Technical Realization of W-Band Muffin-Tin WBAND-003 with Wire EDM (Electro Discharge Machining)

Rolf Merte
Technical University Berlin
Department of Electrical Engineering
Institute of Theory of Electricity
D-10587 Berlin
merte@tetibm1.ee.tu-berlin.de

This paper is part 5 of a group of papers about the first TU-Berlin structure WBAND-003

Abstract

This Paper presents the technical realization of the first TU-Berlin W-Band accelerating structure WBAND-003. This structure should be realized with Wire EDM. All steps to build such a structure are listed. Special problems, like cutting an iris with a defined angle and improved contact of different sheets due to diffusion bonding were taking into account. This is not more than a technical report which may be helpful for those which are not familiar with EDM procedures.

I. Introduction

The structure we are talking about is presented in [1], [2], [3], [4] and [5]. Subject of this paper should be only the technological, mechanical way from three pieces of oxygen free chopper to a planar accelerating structure.

The technology for fabrication is called EDM (Electro Discharge Machining). EDM is an erosion process. In this method a tool uses sparks to erode small pieces of metal off a work piece. We have to differentiate between Wire EDM or Wire-Cutting EDM and Die Sink EDM. The first is a wire erosion, the second a spark erosion process. Fig. 1 shows the Wire EDM. In case of wire erosion the sparks are formed along a moving wire electrode, which cuts shapes in metal determined by a specific program, much like a band saw. The EDM process is generally thought as a process with long machining times and high electrode cost. In the Wire EDM process, a simple and inexpensive electrode is always available and tool wear is not considered. In spark erosion a shaped tool erodes a mirror shaped cavity. Die sinking, however, can require complex shaped electrodes and requires adjusting the process parameters to minimize electrode wear. This generally means long burn times at reduced power.

However, both methods are really great. With Wire EDM we can get an accuracy of up to 0.003 mm, with Spark Erosion up to 0.001 mm.

Wire EDM is at this time the preferred method, because we can live with an accuracy of 0.003 mm and it is payable. For more information about EDM or fabrication of planar structures with EDM use a

web browser and look with ALTAVISTA for items of „EDM, DIE SINK, WIRE, ...“. You will be busy for the next days ...!

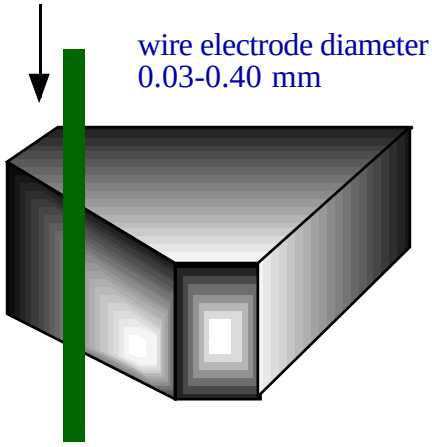


FIGURE 1. Wire Electro Discharge Machining.

II. Procedure of fabrication

The following section should show, how and in which order to do a fabrication with Wire EDM.

a) Step 1. Preparation of copper blocks

The first step to do is to blank up, square up, and get the surface plan parallel, and grind up all. The pieces will be reduced to a defined outer dimension. This dimension is oversized because of stabilization reasons, this means they have sacrificial area, which will be cut away after final mounting. After this the pieces will be sent out of the machine shop [6] for lapping. Lapping has four main purposes: - to obtain greater accuracy in dimensions, - to reduce imperfections of shape, - to obtain a smoother precisely polished surface, - to improve the exact fit between surfaces. See Fig. 2. After lapping, the surfaces are in principle prepared for diffusion bonding, which will be used in the next generation of structures.

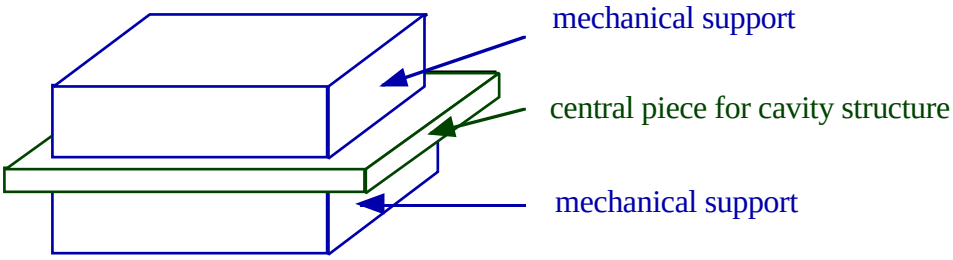


FIGURE 2. Start, 3 pieces of oxygen free copper.

b) Step 2. Drilling start holes for all features

After we have got three prepared copper blocks, they will be mounted together and all start holes for all features, this means for further finally bolting, like screw-holes and holes for alignment pins, will be drilled through all pieces, the end plates and the center cavity plates, in one time. This is necessary to get a reference point for the central piece. After the start holes are drilled, defined hole diameters for screws and alignment pins will be cut with Wire EDM, see Fig. 3.

