TS-SSC 91-208
28 OCT 91
W. A. HIGINBOTHAM

<u>Experiences of Welding the End Bell Ass'y to the End Plate</u>

The weld was originally configured for an approximate 7/16" throat depth, V-groove, 37.5 deg. bevel weld prep. After various tests and trial procedures were conducted at SSCL, it was decided that the following parameters should be followed to achieve an optimum weld with minimal distortion, and to protect the electrical components within the extension tube housing. A Gas Tungsten Arc Weld, TIG, using a stringer bead welding technique was chosen. This technique utilizes a bead that is 1.5 times the diameter of the electrode in width. The electrode being used is 3/32" in diameter and 2% Thoriated. This translates to a maximum bead width of .150". This narrower and smaller bead size produces less distortion and projects lower running temperatures. A maximum running temperature of 130 deg. C and a maximum interpass temperature of 100 deg. C is specified.

* 2% Thoriated - Electrodes come in differing chemical compositions, with some being proprietary alloys. Different coatings are also applied to provide shielding to protect the arc from the atmosphere, and determines the operating characteristics of the electrode.

Direct Current, Straight Polarity was chosen due to providing the best operation on critical applications. Pulsed Arc is the preferred mode to maintain lower running temperatures and longer bead lengths. With the peak amps set at 100%, the background amps at 60%, a 2.5 step rate, and 50% on time the current range should be set between 75 and 150 amps. If straight current is used, an approved alternate method, the amperage should be set between 85-135 amps. The highest current possible, in either case, is recommended to achieve good bead shape and quality, although temperature and bead size must be maintained.

The filler wire is specified to be 316L to match the parent material. To control the bead size and temperature input, a 1/16" maximum diameter filler wire is used with a 3% - 8% ferrite content to promote weldability.

The assembly is secured to the end plate with 8 - 10 tacks, approximately 1/4" long. The root passes cover quadrants alternating diagonally across the diameter to prevent the "pulling" of the assembly off location due to weld distortion. Cover passes are then applied in approximately 4" long beads, a quadrant maximum depending upon temperature, also alternating diagonally across the diameter.

Production initially estimated 4 days to accomplish the weld per specification. This proved to be an accurate estimate, the welding of DCA311 took approximately 50 hrs. to complete. This process consisted of 1 root fusion pass and 31 filler passes. The time measurement included set up, torch time, cooling time, and strain gage readings.

The dimensional parameters to be held after welding are +/- 6 mm from the face of the beam tube flange to the face of the beam tube flange, the Z direction, and +/- .5 mm in the X & Y directions from the centerline of the beam tube, geometric center of the cold mass, for the upper and lower single phase lines.

After welding DCA310 and DCA311 several anomalies encountered by production prompted the reconfiguration of the weld joint. Apparently there was too much weld material being "poured" into the weld. From the analysis of the weld joint for conformance, the weld was found to be much stronger than required. This was not an arbitrary number however, the extension tube thickness had been chosen to accommodate the access ports without additional support.

The amount of weld material added caused excessive distortion of the assembly after welding. The X, Y, & Z position of the extension tube assembly could not be held within the specified parameters. The assembly ended up kicked off approximately 1.8 mm in the + X direction, 1 mm in the - Y direction, and 5 mm in the - Z direction. Also, as a result of the circumferential weld the end plate was dished inwards approximately .5 - .8 mm. This caused the preload of the bullets to exceed the desired end load of coil assembly by an average load of 2500 lbs. per bullet, bringing the total coil preload to an average of 14000 lbs. This is 10000 lbs. more than is desired per Wayne Koska, Jim Strait, and Gianni Tassotto. The data were gathered after each weld pass and after cooling below the specified interpass temperature of 100 deg. C. Also, the readings were taken before and after the weld crew either broke for lunch or at the end of the shift.

From the graph of force versus weld pass the end force increased very gradually, as expected by following the weld procedure, for the first 17 passes. Then for the next 6 passes, and this is somewhat of an enigma, there was a sharp increase in the load. After pass 23, the increase again slowed to a more moderate rate. A slight decrease in load, which is not understood, was noted between passes 27 and 28.

The extremely rapid increase in load experienced after pass 17 corresponds roughly to half of the final load after welding. There have been several possibilities suggested for this rapid increase. John Carson suggests that this region corresponds approximately to the point where the amount of weld material in this weld is approximately equal to that of the weld of the skin to the end plate on the opposing edge. This causes the end plate to be in a somewhat unstable state due to the forces of the two welds. Then, as more material is added, the end plate "pops" like a Belleville washer from bulging outwards from the skin weld to bulging inwards. Also suggested is the possibility that a change in welders, which corresponds roughly to the beginning and end of the sharp increase in load, may be a cause. This may be due to the "human factor" in the procedure. In other words, all welders, whether they follow the same procedure or not, do not weld the same or do not possess the same degree of ability. Therefore differences in how the material is deposited directly affects the end plate distortion. It is our belief that a configuration and procedure this sensitive is not suggested to produce the desired results in end loading and configuration.

