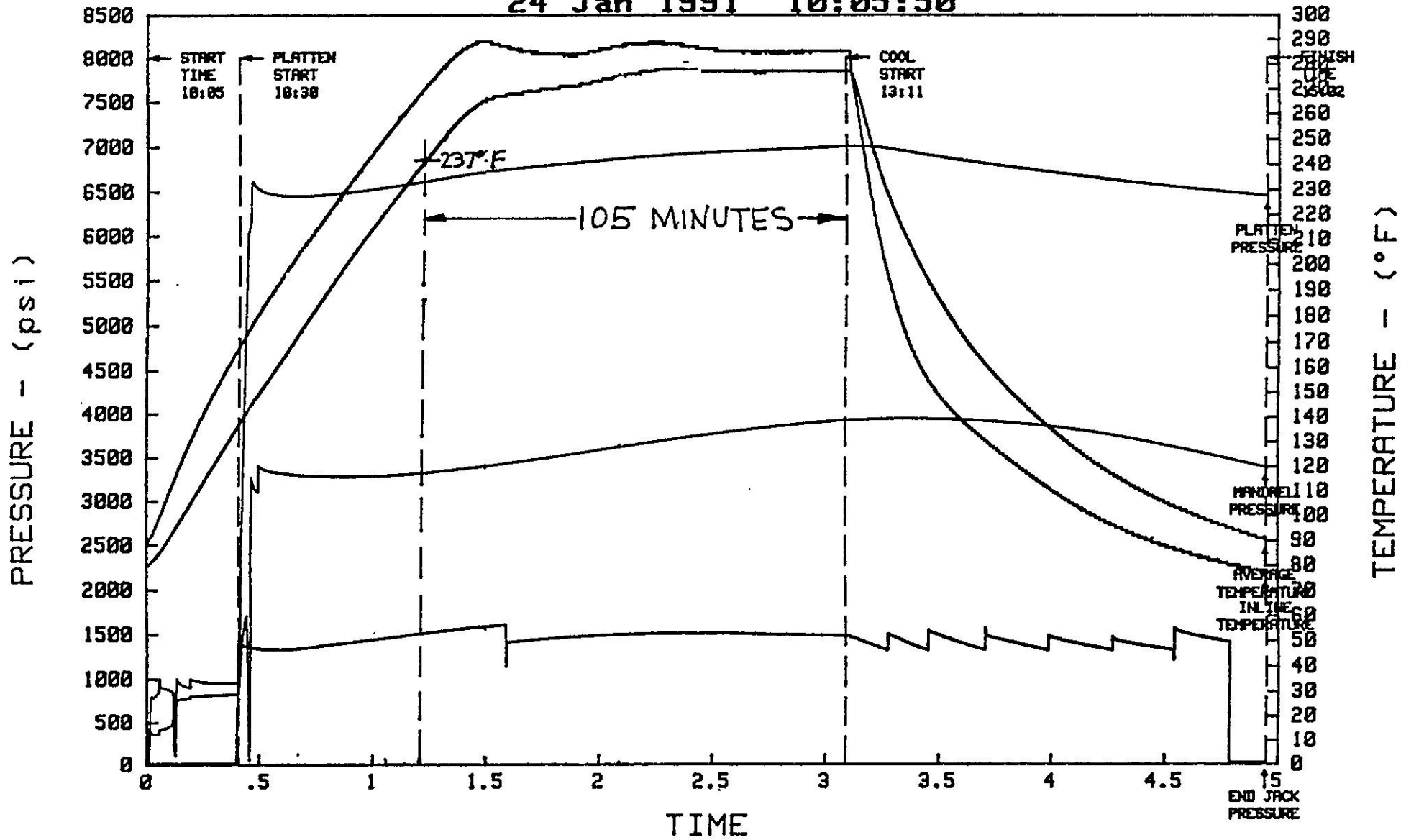
INNER COIL DATA	SIZE AVERAGE QUAD. I/III	SIZE AVERAGE QUAD. II/IV	SIZE AVERAGE WHOLE COIL	SIZE RANGE	M.Q.E. AVERAGE	WHOLE COIL STD. DEV.	VERTICAL ERROR	HORIZONTAL ERROR
AVERAGE	0.0108	0.0108	0.0108	0.0072	2.39E+06	0.0018	0.0108	0.0000
STD DEV	0.0022	0.0025	0.0020	0.0012	2.40E+05	0.0004	0.0020	0.0011
RANGE	0.0063	0.0060	0.0051	0.0032	5.50E+05	0.0011	0.0052	0.0029
MIN	0.0086	0.0081	0.0094	0.0059	2.15E+06	0.0014	0.0094	-0.0015
MAX	0.0149	0.0141	0.0145	0.0091	2.70E+06	0.0025	0.0145	0.0015