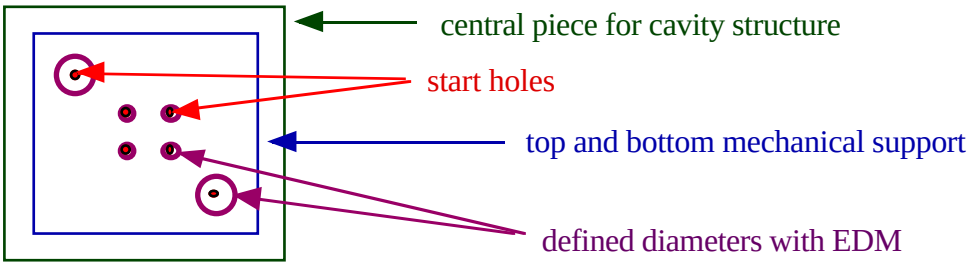


FIGURE 3. Step 2. Start holes and holes for screws and alignment pins.

c) Step 3. Center cavity plate, cavities and wave guide

The next step concerns only the central cavity plate. Seven start holes, for each cavity one, and two for the input and output wave guide, will be drilled to prepare the Wire EDM cut. Followed by cutting the cavities and wave guide. See Fig. 4.

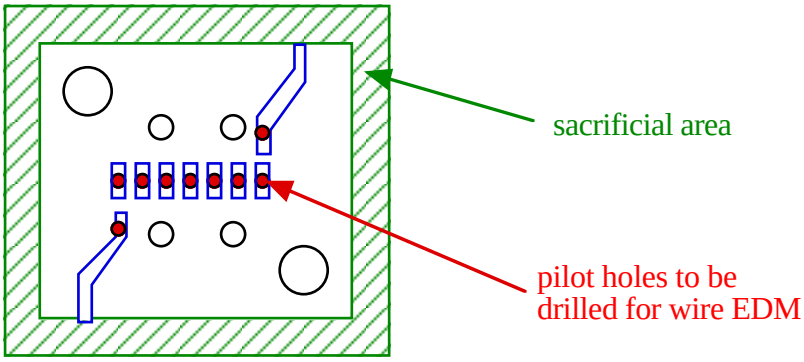


FIGURE 4. Step 3. Cutting the cavities and wave guides.

d) Step 4. Center cavity plate, aperture and pumping slot

The wire cut of the aperture and pumping slot is one of the most difficult parts. Besides the central piece there are two start holes in both planes to drill, for the beam pipe and the pumping slot. After this is done, these two pipes will be wire cut clear through the structure. See Fig. 5.

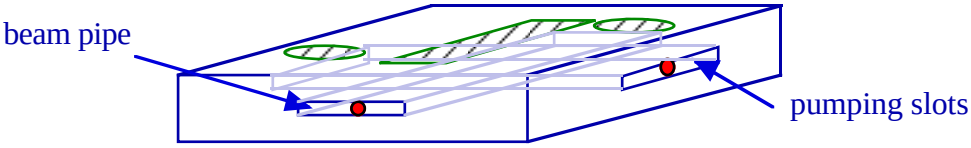


FIGURE 5. Step 4. Wire cut the aperture and pumping slot.

e) Step 5. Cutting a lower coupling iris

This is the most complicated step by fabricating this structure. For reasons which are explained in [4] it is necessary to wire cut an iris roof over the two coupling irises. To fabricate this, the wire has to tilt. This operation is very sensitive, because we need a high accuracy for this iris roof. Figs. 6-7 explain how to do this.