To resolve this problem, the configuration of the weld has been altered to a 1/4" throat depth. In doing so the amount of weld material deposited has been reduced by 2/3. This, according to the data from DCA 311, results in an estimated 10 - 11 passes to complete the weld. This was confirmed by a count taken during the welding of the lead end bell assembly on DCA312, which was reconfigured in this manner. As a result of this, the weld procedure became less sensitive. Production time was reduced to approximately 1/2 of a shift once the assembly was located and secured. This was due to the lack of cooling time when the specified maximum temperatures had been reached, and 2/3 less material had to be deposited to achieve an adequate weld. The distortion noted from the reconfigured weld was observed to be much more in accord with the specified parameters. The assembly was off approximately .2 mm in the - X & 1mm in the - Y direction and only 2 mm in the - Z direction. These movements are much more controllable and can be compensated for prior to welding. The assembly of the beam tube hardware was moved to installation after the end bell assembly was welded to the end plate. This insures the proper slot length and alignment of the beam tube will be held. This weld configuration is also conformant to ASME Boiler & Pressure Vessel Code.

Unfortunately, due to a miscommunication, the bullets on the return end of DCA312 had not been read or properly loaded prior to and during welding to test the preload of 200 lbs. per bullet. This was estimated to produce an end load resultant of 1000 lbs. per bullet after completion of the reconfigured weld. These readings shall be taken and analyzed during the welding of DCA313 and adjusted accordingly.

Acknowledgements:

* J. Strait, DCA311 and DCA312 Return End coil Spring Rates, TS-SSC 91-194, 7 Oct 91.
* J. Strait, DCA311 End Loads from End Bell Welding, TS-SSC 91-198, 15 Oct 91.
* M. Tuli, Extension Tube Welding Procedure, M35-000016 Rev. "-", 15 Sept 91.
* W. Higinbotham, End Cap/ Extension Assembly Installation, Rev."A", 25 Oct 91.
* J. Kerby, W. Smith, for calculations of the reconfigured weld for compliance to ASME Boiler & Pressure Vessel Code.
* J. Carson, Private conversation.
* J. Zbasnik, Private conversation.

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SUMMARY

Experiences of Welding the End Bell Ass'y to the End Plate

The original design of the weld of the end bell assembly to the end plate was found to be too time consuming and create problems with the end loading of the coil assembly. Even after following the specified procedure problems arose. The weld configuration in conjunction with the procedure was too sensitive to be practical.

The weld and order of operations were reconfigured to reduce the weld size by 2/3 and the distortion due to welding. This in turn made the procedure less sensitive. After welding DCA312, weld distortion and weld time were drastically reduced. The additional end load of the bullets was also reduced to a more controllable level. The redesign of this weld still conforms to ASME Boiler & Pressure Vessel Code. Data will continue to be gathered on the bullets to insure proper coil preloading. Several adjustments are being made to maintain the required dimensional parameters after welding.

Acknowledgements:

