LBL-7069 v.2
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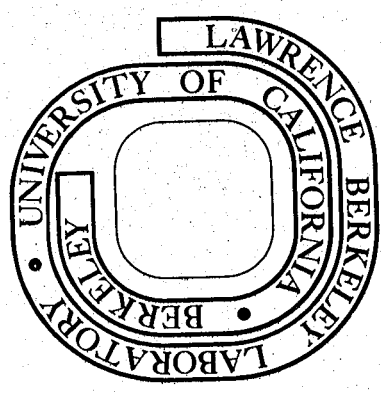
Preliminary Thermal and Thermomechanical Modeling for the Near Surface Test Facility Heater Experiments at Hanford

VOLUME II (Appendix D)

Tin Chan and Janet S. Remer
Earth Sciences Division

December 1978



Prepared for the U. S. Department of Energy
under Contract W-7405-ENG-48
and for Rockwell Hanford Operations —
a Department of Energy Prime Contractor —
under Memorandum Order No. W8A-SBB-51760

LBL-7069

PRELIMINARY THERMAL AND THERMOMECHANICAL MODELING FOR THE NEAR SURFACE TEST FACILITY HEATER EXPERIMENTS AT HANFORD

Volume 2 (Appendix D)

Tin Chan and Janet S. Remer

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Berkeley, California 94720

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CONTENTS: Volume 2 (Appendix D)

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PREFACE

Appendix D is a complete set of figures illustrating the detailed calculations necessary for designing the heater experiments at the Near Surface Test Facility (NSTF) at Hanford, Washington. The discussion of the thermal and thermomechanical modeling that yielded these calculations is presented in Volume 1. A summary of the figures and the models they illustrate is given in Table D1. The most important figures have also been included in the discussion in Volume 1, and Table D2 lists the figure numbers in this volume that correspond to figure numbers used there.

Contents: Volume 1

Table D1. Summary of figures representing models studied.

(a) Full-Scale Experiments

	Temperature Calculations		Displacement Calculations		Stress Calculations	
Power Schedule	Infinite Medium	Isothermal Boundary	Mesh 1	Mesh 7	Mesh 1	Mesh 7
1a (Fig. 2a)	D6a,D7a D8a-D8m	D9a-D9m	D12a,D12b D14a,D14b D15a,D15b D16a,D16b D20a-D20l	D12a,D12b D17a,D17b D18a,D18b D19a,D19b D22a,D22b	D24a-D24m	D26a,D26b,D27a,D27b
1b (Fig. 2b)	D6b,D7b					
1c (Fig. 2c)	D6c,D7c					
2a (Fig. 2d)	D6d,D7d D10a-D10m	D11a-D11m	D13a,D13b D14a,D14b D15a,D15b D16a,D16b D21a-D21l	D13a,D13b D17a,D17b D18a,D18b D19a,D19b D23a,D23b	D25a-D25m	D26a,D26b,D27a,D27b
2b (Fig. 2e)	D6e,D7e					
2c (Fig. 2f)	D6f,D7f					
Interference between Experiments with 1a (Fig. 2a) and 2a (Fig. 2d)	D28a,D28b		D30a,D30b		D29a,D29b	

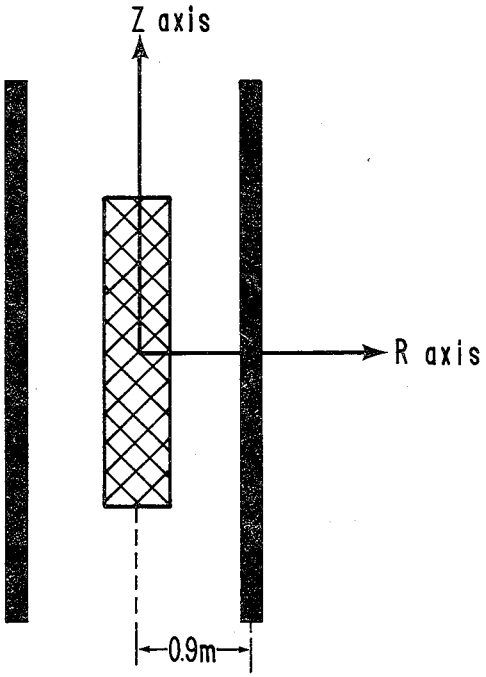
(b) Time-Scaled Experiment

3 (Fig. 4)	D31a-D31h D32a-D32k D33					

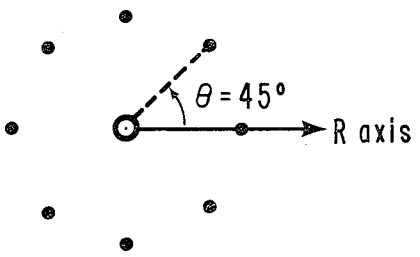
Table D2. Correspondence between figures in Volume 1 and Appendix D, Volume 2.

Figure Number in Volume 1	Figure Number in Appendix D, Volume 2
1	D1
2a-2f	D2a-D2f
3	D3
4	D4
5a-5c	D5a-D5c
6a-6c	D6a,D6d,D6f
7a-7c	D7a,D7d,D7f
8a,8b	D8e,D8i
9a-9c	D9b,D9e,D9i
10a,10b	D10e,D10i
11a-11c	D11b,D11e,D11i
12a,12b	D12a,D12b
13a-13c	D17a,D18a,D19a
14a-14f	D20b-D20f,D20i
15	D22a
16a-16e	D24a-D24c,D24f,D24g
17	D26a
18	D27a
19	D28a
20	D29a
21	D30a
22	D31a
23a,23b	D31b,D31i
24a,24h	D32a,D32c-D32g,D32j,D32k
25	D33

HANFORD FULL-SCALE EXPERIMENT



Vertical plane view



Horizontal plane view

⊙ Central (main) heater :
length = 2.4384 m (8 ft.), radius = 0.2286 m (9 in)
energized at start of experiment.

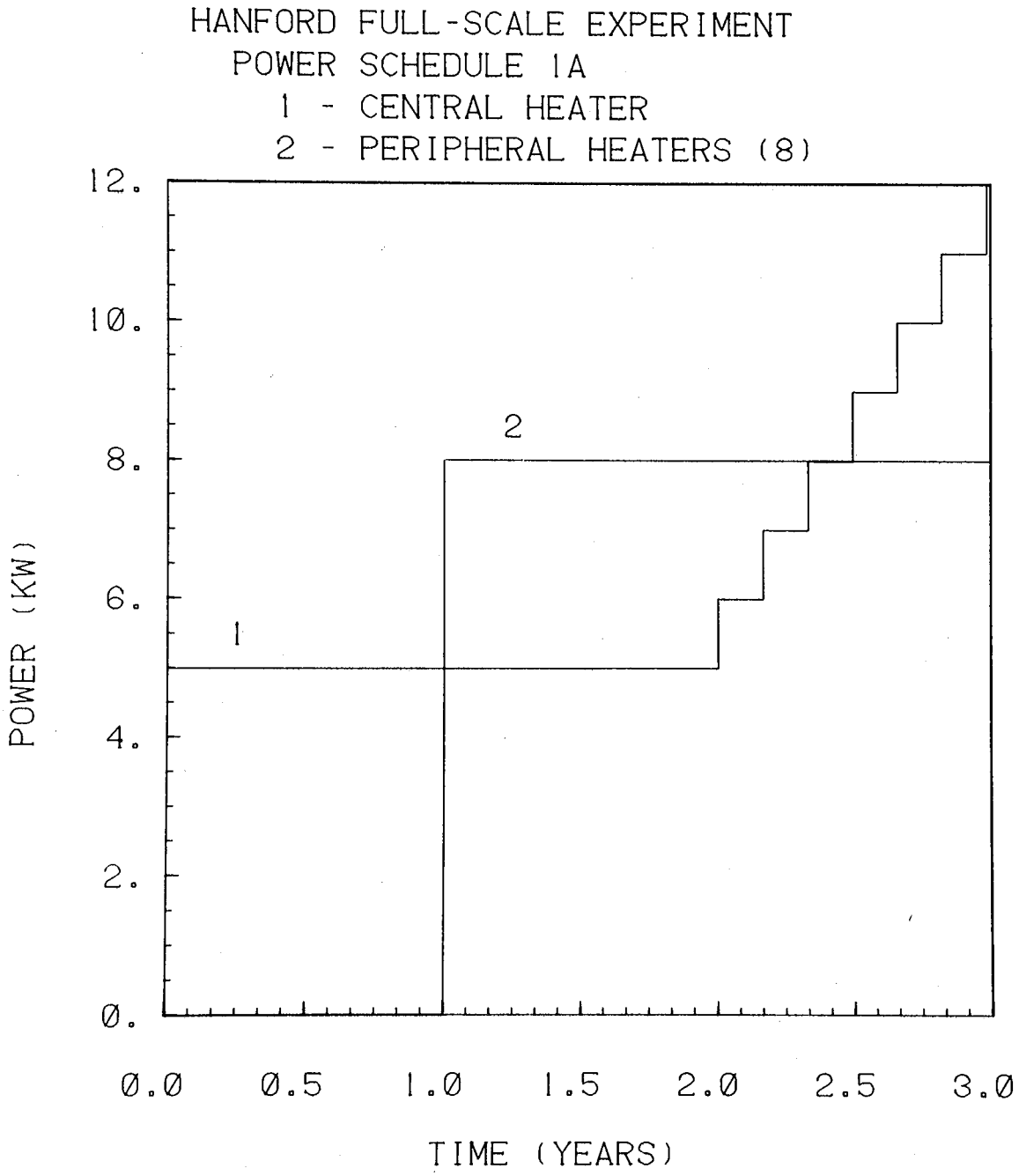
• Peripheral heaters :
length = 4.2672 m (14 ft), radius = 0.0191 m (0.75 in) ;
energized 365 days after start of experiment

Axes represented are those used in numerical modeling.

Diameters of heaters in diagram are greately exaggerated.