INNER 50MM COIL # 1M-50-	SHIM USED	SIZE AVERAGE QUAD. I/III	SIZE AVERAGE QUAD. II/IV	SIZE AVERAGE WHOLE COIL	SIZE RANGE	M.Q.E. AVERAGE	WHOLE COIL STD. DEV.	VERTICAL ERROR	HORIZONTAL ERROR	REEL SERIAL NUMBER
101	NONE	0.0103	0.0084	0.0094	0.0068	2.24E+06	0.0017	0.0094	0.0010	SSC51-458
102	NONE	0.0104	0.0133	0.0119	0.0081	2.15E+06	0.0020	0.0119	-0.0015	SSC51-458
103	5 MIL	0.0149	0.0141	0.0145	0.0059	2.21E+06	0.0014	0.0145	0.0004	SSC51-458
104	NONE	0.0097	0.0101	0.0099	0.0064	2.67E+06	0.0016	0.0099	-0.0002	SSC 3-I-021
105	NONE	0.0086	0.0106	0.0096	0.0071	2.70E+06	0.0017	0.0096	-0.0010	SSC 3-I-021
106										
107	NONE	0.0110	0.0081	0.0095	0.0091	2.35E+06	0.0025	0.0096	0.0015	SSC 3-I-021
107 "RE-SIZED"	NONE	0.0089	0.0063	0.0076	0.0066	2.58E+06	0.0022	0.0076	0.0013	SSC 3-I-021
108	NONE	0.0071	0.0066	0.0068	0.0048	2.18E+06	0.0013	0.0069	0.0003	SSC 3-I-021
108 "RE-SIZED"	NONE	0.0048	0.0036	0.0042	0.0059	2.32E+06	0.0014	0.0042	0.0006	SSC 3-I-021
109	NONE	0.0065	0.0037	0.0051	0.0080	2.21E+06	0.0022	0.0051	0.0014	SSC 3-S-00021
110	NONE	0.0064	0.0049	0.0056	0.0061	2.10E+06	0.0016	0.0057	0.0008	SSC 3-S-00021
113	NONE	0.0055	0.0059	0.0057	0.0047	2.34E+06	0.0013	0.0057	-0.0002	SSC 3-S-00021
114	NONE	0.0070	0.0068	0.0069	0.0046	2.30E+06	0.0012	0.0069	0.0001	SSC 3-S-00021
115	NONE	0.0070	0.0054	0.0062	0.0071	2.42E+06	0.0017	0.0062	0.0008	SSC 3-S-00021
116	NONE	0.0069	0.0068	0.0069	0.0072	2.35E+06	0.0019	0.0069	0.0001	SSC 3-S-00021
117	NONE	0.0057	0.0064	0.0061	0.0058	2.38E+06	0.0014	0.0061	-0.0004	SSC 3-S-00021

NOTES:

