SDC-92-266

SDC
SOLENOIDAL DETECTOR NOTES

THE MAGNETIC ANALYSIS OF THE SDC MUON BARREL TOROID (MBT) (THE SIMPLIFIED CONFIGURATION)

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SSC Laboratory

The Magnetic Analysis of the SDC MBT was carried out using the PE2D program on SSCVX1 and the simplified configuration of the SDC MBT.

D:

PE2D program-is the suite of programs for the calculation of electromagnetic fields which was developed first at the RAL in England. They have been further developed and enhanced by Vector Fields Limited. PE2D solves a wide range of electromagnetic and electrostatic problems in 2-dimensional XY and axisymmetric coordinates.

CONFIGURATION:

The current configuration of the SDC MBT is presented in Fig.1. Using the symmetries of the MBT only 1/8 of MBT was simulated (shown by dotted line in Fig.1). The configuration that has been used for analysis is presented in Figs.2,3. Regions 1-4 represent the coils, regions 5,9 - the steel, regions 6,7,8,10,11-the air.The main differences of the model used, from the current configuration are:

-absense of the gaps between the blocks,
-absense of the gaps between the coil and the steel,
-absense of the gaps between the neighbouring layers of the toroid.

The configuration as assumed has infinite length in Z-direction.

COILS:

The current configuration of the coil is presented in Fig.4. For analysis eight turns of each coil were simulated by one turn with H=35mm and W=416mm.Because the position of the coils is not yet defined, free positions of the coils have been used.

STEEL:

For this analysis,two types of steel, that are considered for ufacturing the SDC MBT - 1010 steel (USA) and A-87 steel (Russia) were taken BH-curves of these steels are presented in Fig.5. These curves were based on data provided by Westinghouse Electric Corporation.The distribution of the permeability for this steels at B=1.8 Tesla is presented in Fig.5-3,4,5. So in the working region (B=1.8 Tesla) the A-87 steel and 1010 steel have identical magnetic properties and they are equivalent for manufacturing the SDC MBT.

PREPARATION of PE2D model of SDC MBT:

PE2D is based on the Finite Element Methods (FEM). The FEM model of the used configuration is presented in Fig.6. For all regions type P - Polygon discretization of the model was used. The Dirichlet boundary condition, (normal component of the flux density zero) was used to define the potential at the outer surfaces of the model (Fig.7). For all other boundaries the Neumann boundary condition (tangential component of the flux density is zero) was used.

ANALYSIS:

For the analysis, the PE2D/ST non-linear magnetostatics analysis program was used. The tolerance value (which is the maximum relative change permitted for any nodal potential between successive non-linear iteraction) was taken equal to 0.0001.

RESULTS:

The overview of potential lines in SDC MBT for A-87 steel is presented Fig.8. The plot of magnetic field for SDC MBT is presented in Fig.9. The ue of current that was necessary to magnetize the SDC MBT with A-87 steel at B=1.8 Tesla is 28392 A.

The contour map (Fig.9) shows, that there exist three interesting regions in analyzing the magnetic field of the toroid. The first region is in the middle cross-section ot the toroid (or along a line Y=0). The second region is near the coils, and the third region is at the corners of the toroid.

Figures 10-1 through 10-7 present the distribution of the magnetic field for SDC MBT in the first interesting region-along the line Y=0 (in the middle cross-section of MBT).For this region:

-the nonuniformity of the magnetic field is about 0.01%,

-the X-component of magnetic field is equal 0.0005 Tesla or 0 of the total value of magnetic field (1.8 Tesla).

-the value of the fringing field varies from 0.0 Tesla to 0.01 Tesla depending on the distance from the toroid.

Figures 11-1 through 11-4 present the distribution of the magnetic field for SDC MBT in the second interesting region-around the coils. For this region:

-the nonuniformity of the magnetic field is about 0.2%,

-the magnetic field increases slightly and reaches the value near 1.83 Tesla.

-the fringing magnetic field varies from 0.05 Tesla near the coil to 0.0 Tesla at the middle of the toroid.

The more nonuniform region of SDC MBT is the region at the corners of the toroid (Fig.9). This is the third interesting region.The detailed view of the magnetic field in this region is presented in Figs.12. For this region the magnetic field varies from 1.8 Tesla to 1.4 Tesla. The fringing field in this region varies from 0.0 Tesla to 0.03 Tesla.

In conclusion, it is necessary to say that the results presented here were received for simplified configuration of the SDC MBT. The next step is the introduction of the gaps between the blocks and between the coils and the steel.It is necessary to consider also the influence of the supports and other elements surrounding the MBT on the magnetic field. It may be possible to minimize the fringing field by optimizing the placement of the coils.

List of Figures:

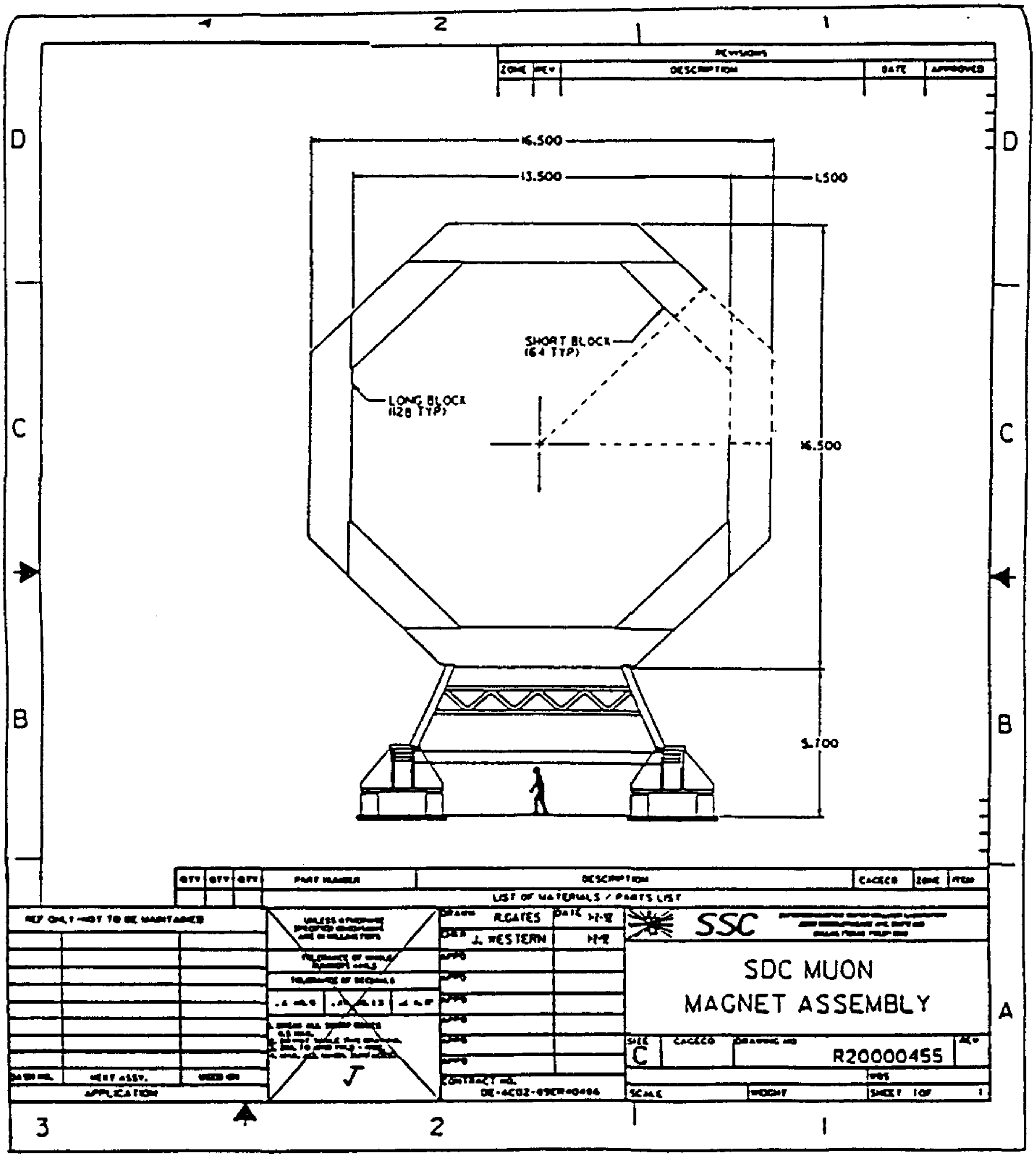
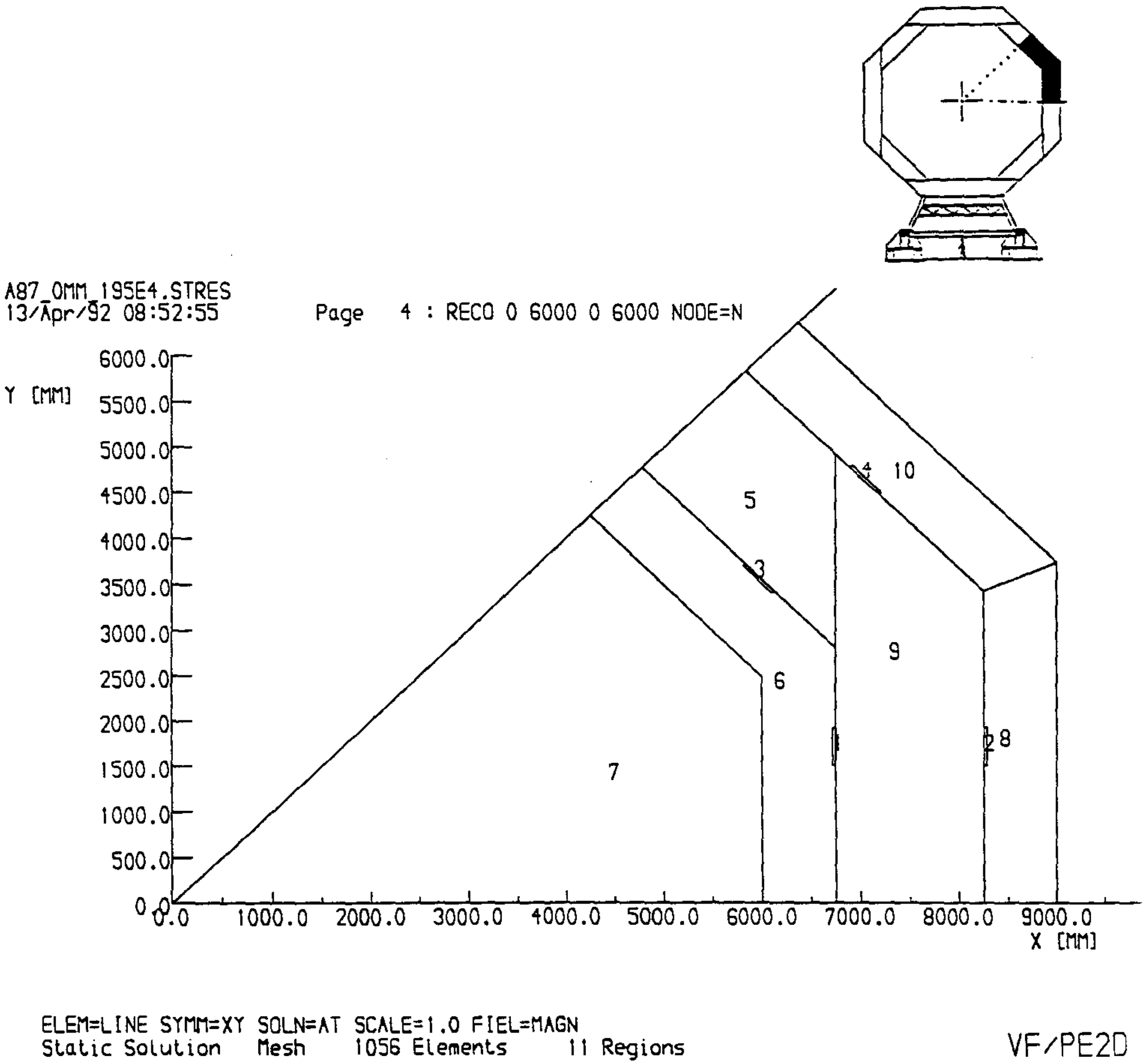

16.500
13.500
1.500
SHORT BLOCK (64 TYP)
LONG BLOCK (128 TYP)
16.500
5.700
LIST OF MATERIALS / PARTS LIST
R.GATES
J. WESTERN
SSC
SDC MUON
MAGNET ASSEMBLY
C
R20000455
APPLICATION

Fig.1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1500.0
1000.0
500.0
0.0
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
9000.0
X [MM]
3
4
5
6
7
8
9
10
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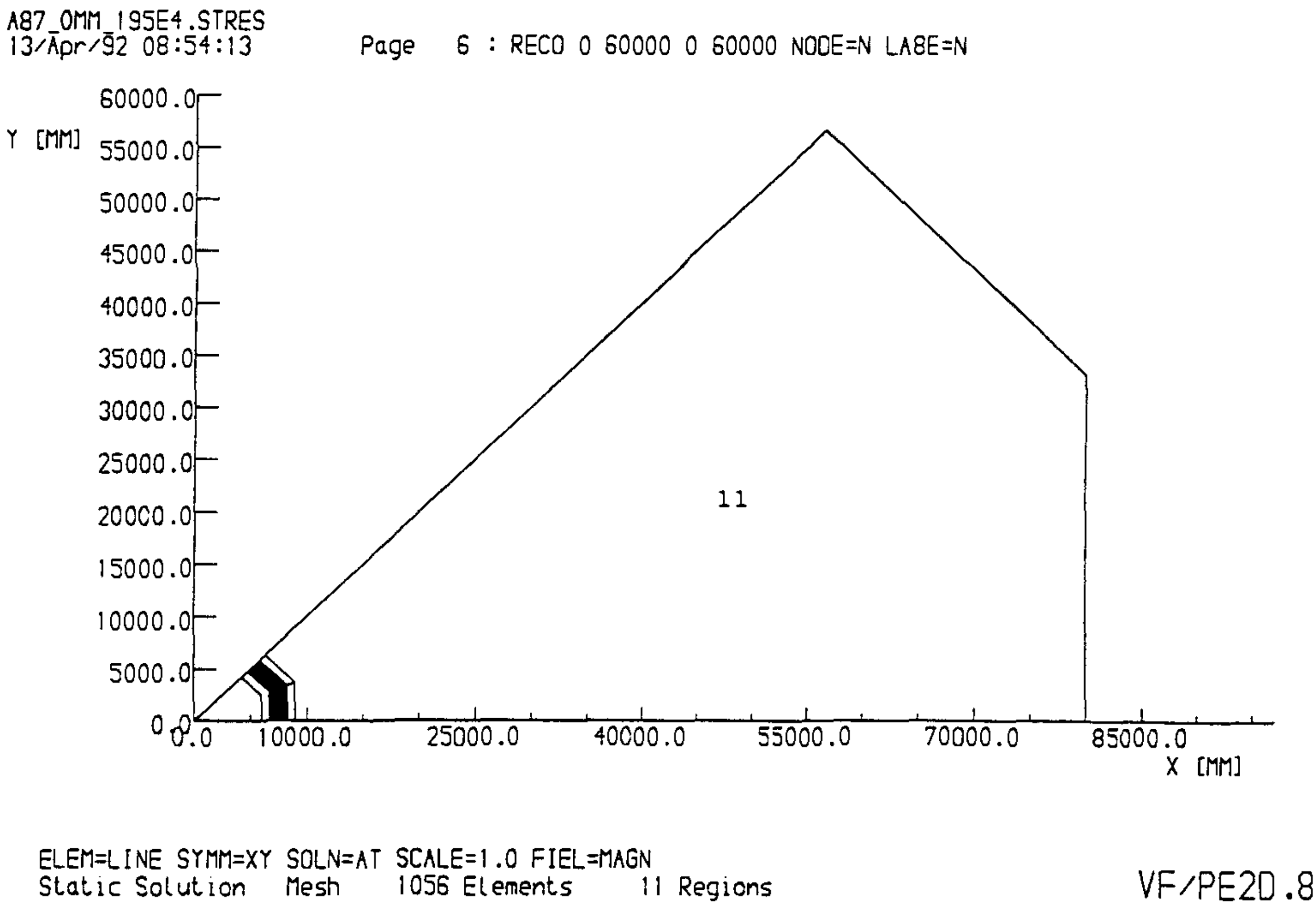
Static Solution Mesh 1056 Elements 11 Regions
VF/PE2D