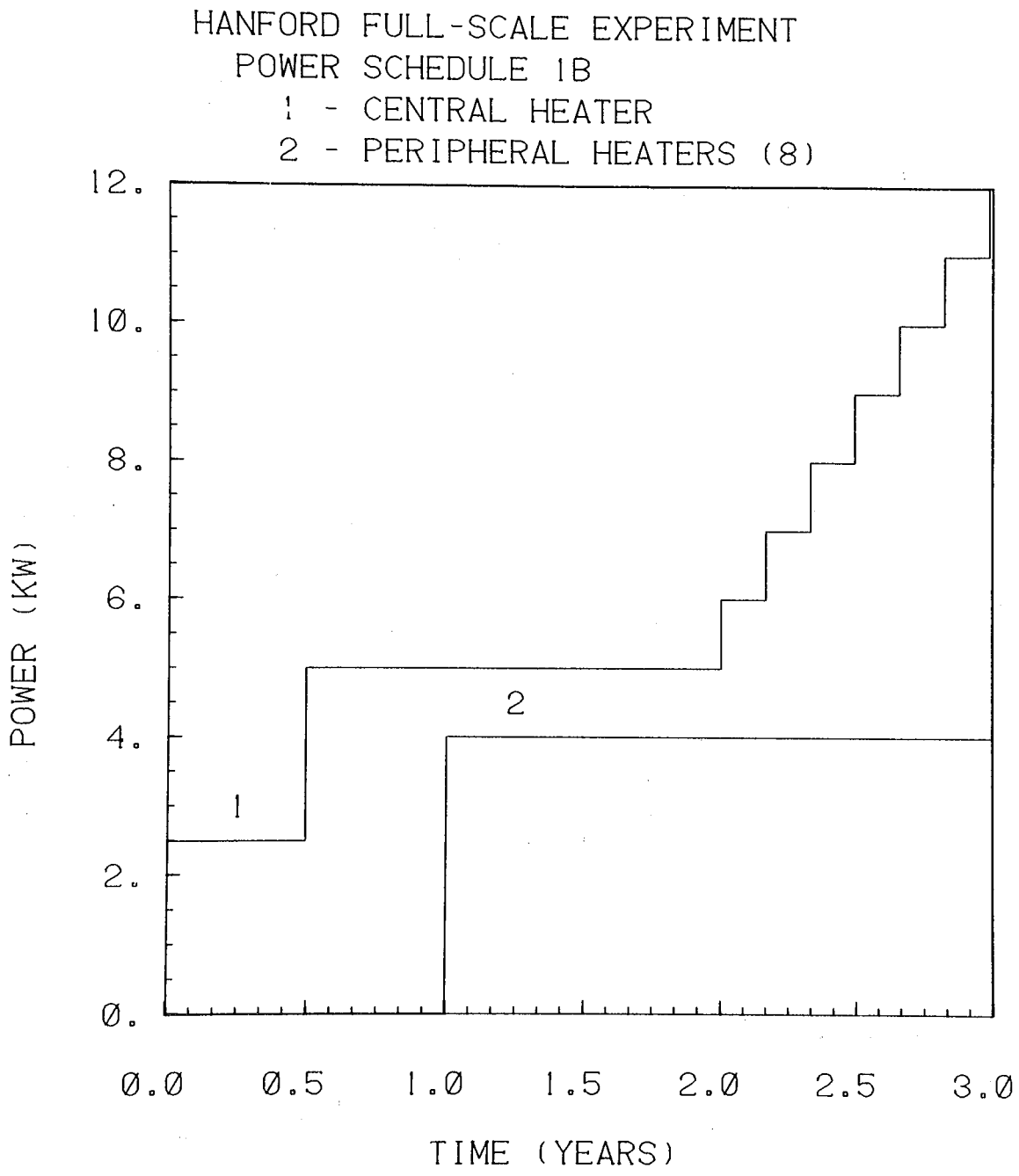
Figure D1

XBL 787-1993



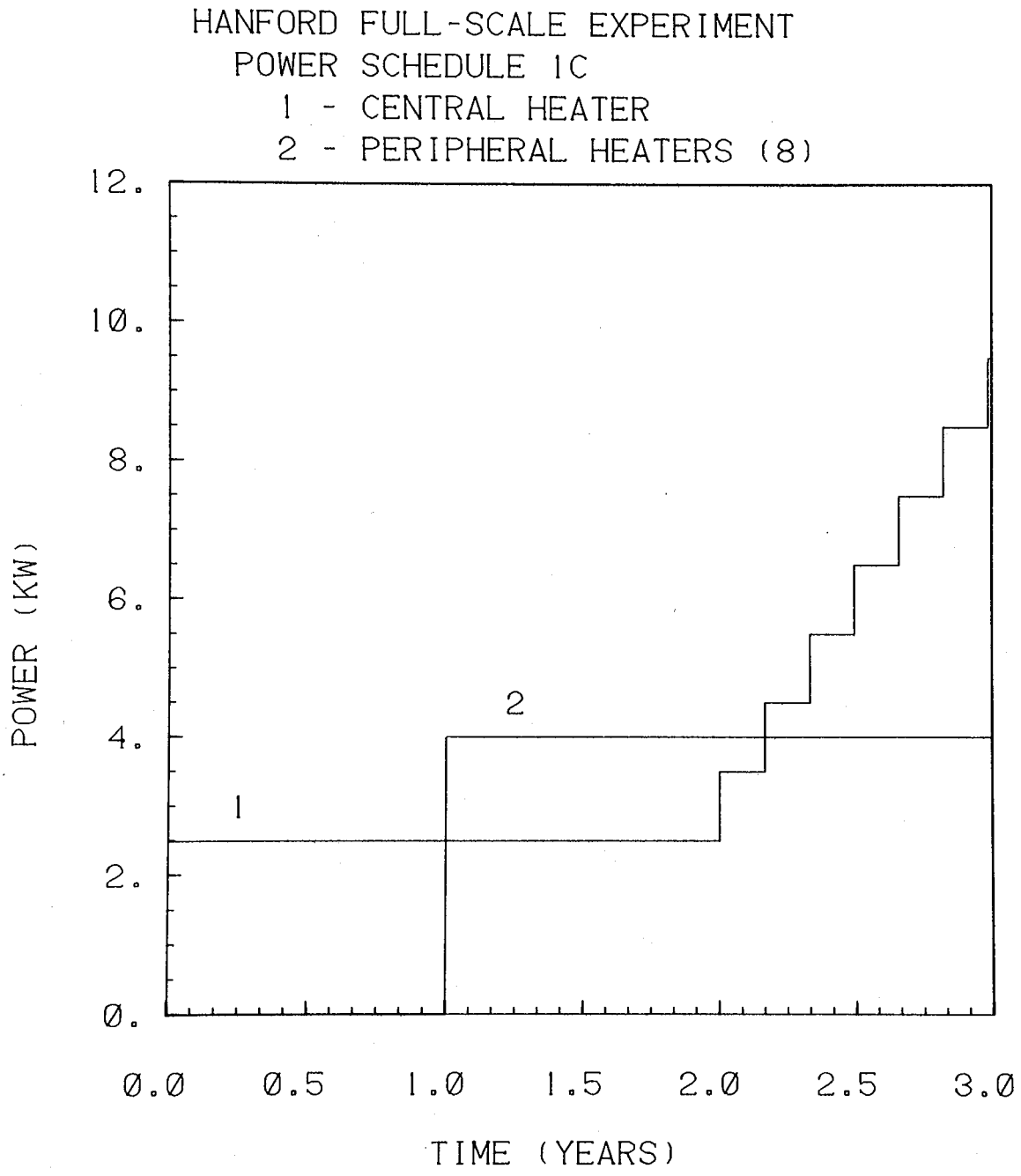
XBL 787-9729

Figure D2a



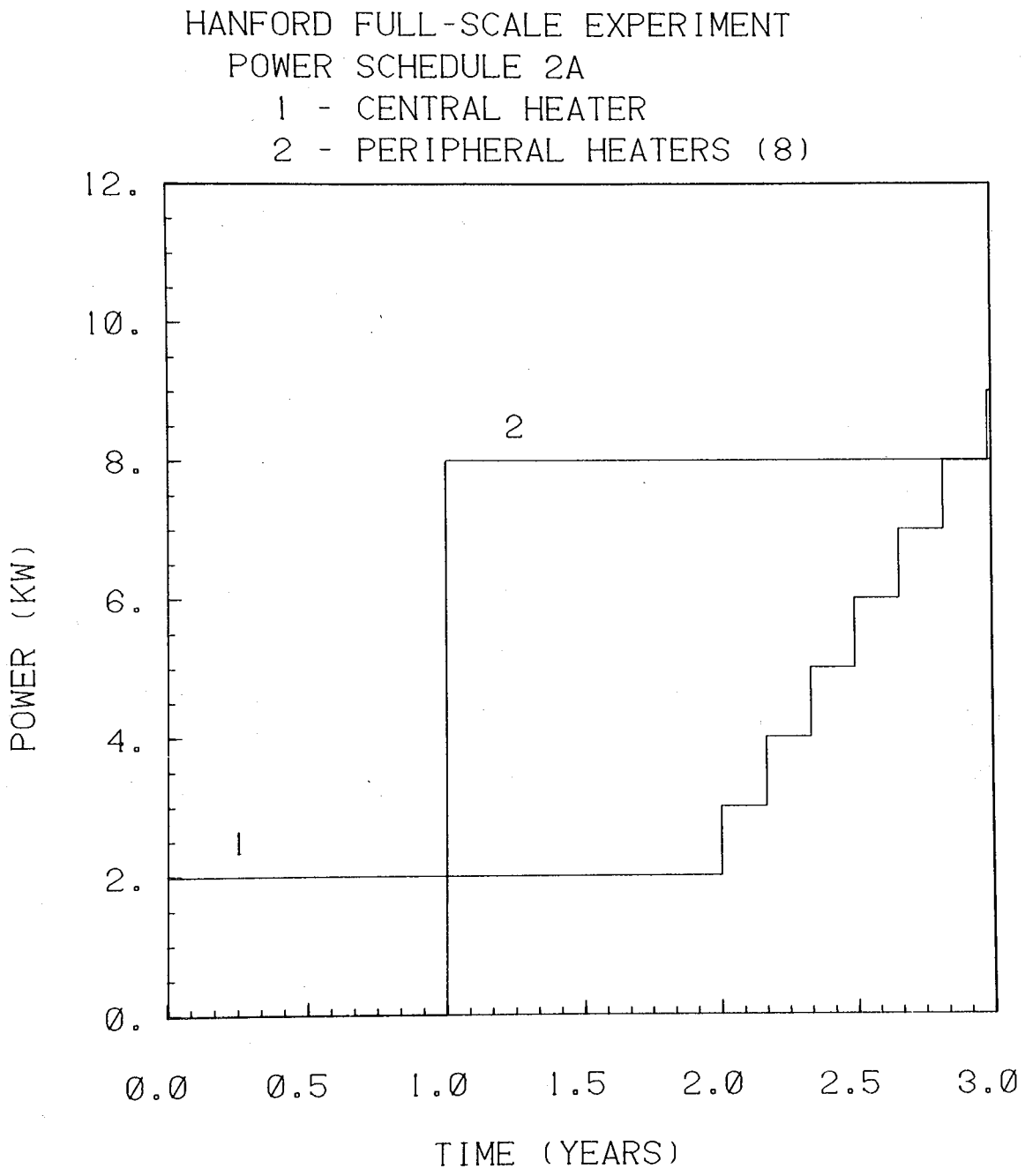
XBL 787-9733

Figure D2b



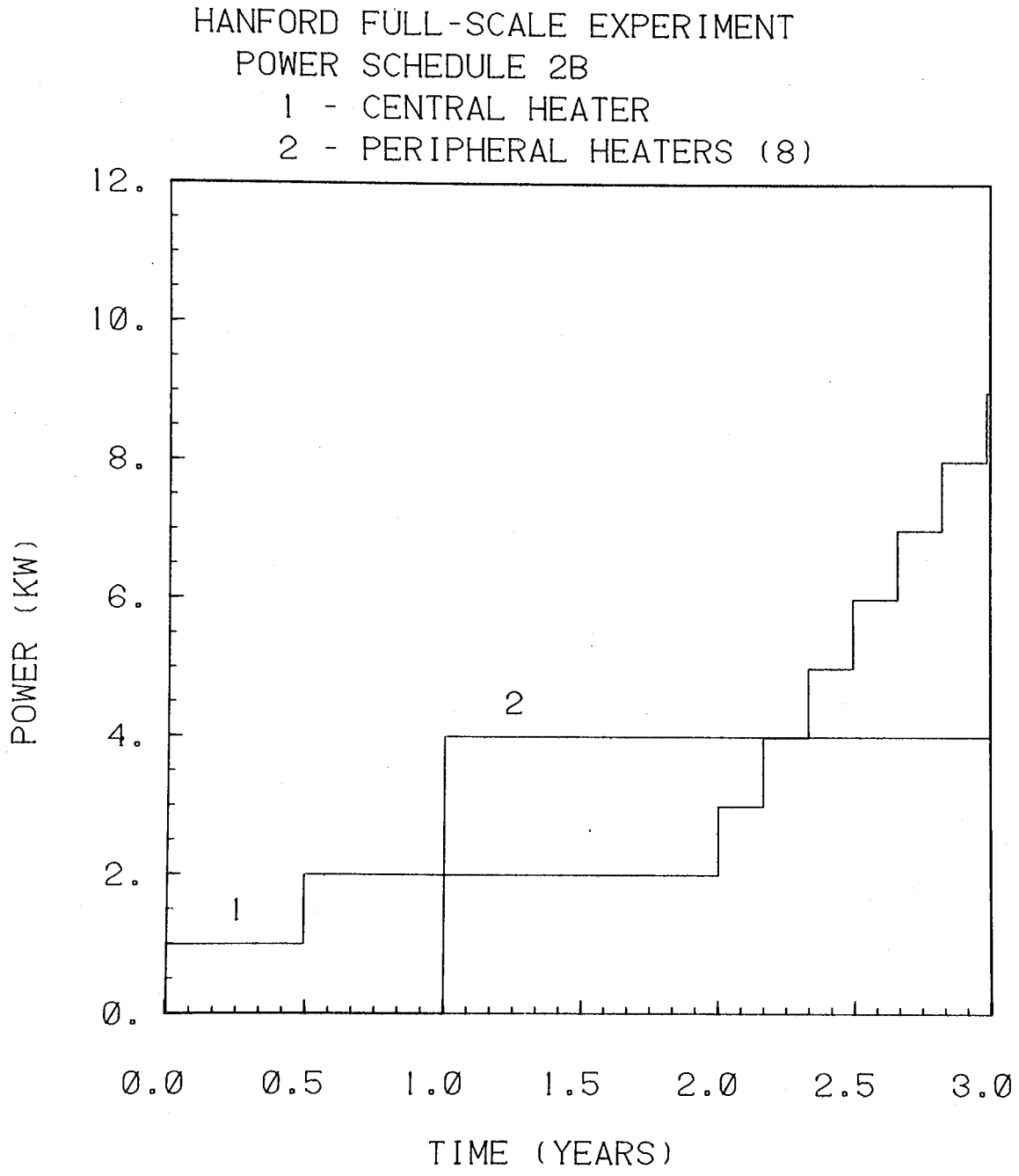
XBL 787-9732

Figure D2c



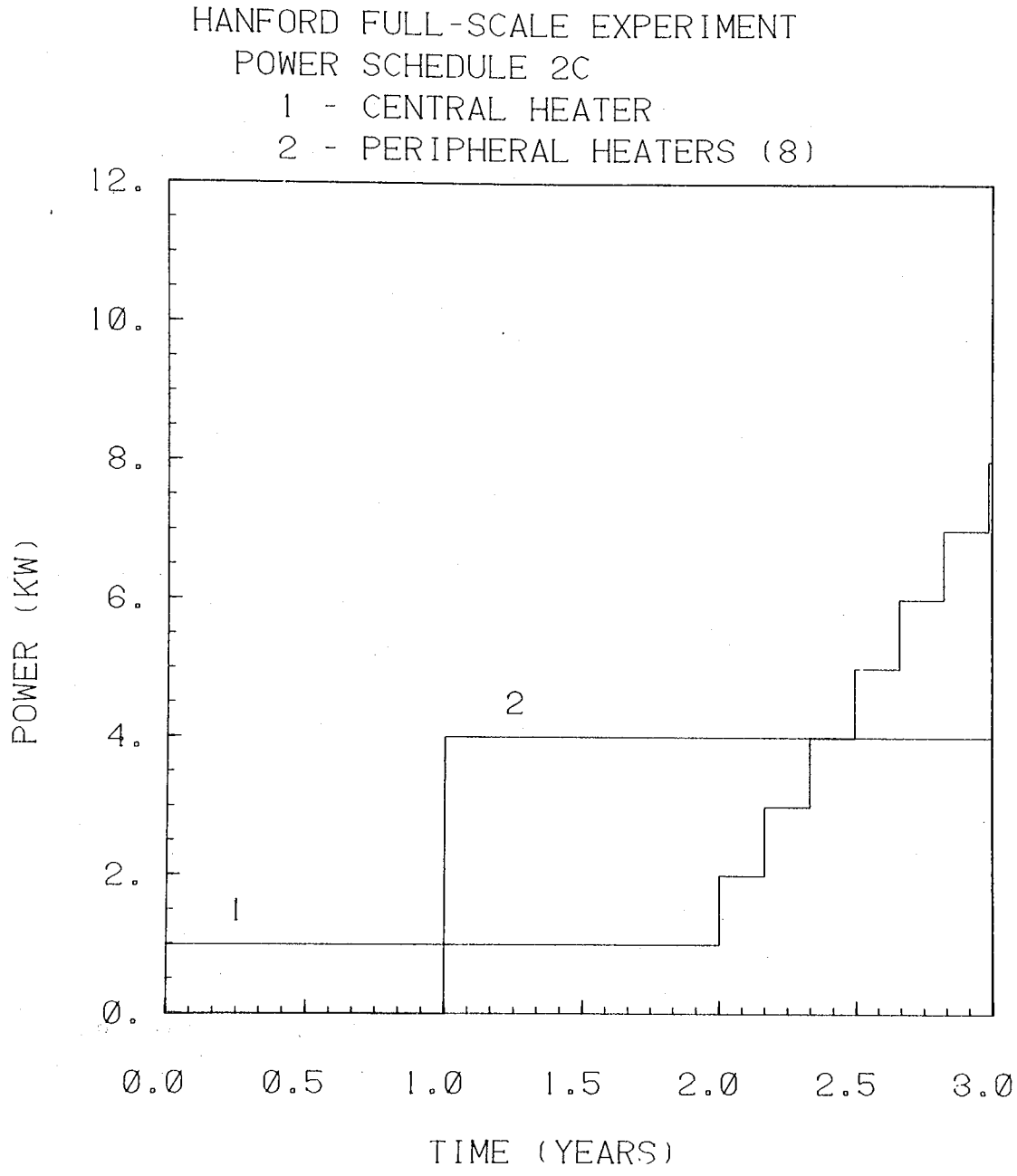
XBL 787-9730

Figure D2d



XBL 787-9731

Figure D2e

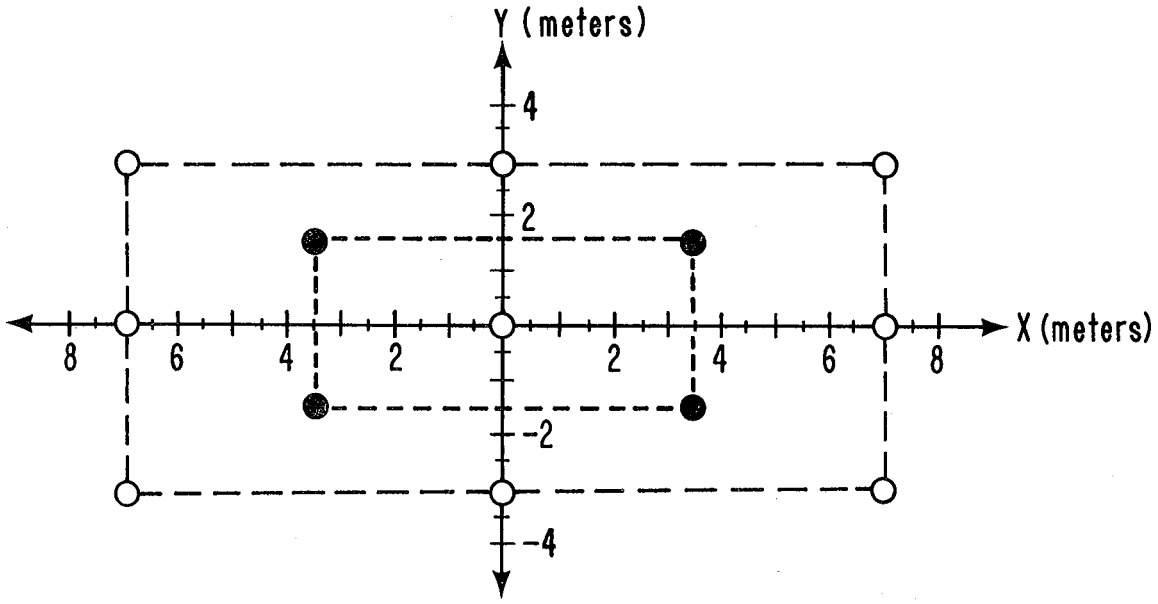


XBL 787-9750

Figure D2f

HANFORD TIME – SCALE EXPERIMENT