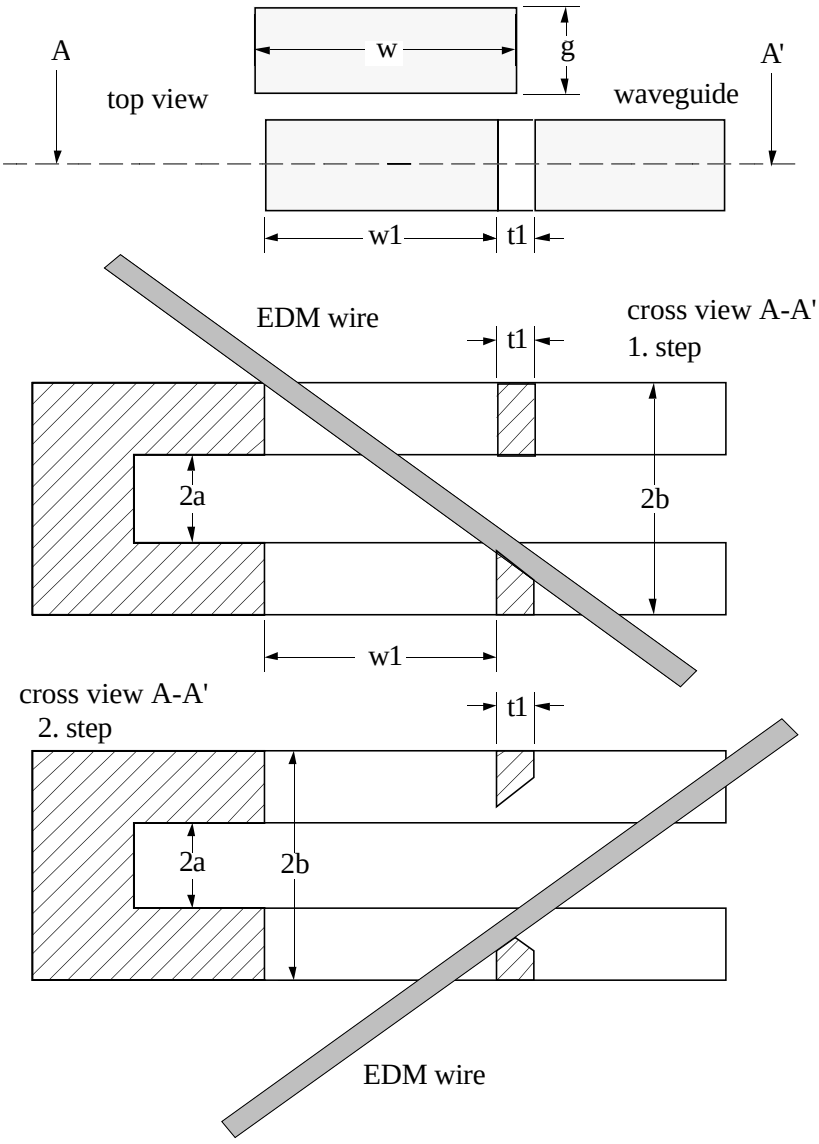


FIGURE 6. Step 5. Wire cut a lower coupling iris.

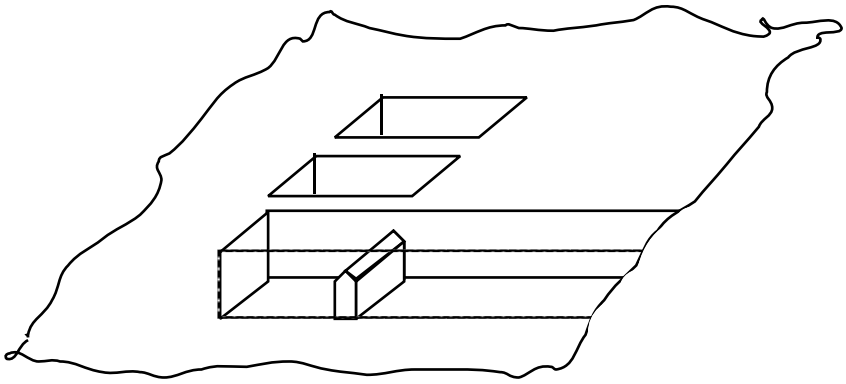


FIGURE 7. Step 5. One half of a finished structure.

f) Step 6. Cleaning the structure.

All features are done now. The next step is an ultrasonic clean (water, high vibration) to clean the surface and remove particles.

g) Step 7. Assemble three pieces.

Now the fabricated parts will be mounted together. Dowel pins will be inserted and screws clamp all together. After all is fixed, the outside shape will be wire cut, this means to remove the sacrificial area to expose the wave guide opening. Then some work is to do to prepare the wave guide connections. Holes for dowel pins and screws for wave guide flange are to drill. Taps will be inserted.

SEE APPENDIX THE FOUR FINAL TECHNICAL DRAWINGS FOR DETAIL QUESTIONS !

VI. References

[1] R. Merte, “First Design of a W-Band Muffin Tin, Cold Test Model”, TET Note 15/97, Inst. f. Theoretische Elektrotechnik, TU-Berlin.