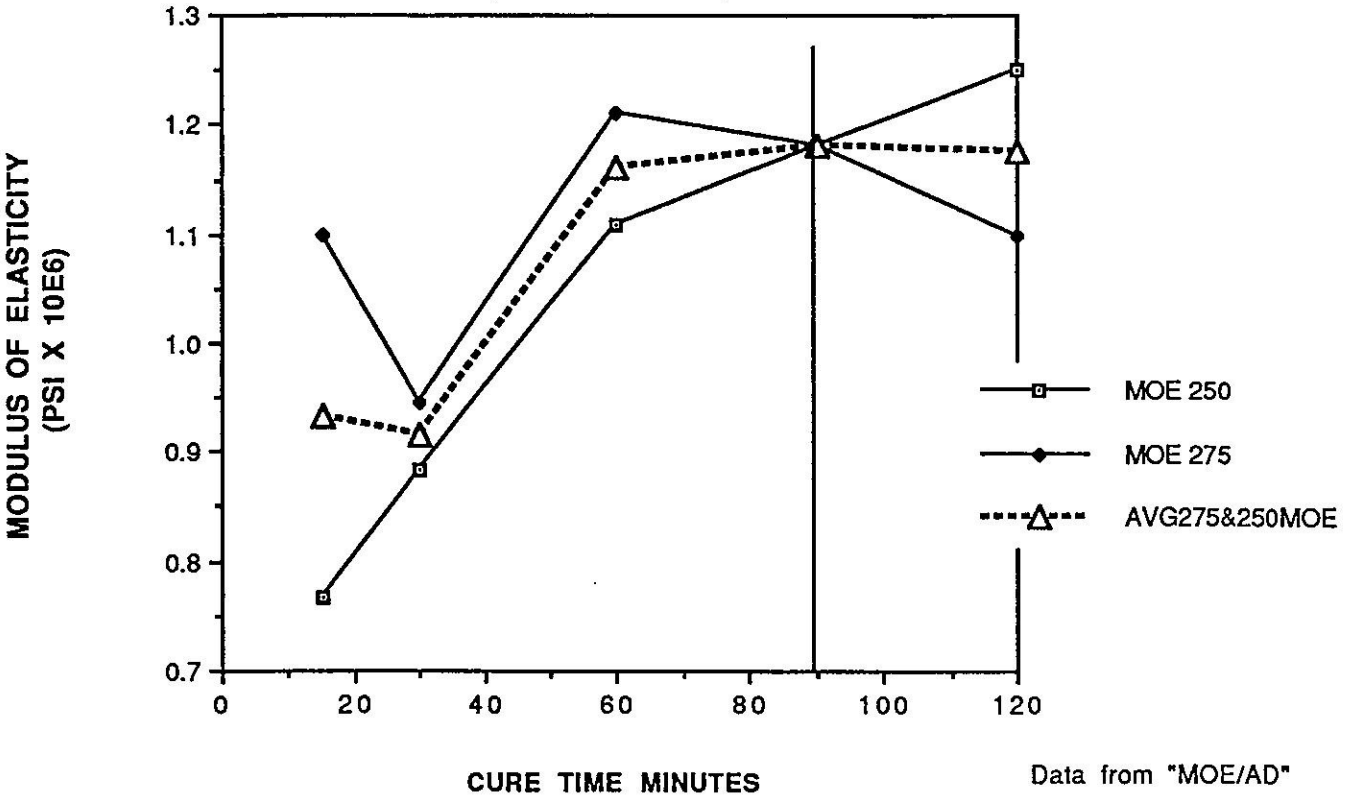
UPDATED 3/27/91

SSC Curing Press Data
Coil Serial# 17M-1008R
24 Jan 1991 10:05:50



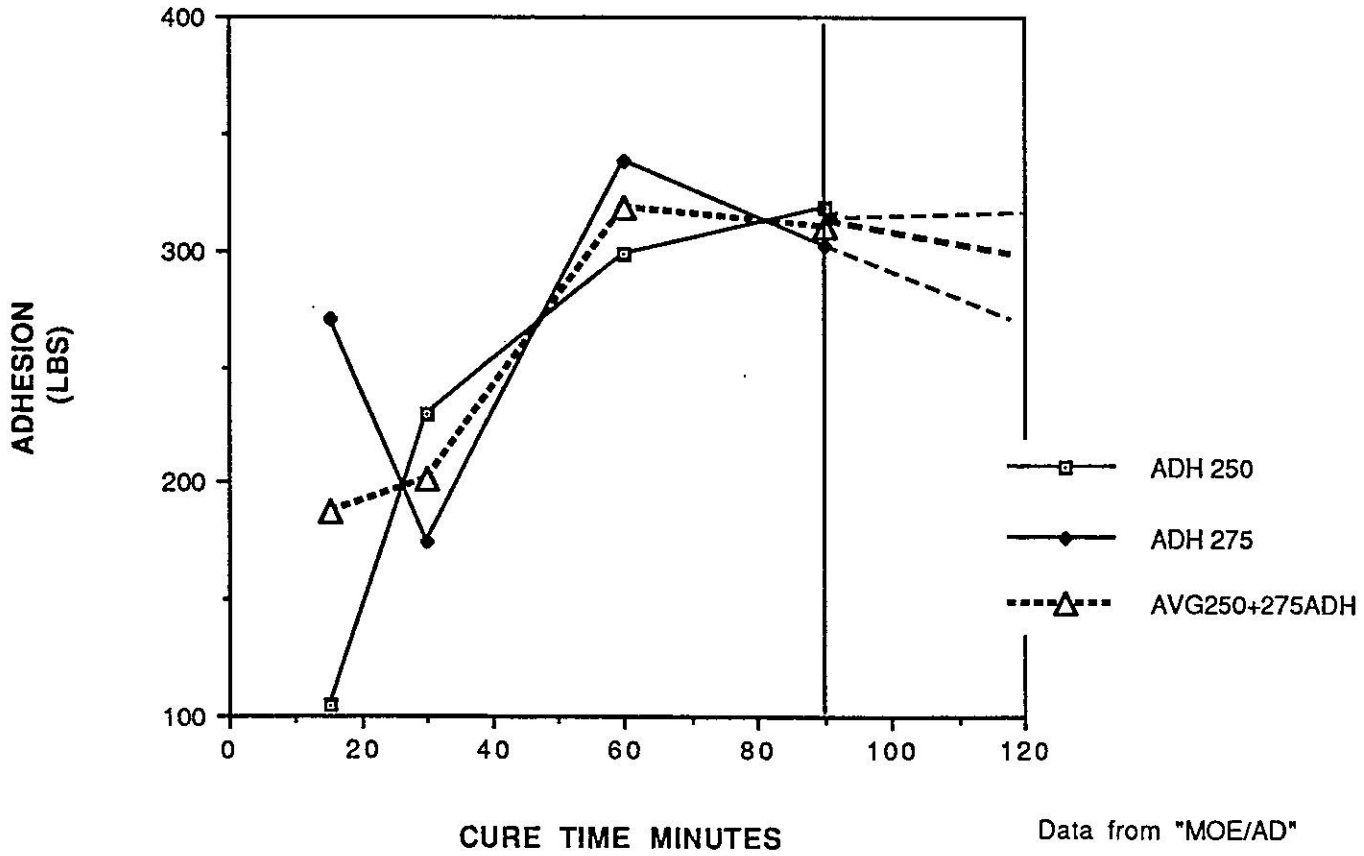
PLATTEN 1000 psi = 2222 #/in
MANDREL 1000 psi = 333 #/in
END JACK 1000 psi = 2000 #