Horizontal plane view of arrangement of heaters.



○ Primary heaters: length = 0.81 m; radius = 0.0635 m; energized at start of experiment.

● Secondary heaters: length = 0.81 m; radius = 0.0635 m; energized 730 days after start of experiment.

Axes represented are those used in numerical modeling.

Diameter of heaters in diagram is greatly exaggerated.

XBL 787-1994

Figure D3

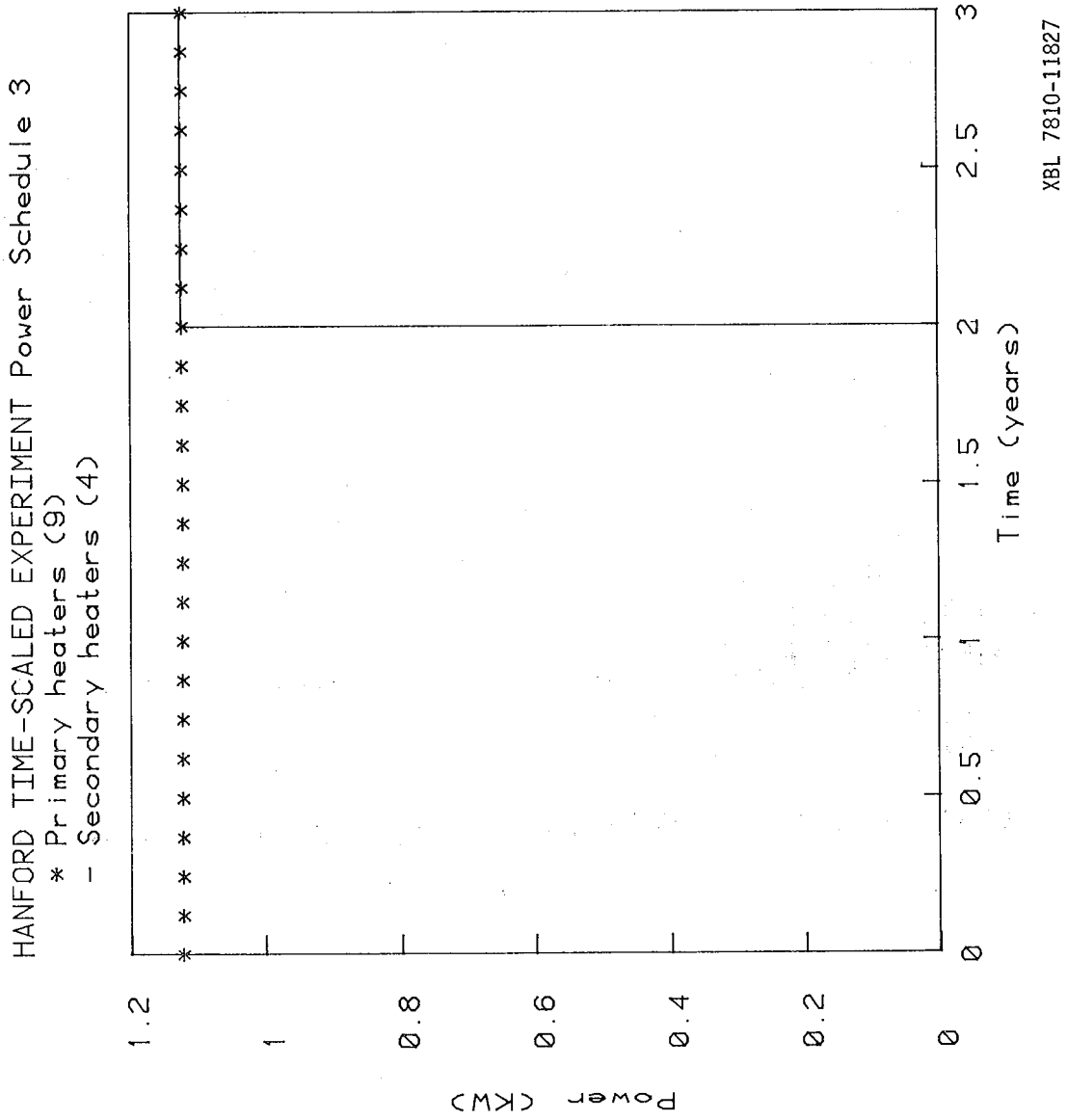
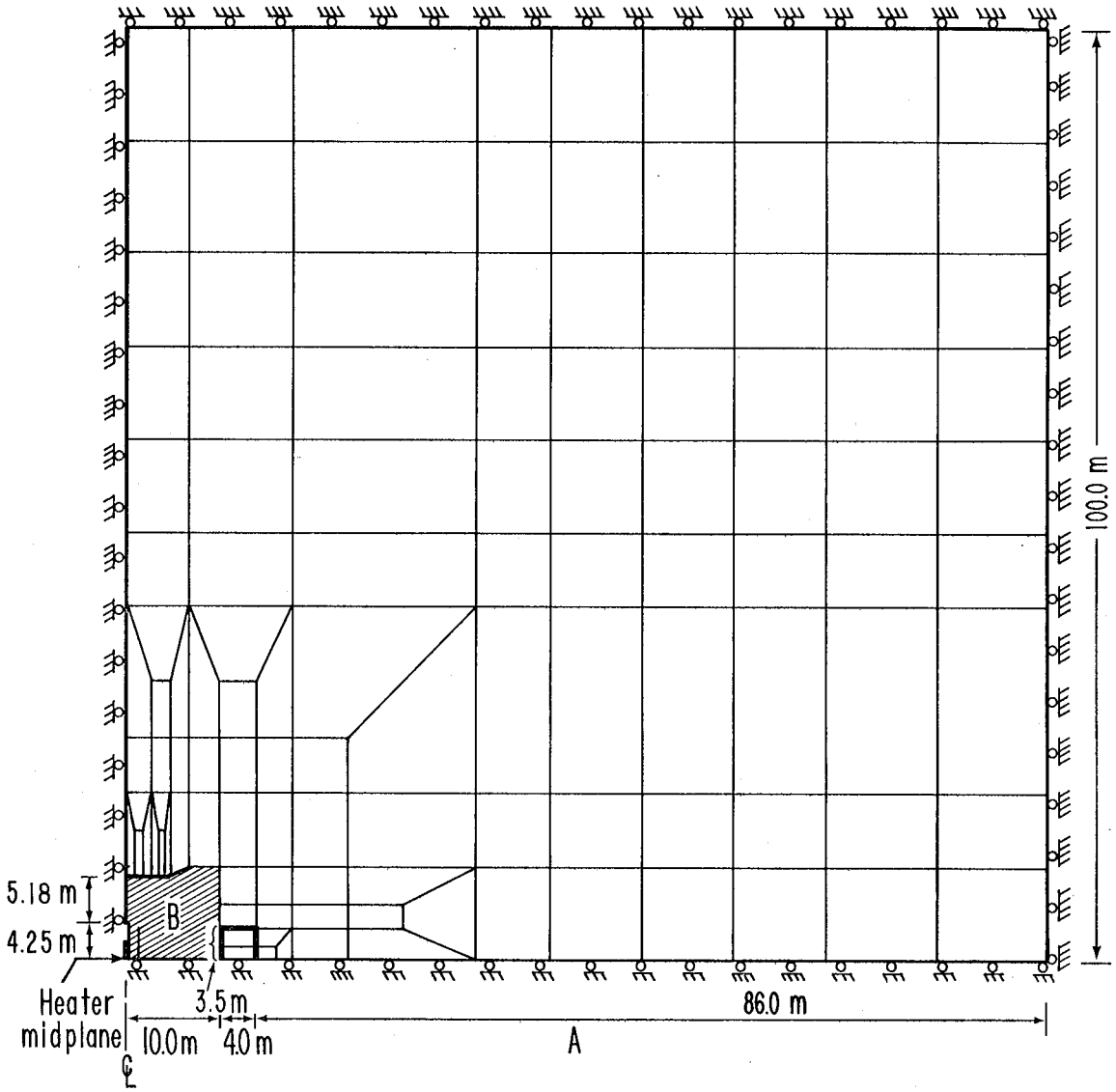