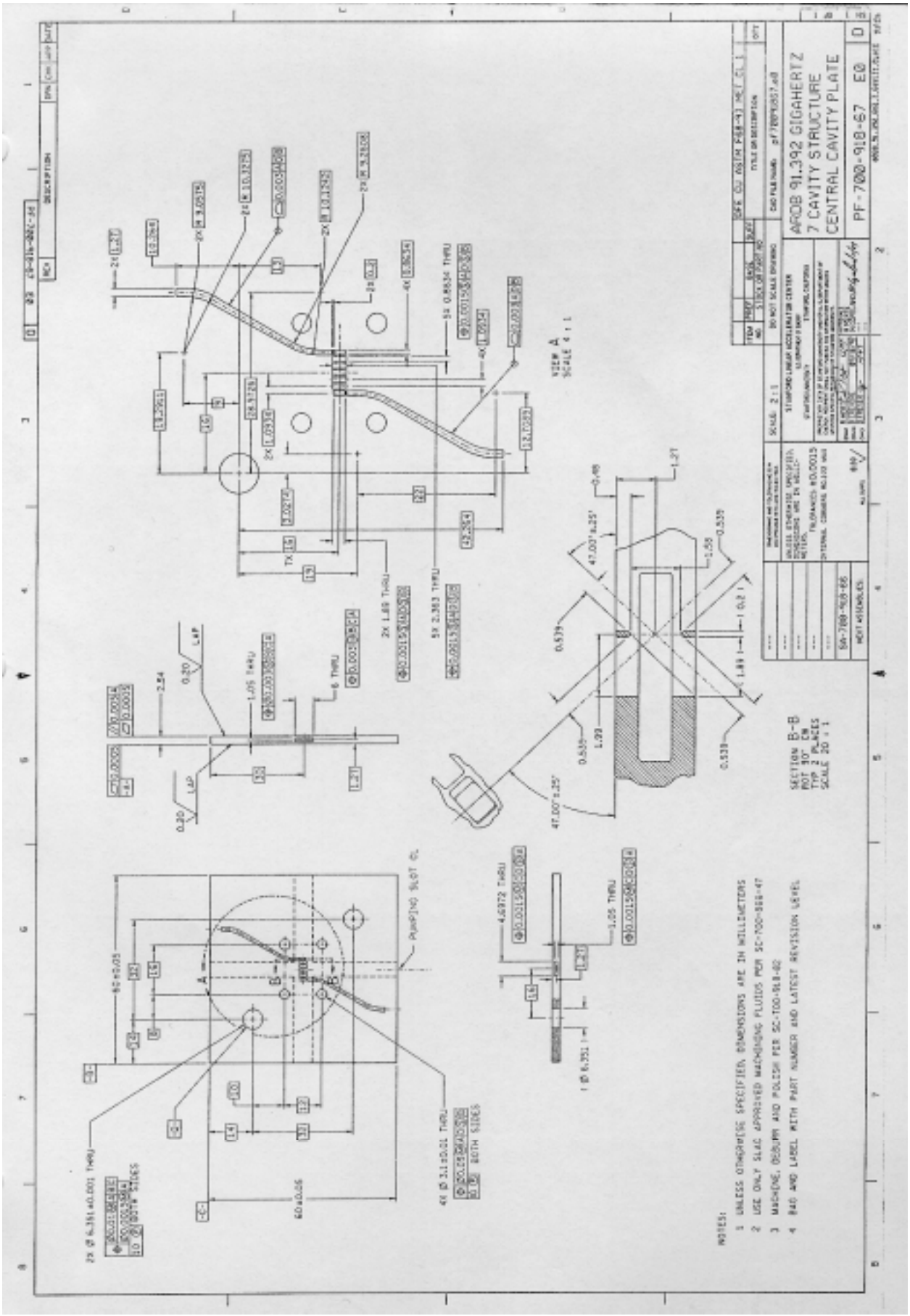
[2] R. Merte, “Improved Shape of an Input/Output Wave Guide with Integrated Taper for W-Band Muffin-Tin WBAND-003”, Tech. Note 140, ARDB, SLAC, Stanford.

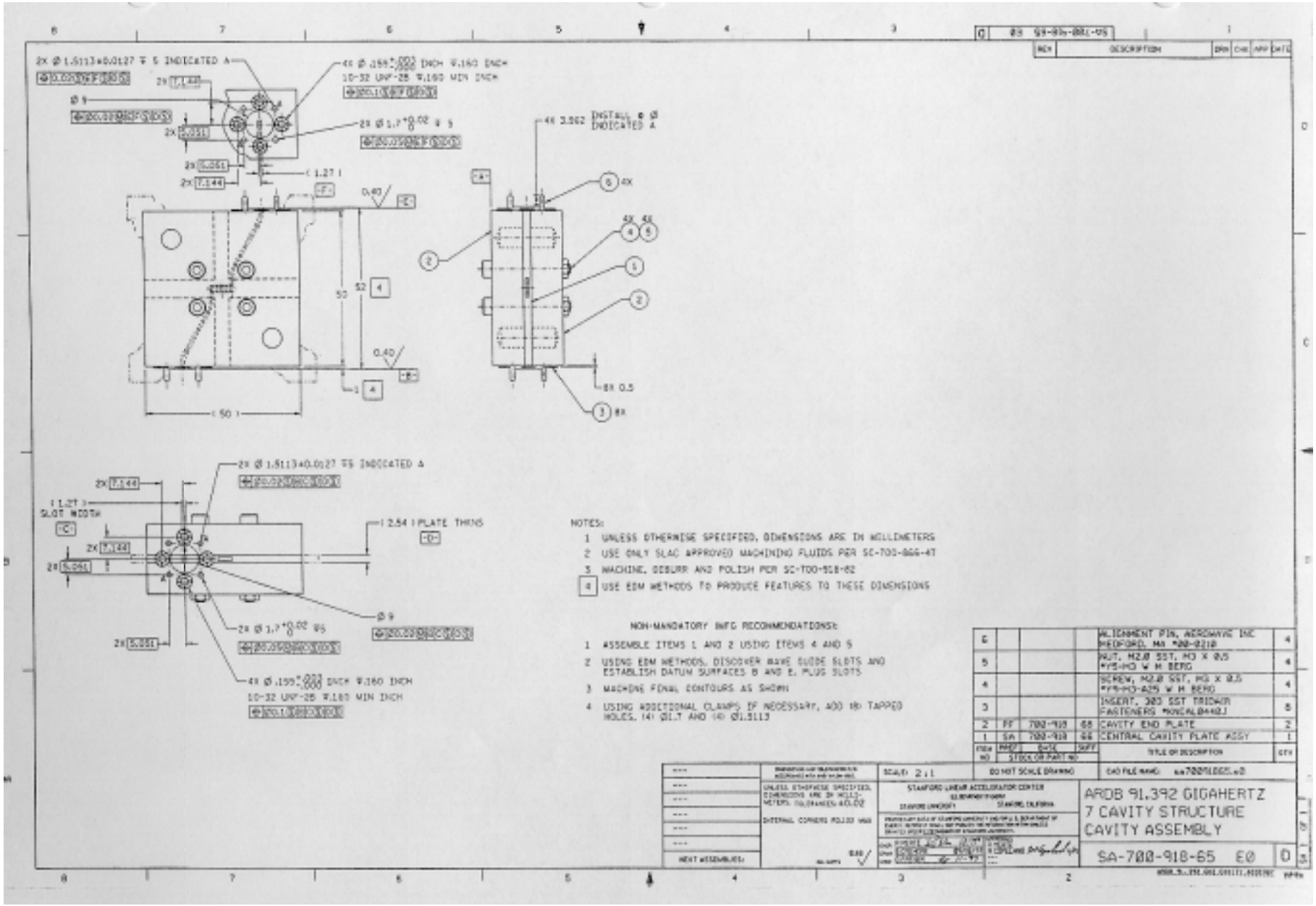
[3] R. Merte, “Detouring and Taping a Wave Guide - A small mathematical Problem”, Tech. Note 141, ARDB, SLAC, Stanford.