Fig.2

TVG



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40000.0
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30000.0
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20000.0
15000.0
10000.0
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0.0
11
0.0
10000.0
25000.0
40000.0
55000.0
70000.0
85000.0
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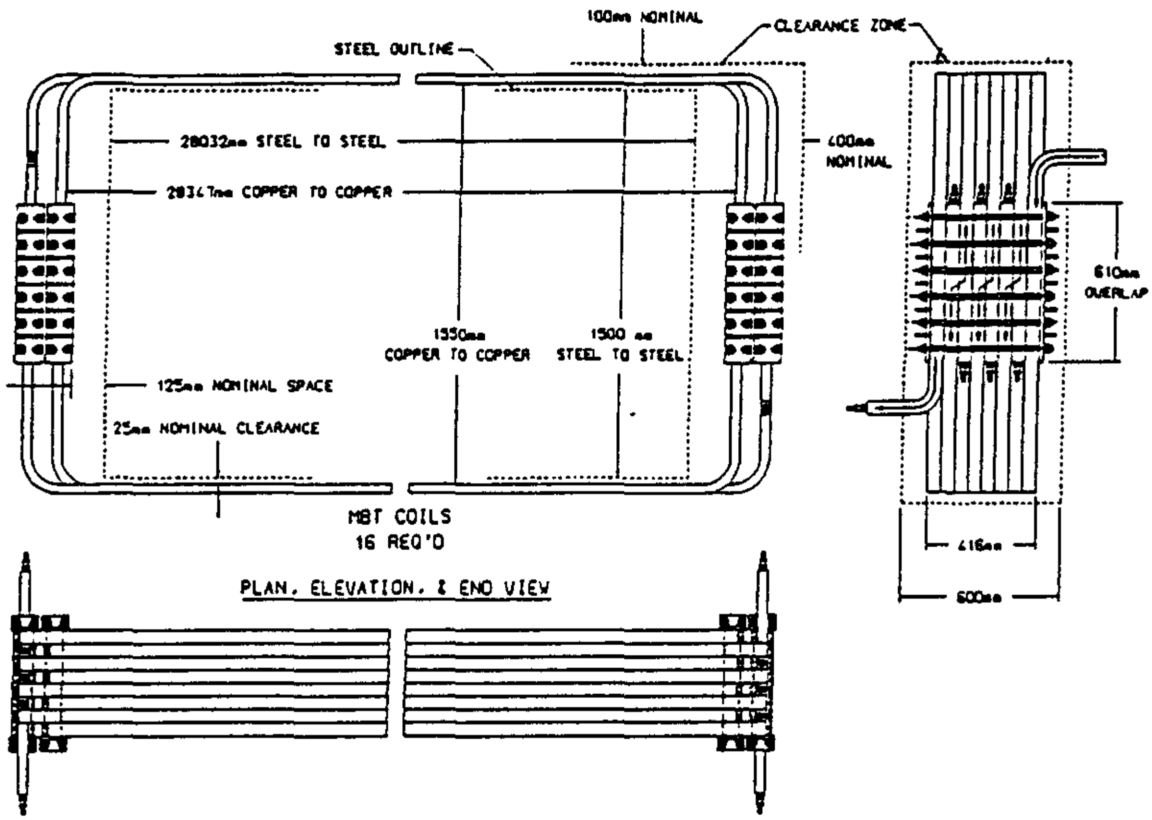
Static Solution Mesh 1056 Elements 11 Regions
VF/PE2D.8

Fig.3



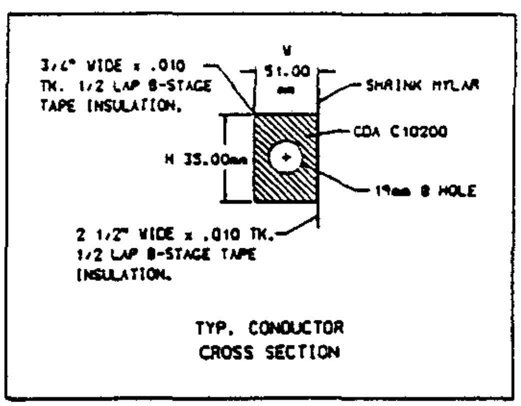


Fig.4

UNIVERSITY OF WISCONSI
PHYSICAL SCIENCES LAB
J.J.C./G.M.G.
2-20-92

STEEL_A87.BH
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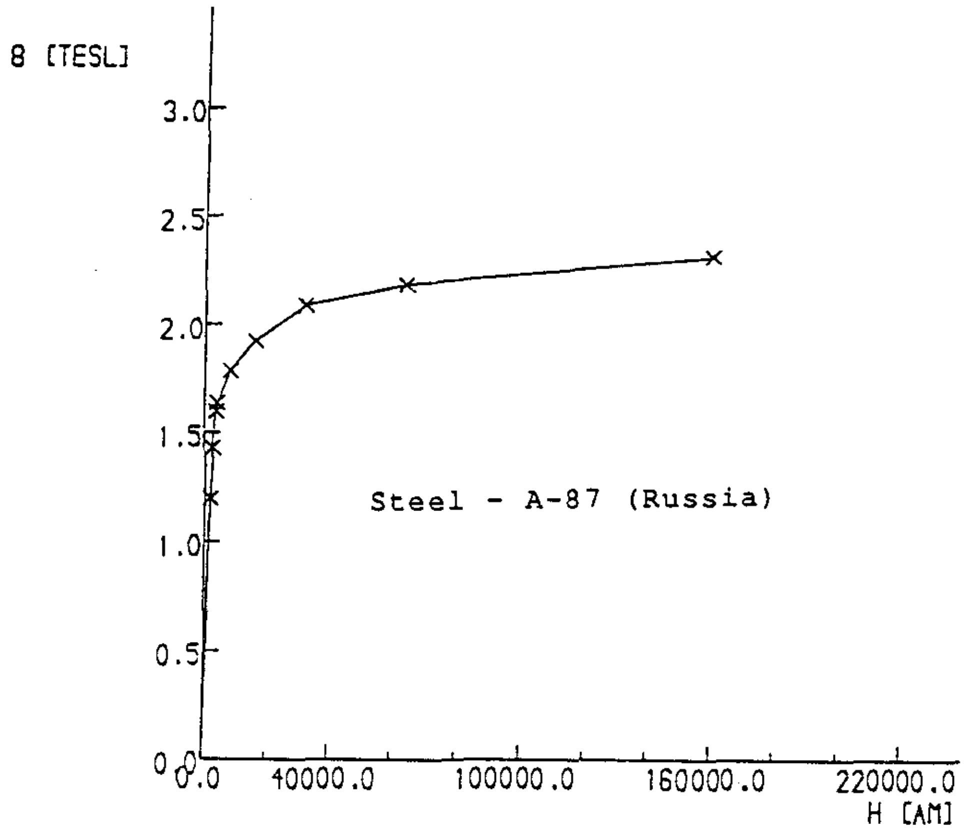

VF/PE2D.8

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    4       1.6         3599.99
    5       1.639       3999.99
    6       1.788       8000.0
    7       1.925       15999.9
    8       2.09        32000.0
    9       2.185       63999.9
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Fig.5-1

STEEL_1010.BH
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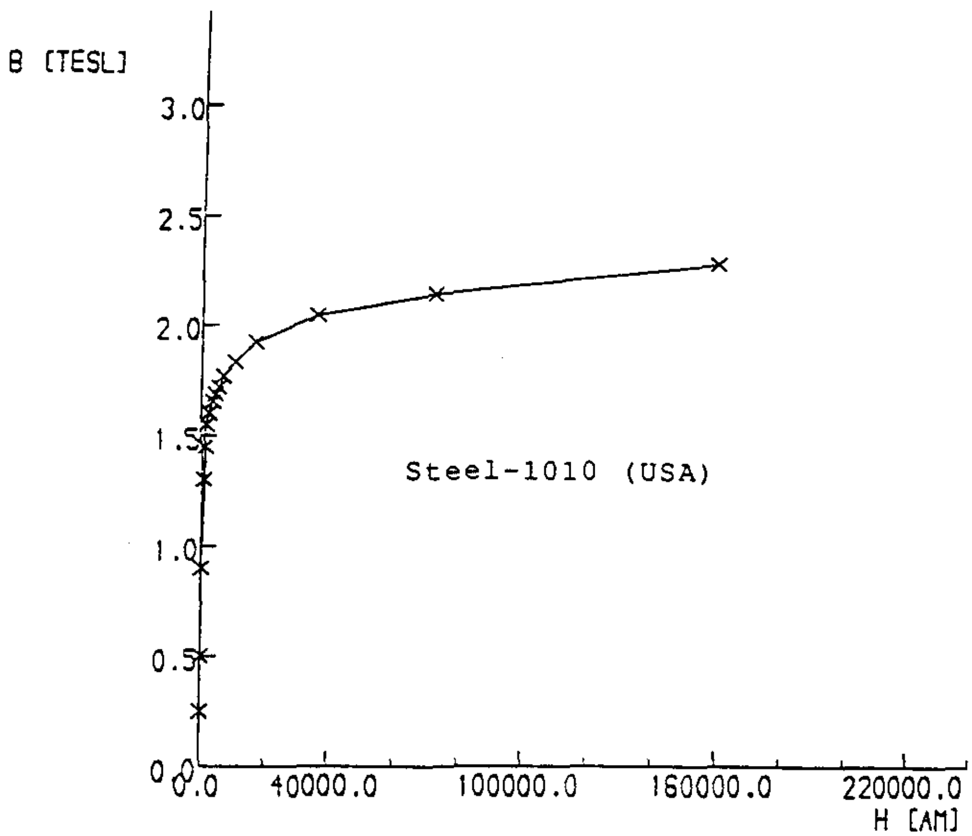


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VF/PE2D.8

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3	0.5	208.0
4	0.9	343.999
5	1.3	720.0
6	1.45	1119.99
7	1.552	1759.99
8	1.603	2559.99
9	1.655	3599.0
10	1.686	4399.99
11	1.717	5399.99
12	1.769	6799.99
13	1.833	10399.9
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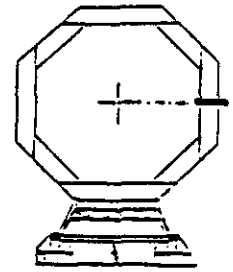
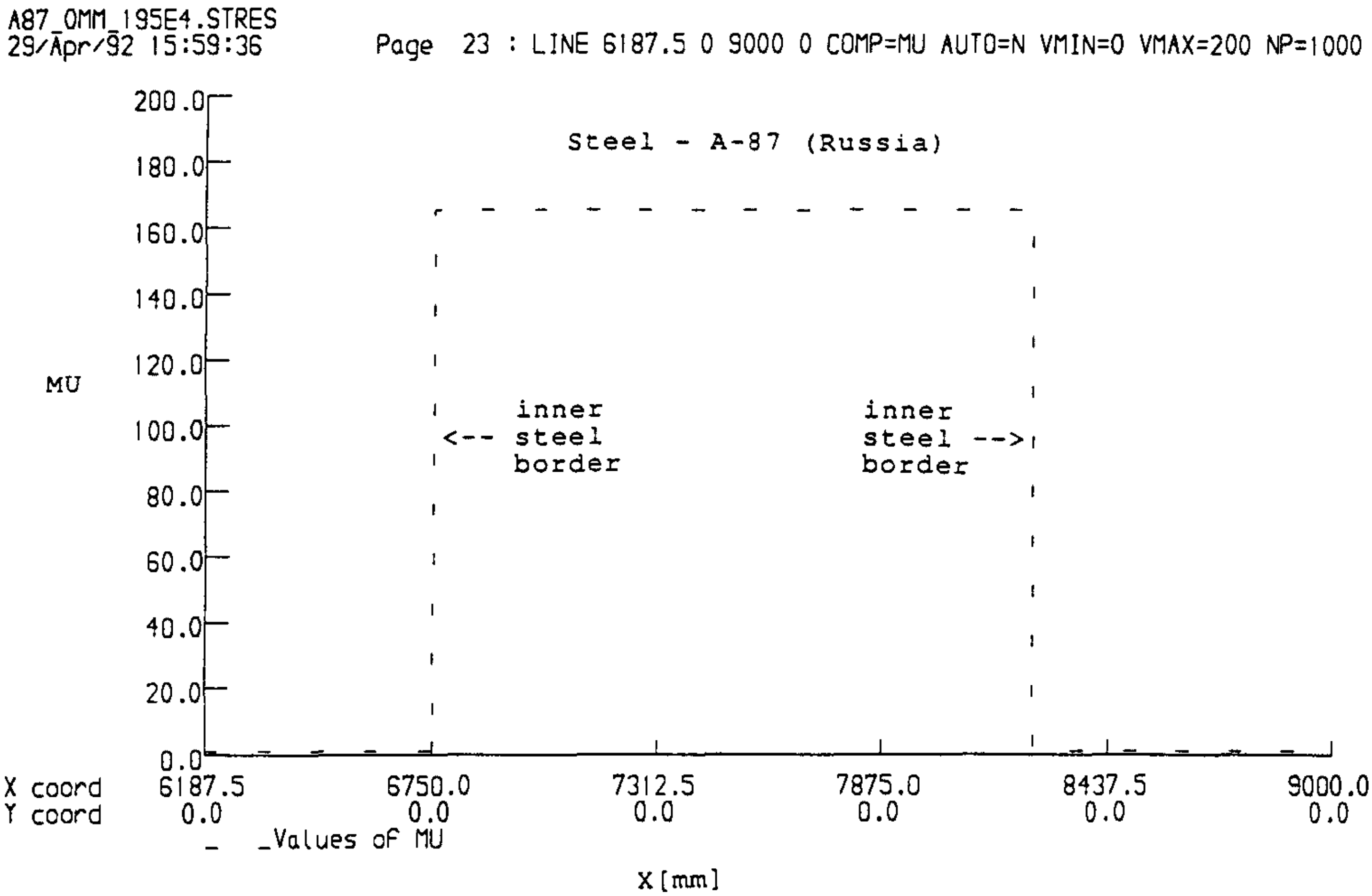
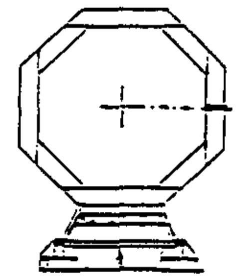
Fig.5-2

