Fermilab

TS-SSC 91-063
4/12/91

To: J. Brandt, J. Carson, S. Delchamps, A. Devred, J. Elliott, I. Gonczy, C. Goodzeit, M. Gordon, S. Gourlay, G. Kobliska, W. Koska, M. Lamm, S. Merkler, E.G. Pewitt, R. Rihel, D. Smith, M. Wake

From: Jim Strait and Rodger Bossert

Subject: Evaluation of collar lamination inspection report (SSC 50 mm collar lamination without shims, part# ME-292059 rev. C)

All short 50 mm dipoles so far have been made with collars which require a collaring shoe but no pole shims and are made from drawing ME-292059 revision A. A revised version of this collar (revision C) is being procured for the long magnets. In this note we summarize our evaluation of the inspection report on this collar and compare the critical dimensions with those on the previous revision. The changes from revision A to revision C are:

1) The radii on most corners have been increased to improve die wear.

2) The slot for instrumentation wires at the pole on the outer surface has been increased in width.

3) The flats on the collar pick-up notches at 45° have been moved 3 mils farther from both the horizontal and vertical the center-lines. The horizontal surfaces mate with features on the collaring tooling and this move is to improve the azimuthal alignment of the collars during keying. In addition to this translation on the drawing Plainfield, who also made the tooling laminations, has agreed to move the horizontal surface an additional 2 mils to mate with 1 mil clearance with respect to the upper tooling and 1 mil interference with the lower tooling.

Evaluation of Revision C Collar Inspection Report

Figure 1 shows the optical contour projector inspection report for the revision C collars. The measured points for the collar interior match the design within a few tenths of a mil except along the long arm on the left which appears to be sprung inwards by about a mil at its tip. Since the slot into which this arm mates is very close to its design size and location, the sprung arm will tend to be forced to its design position, making the entire interior surface good to better than 0.5 mil. The active key surfaces (69 and 85) are translated up by a little over a mil. Thus the collar cavities, both for the inner and the outer coils, will be about 1 mil (per quadrant) larger than the design.

The "vertical" collar outer surface (33, 44, 52, 60) are shifted up by 1 mil. This shift is comparable to the shift in the key slots, so the undeflected collar diameters along these surfaces should be equal to the design within about a mil.

The fit between the collars and the tooling is set by the relation between the collar outer surface (principally surfaces 44 and 52) and the alignment flats (40 and 56). In a coordinate system set by surfaces 44 and 56, the alignment flats are shifted down by 1.5 mils, very close to the promised 2 mils. Because the "vertical" outer surface and the active key slot surfaces are both shifted up, the relationship between the two, which determines the amount of collaring tooling closure required for key insertion, is within a mil of the design.

The "horizontal" collar outer surfaces (33, 63 and 87) are designed to have an interference fit with the yoke. These are shifted inwards by about 1-1.5 mils. If the long arm on the left is moved closer to its design position under assembly, the "horizontal" outer surfaces are within a mil, although still shifted inwards, of the design. A modest inward shift is, in fact, desirable. The collar was designed[1] based on calculations[2] that indicated that the collar horizontal radius would decrease by about 0.5 mil under coil prestress. Experimentally the horizontal radius actually increases by 1-1.5 mils under prestress resulting in a horizontal yoke-collar interference up to 2 mils larger than called for in the design.

Comparison with Revision A

Figure 2 shows the optical contour projector inspection report for the revision A collars. The active key surfaces (73 and 89) are shifted down by about 0.5 mil and the entire collar interior (1, 3, 5, 7, 17, 19 21 and 23) is shifted down by 1.5-2 mils. In a coordinate system normalized vertically to put the key surfaces at the design position (these are the coordinates that describe the collars after they are keyed) the collar interior is shifted down by an average of a bit over a mil. Therefore the coil cavities are a little over a mil larger than the design size. The difference between the coil cavities of the revision C and revision A collars is less than a mil and is probably zero within the measurement accuracy.