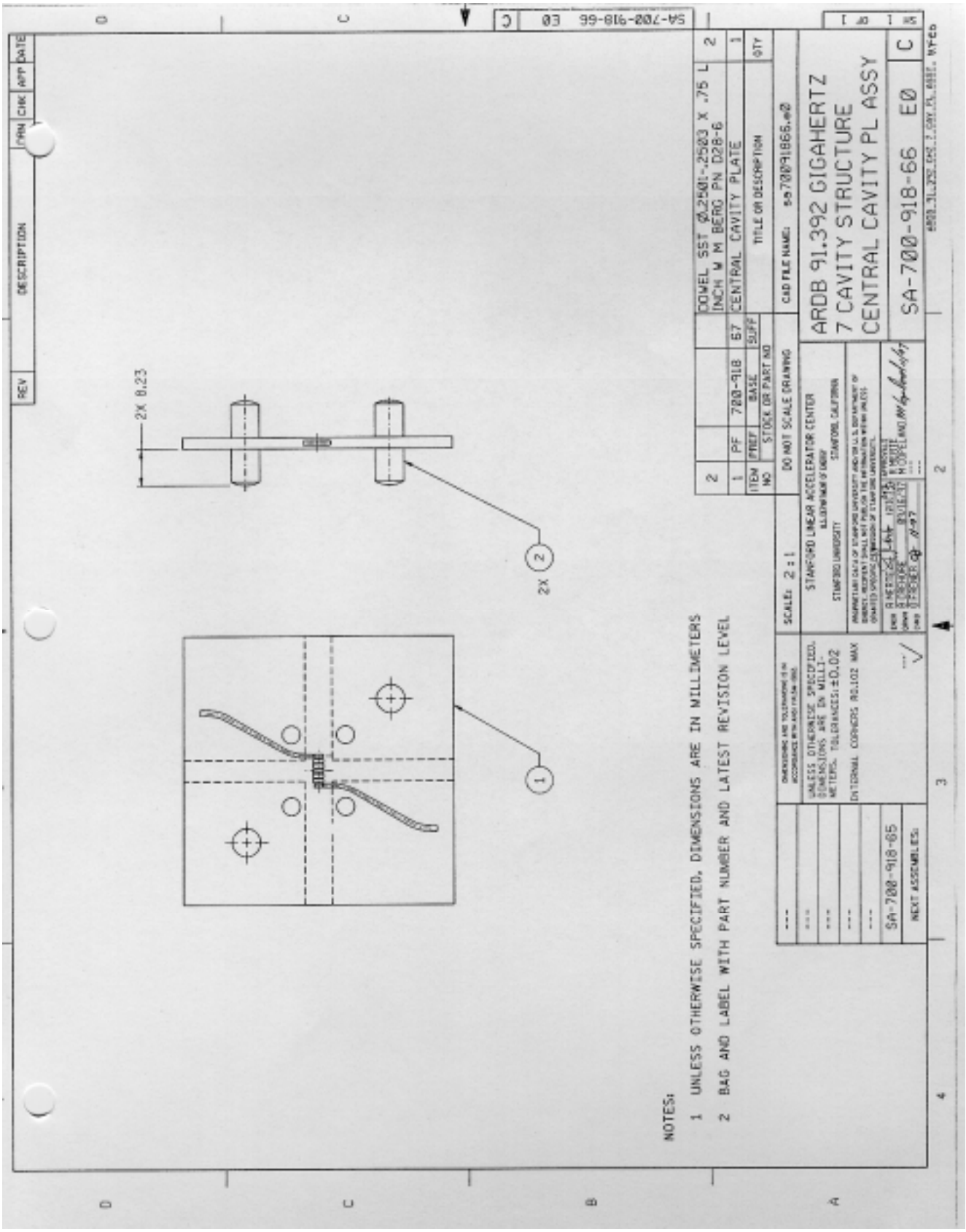
[4] R. Merte, “Matched Input/Output Cavities of W-Band Muffin Tin WBAND-003”, Tech. Note 142, ARDB, SLAC, Stanford.