COMPARISON OF MODULUS OF ELASTICITY AT 250F, 265F(PROJECTED) &275F



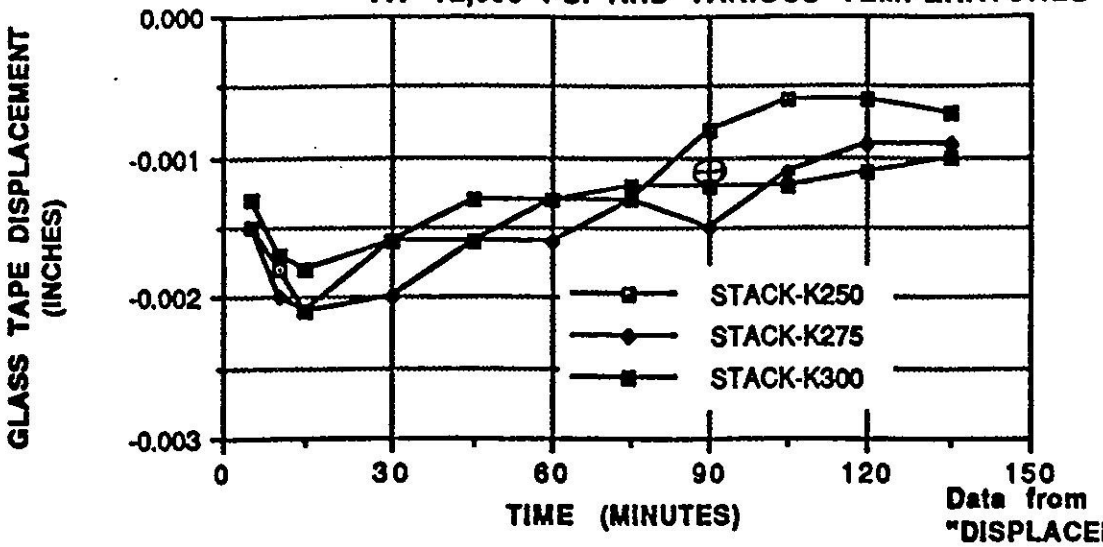
Data from "MOE/AD"

COMPARISON / PROJECTION OF ADHESION 250F, 265F PROJECTED, 275F



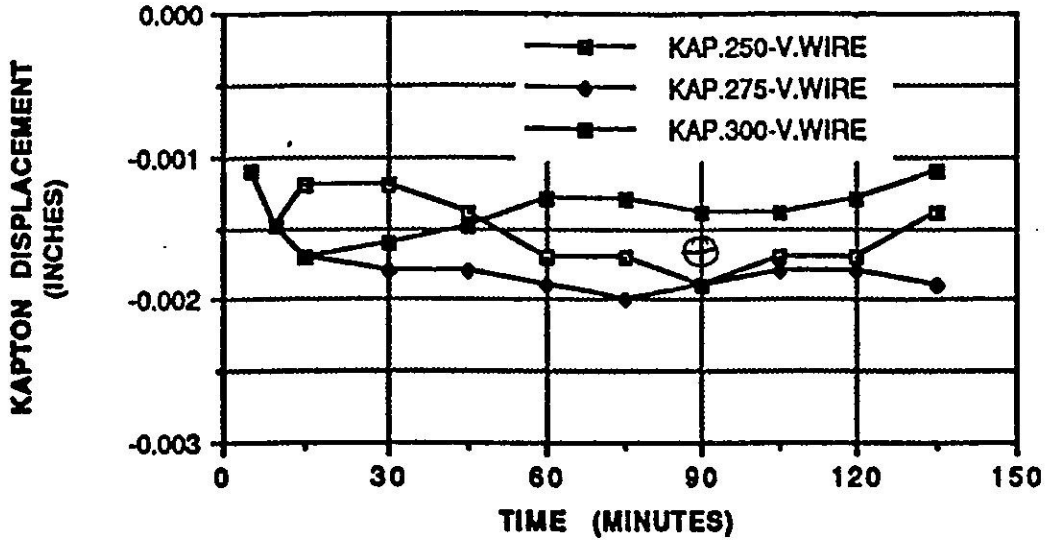
Data from "MOE/AD"