Normalized to the "vertical" outer surface (47 and 53) the active key surfaces are within a few tenths of a mil of the design. This is the same within the probable measurement accuracy as for the revision C collars. Thus the revision C collars will require about the same compression for key insertion as used for the revision A collars. Normalized to the "vertical" outer surface the alignment flats are within a few tenths of a mil of the design. Relative to revision A, therefore, the revision C collar flats are about 4.5 mils closer to the tooling which will eliminate the current need for 5 mil shims on these surfaces.

On the revision A collar the "horizontal" outer surfaces (33, 67 and 91) are radially shifted relative to the design by from -1 mil (surface 91) to +1 mil (surface 67). On the average these surfaces on the revision C collar are at a radius 0-1 mil smaller than on the revision A collars. This is desirable, as noted above, since it will result in a fit between the collared coil and the yoke that is closer to the design.

It should be noted that the initial inspection of the revision A collars was made with respect to an incorrect version of the revision A drawing, which had the outer coil pole surfaces shifted by 5 mils away from the mid-plane in a direction perpendicular to the pole surface relative to the correct drawing. According to Steve Merkler this error was corrected on 10/4/90. Any inspections done before this are incorrect and the corresponding reports should be discarded. An example incorrect inspection report is attached as Figure 3.

References

[1] J. Strait, Mechanical Design, in 50 mm Collider Dipole Magnet Requirements and Specification (Yellow Book), 10/10/90.

[2] J. Kerby, Mechanical Analysis of the Vertically Split Yoke 50 mm SSC Dipole, Fermilab Technical Support Section internal note TS-SSC 91-001, 12/13/90.

FERMILAB	O.G.P. OQ-20 OPTICAL CONTOUR PROJECTOR	INSPECTOR Steve Merkler	DATE 04/08/91
SUBJECT	PART# ME-292059 Rev. C SSC 50mm COLLAR LAM. W/O SHIMS VERTICALLY SPLIT YOKE	RECEIVED 04/02/91	SAMPLE 42777_3A

NUMBERS......=SURFACE NO.

RAD OF ARCS

SURF#	NOM	ACT	DEV
19	1.4930	1.4922	-.0008
23	2.0010	2.0009	-.0001
60	2.6700	2.6689	-.0011
96	.1280	.1290	.0010
97	.1280	.1291	.0011

ANGLES

SURF#	NOM	ACT	DEV
3	30.6618	30.6459	-.0159
7	72.0730	71.9864	-.0866
17	207.9260	207.8991	-.0269
21	321.3380	321.2979	-.0401
25	272.0070	272.0977	.0907
65	3.0000	3.0653	.0653
69	177.0000	177.0299	.0299
73	171.4120	171.2295	-.1825
77	8.5880	8.8477	.2597
81	3.0000	3.0055	.0055
85	177.0000	177.0109	.0109
95	272.0000	271.9416	-.0584