HANFORD TIME-SCALED EXPERIMENT Power Schedule 3
* Primary heaters (9)
- Secondary heaters (4)
Power (KW)
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
Time (years)
XBL 7810-11827

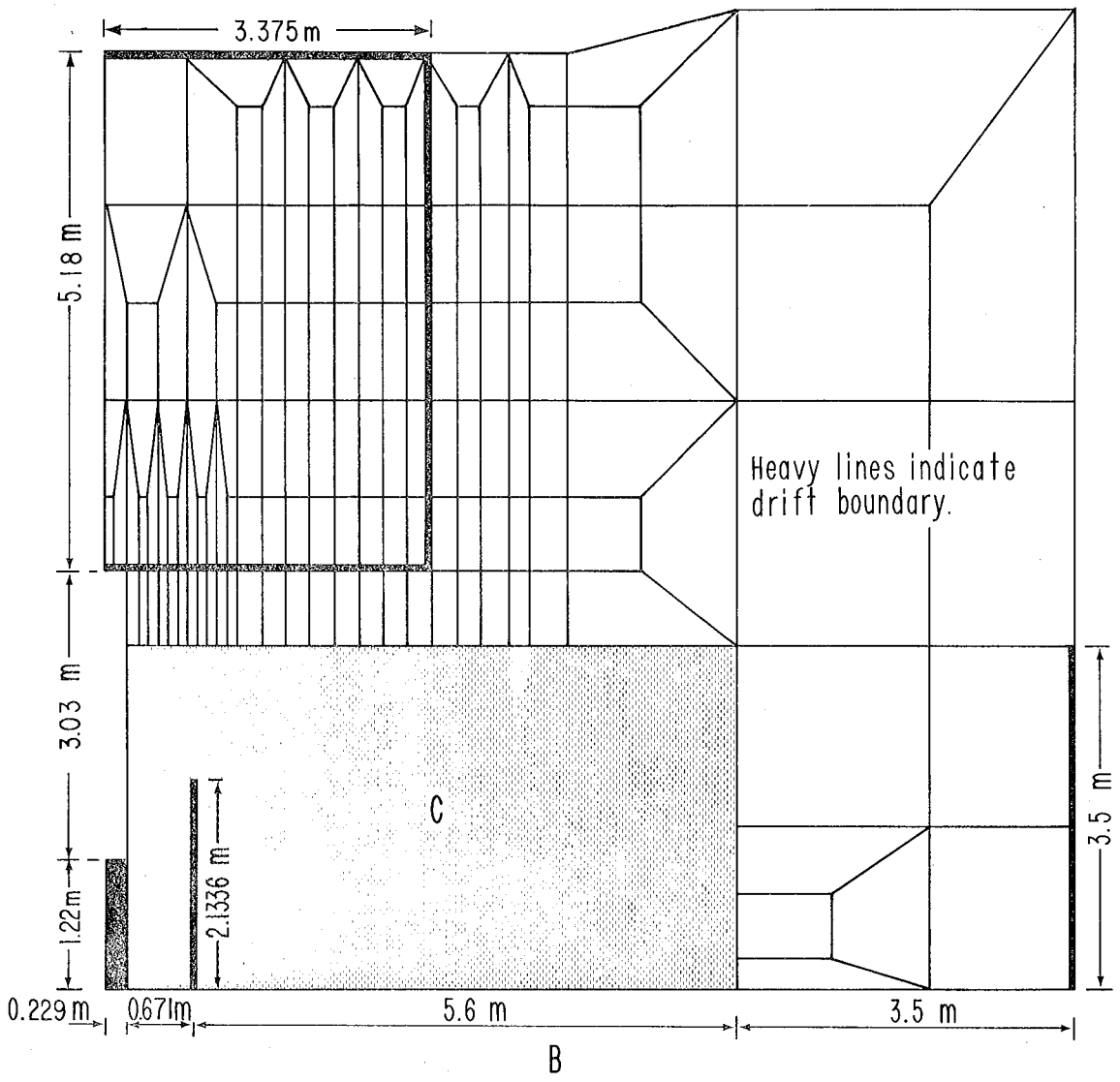
Figure D4



FINITE ELEMENT MESH AND BOUNDARY CONDITIONS FOR FULL SCALE HEATER EXPERIMENT 2.

XBL 786-1962A/B

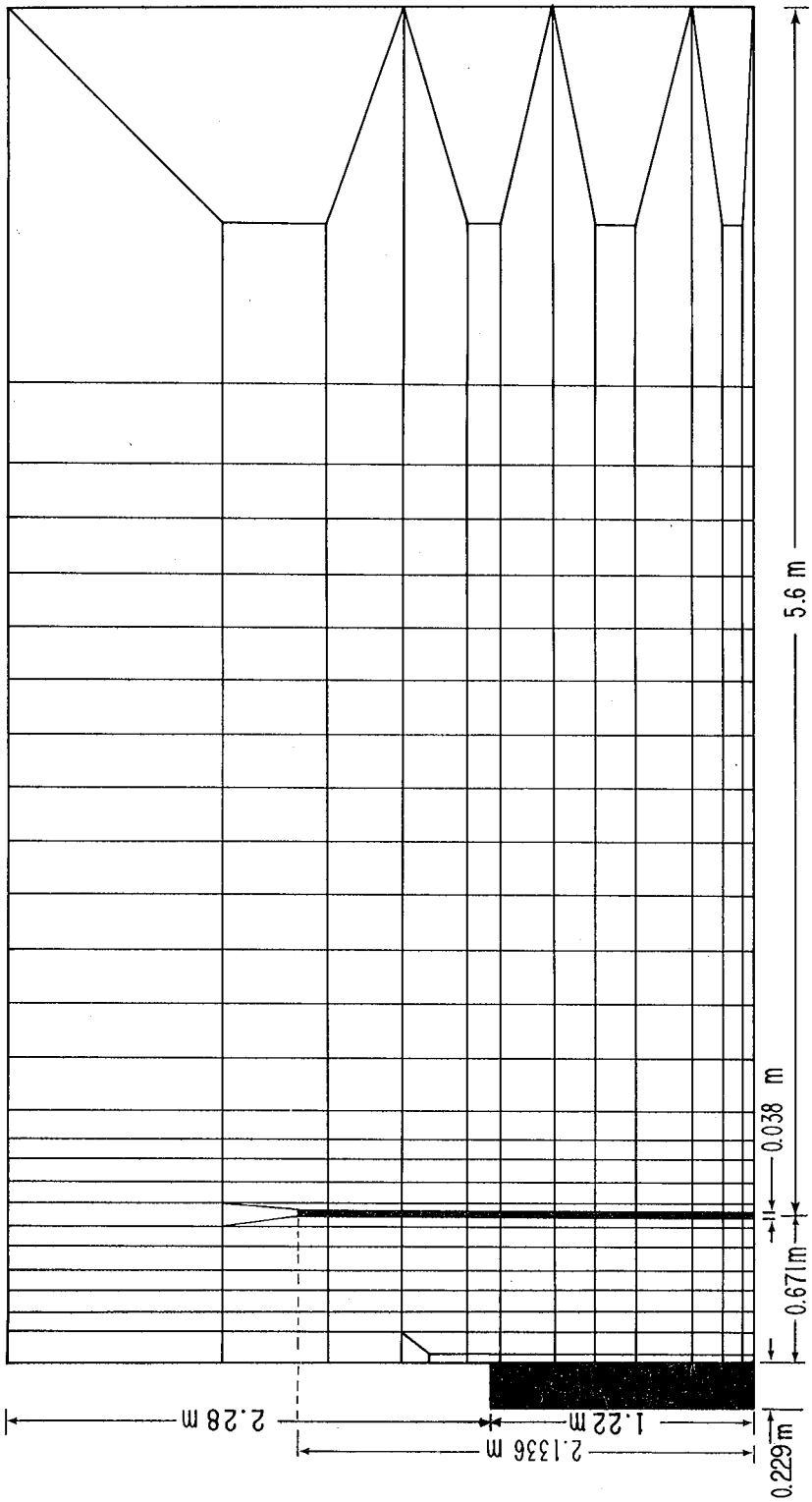
Figure D5a



DETAILS OF AREA "B" IN "A".