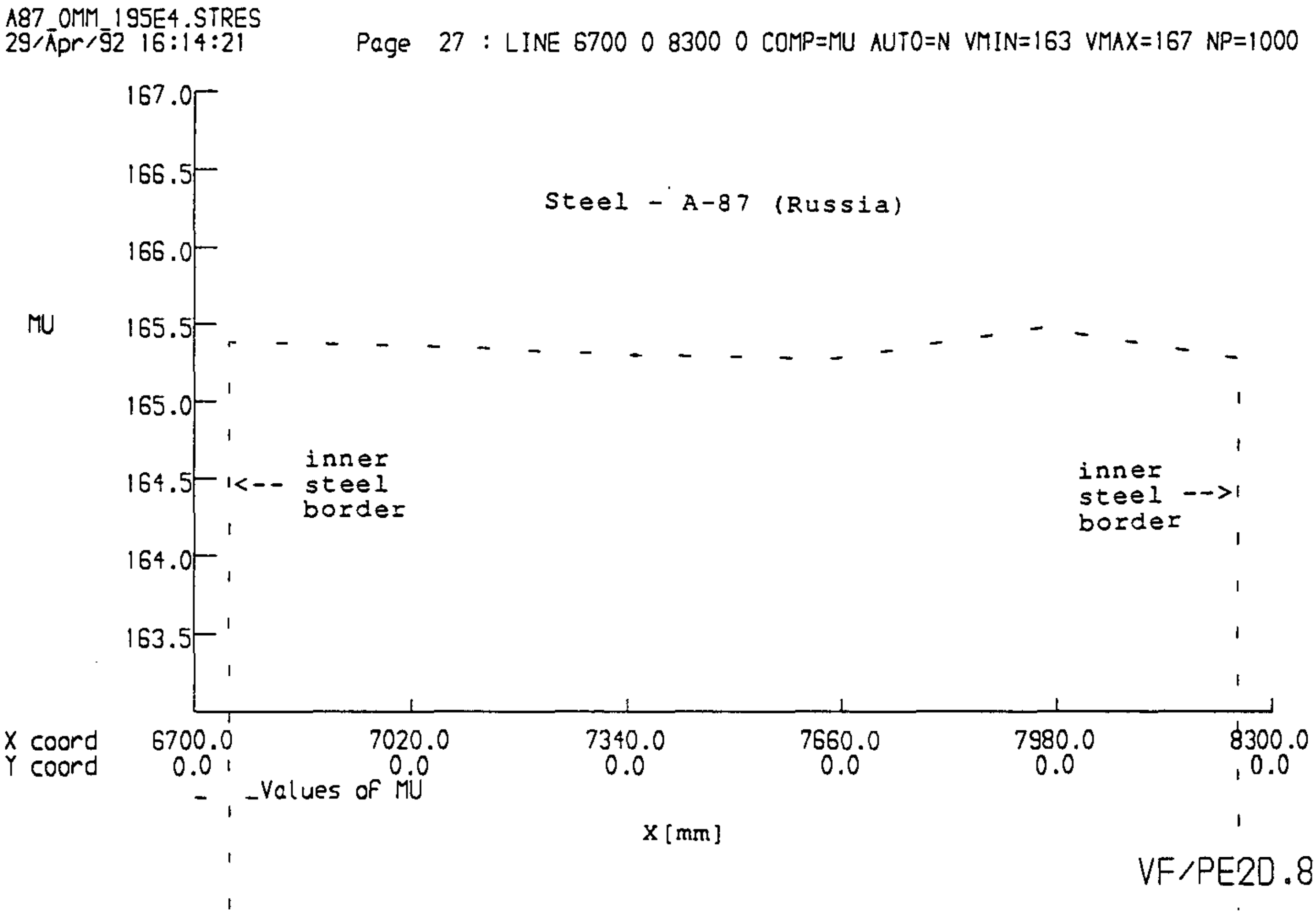




VF/PE2D.8

Fig.5-3

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166.5
166.0
165.5
165.0
164.5
164.0
163.5
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inner steel border -->
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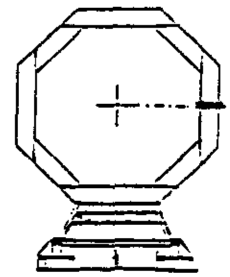
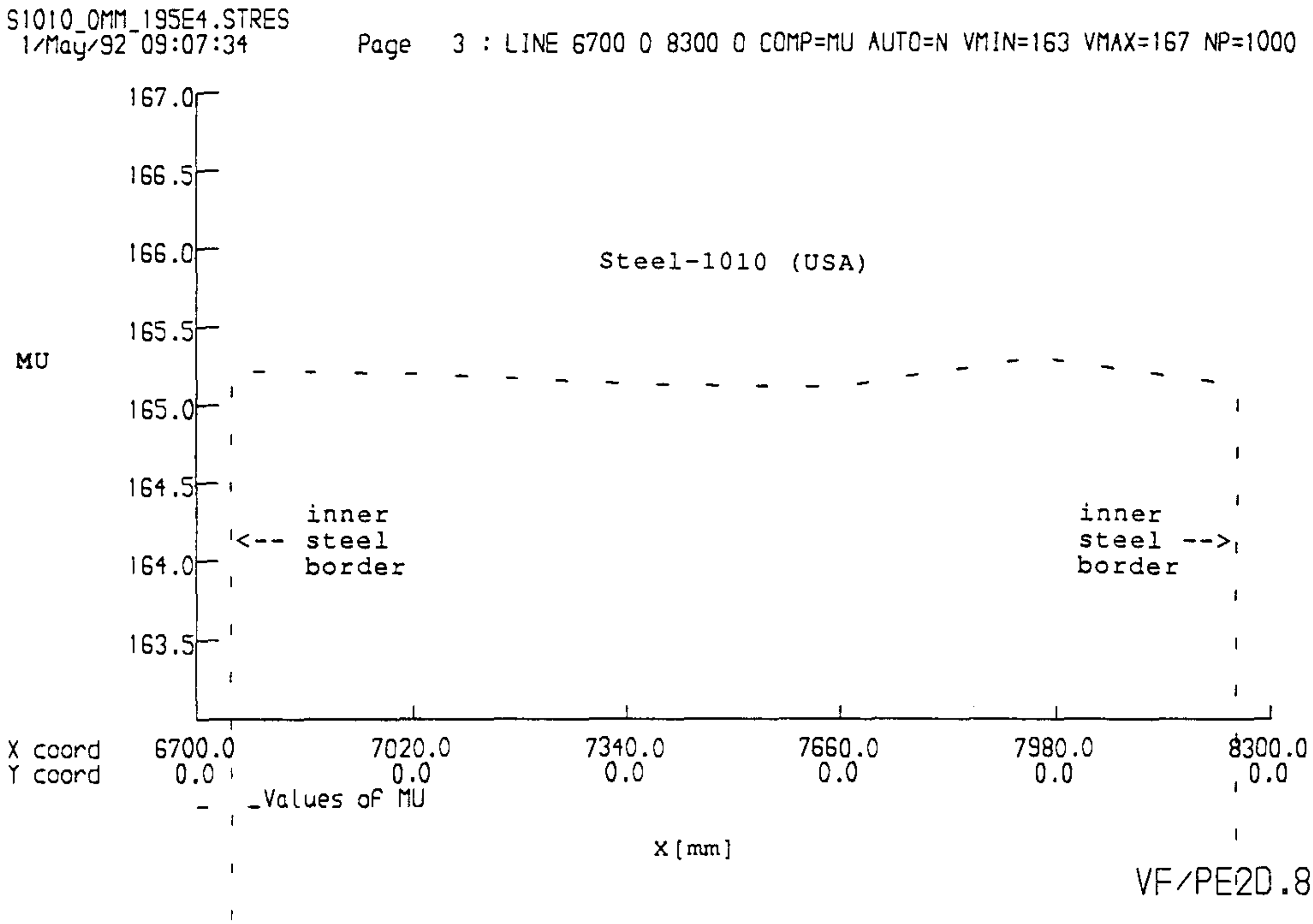
_ _Values of MU
X[mm]
VF/PE2D.8

Fig.5-4

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MU
Steel-1010 (USA)
inner steel border
inner steel border
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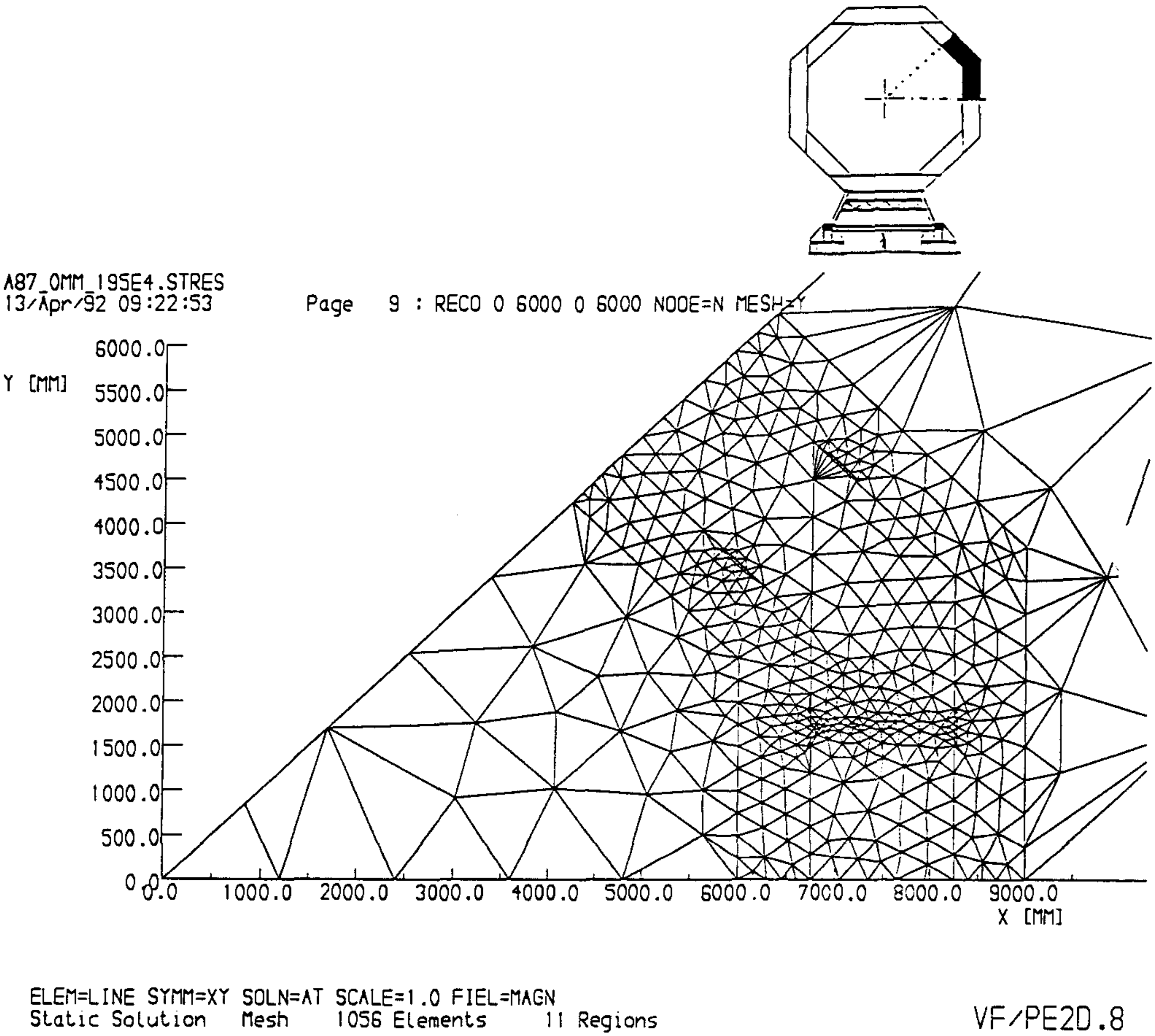
X[mm]
VF/PE2D.8

Fig.5-5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5000.0
6000.0
7000.0
8000.0
9000.0
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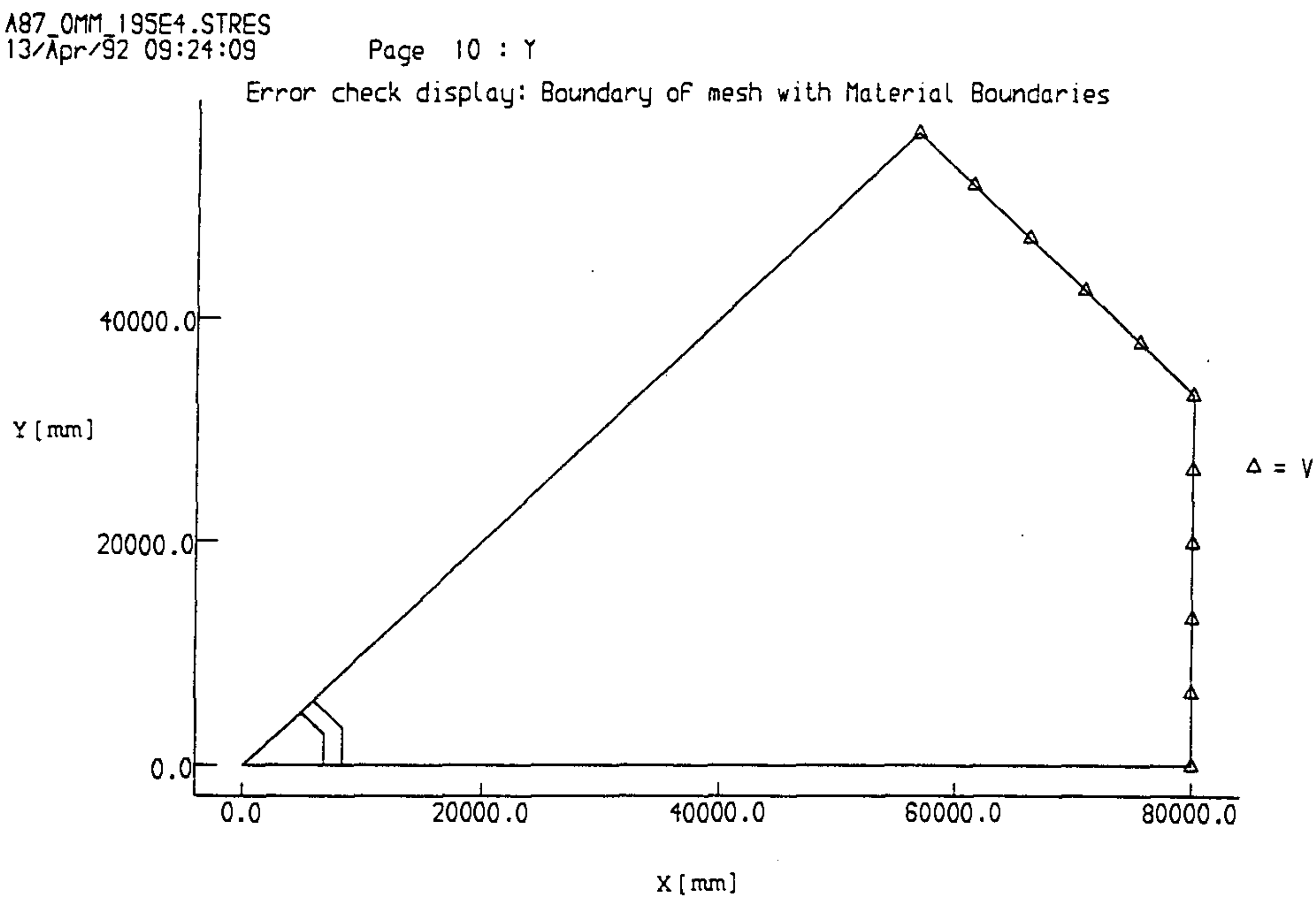
Static Solution Mesh 1056 Elements 11 Regions
VF/PE2D.8