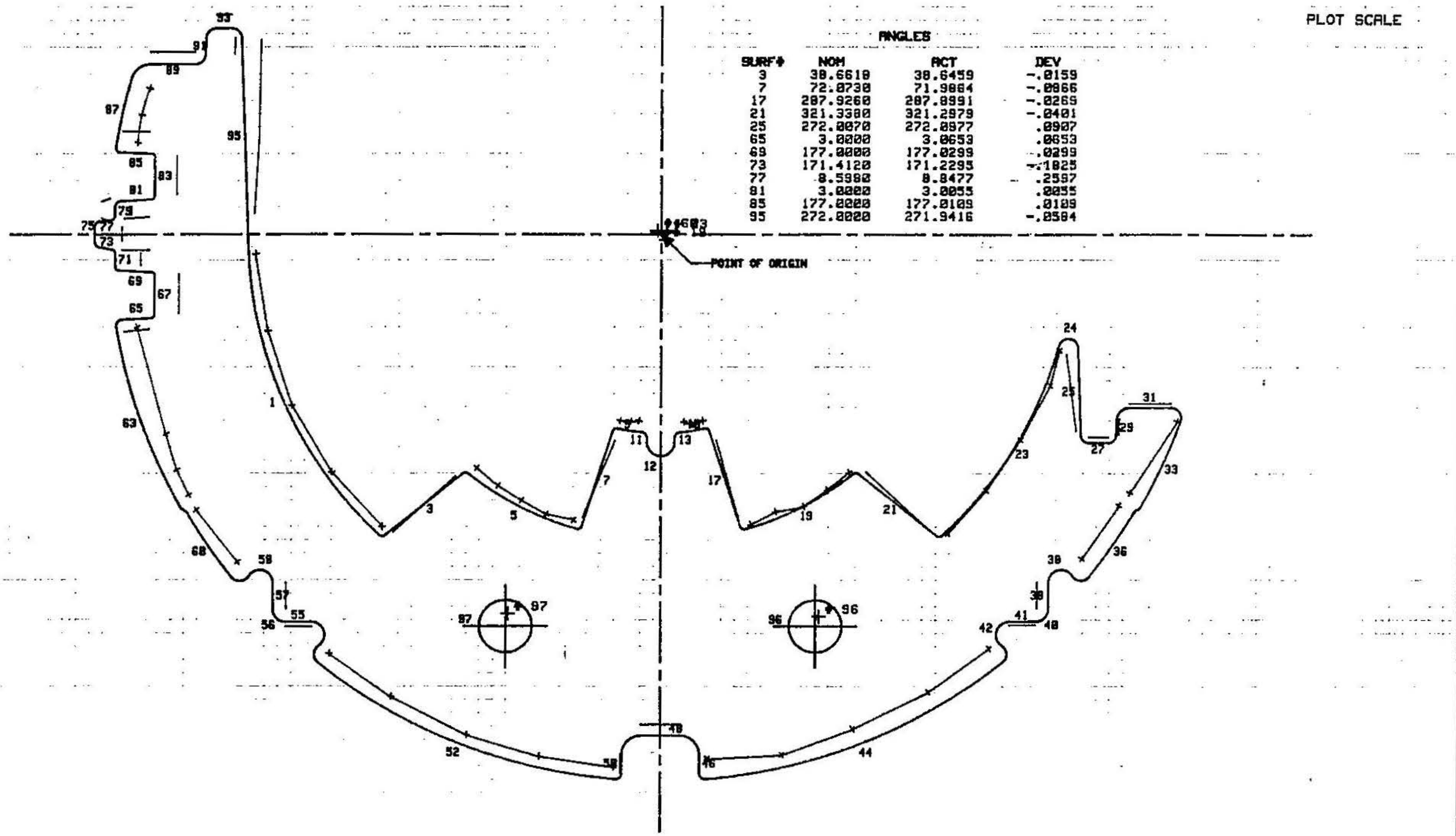

Figure 1

FERMILAB	O.G.P. OQ-20 OPTICAL CONTOUR PROJECTOR	INSPECTOR Steve Merkler	DATE 11/16/1990
SUBJECT PART# ME-292059 Rev. A SSC 50mm COLLAR LAM. W/O SHIMS VERTICALLY SPLIT YOKE		RECEIVED 11/13/90	SAMPLE 3A

NUMBERS......=SURFACE NO.

RAD OF ARCS

SURF#	NOM	ACT	DEV
10	1.4930	1.4932	.0002
23	2.0010	2.0007	-.0003
63	2.6700	2.6706	.0006
100	.1200	.1204	.0004
101	.1200	.1203	.0003

DRAWING SCALE

PLOT SCALE

ANGLES

SURF#	NOM	ACT	DEV
3	30.6618	30.6313	-.0305
7	72.0730	72.0872	.0142
17	207.9260	207.8808	-.0452
21	321.3380	321.3594	.0214
25	272.0070	272.2374	.2304
69	3.0000	2.9924	-.0076
73	177.0000	177.1006	-.1006
77	171.4120	171.0714	-.3406
81	0.5880	0.8151	.2271
85	3.0000	3.0141	.0141
89	177.0000	177.0595	.0595
99	272.0000	271.9496	-.0504