XBL 786 – 1964 / B

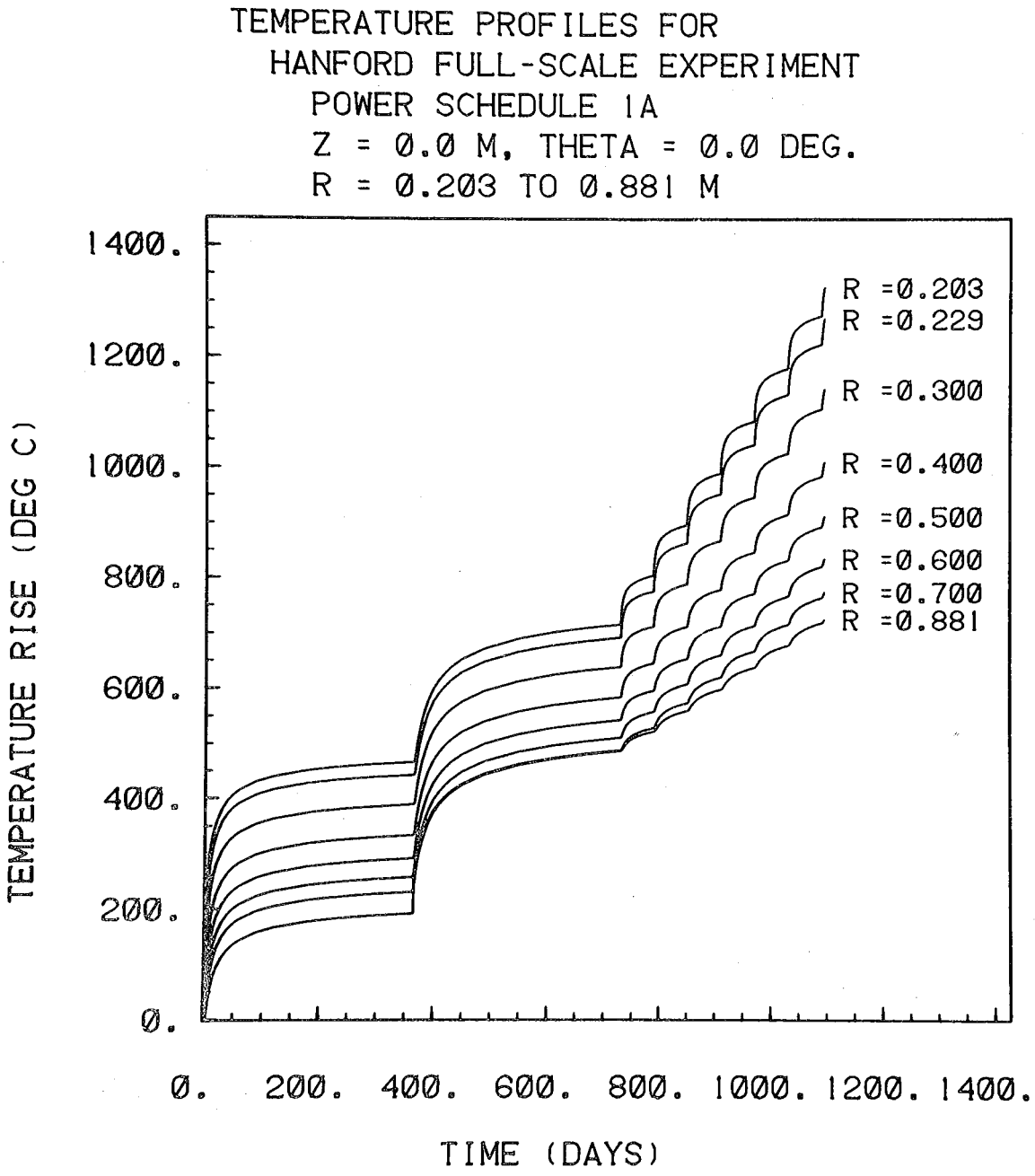
Figure D5b



DETAILS OF AREA "C" IN "B".