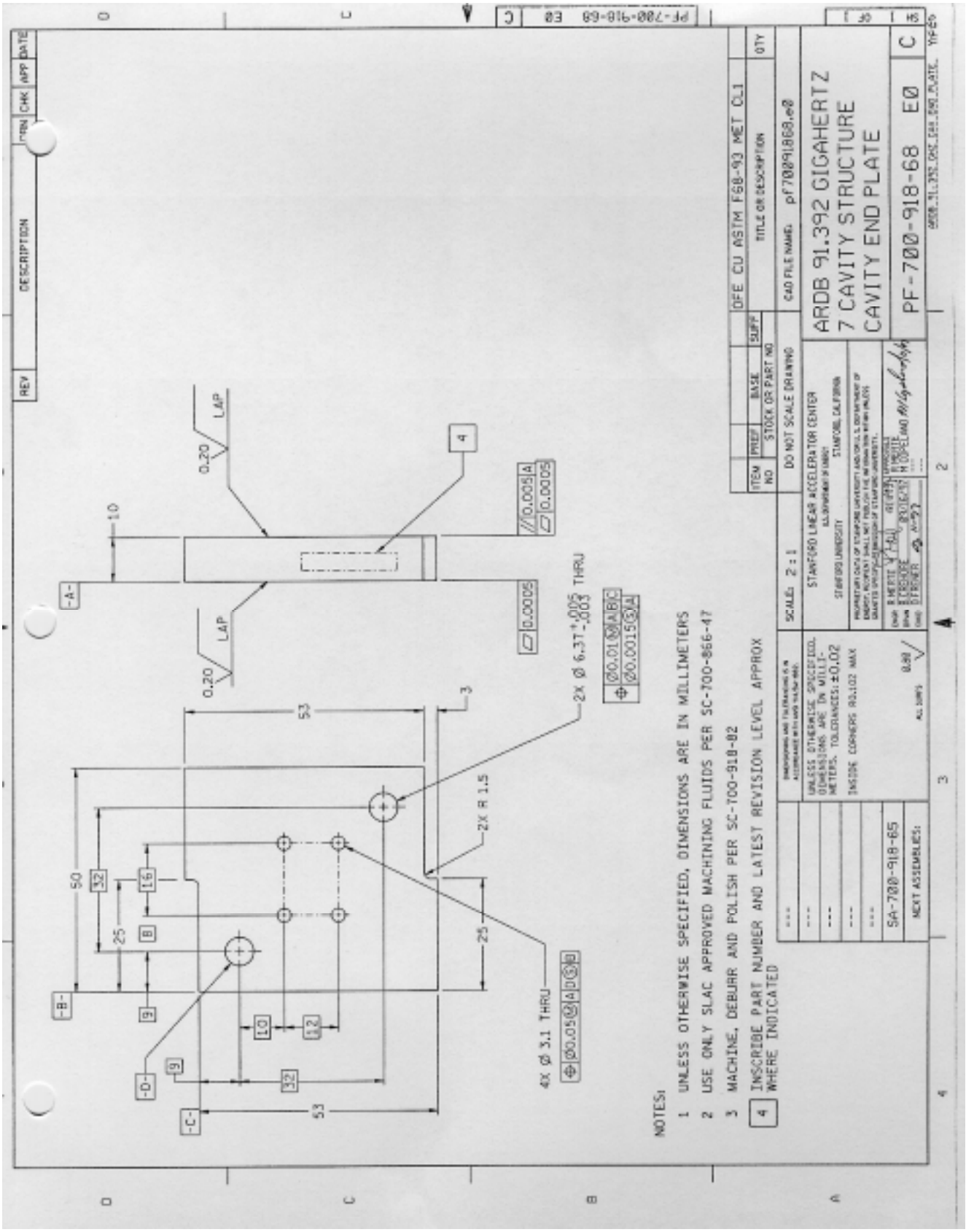
[5] R. Merte, “Improved Design of W-Band Muffin Tin WBAND-003”, Tech. Note 144, ARDB, SLAC, Stanford.

[6] Ron Witherspoon Inc., Precision Tooling Assembly and Production, 430 Industrial St., Campbell, CA 95008, USA.