* J. Strait, DCA311 and DCA312 Return End coil Spring Rates, TS-SSC 91-194, 7 Oct 91.
* J. Strait, DCA311 End Loads from End Bell Welding, TS-SSC 91-198, 15 Oct 91.
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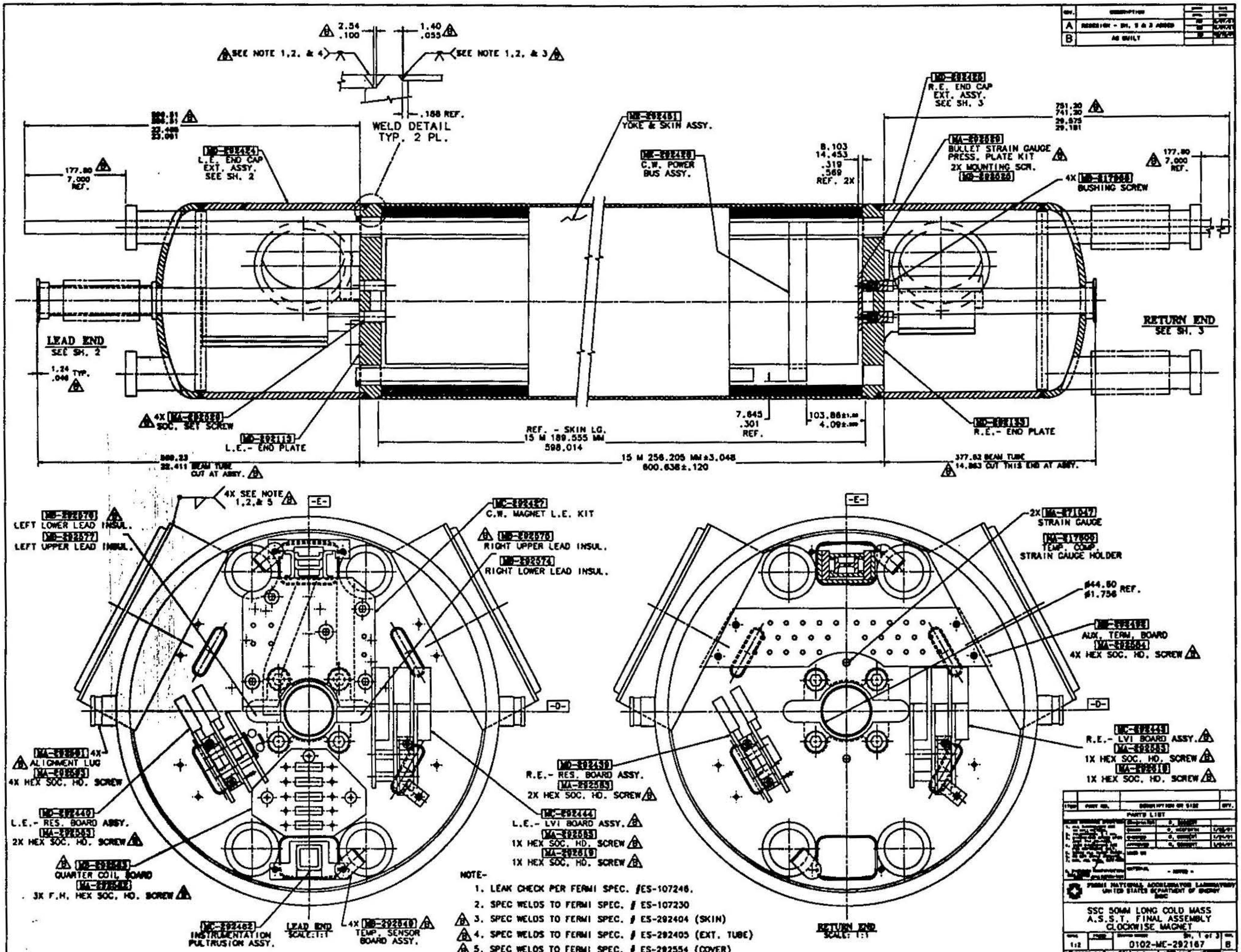
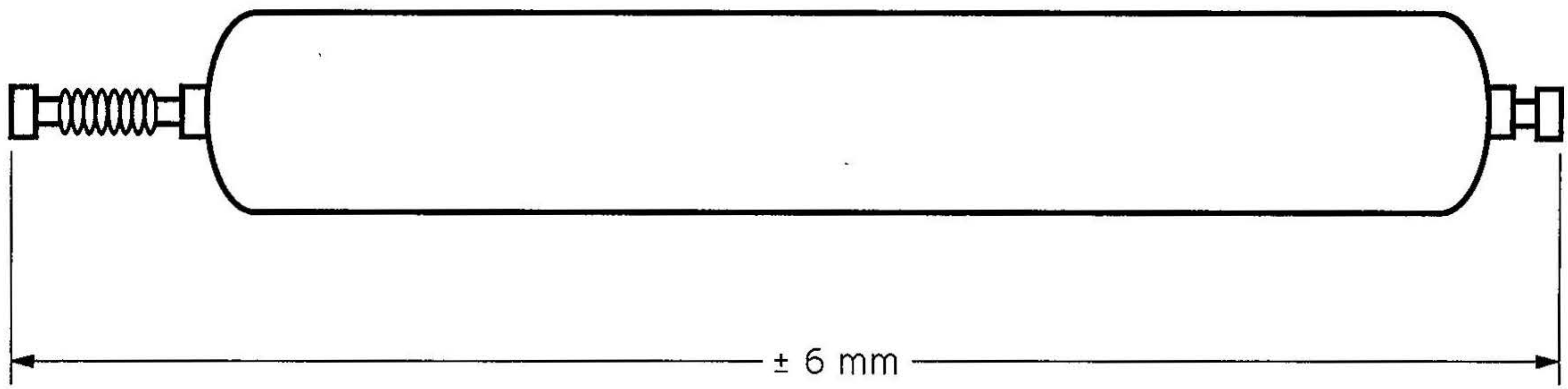
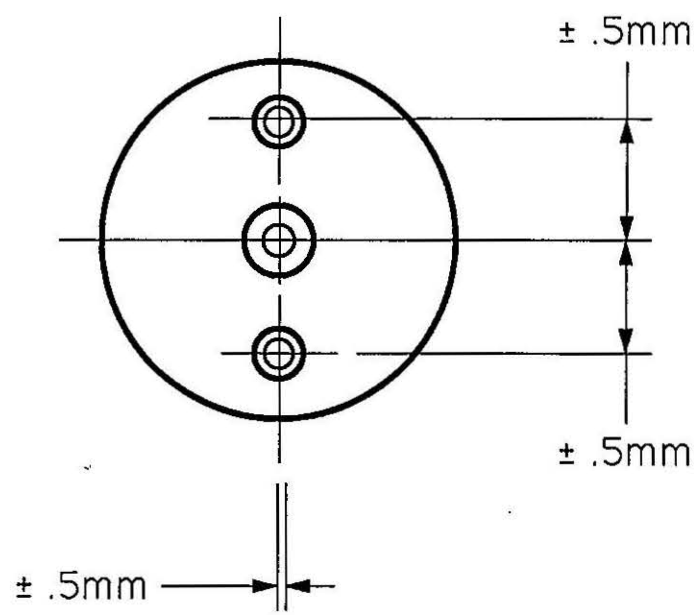
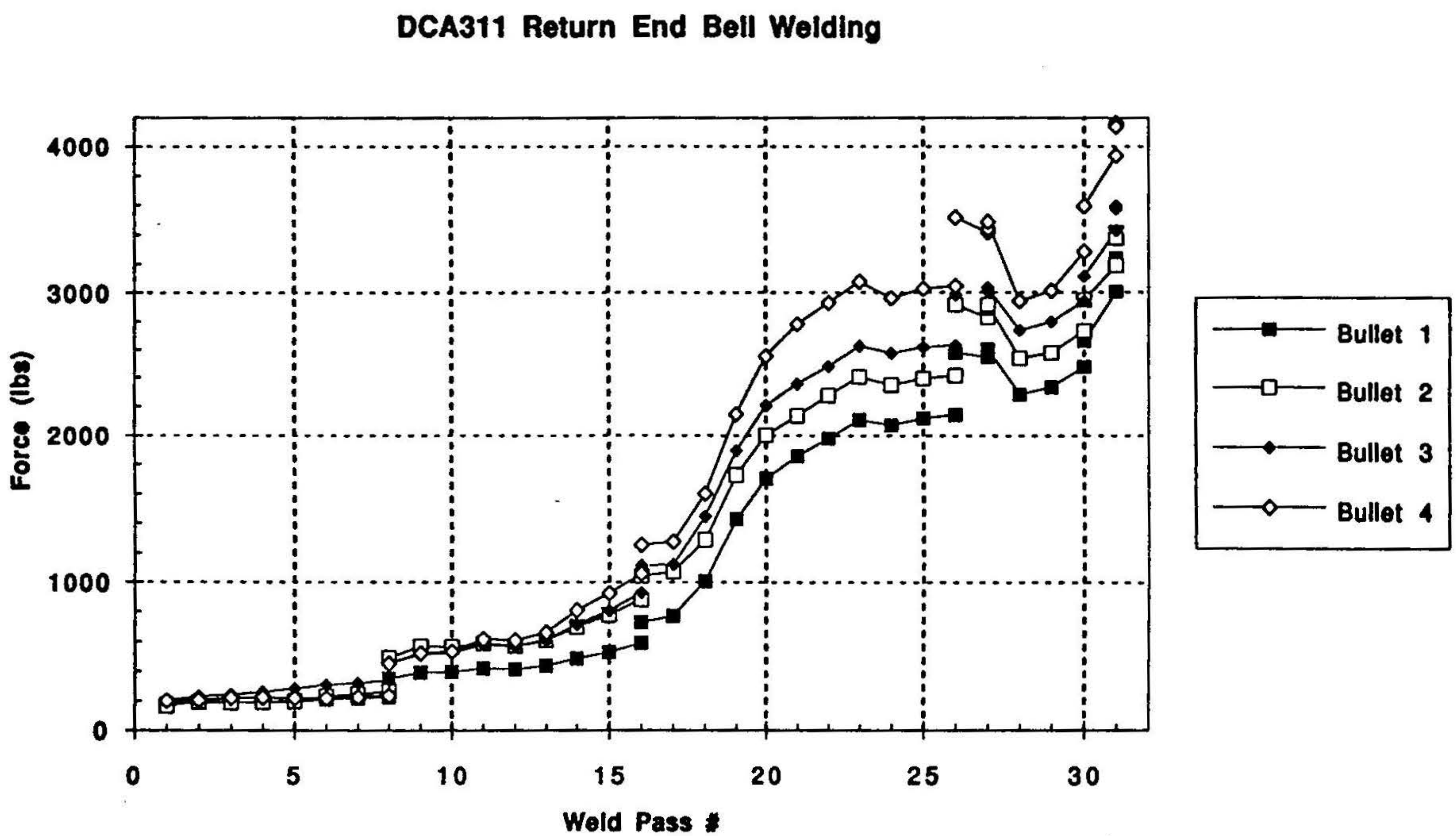