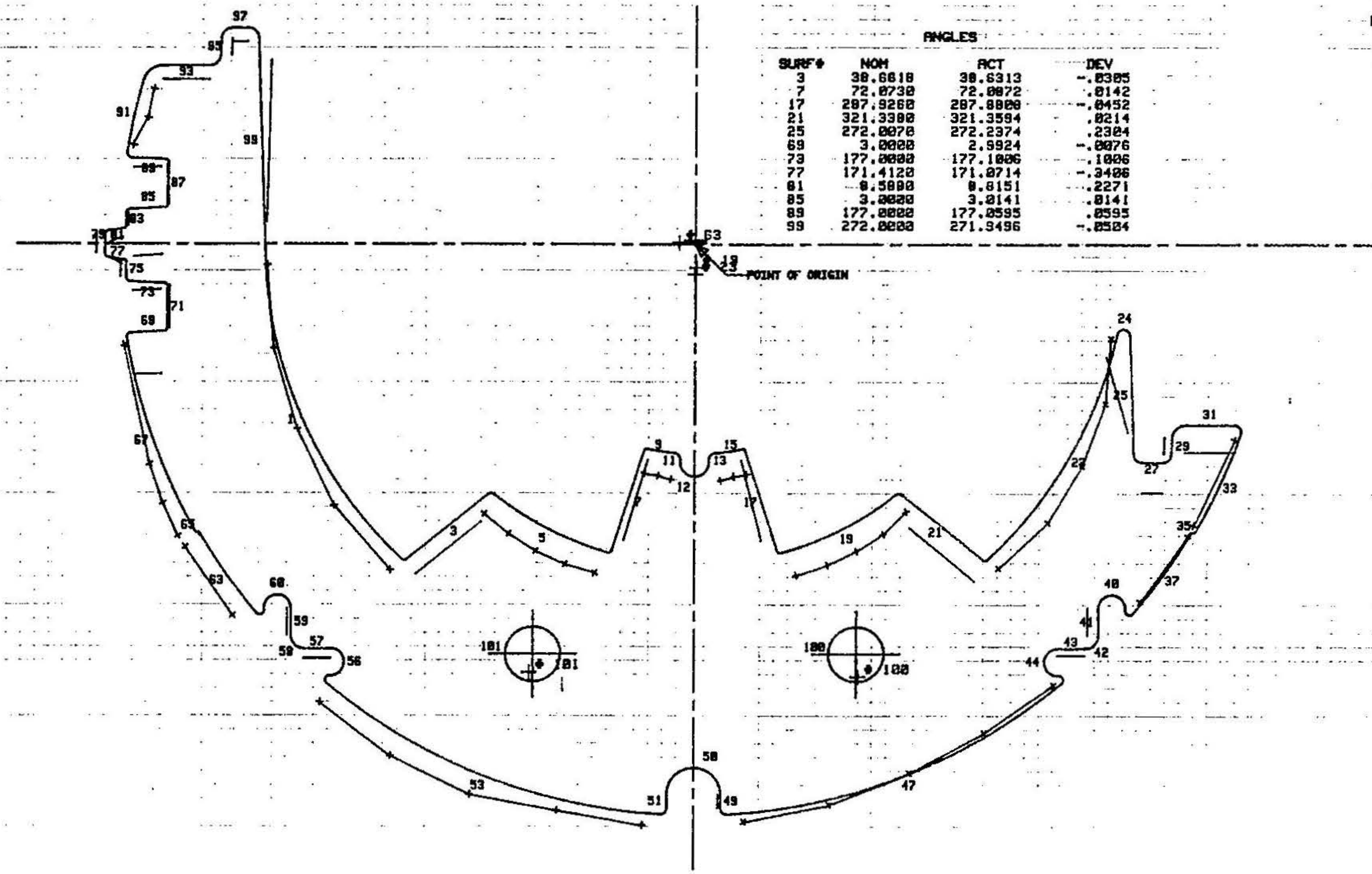

Figure 2

FERMILAB	O.G.P. OQ-20 OPTICAL CONTOUR PROJECTOR	INSPECTOR Steve Merkler	DATE 09/10/1990
SUBJECT	PART# ME-292059 Rev. A SSC 50mm COLLAR LAM. W/O SHIMS VERTICALLY SPLIT YOKE	RECEIVED 09/13/90	SAMPLE 1A

NUMBERS.......=SURFACE NO.