Fig.6

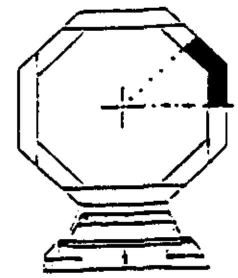
TVG

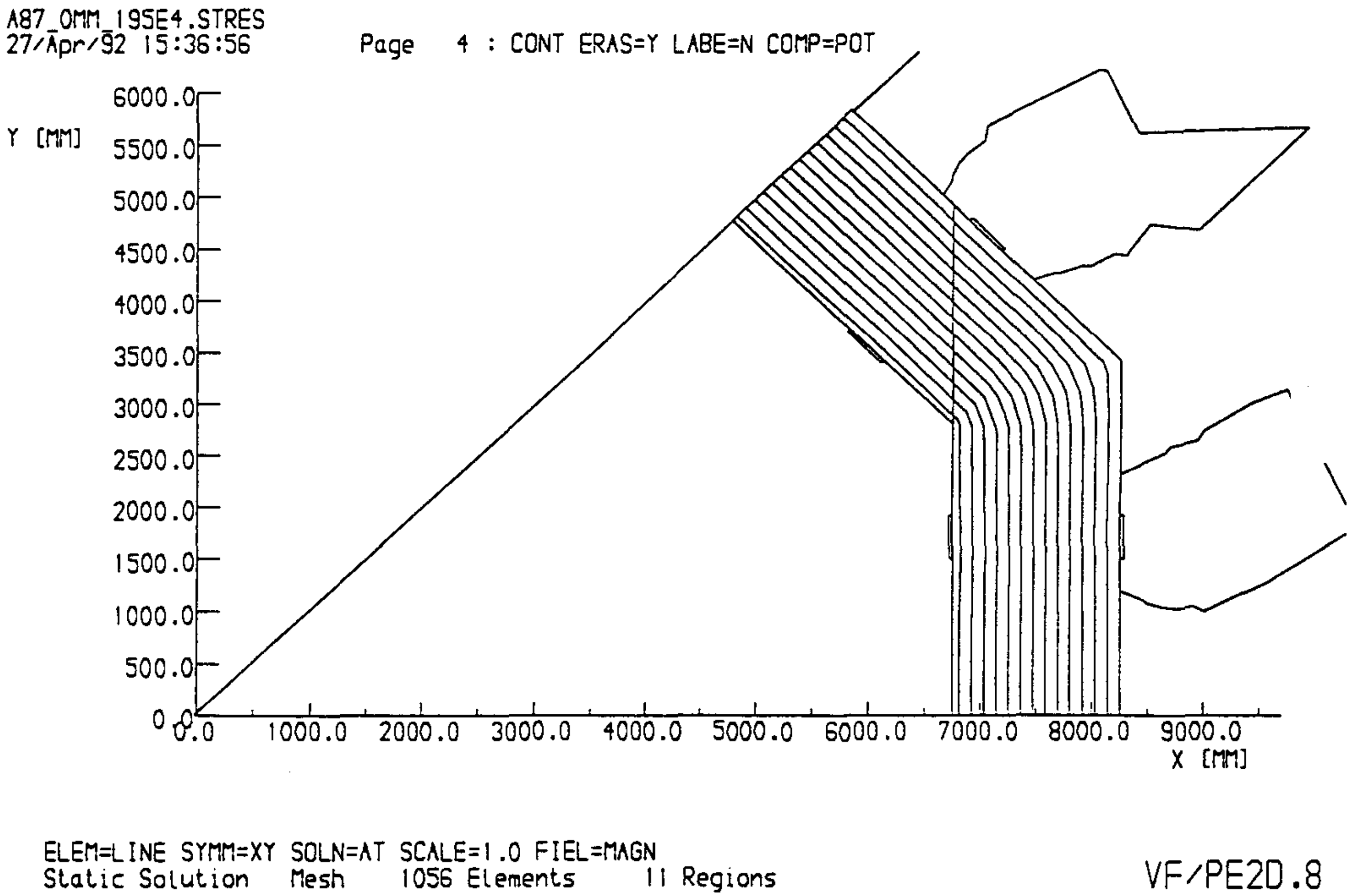


VF/PE2D.8

Fig.7

TVG





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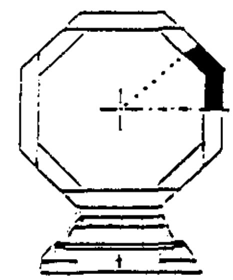
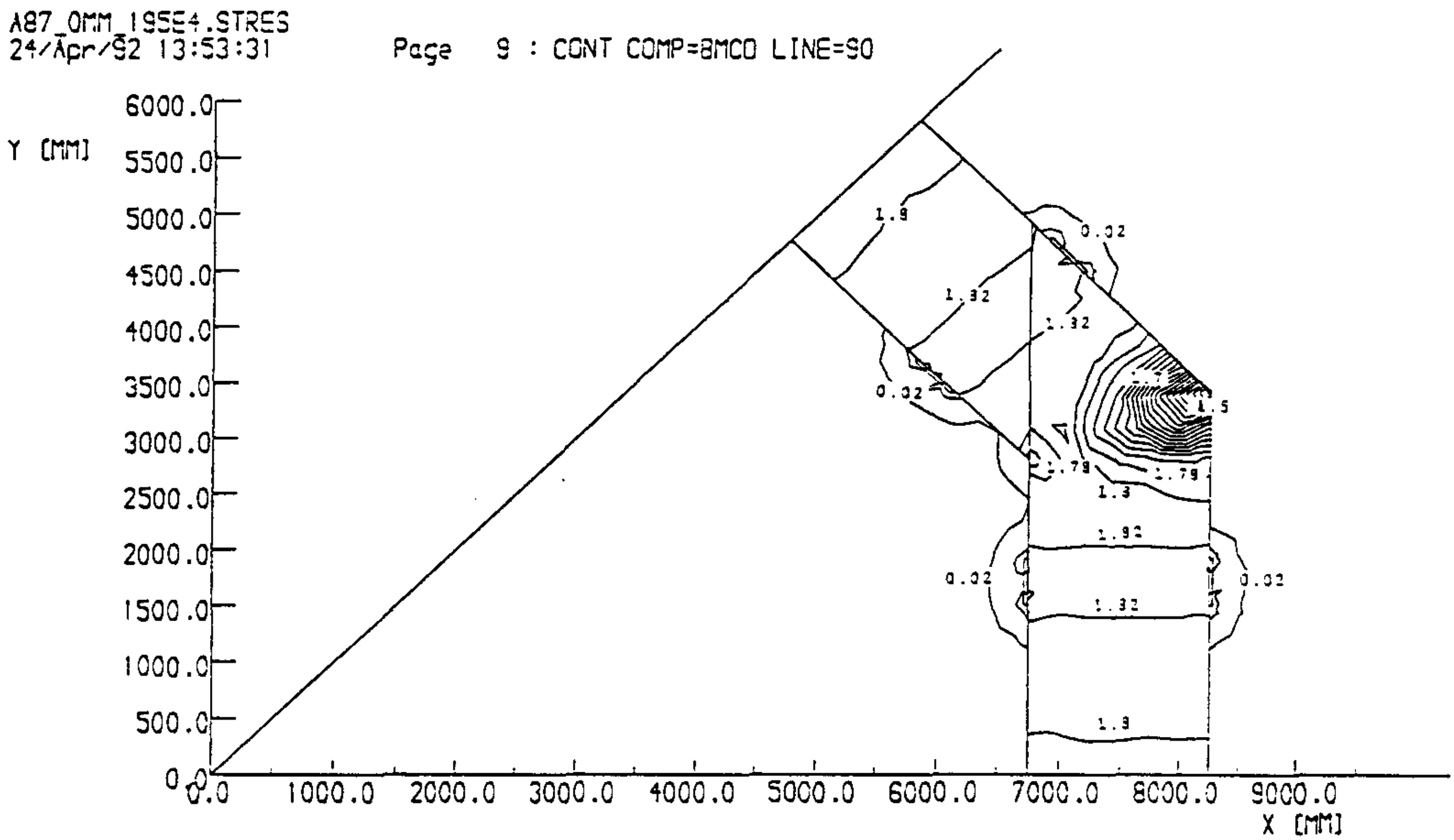
Steel - A-87 (Russia)

Fig.8





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Static Solution Mesh 1055 Elements 11 Regions

VF/PE2D.8

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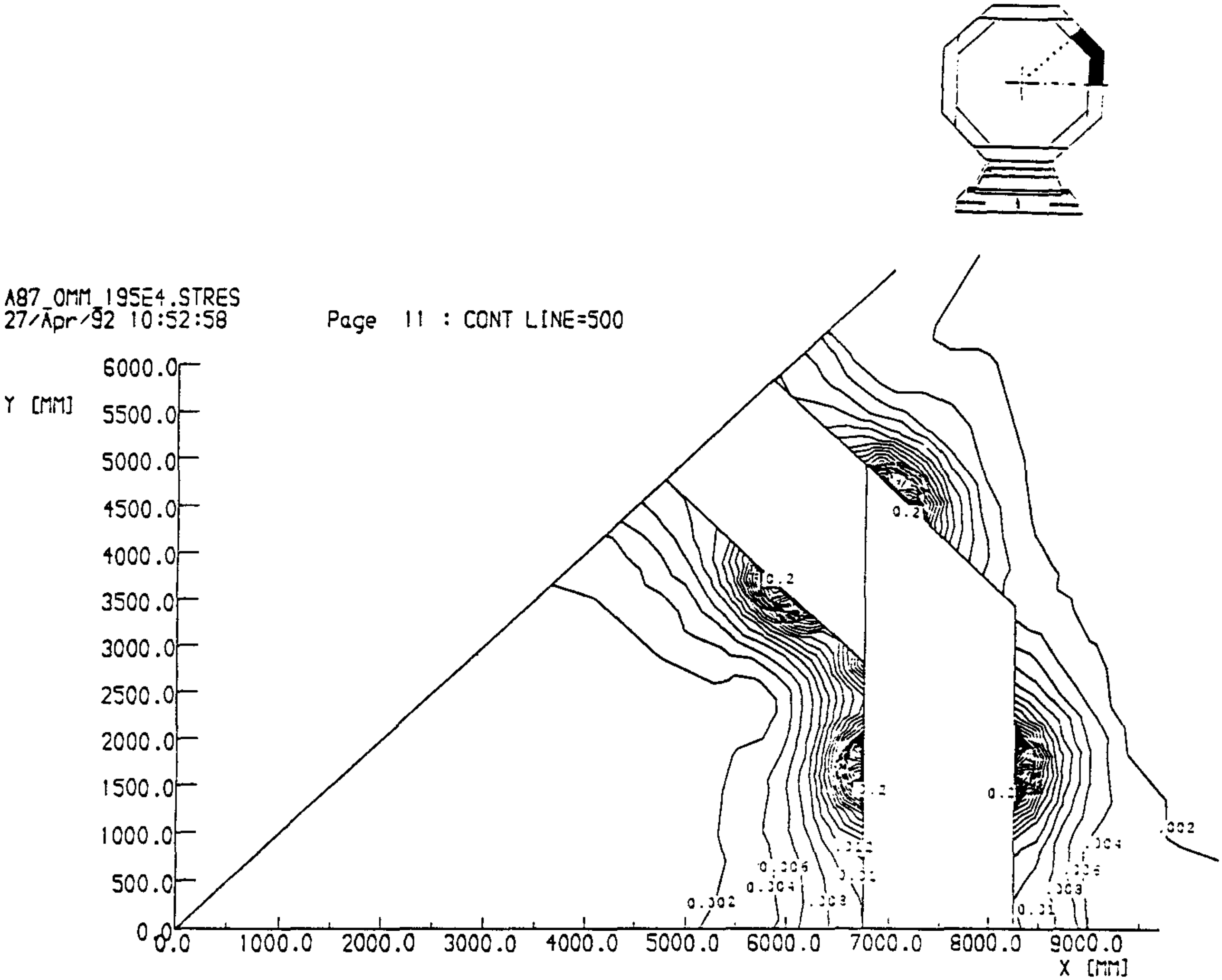
Steel - A-87 (Russia)

Fig.9-1

TVG



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Static Solution Mesh 1056 Elements 11 Regions

VF/PE2D.8

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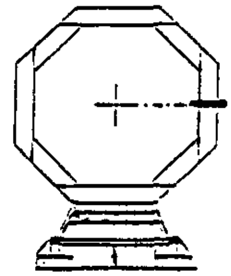
Fig.9-2