APOB 91.392 GIGAHERTZ
7 CAVITY STRUCTURE
CENTRAL CAVITY PLATE
PF-700-918-67 E0
SCALE 2:1
DO NOT SCALE DRAWING
VIEW A
SCALE 4:1
SECTION B-B
ROT 90° CW
TYP 2 PLACES
SCALE 20:1
NOTES:
1 UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS
2 USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-988-47
3 MACHINE, DEBURR AND POLISH PER SC-700-918-82
4 BAR AND LABEL WITH PART NUMBER AND LATEST REVISION LEVEL


2X Ø 1.5113±0.0127 TO 5 INDICATED A
4X Ø .159 +.002 -.000 INCH Ø.160 INCH
10-32 UNF-2B Ø.160 MIN INCH
2X Ø 1.7 +0.02 -0 Ø 5
4X 3.562 INSTALL 6 Ø INDICATED A
2X Ø 1.5113±0.0127 TO INDICATED A
SLOT WIDTH
1.54 PLATE THINS
2X Ø 1.7 +0.02 -0 Ø5
4X Ø .159 +.002 -.000 INCH Ø.160 INCH
10-32 UNF-2B Ø.160 MIN INCH
NOTES:
1 UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
2 USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47
3 MACHINE, DEBURR AND POLISH PER SC-700-918-62
4 USE EDM METHODS TO PRODUCE FEATURES TO THESE DIMENSIONS
NON-MANDATORY INFO RECOMMENDATIONS:
1 ASSEMBLE ITEMS 1 AND 2 USING ITEMS 4 AND 5
2 USING EDM METHODS, DISCOVER WAVE GUIDE SLOTS AND ESTABLISH DATUM SURFACES B AND E. PLUG SLOTS
3 MACHINE FINAL CONTOURS AS SHOWN
4 USING ADDITIONAL CLAMPS IF NECESSARY, ADD (8) TAPPED HOLES, (4) Ø1.7 AND (4) Ø1.5113
6 ALIGNMENT PIN, AEROWAVE INC MEDFORD, MA 700-0210 4
5 NUT, M2.0 SST, M3 X 0.5 PYS-M3 W H BERG 4
4 SCREW, M2.0 SST, M3 X 0.5 PYS-M3-025 W H BERG 4
3 INSERT, 303 SST TRIDAIR FASTENERS MONEAL@4-40J 8
2 FF 700-918 -65 CAVITY END PLATE 2
1 SA 700-918 -66 CENTRAL CAVITY PLATE ASSY 1
ITEM NO PART STOCK OR PART NO SHAPE SIZE SOFT TITLE OR DESCRIPTION QTY
SCALE: 2:1
DO NOT SCALE DRAWING
CAD FILE NAME: sa700918065.v0
STANFORD LINEAR ACCELERATOR CENTER
STANFORD UNIVERSITY STANFORD, CALIFORNIA
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS. TOLERANCES ±0.02
INTERNAL CORNERS R0.100 MAX
NEXT ASSEMBLIES:
ARDB 91.392 GIGAHERTZ
7 CAVITY STRUCTURE
CAVITY ASSEMBLY
SA-700-918-65 E0 0


2X 0.23
2X
NOTES:
1 UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
2 BAG AND LABEL WITH PART NUMBER AND LATEST REVISION LEVEL
DOWEL SST Ø.2501-.2503 X .75 L
INCH W M BERO PN D28-6
CENTRAL CAVITY PLATE
TITLE OR DESCRIPTION
QTY
ARDB 91.392 GIGAHERTZ
7 CAVITY STRUCTURE
CENTRAL CAVITY PL ASSY
SA-700-918-66
E0
C
SCALE: 2:1
DO NOT SCALE DRAWING
STANFORD LINEAR ACCELERATOR CENTER
STANFORD UNIVERSITY
STANFORD, CALIFORNIA
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLI-METERS. TOLERANCES:±0.02
INTERNAL CORNERS R0.102 MAX
SA-700-918-65
NEXT ASSEMBLES:
REV
DESCRIPTION
DATE
SA-700-918-66 E0


NOTES:
1 UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
2 USE ONLY SLAC APPROVED MACHINING FLUIDS PER SC-700-866-47
3 MACHINE, DEBURR AND POLISH PER SC-700-918-02
4 INSCRIBE PART NUMBER AND LATEST REVISION LEVEL APPROX WHERE INDICATED
ARDB 91.392 GIGAHERTZ
7 CAVITY STRUCTURE
CAVITY END PLATE
PF-700-918-68
E0
C
DFE CU ASTM F68-93 MET CL1
DO NOT SCALE DRAWING
SCALE: 2 : 1
STANFORD LINEAR ACCELERATOR CENTER
STANFORD UNIVERSITY
STANFORD, CALIFORNIA
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLI-METERS. TOLERANCES: ±0.02
INSIDE CORNERS R3.102 MAX
SA-700-918-65
NEXT ASSEMBLIES:
2X Ø 6.37 +.005 -.003 THRU
4X Ø 3.1 THRU
2X R 1.5
0.20 LAP
0.005 A
0.0005
0.0005
Ø0.01 M A B C
Ø0.0015 S A
Ø0.05 M A D S B
DESCRIPTION
REV
CHK
APP
DATE

SC-700-918-82 E0 B

REV	DESCRIPTION	DRN	CHK	APP	DATE

ACCEPTABLE TECHNIQUES AND MATERIAL FOR USE IN THE MACHINING, DEBURRING, AND POLISHING OF MUFFIN-TIN COMPONENTS.