GLASS TAPE DISPLACEMENT IN A IO STACK
AT 12,000 PSI AND VARIOUS TEMPERATURES

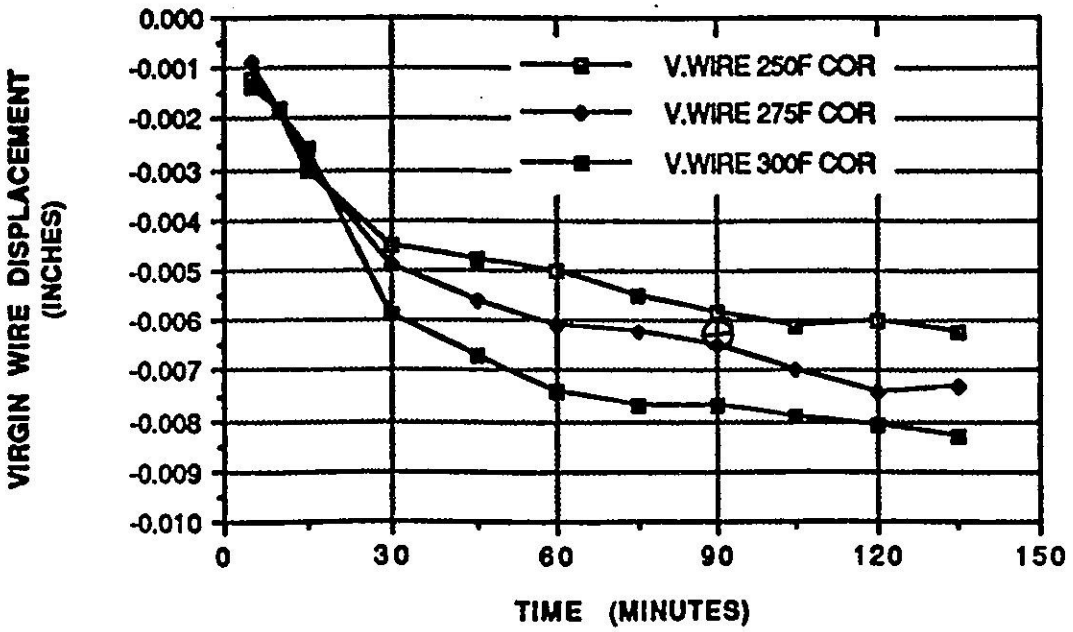


Data from "DISPLACEMENT DATA 2"