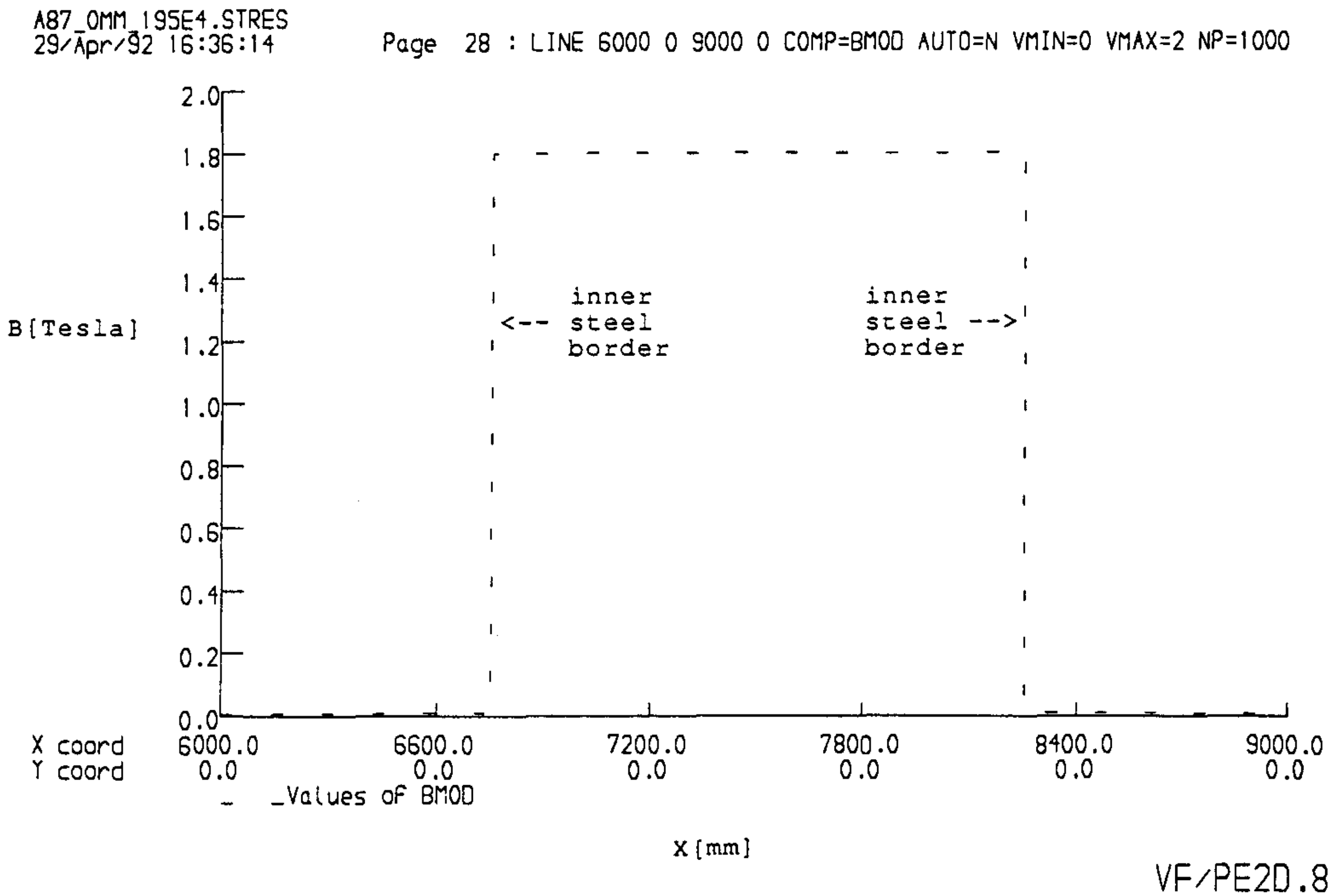


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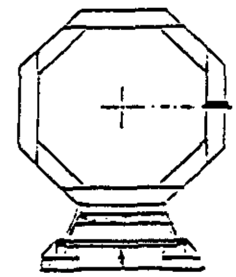
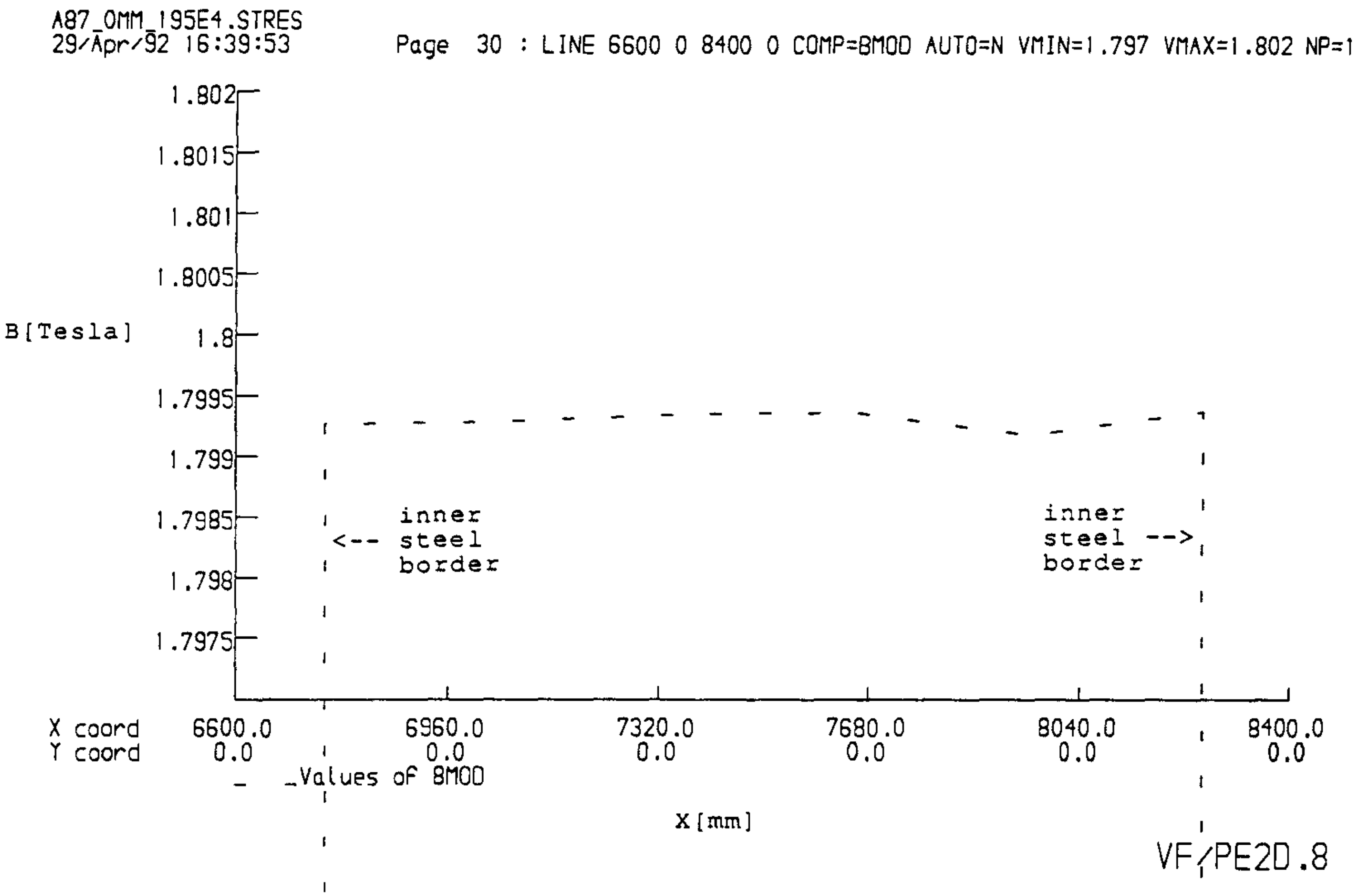
Fig.10-1

TVG





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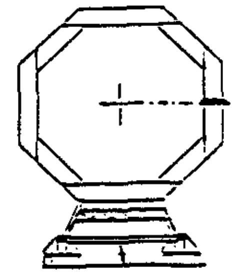
Steel - A-87 (Russia)

Fig.10-2



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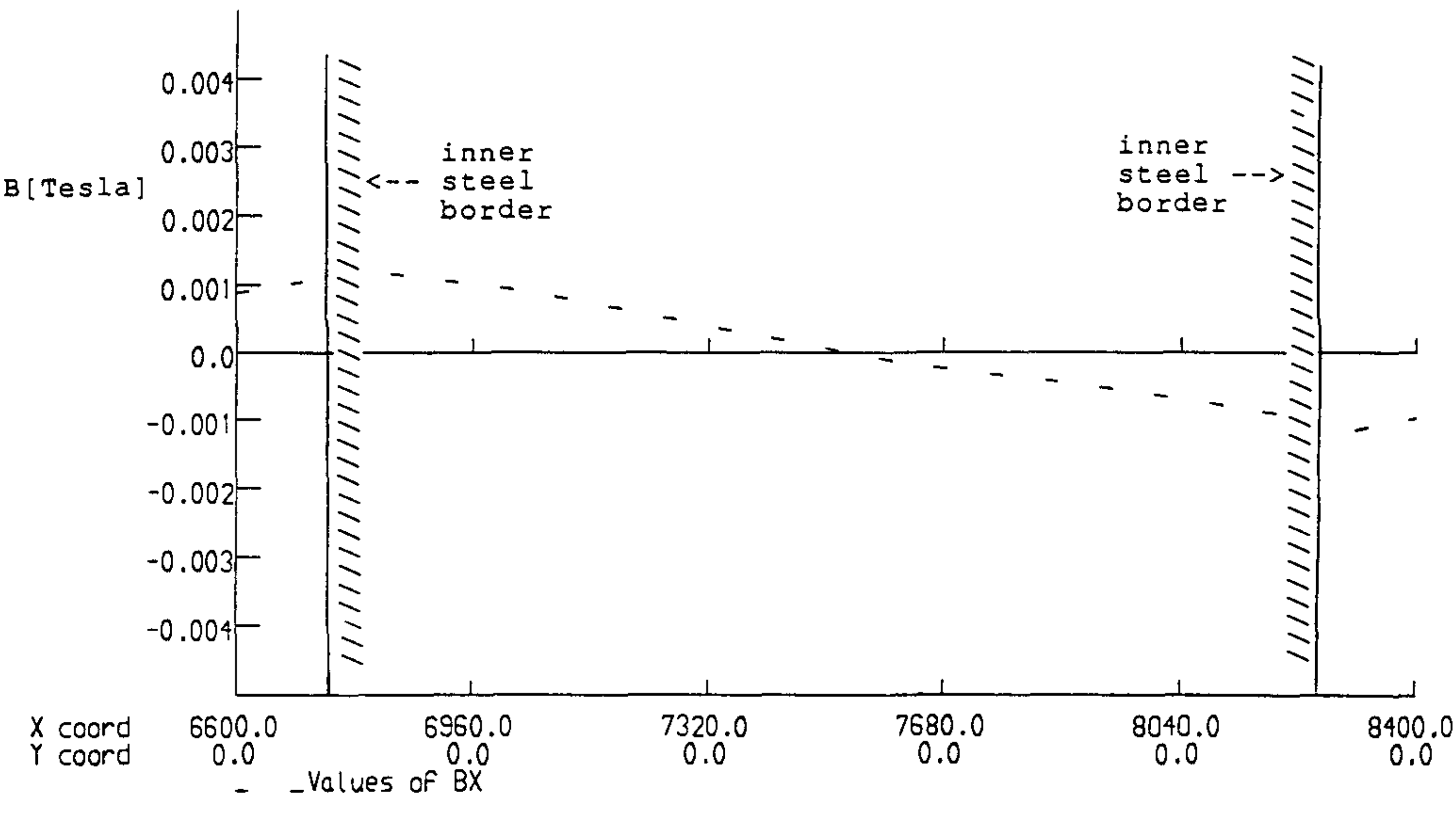

VF/PE2D.8

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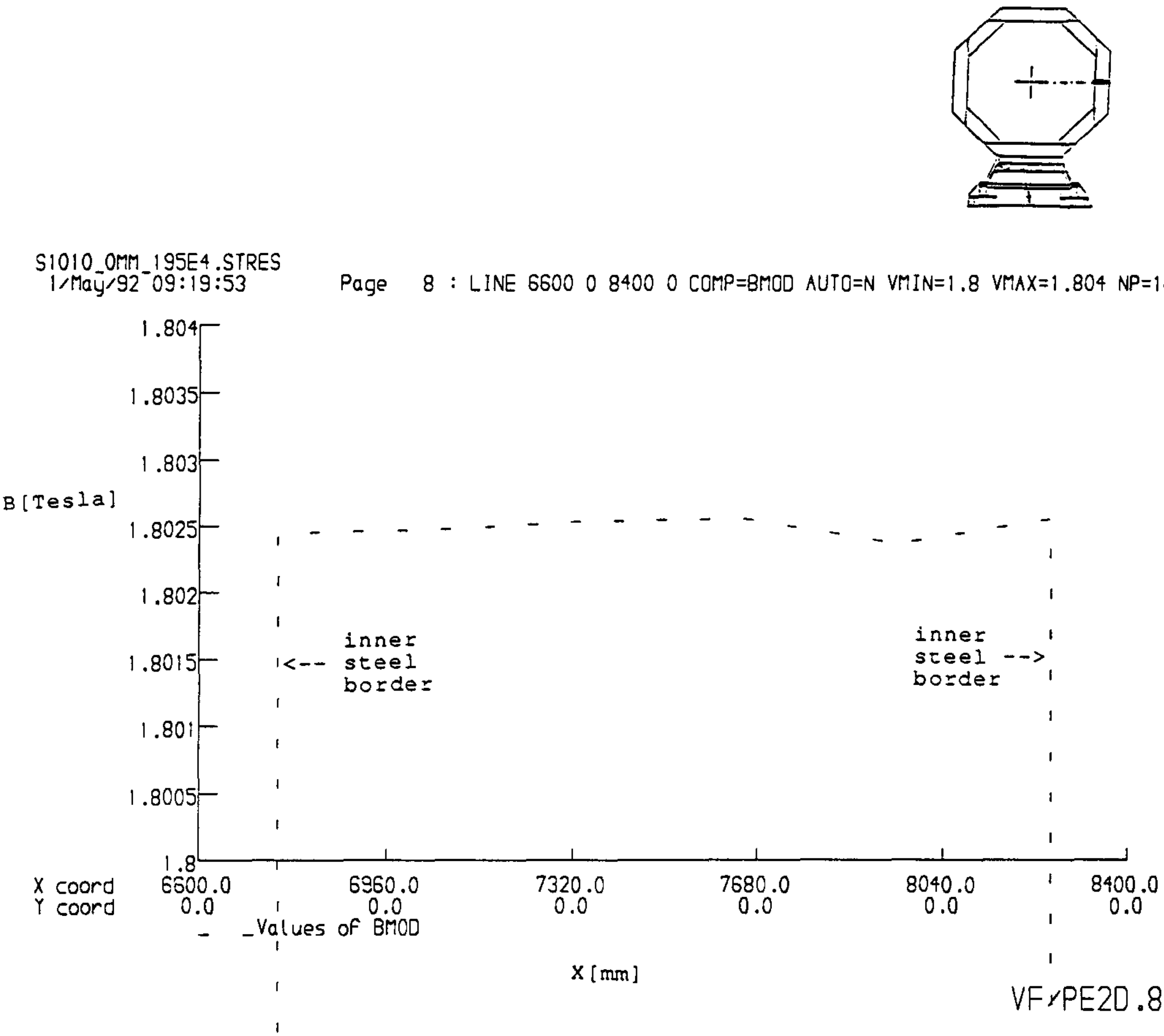
Fig.10-3