SEE NOTE 1,2, & 4
SEE NOTE 1,2, & 3
2.54 .100
1.40 .055
.188 REF.
WELD DETAIL TYP. 2 PL.
YOKE & SKIN ASSY.
L.E. END CAP EXT. ASSY. SEE SH. 2
C.W. POWER BUS ASSY.
R.E. END CAP EXT. ASSY. SEE SH. 3
BULLET STRAIN GAUGE PRESS. PLATE KIT
2X MOUNTING SCR.
4X BUSHING SCREW
177.80 7.000 REF.
8.103 14.453 .319 .569 REF. 2X
LEAD END SEE SH. 2
RETURN END SEE SH. 3
1.24 .049 TYP.
4X SOC. SET SCREW
L.E.- END PLATE
R.E.- END PLATE
REF. - SKIN LG. 15 M 189.555 MM 598.014
7.645 .301 REF.
103.88 4.09
15 M 256.205 MM±3.048 600.638±.120
BEAM TUBE CUT AT ASSY.
377.82 BEAM TUBE 14.863 CUT THIS END AT ASSY.
4X SEE NOTE 1,2,& 5
-E-
-D-
LEFT LOWER LEAD INSUL.
LEFT UPPER LEAD INSUL.
C.W. MAGNET L.E. KIT
RIGHT UPPER LEAD INSUL.
RIGHT LOWER LEAD INSUL.
4X ALIGNMENT LUG
4X HEX SOC. HD. SCREW
L.E.- RES. BOARD ASSY.
2X HEX SOC. HD. SCREW
QUARTER COIL BOARD
3X F.H. HEX SOC. HD. SCREW
INSTRUMENTATION PULTRUSION ASSY.
LEAD END SCALE: 1:1
4X TEMP. SENSOR BOARD ASSY.
R.E.- RES. BOARD ASSY.
2X HEX SOC. HD. SCREW
L.E.- LVI BOARD ASSY.
1X HEX SOC. HD. SCREW
1X HEX SOC. HD. SCREW
2X STRAIN GAUGE
TEMP. COMP. STRAIN GAUGE HOLDER
ø44.50 ø1.750 REF.
AUX. TERM. BOARD
4X HEX SOC. HD. SCREW
R.E.- LVI BOARD ASSY.
1X HEX SOC. HD. SCREW
1X HEX SOC. HD. SCREW
RETURN END SCALE: 1:1
NOTE-
1. LEAK CHECK PER FERMI SPEC. # ES-107246.
2. SPEC WELDS TO FERMI SPEC. # ES-107230
3. SPEC WELDS TO FERMI SPEC. # ES-292404 (SKIN)
4. SPEC WELDS TO FERMI SPEC. # ES-292405 (EXT. TUBE)
5. SPEC WELDS TO FERMI SPEC. # ES-292554 (COVER)
PARTS LIST
SSC 50MM LONG COLD MASS A.S.S.T. FINAL ASSEMBLY CLOCKWISE MAGNET
1:2
SH. 1 of 3
0102-ME-292167
B