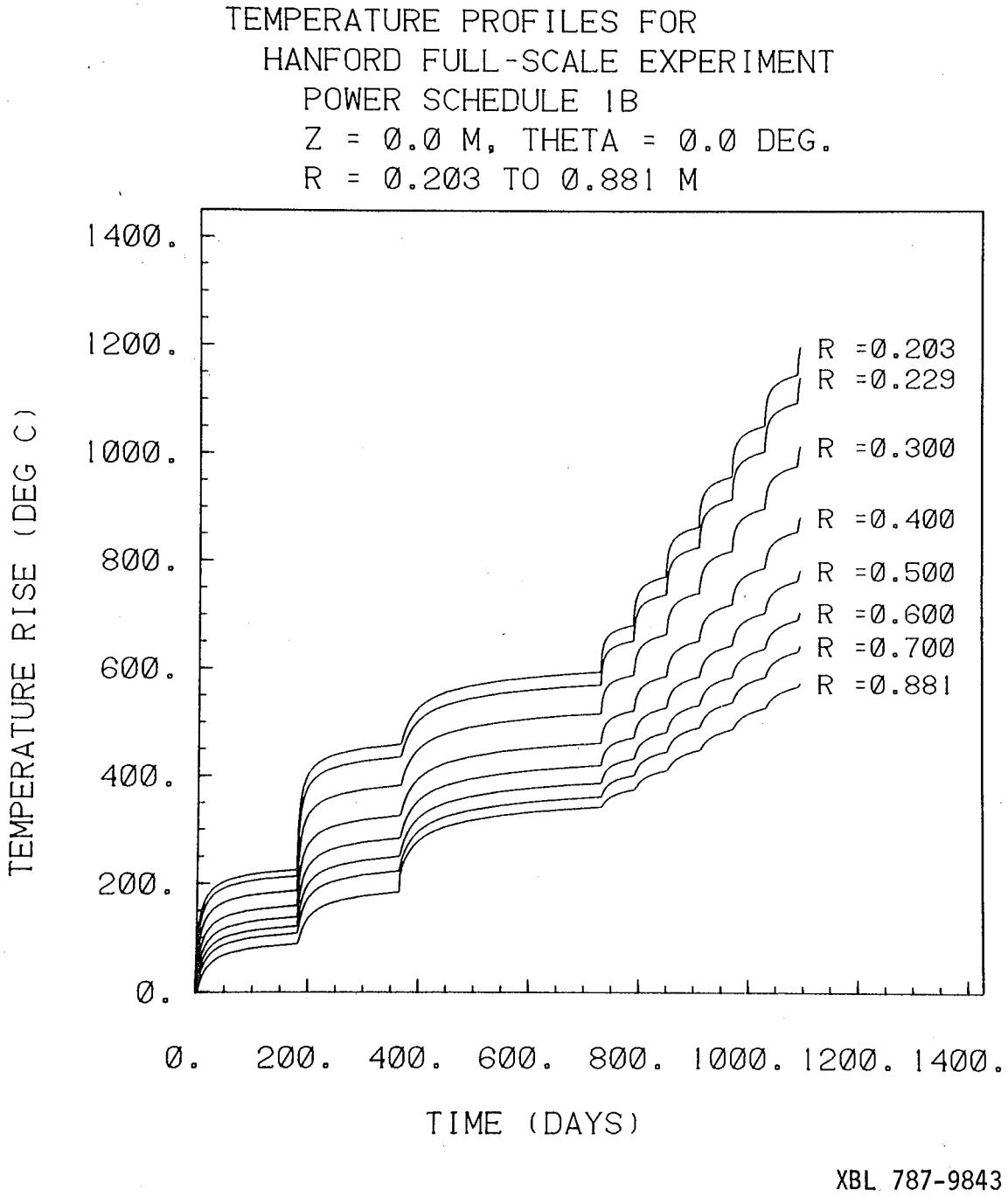
XBL 786-1965A/B

Figure D5c



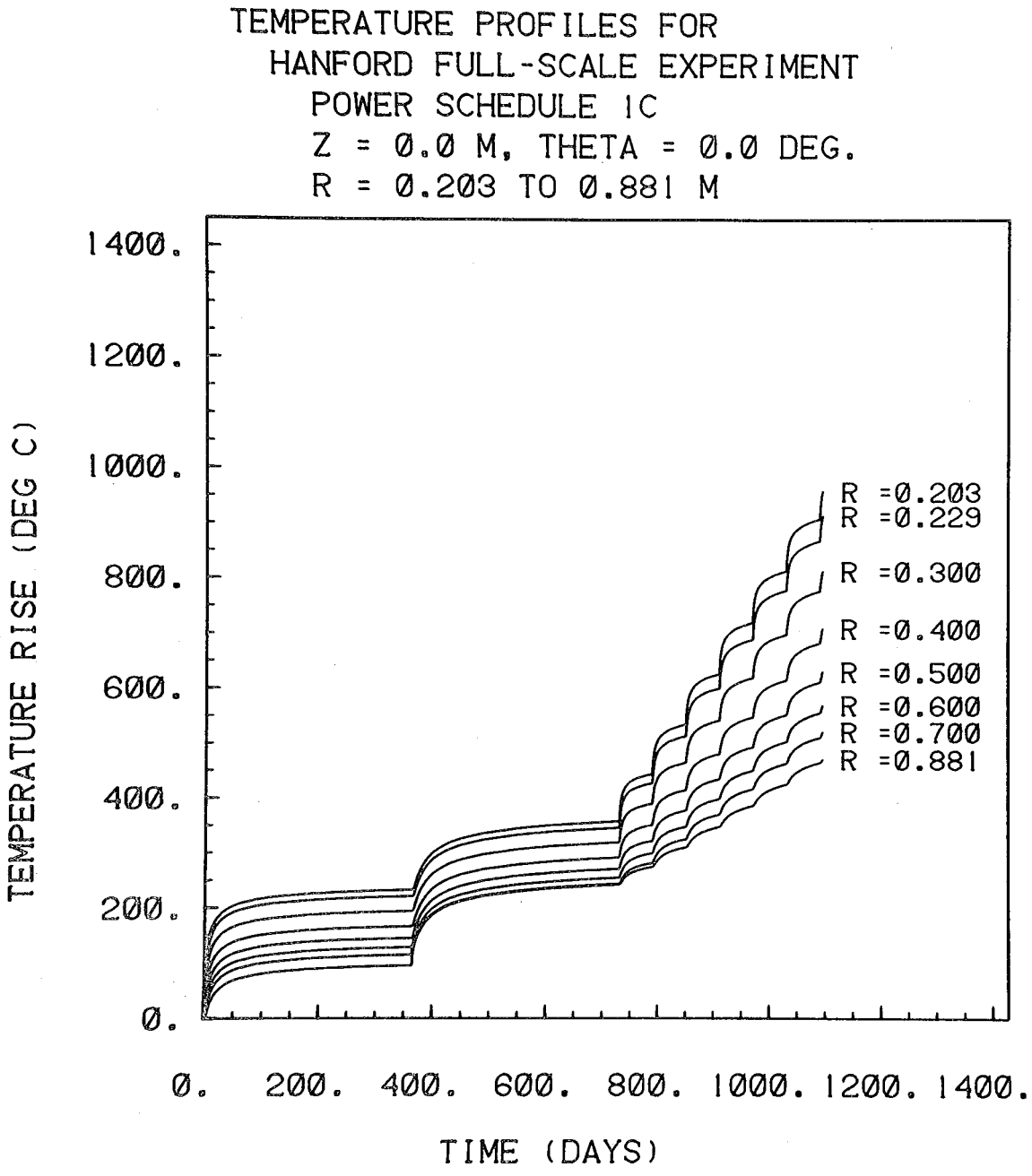
XBL 787-9847

Figure D6a



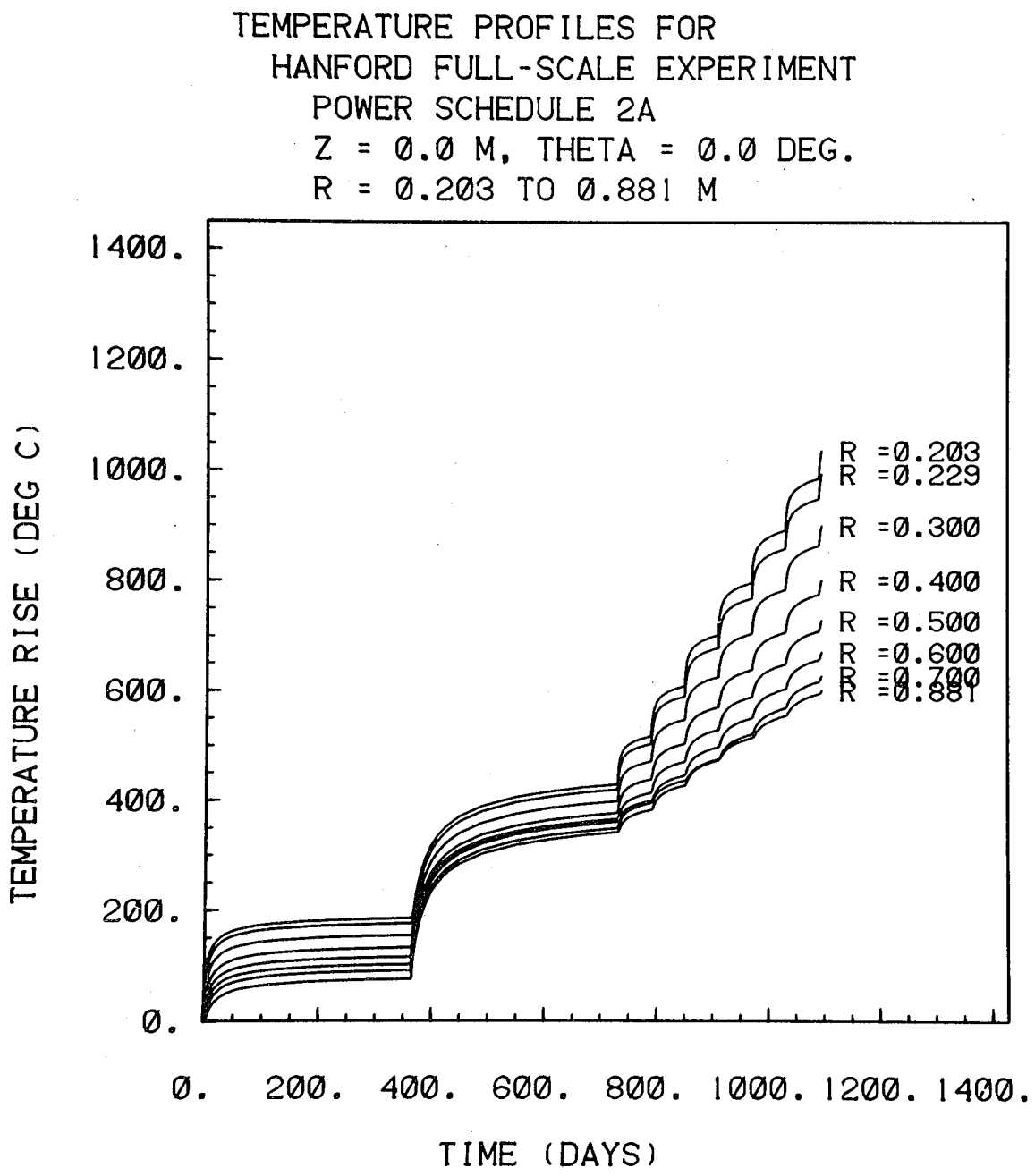
XBL 787-9843

Figure D6b



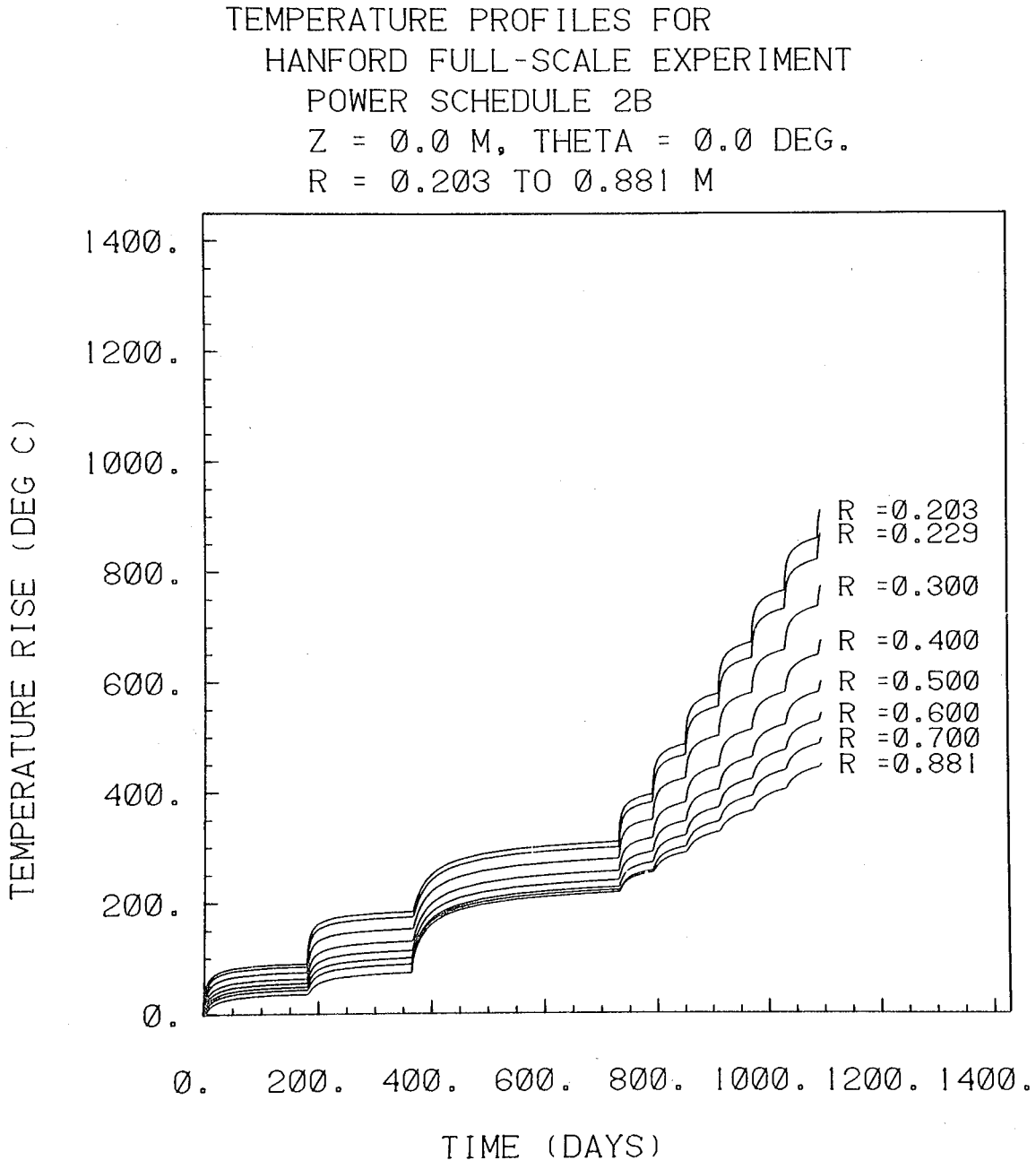
XBL 787-9845

Figure D6c