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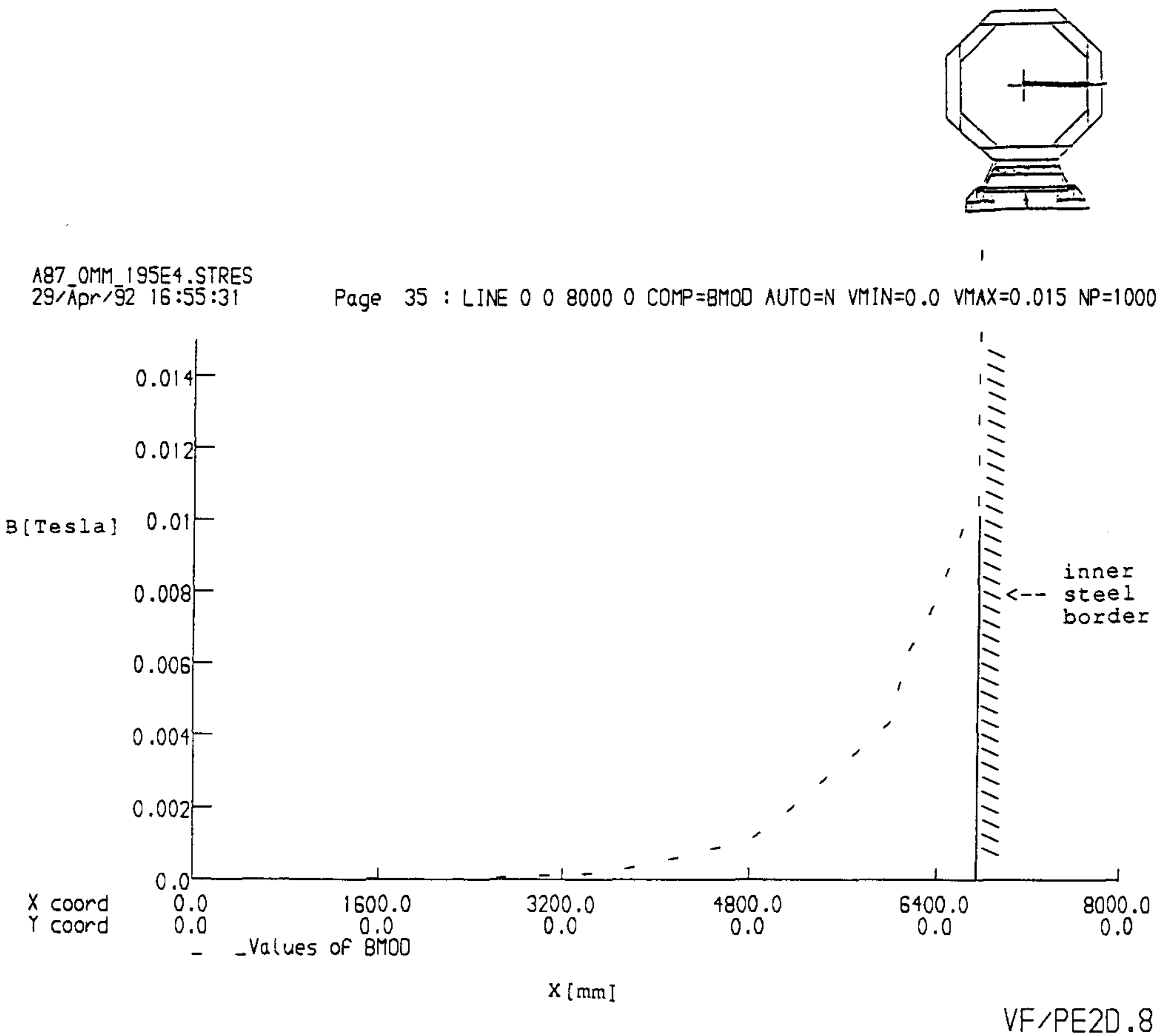
Steel-1010 (USA)

Fig.10-4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0.002
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steel
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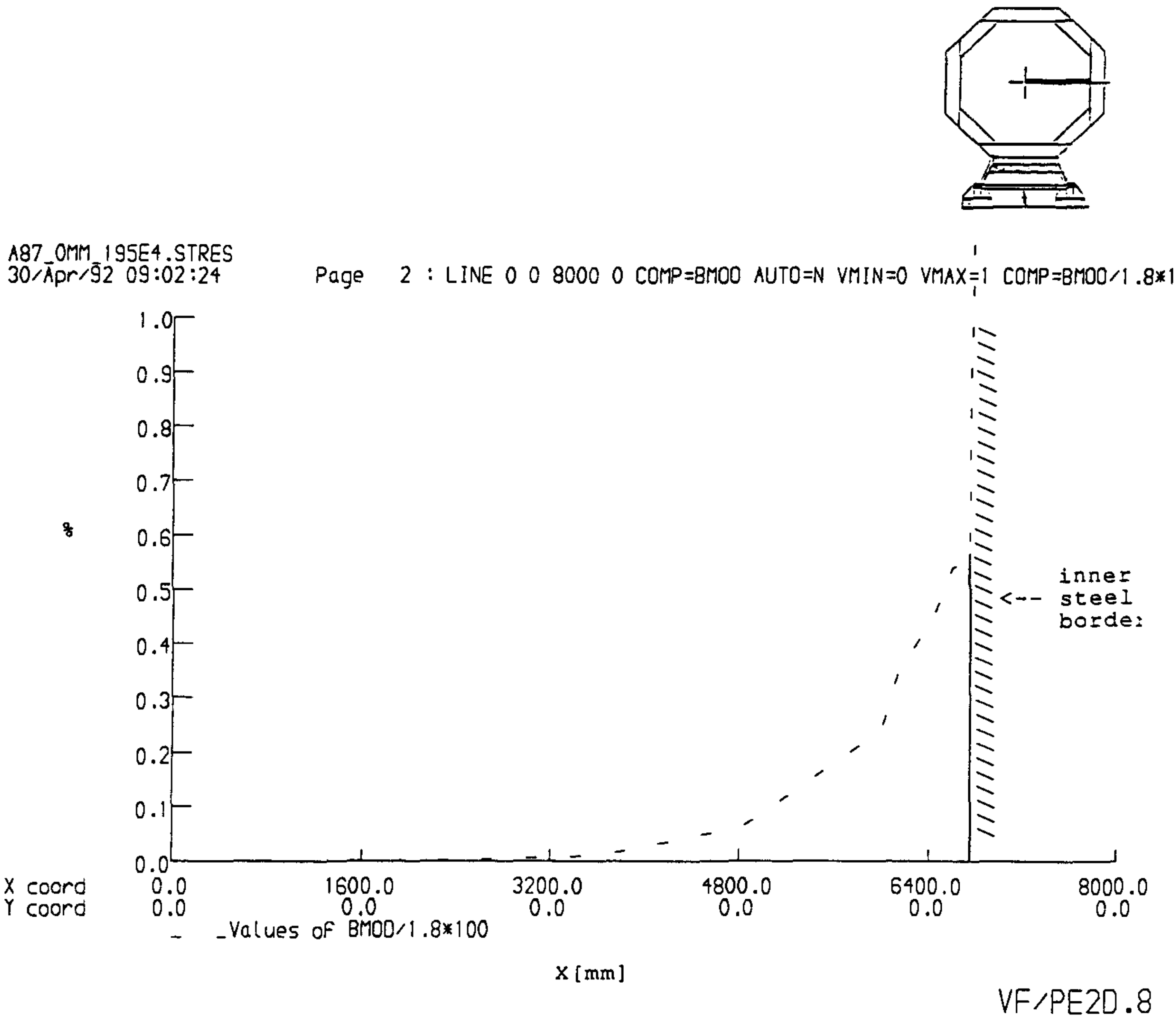
X[mm]
VF/PE2D.8

Fig.10-5



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0.5
0.4
0.3
0.2
0.1
0.0
inner
steel
borde:
<--
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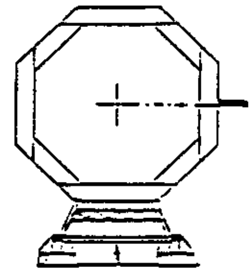
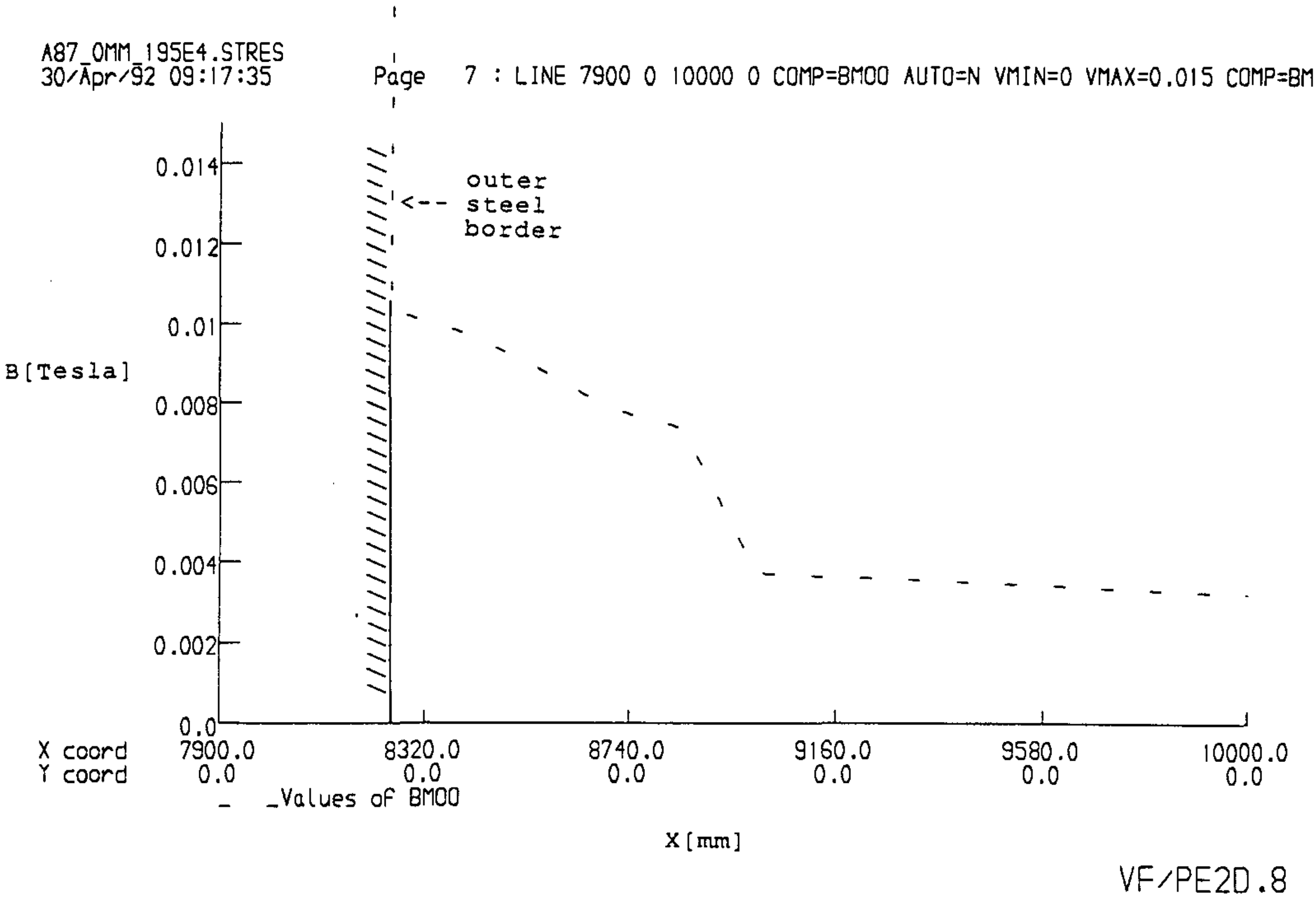
X[mm]
VF/PE2D.8

Fig.10-6

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0.012
0.01
0.008
0.006
0.004
0.002
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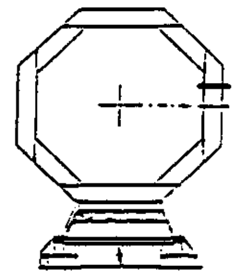
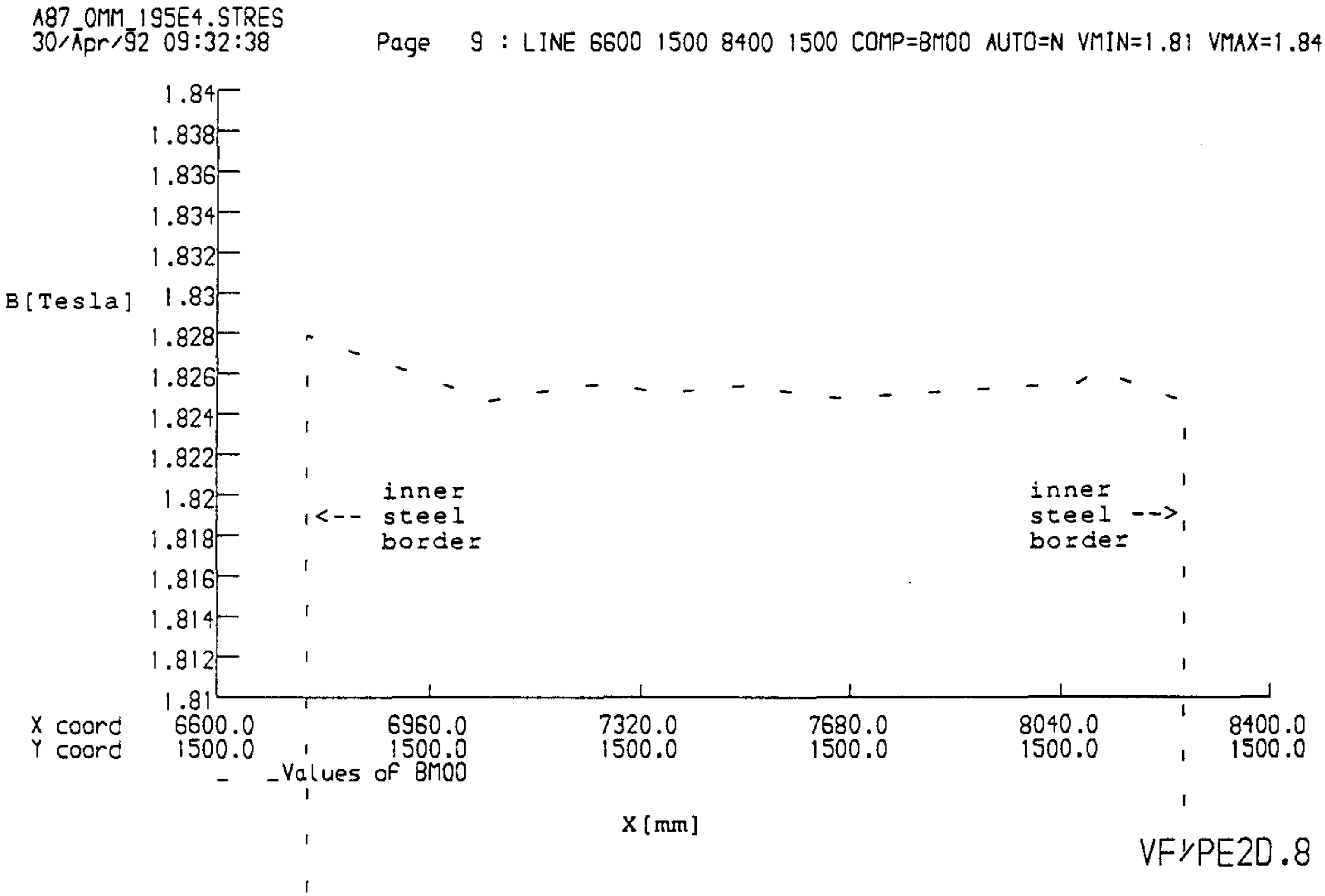
X[mm]
VF/PE2D.8