INSPECTED W.R.T. WRONG DRAWING REVISION

RAD OF ARCS

SURF#	NOM	ACT	DEV
19	1.4930	1.4925	-.0005
23	2.0010	2.0008	-.0002
63	2.6700	2.6700	-0.0000
100	.1200	.1203	.0003
101	.1200	.1203	.0003

DRAWING SCALE

0.000 0.063 0.125 0.250 0.500

0.000 0.001 0.002 0.008

PLOT SCALE

ANGLES

SURF#	NOM	ACT	DEV
3	38.6618	38.6651	.0033
7	72.0730	72.0384	-.0346
17	287.9260	287.9289	.0029
21	321.3380	321.3561	.0181
25	272.0070	272.1535	.1465
69	3.0000	3.0151	.0151
73	177.0000	177.0568	.0568
77	171.4120	171.1733	-.2387
81	8.5880	8.8344	.2464
85	3.0000	3.1817	.1817
89	177.0000	177.0891	.0891
99	272.0000	271.9565	-.0435

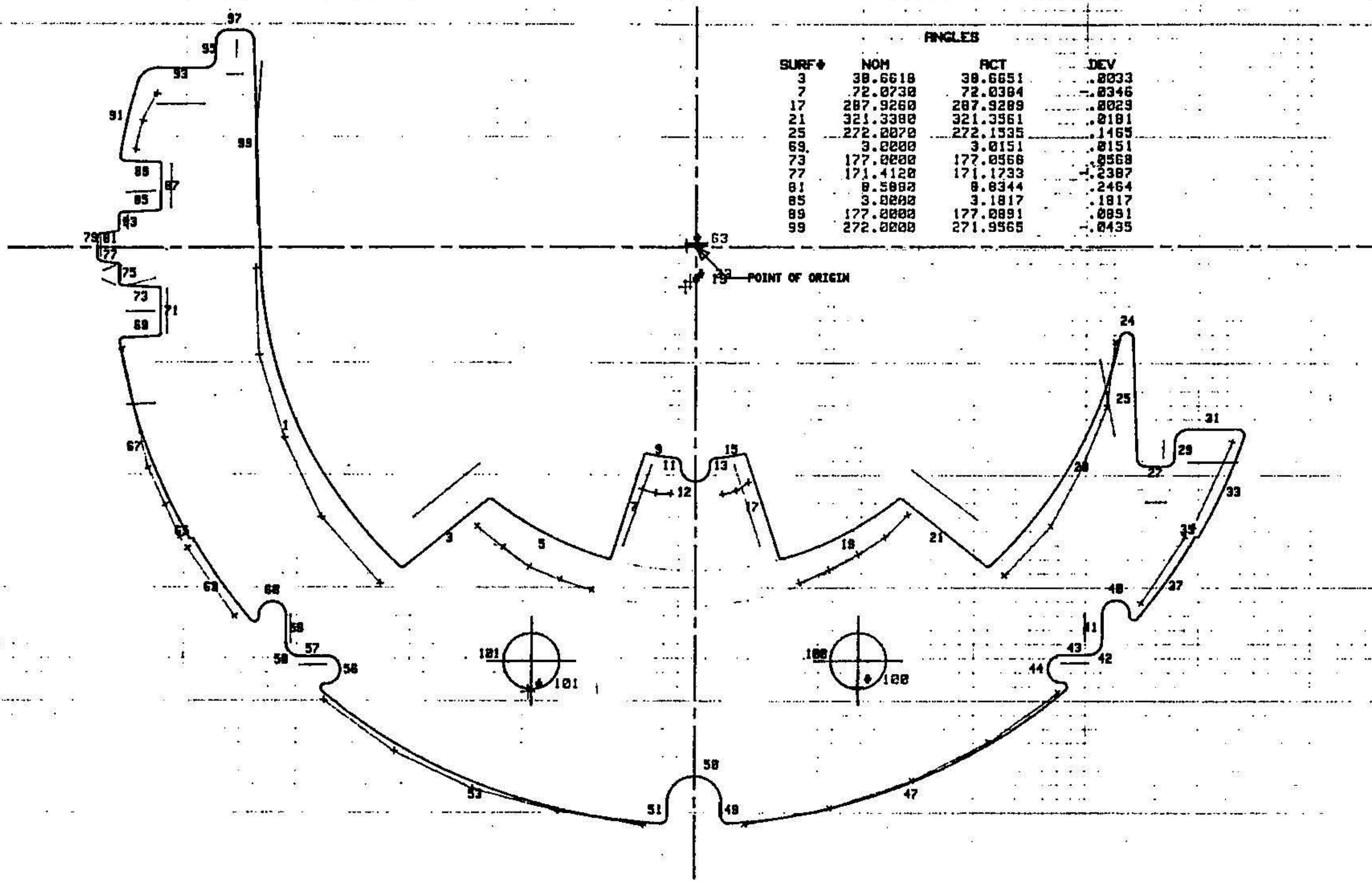

Figure 3

From: SSCVX1::DEVRED 18-APR-1991 18:05:23.49
To: FNAL::JBS
CC: DEVRED
Subj: Collar Inspection

Dear Jim,

Thanks for your note on collar inspection. It contains valuable informations and I am pleased to see that this time we are not going as blindly as for the previous magnets. I spent some time with Giancarlo and Toru looking at it (we all decided it was your masterpiece, although I personnally still prefer Henry James' style....). There are a couple of points we cannot make out.

- In the first paragraph of "Evaluation of Rev. C Collar," how do you deduce the 0.5 mil?
- In the last paragraph of the same section you metion that "experimetnally the horizontal radius actually increases under prestress." This probably refers to the last collar deflection measurements you made. Could you fax or mail me your data?
- In the second paragraph of "Comparison with Revision A" you refer to the vertical outer surface. Do you mean the "design" surface or the "actual" one.
- At the end of the same paragraph, we cannot make out the 4.5 mils number you give.

Arnaud

From: FNAL::JBS 19-APR-1991 09:23:50.24
To: SSCVX1::DEVRED
CC: MYSELF
Subj: RE: Collar Inspection

In the "going as blindly as..." department, I would like to assure you and your colleagues that Rodger and I did the same sort of evaluation of the Revision A collars when they came in. Where we fell short was in not writing it down. Since our conclusion was that all the critical dimensions were within tolerance, I do not believe that there was any great loss resulting from the previous lack of dissemination of the inspection report. I address now your specific questions:

- In the first paragraph of "Evaluation of Rev. C Collar," how do you deduce the 0.5 mil?