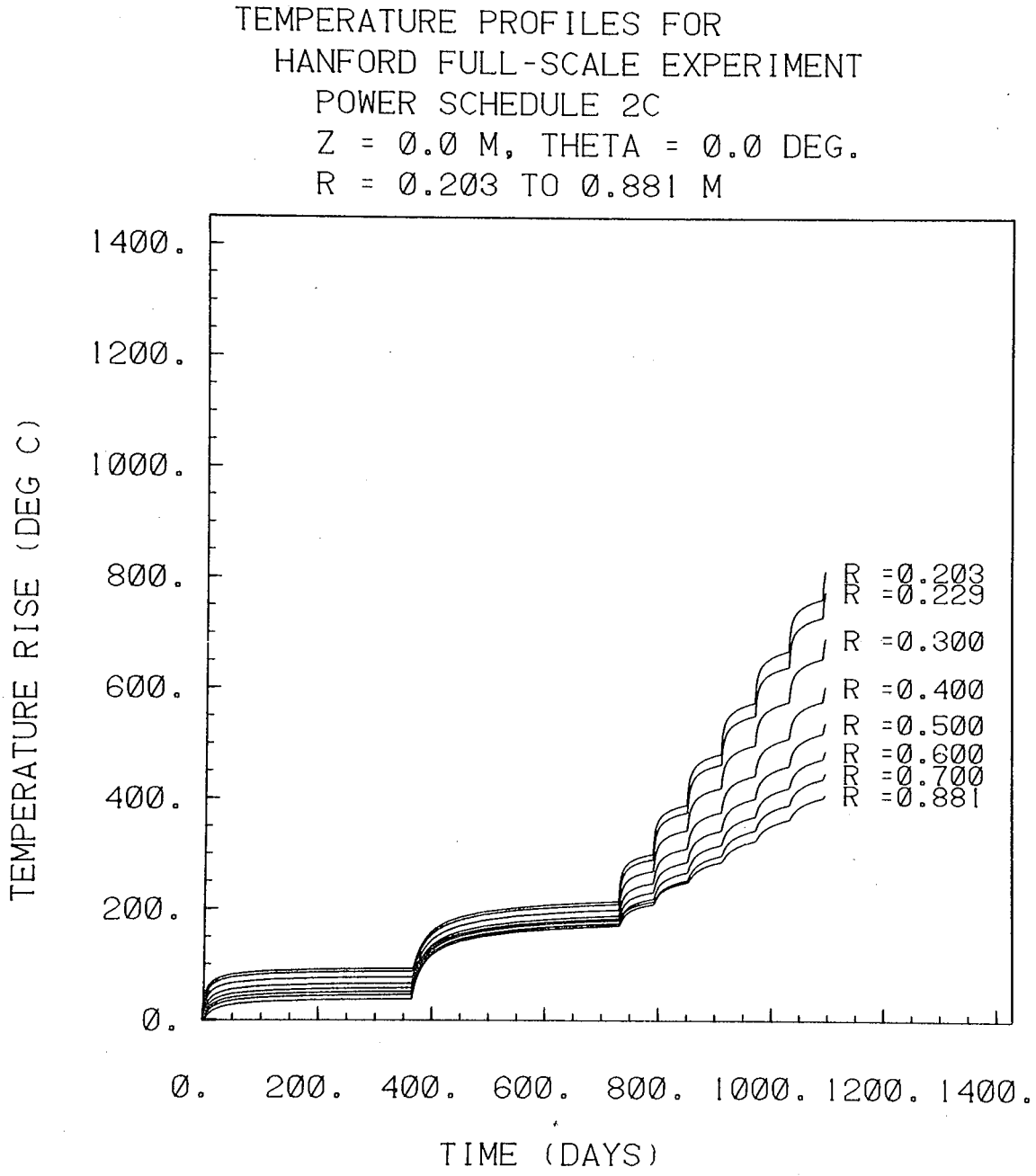
XBL 787-9846

Figure D6d



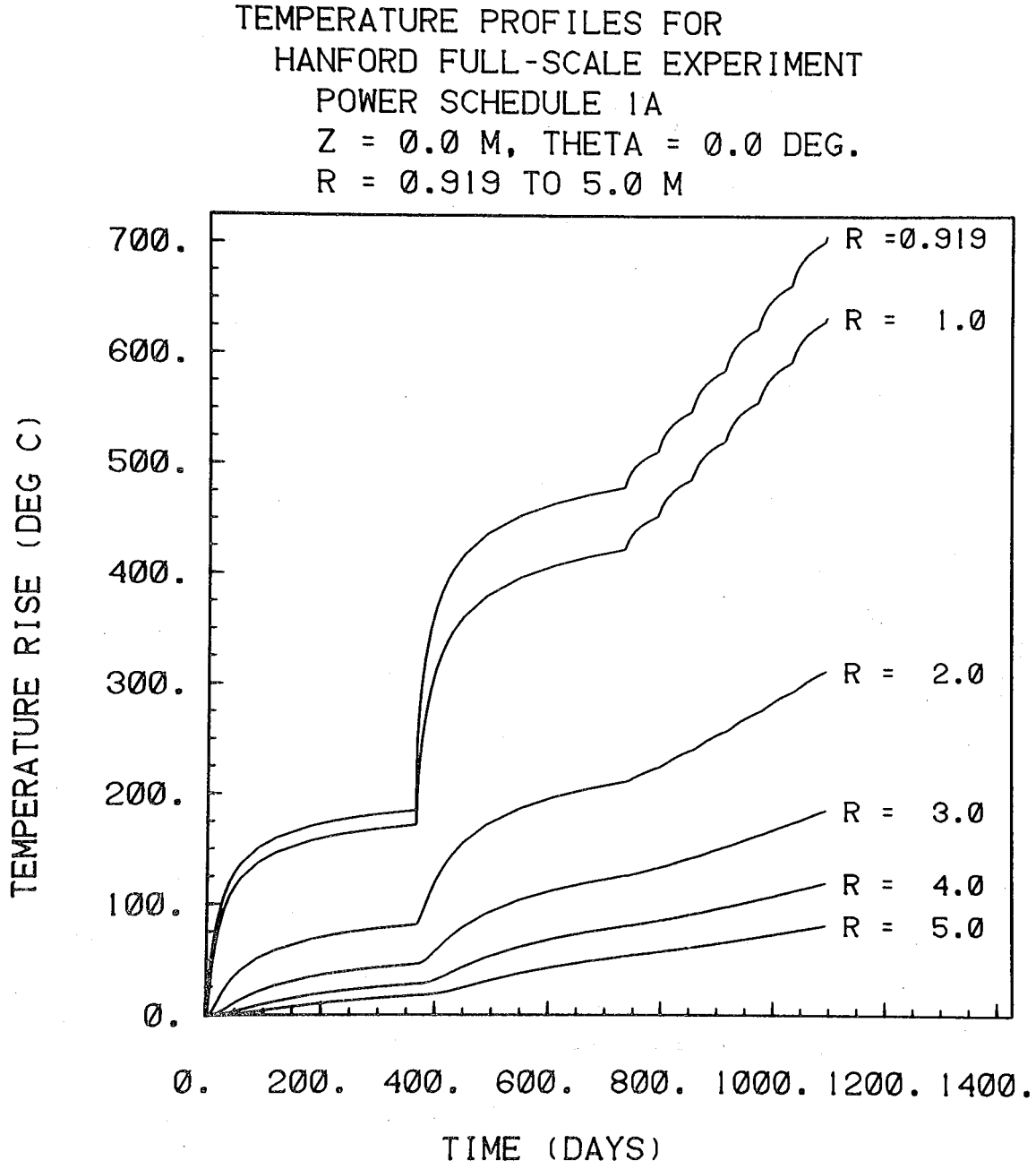
XBL 787-9842

Figure D6e



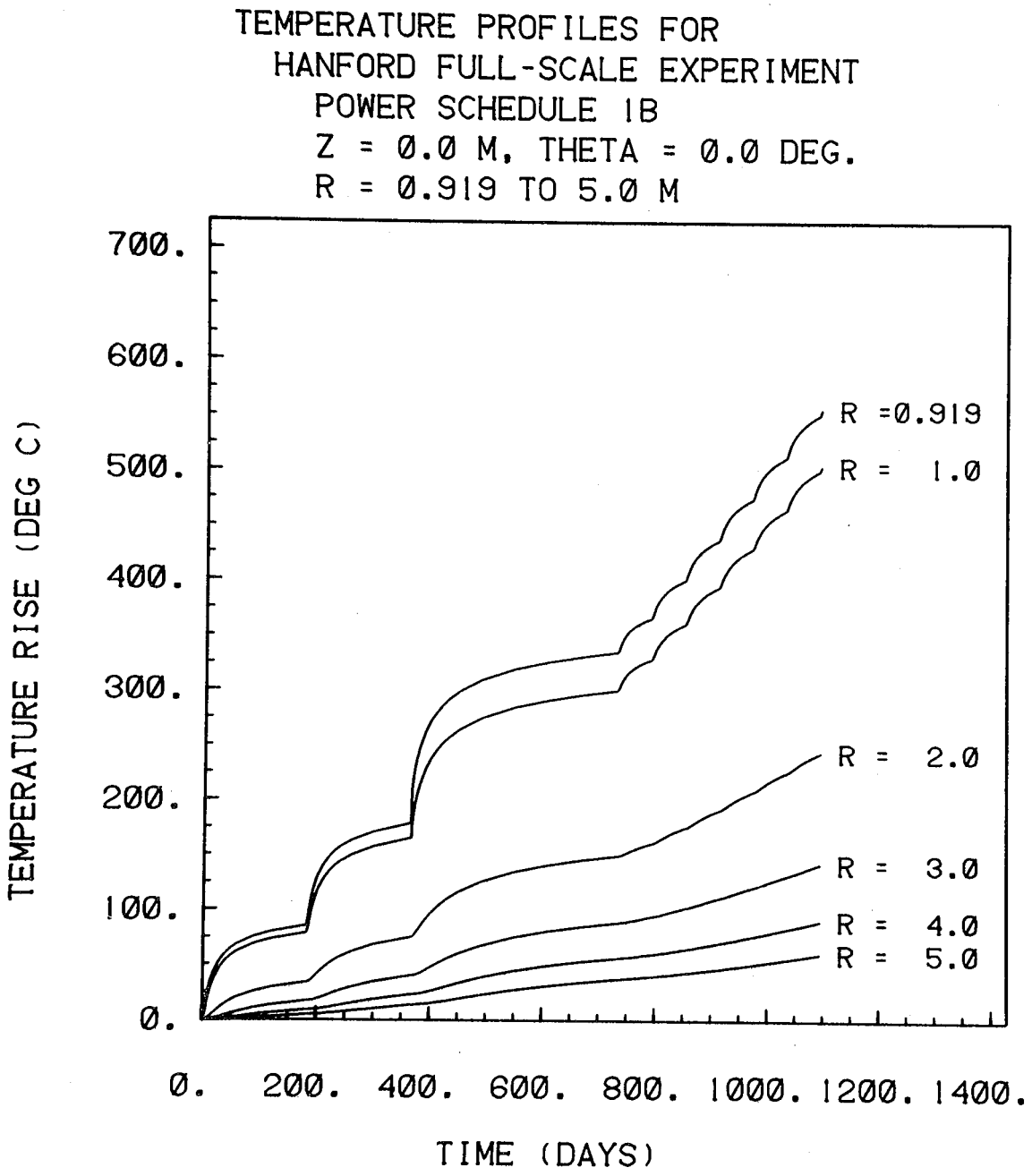
XBL 787-9844

Figure D6f



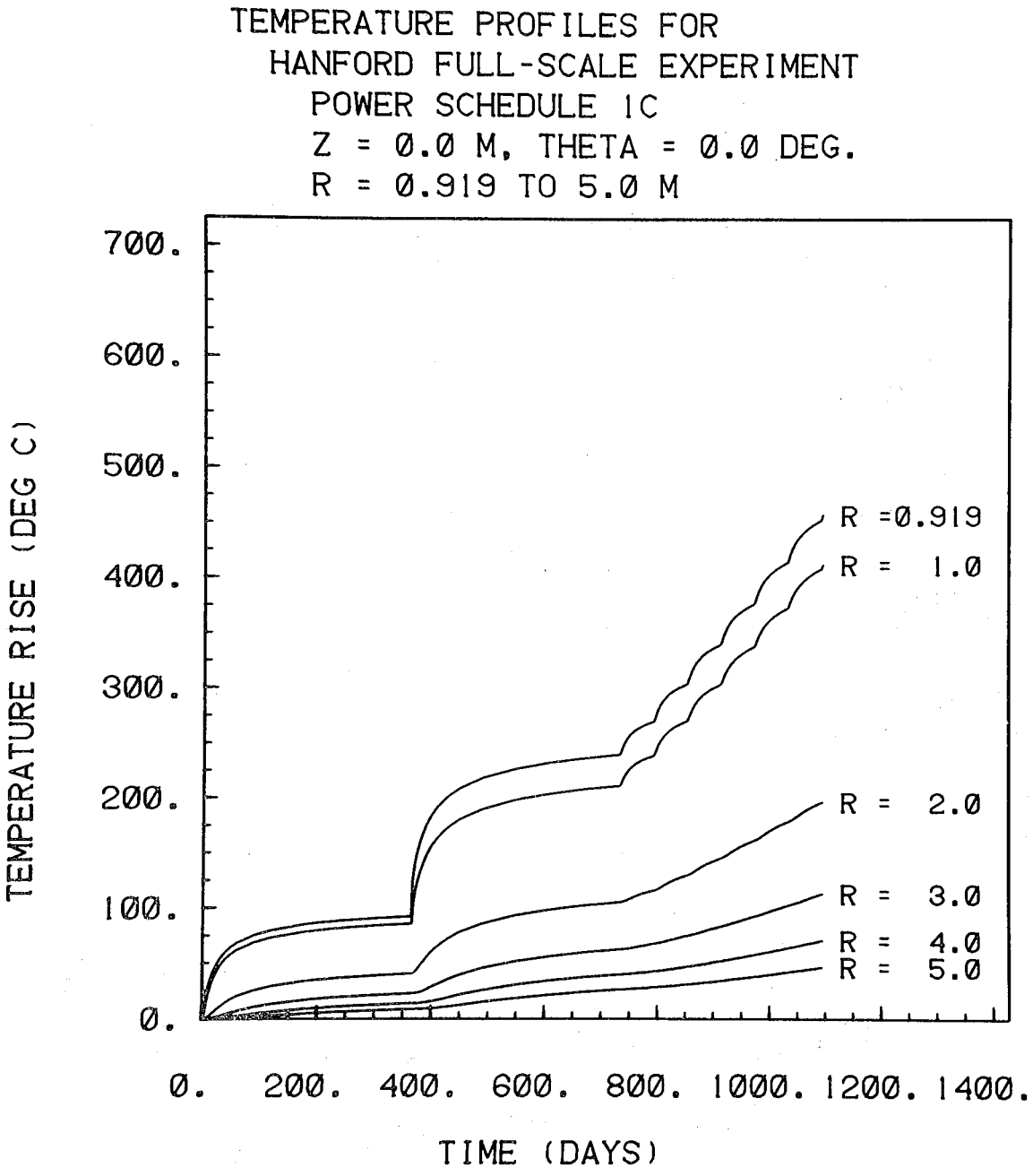
XBL 787-9852

Figure D7a



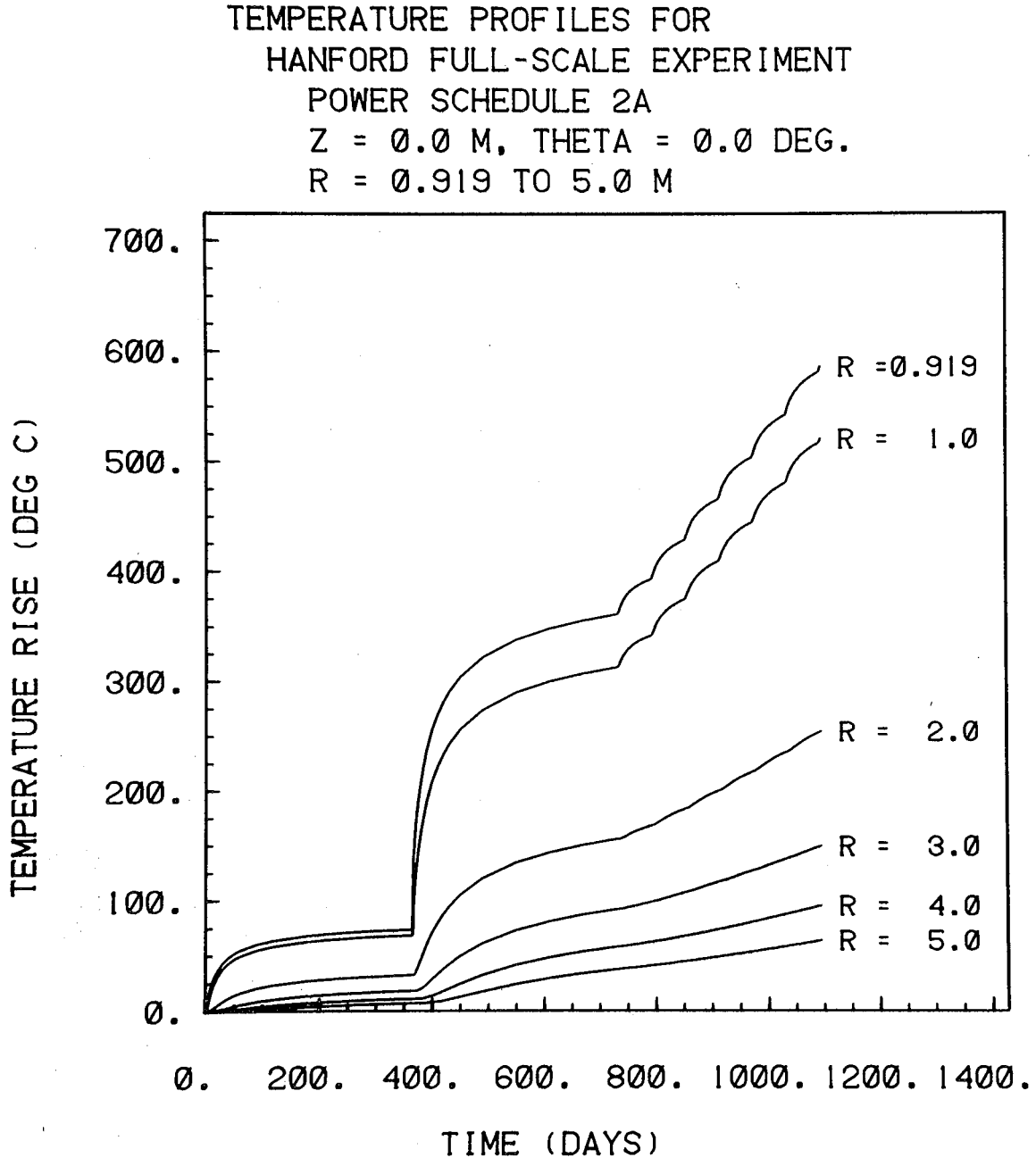