± 6 mm


± .5mm
± .5mm
± .5mm



DCA311 Return End Bell Welding
Force (lbs)
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Weld Pass #
Bullet 1
Bullet 2
Bullet 3
Bullet 4

Figure 1

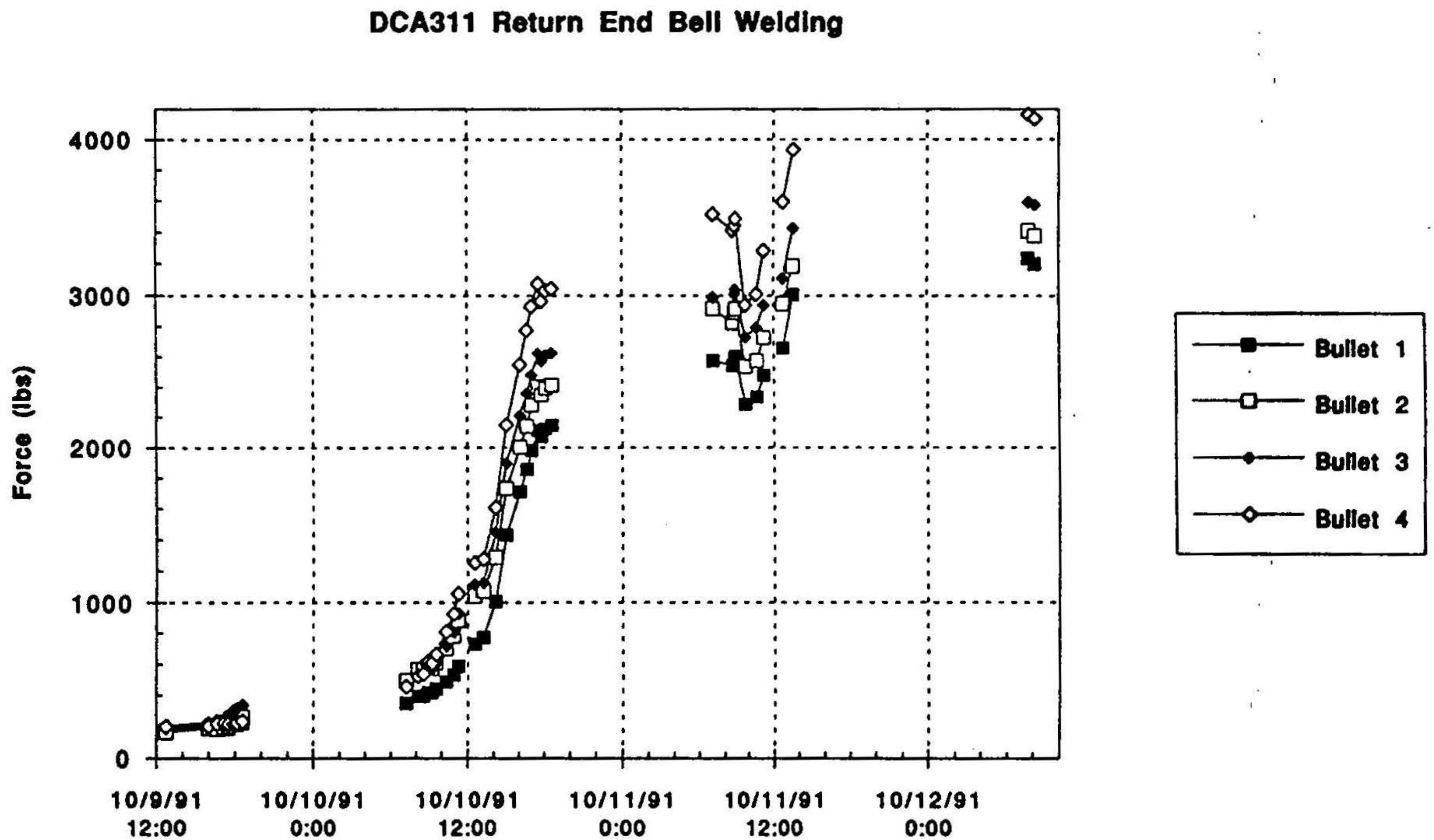
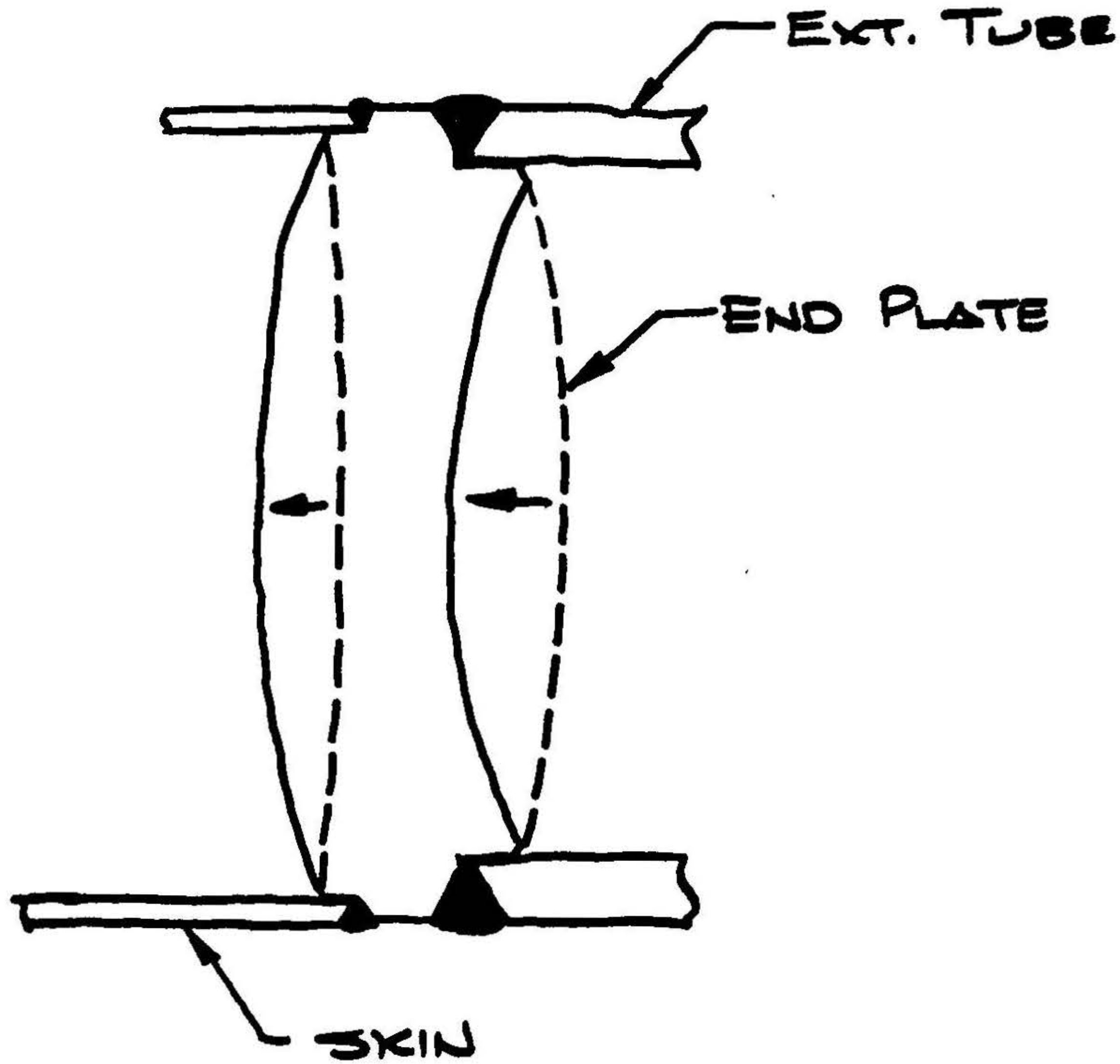
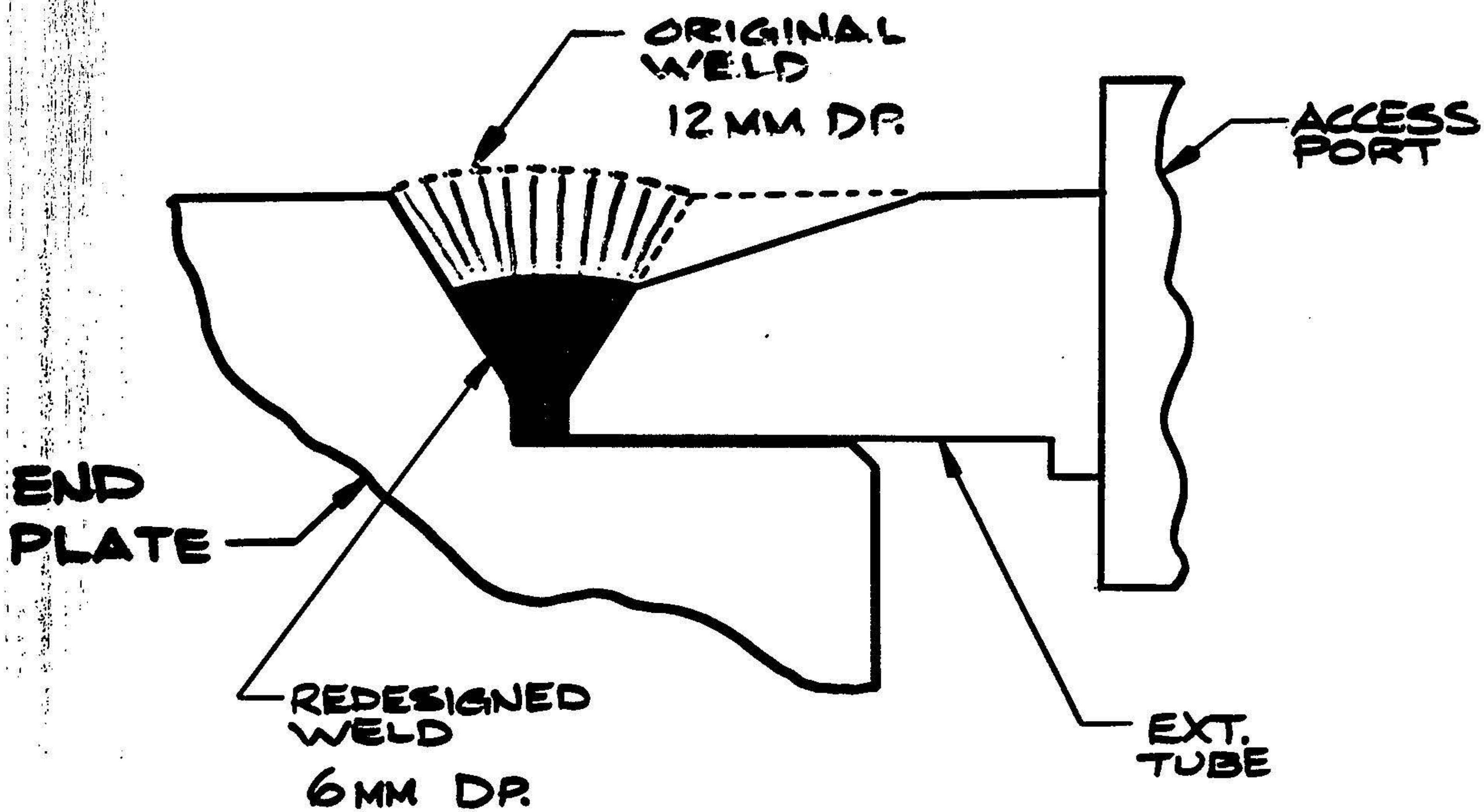