KAPTON DISPLACEMENT IN A 10 STACK
AT 12,000 PSI AND VARIOUS TEMPERATURES



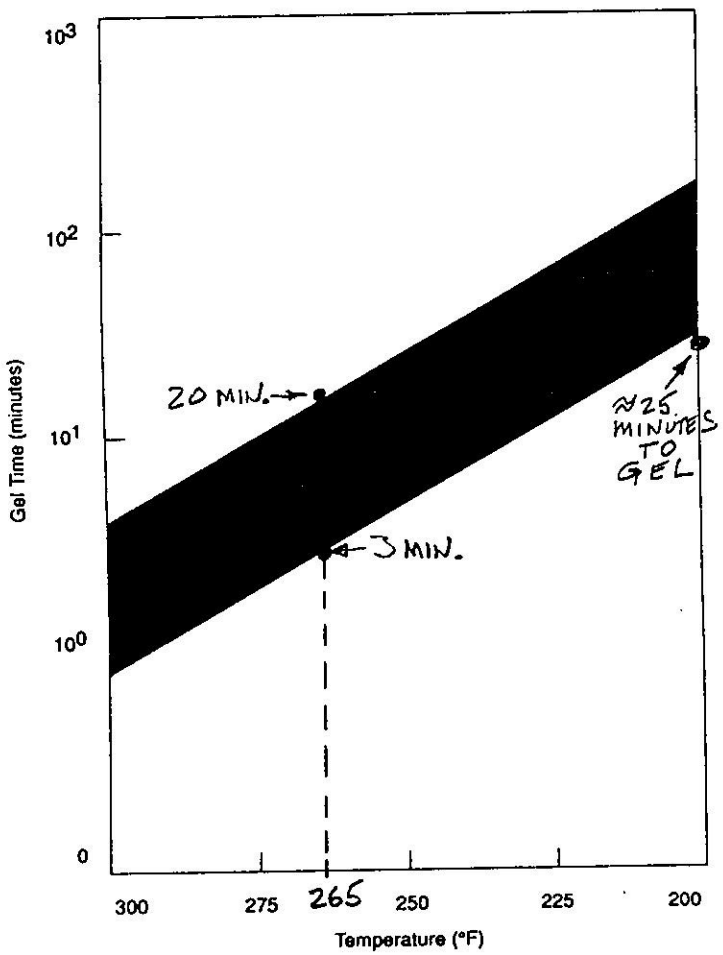
VIRGIN WIRE DISPLACEMENT IN A 10 STACK
AT 12,000 PSI AND VARIOUS TEMPERATURES



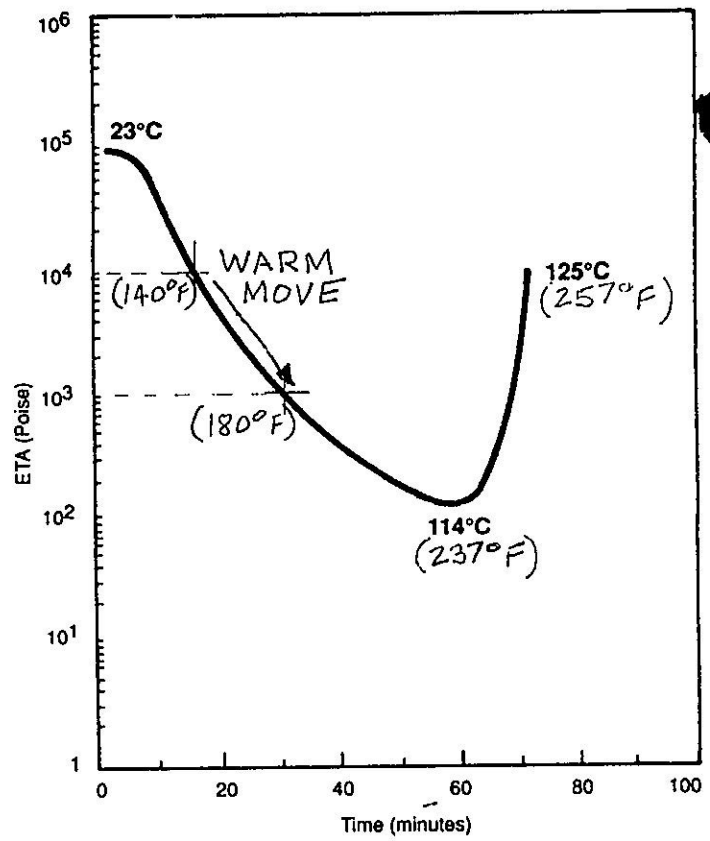
6.04 KJ/m²

Gel Time @ 250°F ..... 5-11 min.