Fig.10-7





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1.824
1.822
1.82
1.818
1.816
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1.81
<-- inner steel border
inner steel border -->
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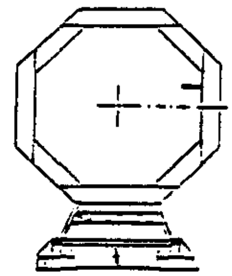
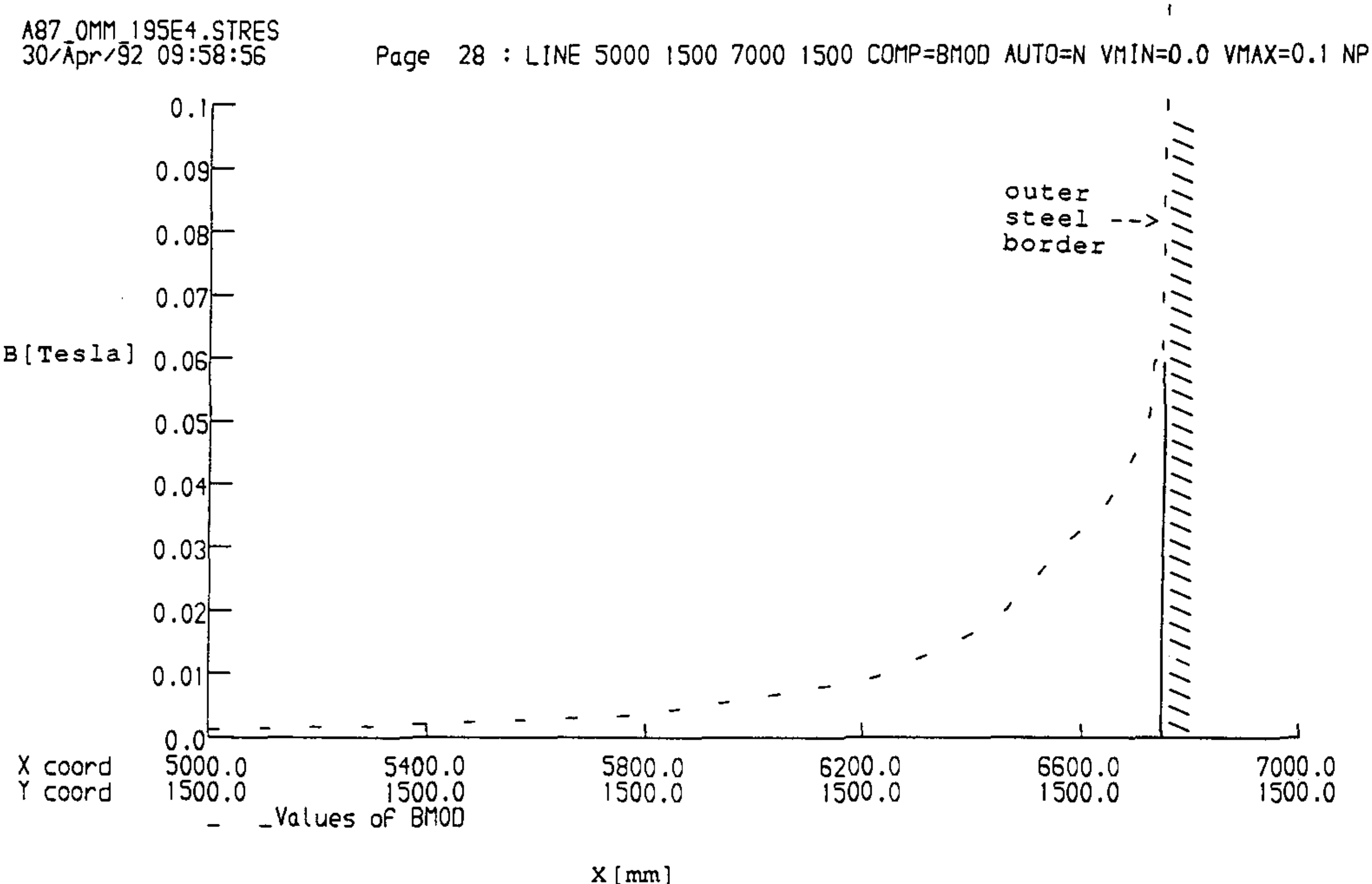
X[mm]
VF/PE2D.8

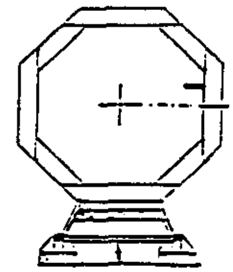
Fig.11-1

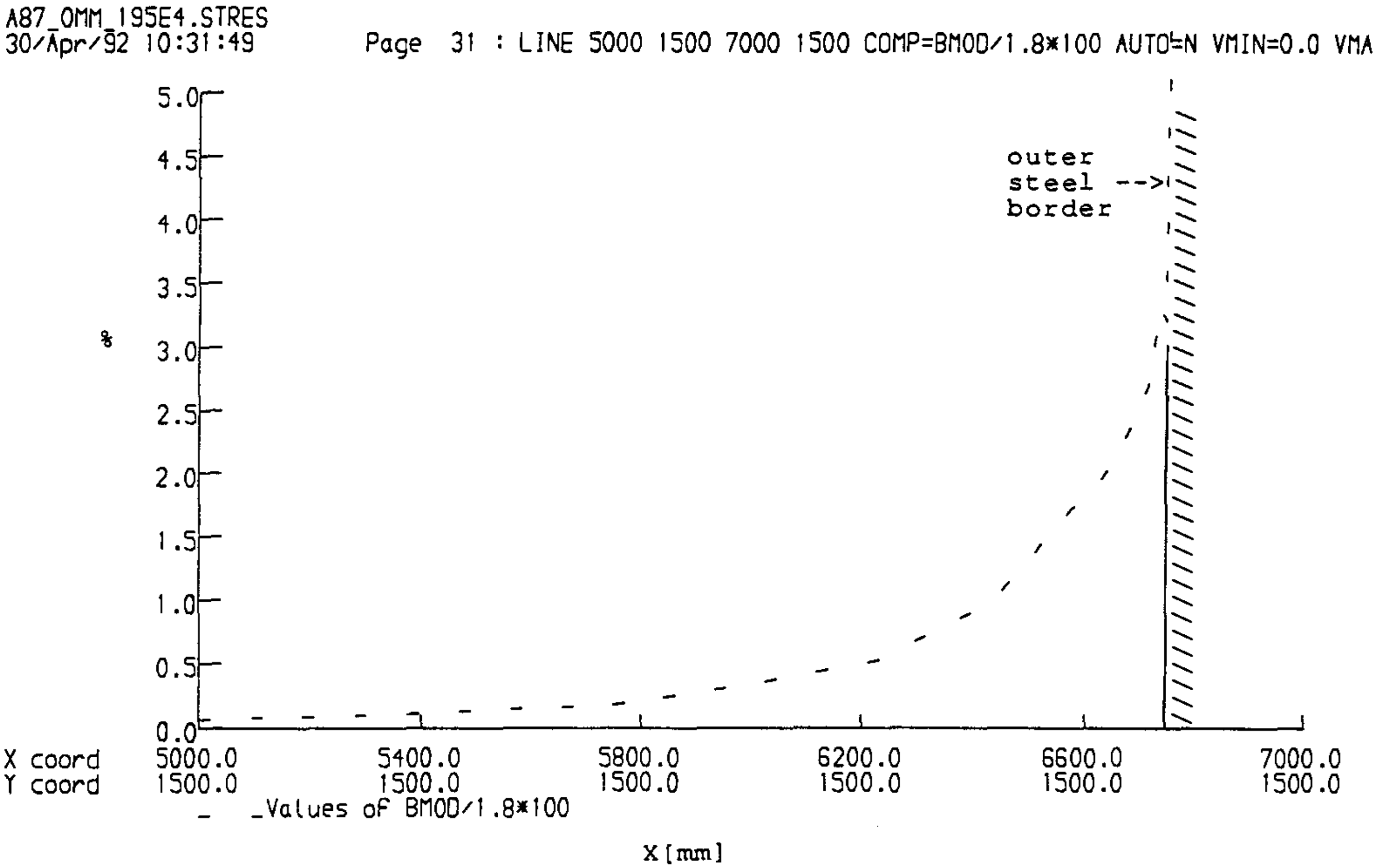




VF/PE2D.8

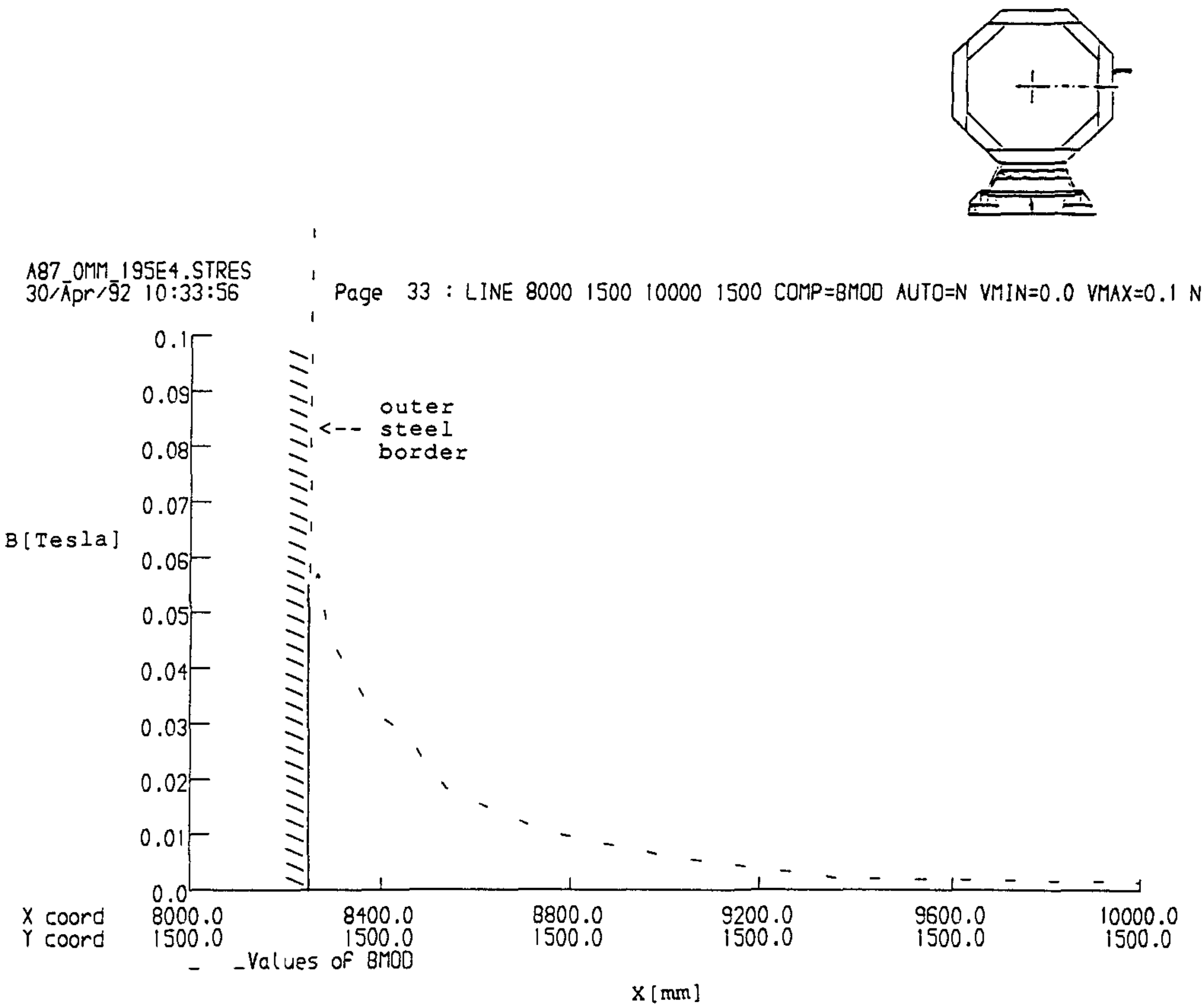
Fig.11-2





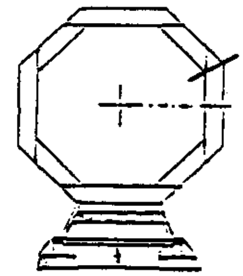
VF/PE2D.8

Fig.11-3



VF/PE2D.8

Fig.11-4



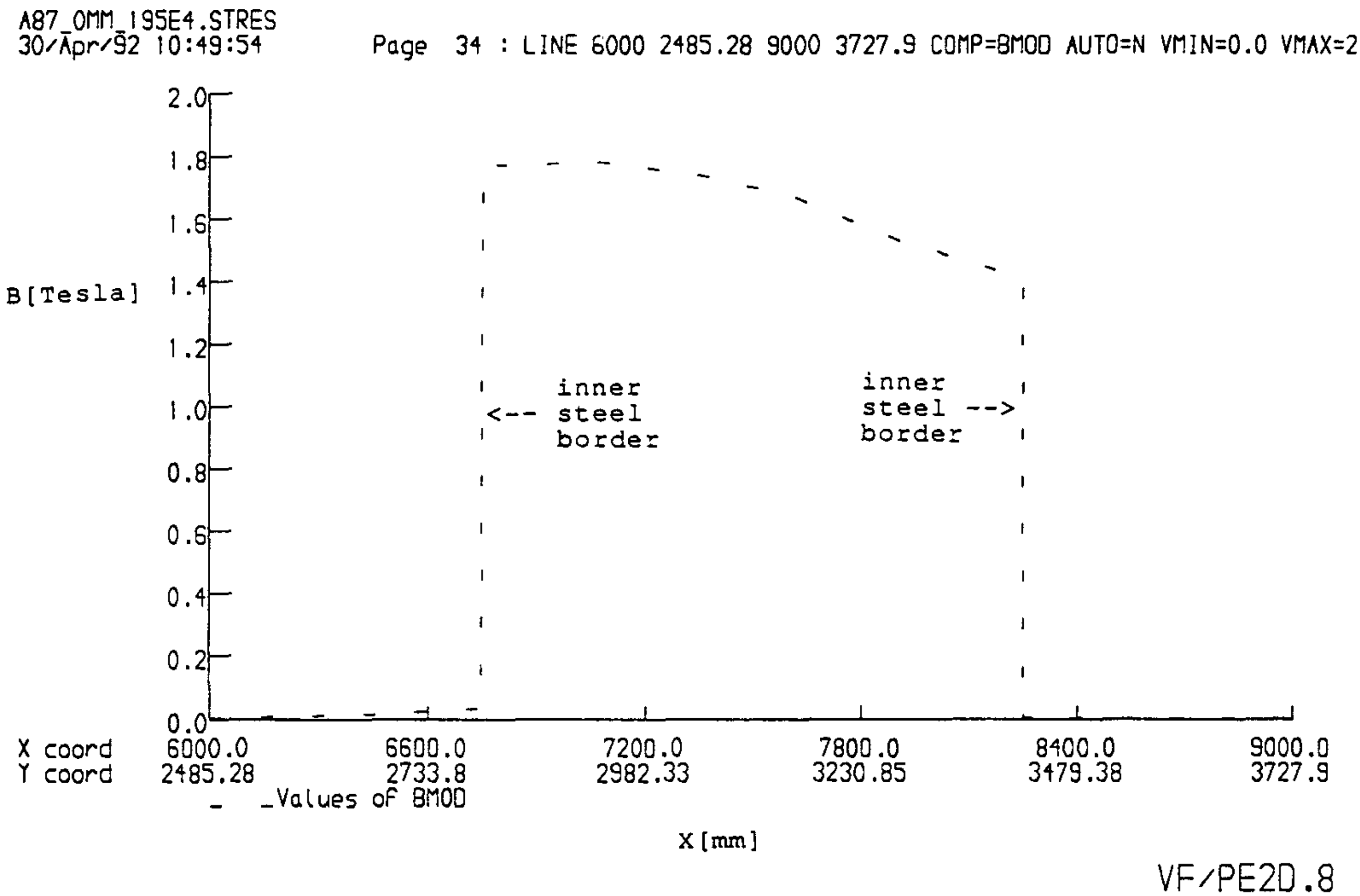
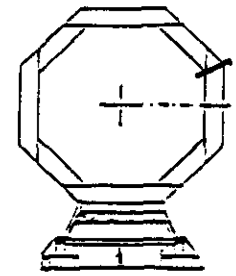