DCA311 Return End Bell Welding
Force (lbs)
4000
3000
2000
1000
0
10/9/91 12:00
10/10/91 0:00
10/10/91 12:00
10/11/91 0:00
10/11/91 12:00
10/12/91 0:00
Bullet 1
Bullet 2
Bullet 3
Bullet 4

Figure 2

DISTORTION OF END PLATE

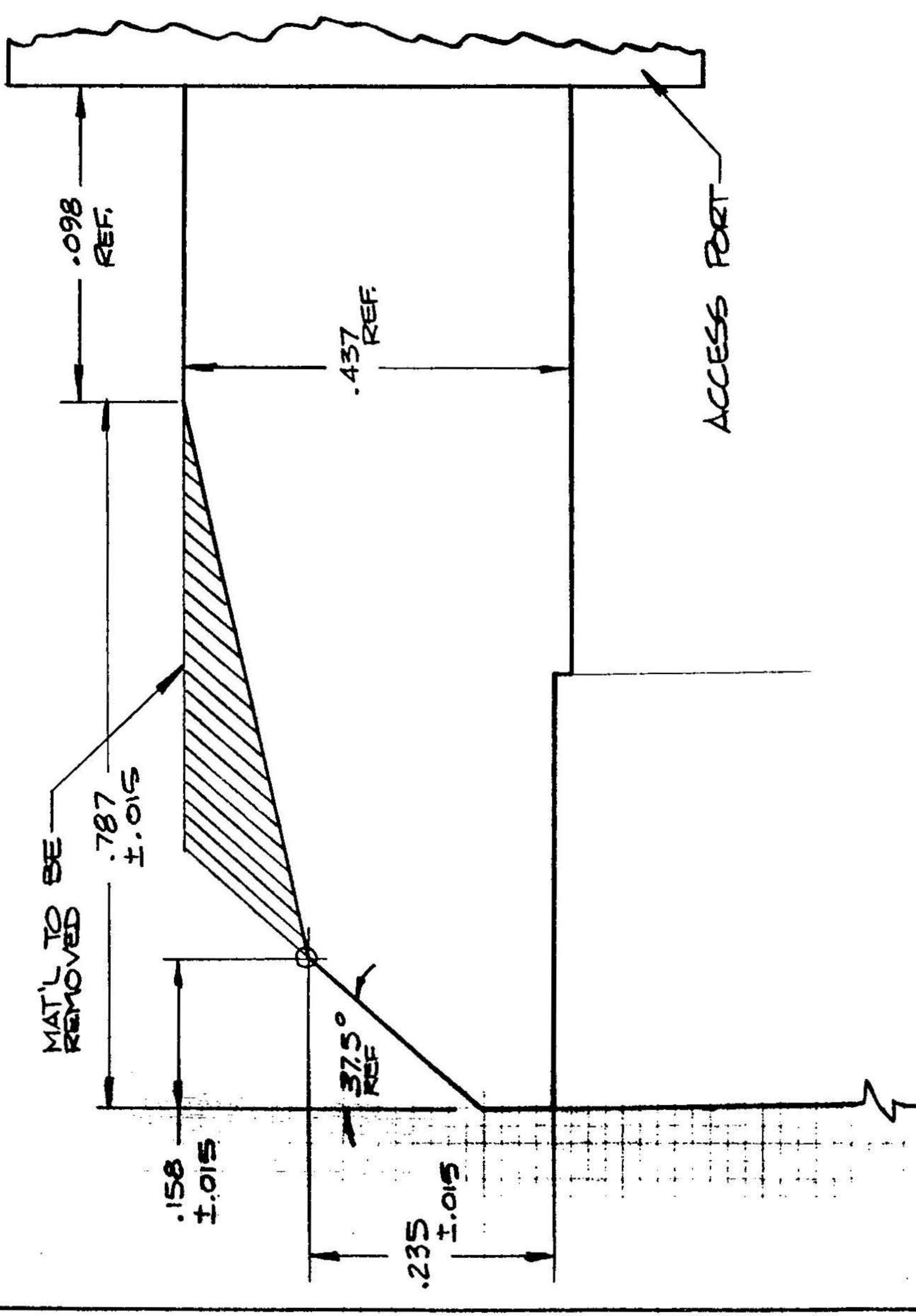


WELD REDESIGN



FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		SSC	50 MM	1

SUBJECT	NAME	
EXTENSION TUBE REWORK	B. HIGINBOTHAM	
	DATE 16OCT91	REVISION DATE



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DATA FROM THE L.E. OF DCA312

* 1 ROOT FUSION PASS
* 10 FILLER PASSES
* WELD TIME FROM TACK TO FINISH
  * APPROX. 8 HRS.
* MAXIMUM TEMPERATURE REACHED - 96.1 deg. C.
* STRAIN GAGE READINGS
  * BEFORE WELD

    1 - 1045 lbs.
    2 - 1131 lbs.
    3 - 946 lbs.
    4 - 994 lbs.

  * AFTER WELD

    1 - 1037 lbs.
    2 - 1123 lbs.
    3 - 955 lbs.
    4 - 993 lbs.

* DISTORTION DUE TO WELDING
  * BEFORE WELDING

    X = 0.00
    Y = 0.00
    Z = 0.00

  * AFTER WELDING

    X = -.006
    Y = -.039
    Z = -.078