  As shown on the inspection report the only part of the collar interior that deviates from the design by more than 0.5 mil is the vertical surface of the long arm on the left above the center line. Since this part of the collar does not contact the coil it is less important than the rest. Note, however, that the slot on the right into which the tab at the end of the long arm fits is, at it bottom, of the design width and position within a few tenths of a mil. Since the short piece on the right is much stiffer than the long arm on the left, when the two are mated it is the long arm that will deflect the match the short one. This will move the arm to the left forcing it to within 0.5 mil of the desig location.

- In the last paragraph of the same section you metion that "experimetnally the horizontal radius actually increases under prestress." This probably refers to the last collar deflection measurements you made. Could you fax or mail me your data?

  As I indicated to you in last week's confessions, much of the collar deflection data (altho not all of it) look unreliable. I am still trying to find time to evaluate it and hope to put our a tech note summarizing and analysing it within the next week or so. I would prefer to wait rather than having to send out data and then apologize for it later. Bug me in a week if you haven't heard from me on this subject.

- In the second paragraph of "Comparison with Revision A" you refer to the vertical outer surface. Do you mean the "design" surface or the "actual" one.

  "Normalized to the 'vertical' outer suface" means that all the measured points are moved upwards until, on the average, the measured points on the "vertical" outer surface lie on top of the design. Then the comparison between measured and design locations of the the key slots and alignment flats is made.

_ At the end of the same paragraph, we cannot make out the 4.5 mils number you give.

  Between Revision A and Revision C the design location of the alignment flats was moved down by 3 mils. In the Revision A collars the flats, relative to the "vertical" outer surface, are at their design location with measurement error. In the Revision C collars the flats, relative to the "vertical" outer surface, are down by 1.5 mils from the design location. Thus the net change in the position of the flats relative to the "vertical" outer surface is $3 + 1.5 = 4.5$ mils.