A87_OMM_195E4.STRES
30/Apr/92 10:49:54
Page 34 : LINE 6000 2485.28 9000 3727.9 COMP=BMOD AUTO=N VMIN=0.0 VMAX=2
B[Tesla]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
<-- inner steel border
inner steel border -->
X coord 6000.0 6600.0 7200.0 7800.0 8400.0 9000.0
Y coord 2485.28 2733.8 2982.33 3230.85 3479.38 3727.9
_Values of BMOD
X[mm]
VF/PE2D.8

Fig.12-1



A87_OMM_195E4.STRES
30/Apr/92 10:55:17 Page 37 : LINE 6600 2734 8400 3479 COMP=BMOO AUTO=N VMIN=1.3 VMAX=1.9 NP

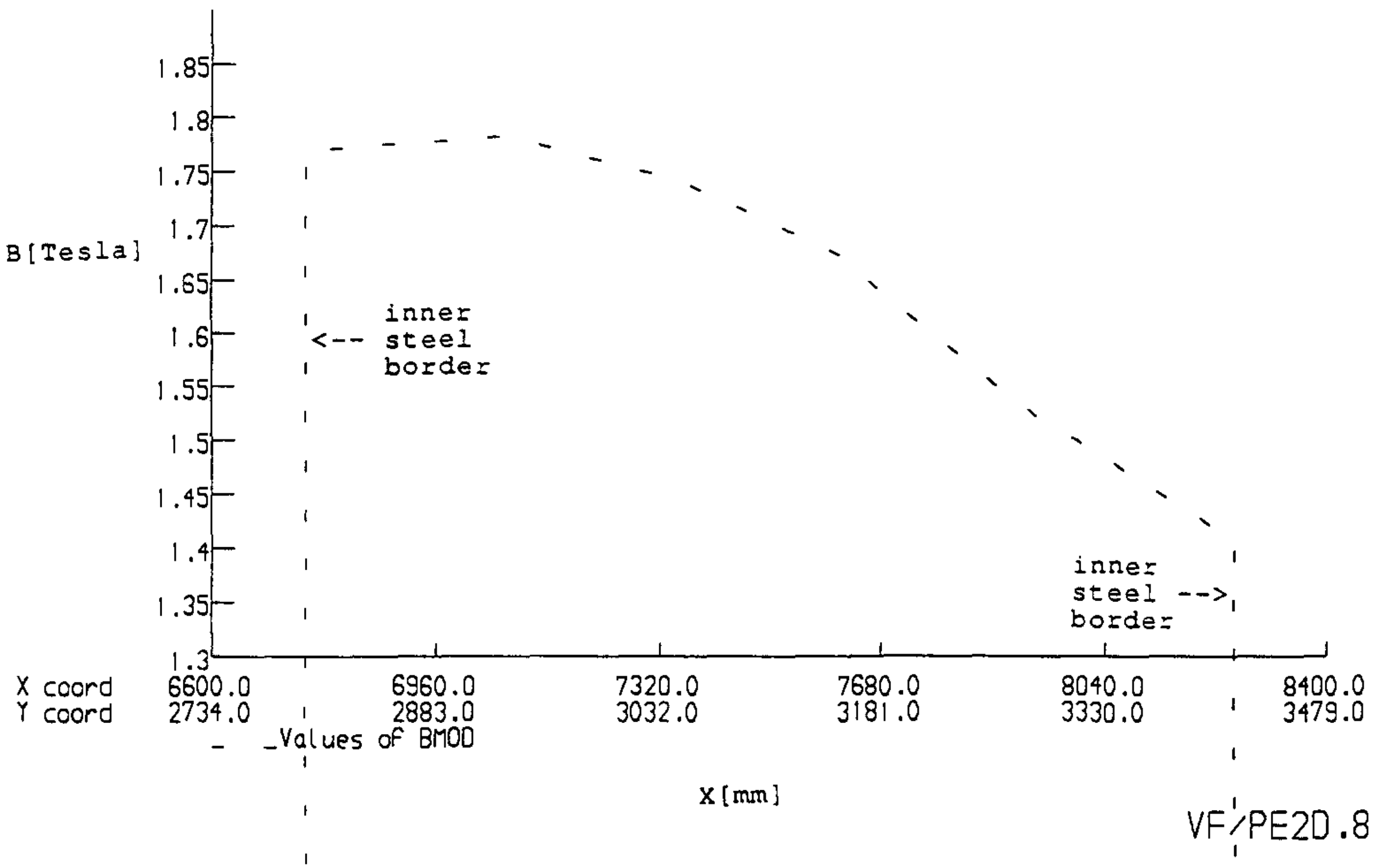
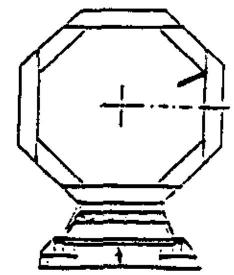
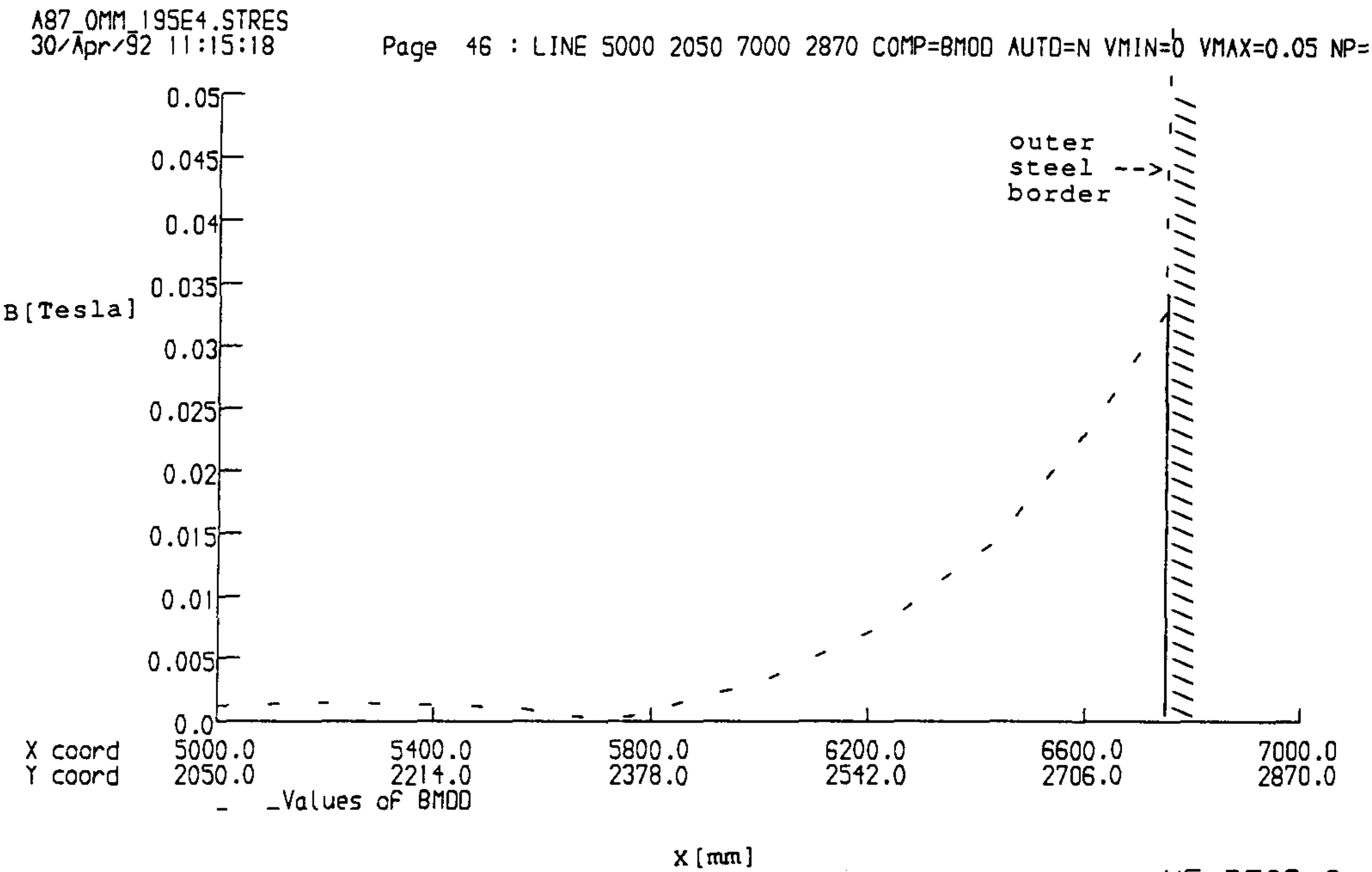


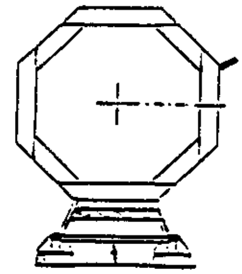
Fig.12-2

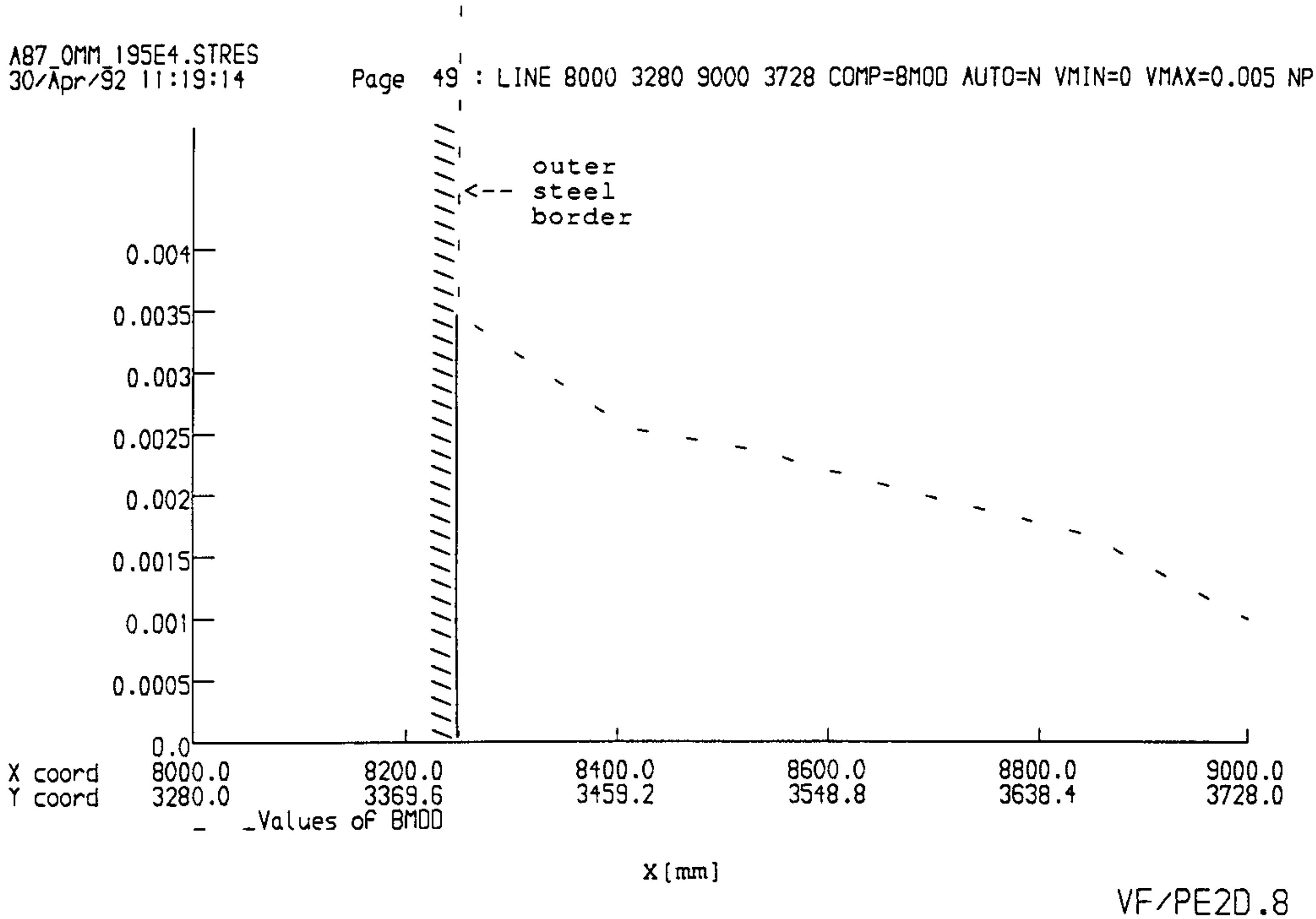




VF/PE2D.8

Fig.12-3





A87_OMM_195E4.STRES
30/Apr/92 11:19:14
Page 49 : LINE 8000 3280 9000 3728 COMP=BMOD AUTO=N VMIN=0 VMAX=0.005 NP
outer
<-- steel
border
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0.0
X coord 8000.0 8200.0 8400.0 8600.0 8800.0 9000.0
Y coord 3280.0 3369.6 3459.2 3548.8 3638.4 3728.0
_Values of BMOD
X [mm]
VF/PE2D.8

Fig.12-4