I. SCOPE

THIS SPECIFICATION IS REQUIRED FOR THE FINISHING OF ALL MUFFIN-TIN COMPONENTS WHICH HAVE SURFACES COMMUNICATING WITH RADIO FREQUENCY AREAS. THE SPECIFICATION IS INVOKED BY REFERRING TO THE SPECIFICATION NUMBER IN THE DRAWING NOTES, PURCHASE ORDER REQUIREMENTS, MANUFACTURING NOTES, OR WORK INSTRUCTIONS.

II. TECHNIQUES

A. MACHINING

THE PREFERRED TECHNIQUE FOR FINISHING IS BY MACHINING ONLY, I.e., NO ABRASIVE OR POLISHING COMPOUNDS ARE TO BE USED UNLESS APPROVED. ALL COMMONLY AVAILABLE CUTTING TOOLS ARE PERMITTED. METAL REMOVAL OTHER THAN BY MACHINING OR EDM, SUCH AS GRINDING, HONING, CHEMICAL MILLING, ETC, ARE EXPRESSLY FORBIDDEN WITHOUT PRIOR WRITTEN PERMISSION FROM SLAC.

B. DEBURRING

DEBURRING SHALL BE WITH FILE, DEBURRING KNIFE OR PERMITTED ABRASIVE. DEBURRING BY ABRASIVE VIBRATING OR TUMBLING IS NOT ALLOWED WITHOUT PRIOR WRITTEN PERMISSION FROM SLAC AND THEN ONLY IF MEDIUM IS SILICON CARBIDE IN CONJUNCTION WITH FLUIDS EXPRESSLY PERMITTED PER SLAC SPEC SC-700-866-47 AT ITS CURRENT REVISION. DEBURRING BY ANY OTHER UNSPECIFIED TECHNIQUE IS PROHIBITED.

C. POLISHING

IF THE SURFACE FINISH REQUIREMENTS CANNOT BE MET BY MACHINING OR EDM ALONE, THEN POLISHING WITH APPROVED ABRASIVES MAY BE PERMITTED. CARE MUST BE TAKEN TO AVOID USING EXCESSIVE PRESSURE DURING POLISHING SO AS TO PRECLUDE CONTAMINATION OF SURFACES BY EMBEDDED ABRASIVES. AVOID ANY BURNISHING OR EXCESSIVE HEATING. ANY EVIDENCE OF EMBEDDED CONTAMINATION WILL BE CAUSE FOR REJECTION.

III. MATERIALS

A. FLUIDS, LUBRICANTS

CUTTING FLUIDS, LUBRICANTS, WETTING AGENTS, ETC. FOR USE IN MACHINING OR POLISHING ARE LIMITED TO THOSE EXPRESSLY PERMITTED PER SLAC SPEC SC-700-866-47 AT ITS CURRENT REVISION.

B. ABRASIVES

ABRASIVES FOR USE IN POLISHING MUFFIN-TIN COMPONENTS ARE LIMITED TO THE FOLLOWING:

3M SCOTCH BRITE	TYPE S, SILICON CARBIDE (GRAY COLOR) TYPE A, ALUMINUM OXIDE (MAROON COLOR) NOTE: TYPE S IS AVAILABLE IN ULTRA FINE (500 GRIT OR EQUIV) WHILE TYPE A IS AVAILABLE IN VERY FINE (240 GRIT OR EQUIVALENT).
3M METOGRAFT FABRICUT CLOTH	ALUMINUM OXIDE OR SILICON CARBIDE (AVAILABLE IN 600 GRIT OR EQUIVALENT).

ITEM NO	PREF	BASE	SUFF	SPECIFICATION TITLE OR DESCRIPTION	QTY
		STOCK OR PART NO			

NEXT ASSEMBLIES: ---

SCALE: ---

DIMENSIONING AND TOLERANCING IS IN ACCORDANCE WITH ANSI Y14.5M-1982.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES: BREAK EDGES .005-.015 INTERNAL CORNERS .015 R MAX
FRACTIONS ± ---
DEC .XX ± ---
.XXX ± ---
.XXXX ± ---
ALL SUFFS ---

DO NOT SCALE DRAWING

STANFORD LINEAR ACCELERATOR CENTER
U.S. DEPARTMENT OF ENERGY
STANFORD UNIVERSITY STANFORD, CALIFORNIA

DWN R.MERTE 10-11-87
CHKD R.OREHORE 10-11-87
CHKD O.FRENER 10/11/87
APPROVED M.CORFLAND 10/11/87
R.MERTE

CAD FILE NAME: sc70091882.e0

ARDB MUFFIN-TIN CMPNT SPECIFICATION
MACHINING, DEBURRING, POLISHING

SC-700-918-82 E0 B

SH 1 OF 1

ARDB SPEC MACH DEBURR POLISH MFED