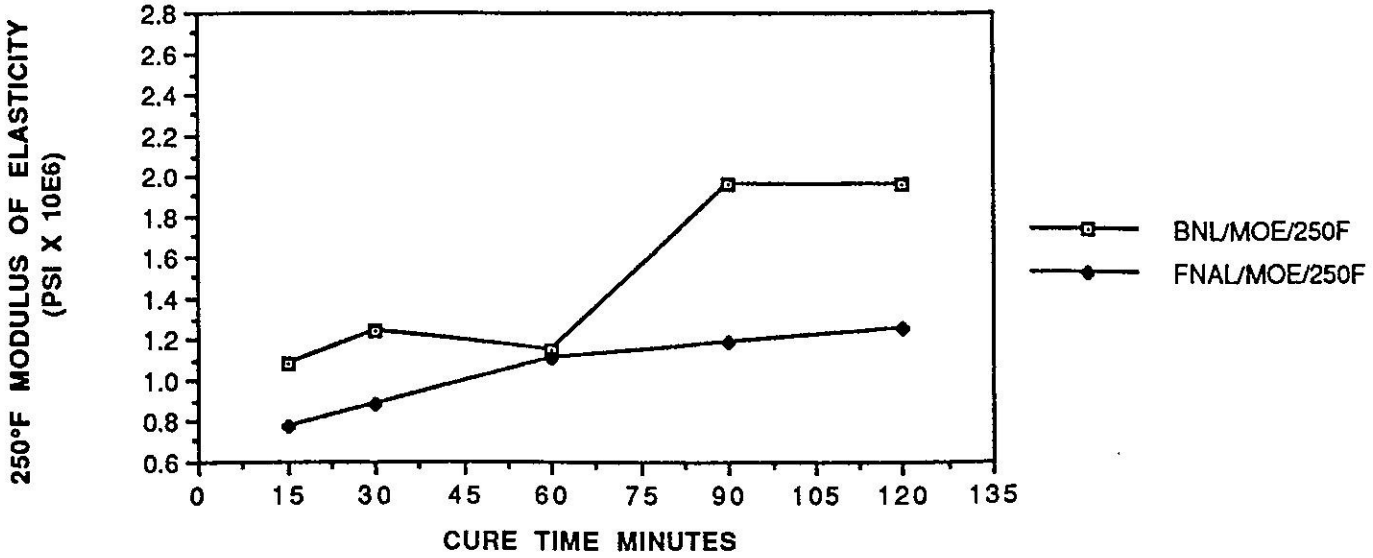
F185
Gel Time vs. Temperature



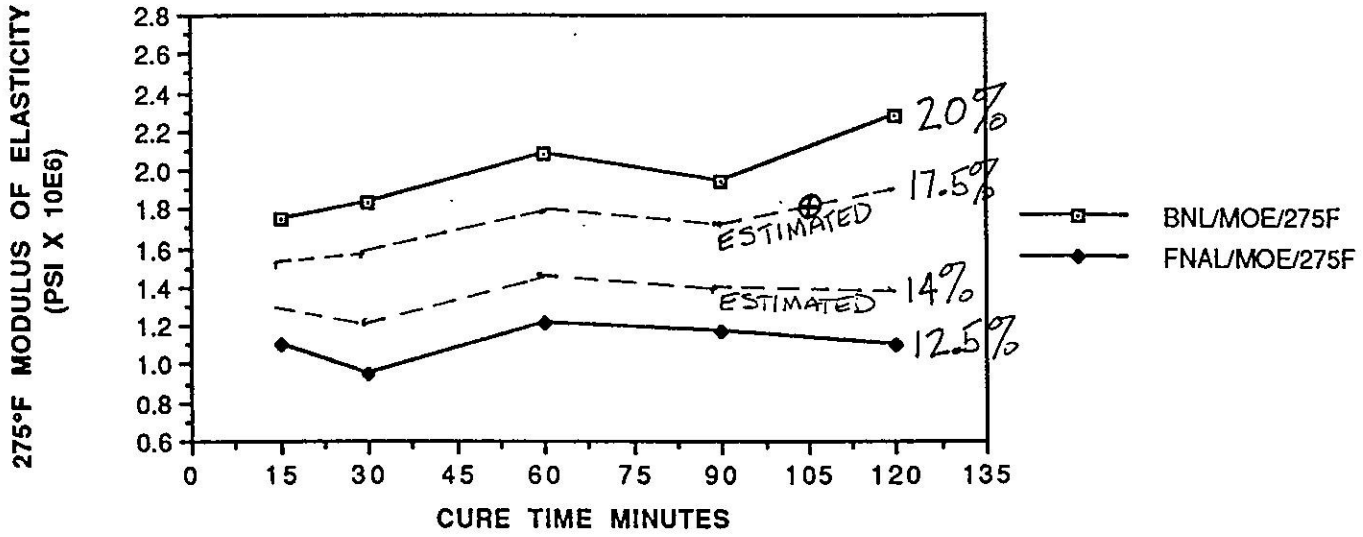
Rheometrics Curve of F185
2 Deg./Min., 10 Rad/Sec,
RDS-7700, 50mm Plates



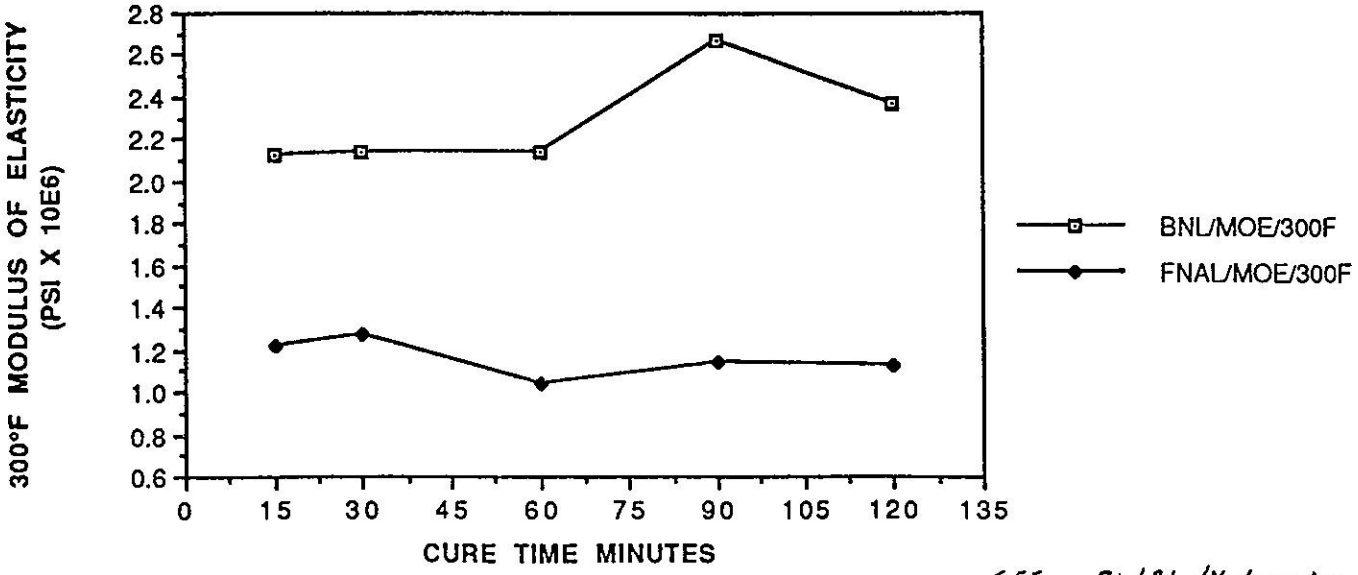
COMPARISON OF FNAL & BNL (ELASTICITY VS CURING TIME AT 250°F GRAPHS)



COMPARISON OF FNAL & BNL (ELASTICITY VS CURING TIME AT 275°F GRAPHS)

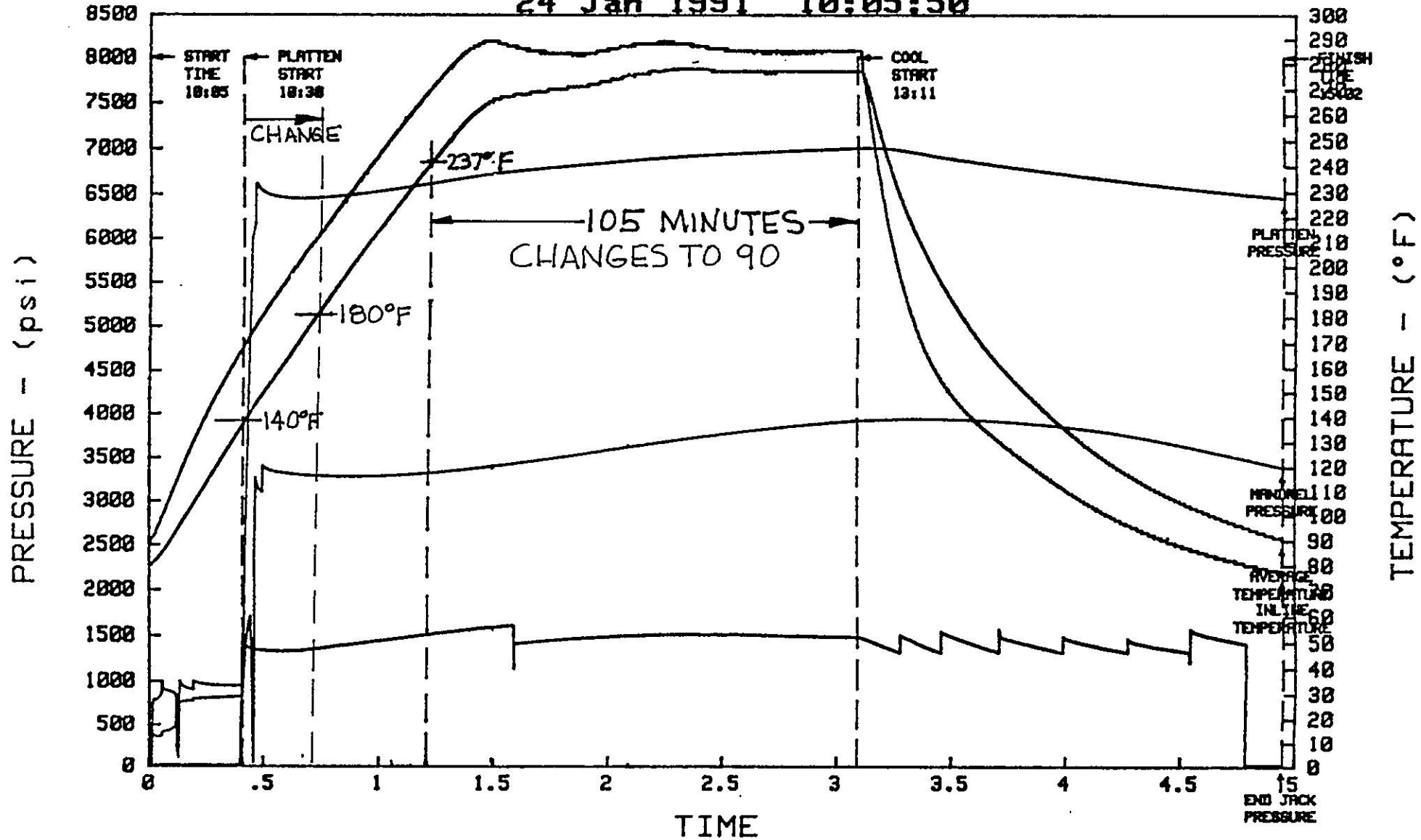


COMPARISON OF FNAL & BNL (ELASTICITY VS CURING TIME AT 300°F GRAPHS)



SEE FL/BL/%/DSP/AD

SSC Curing Press Data
Coil Serial# 17M-1008R
24 Jan 1991 10:05:50



PLATTEN 1000 psi = 2222 #/in
MANDREL 1000 psi = 333 #/in
END JACK 1000 psi = 2000 #