XBL 787-9849

Figure D7b



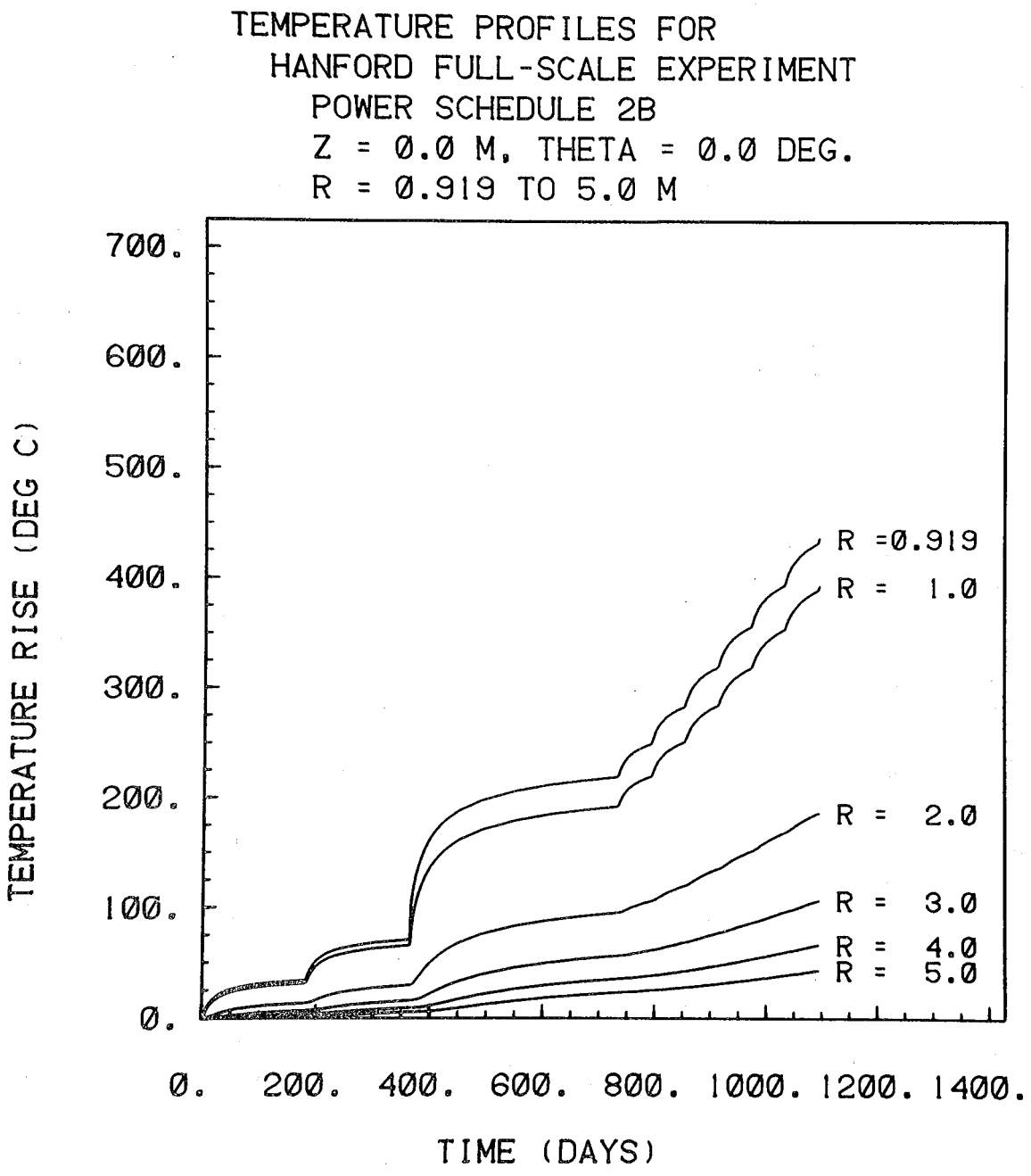
XBL 787-9850

Figure D7c



XBL 787-9853

Figure D7d



XBL 787-9848

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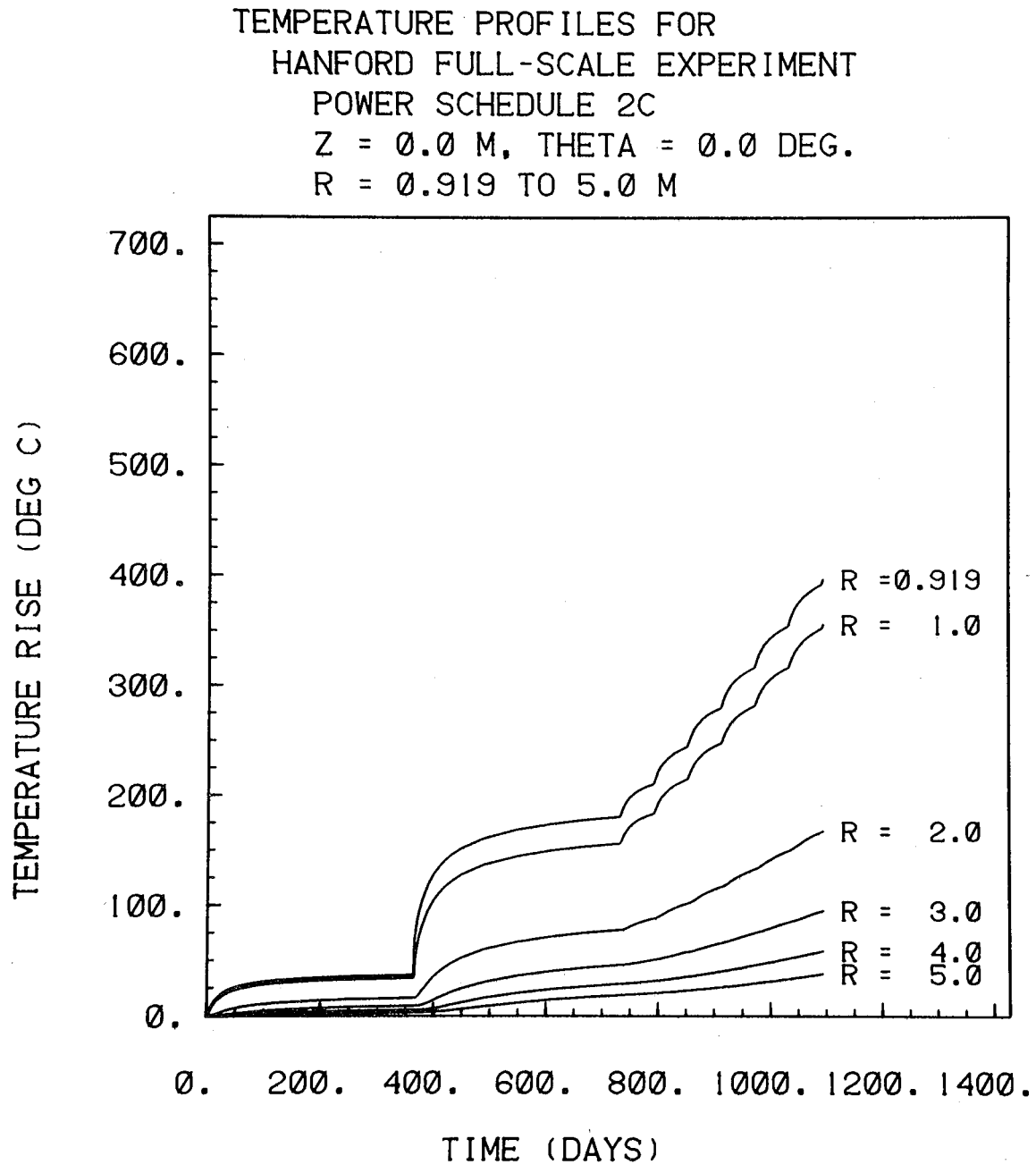
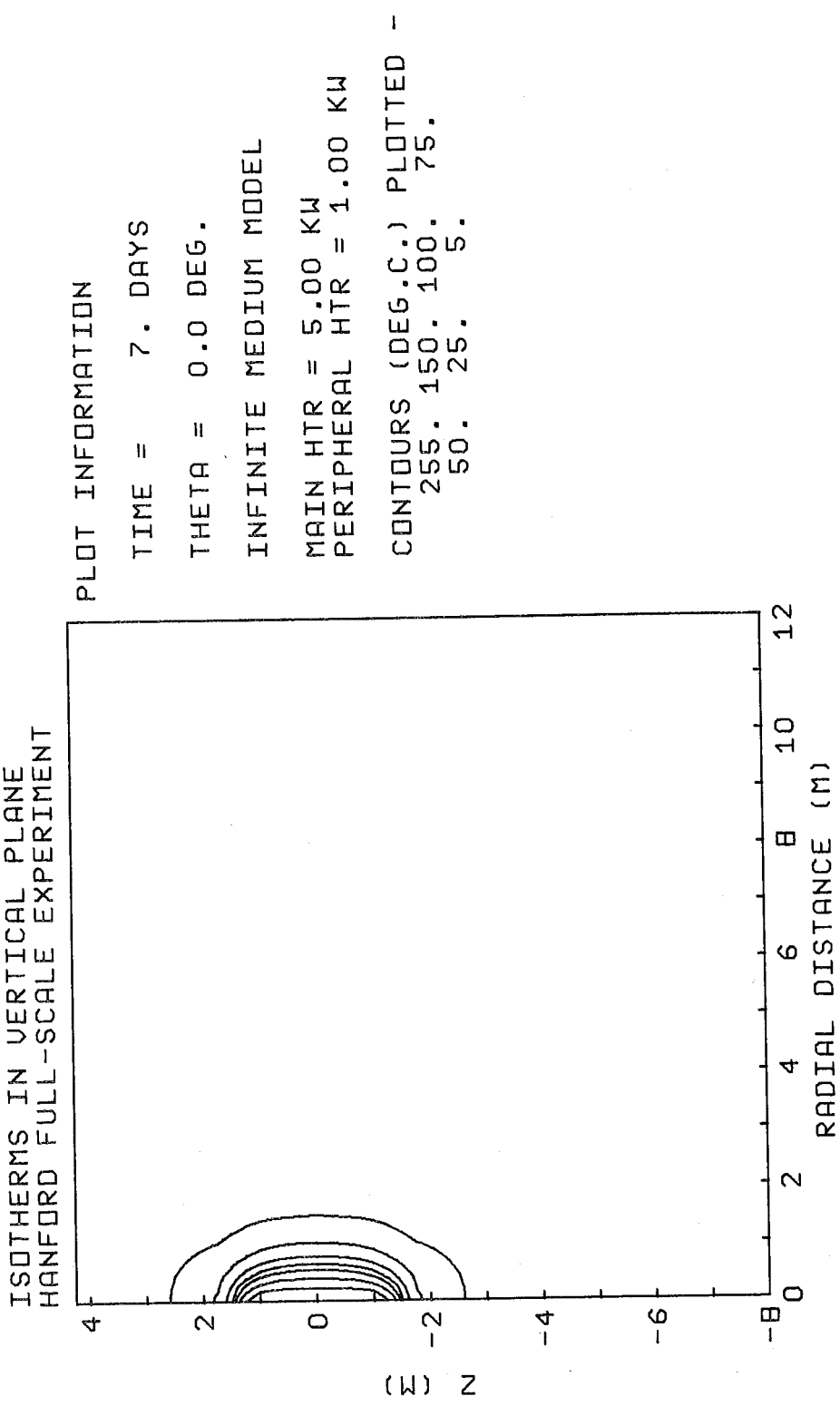


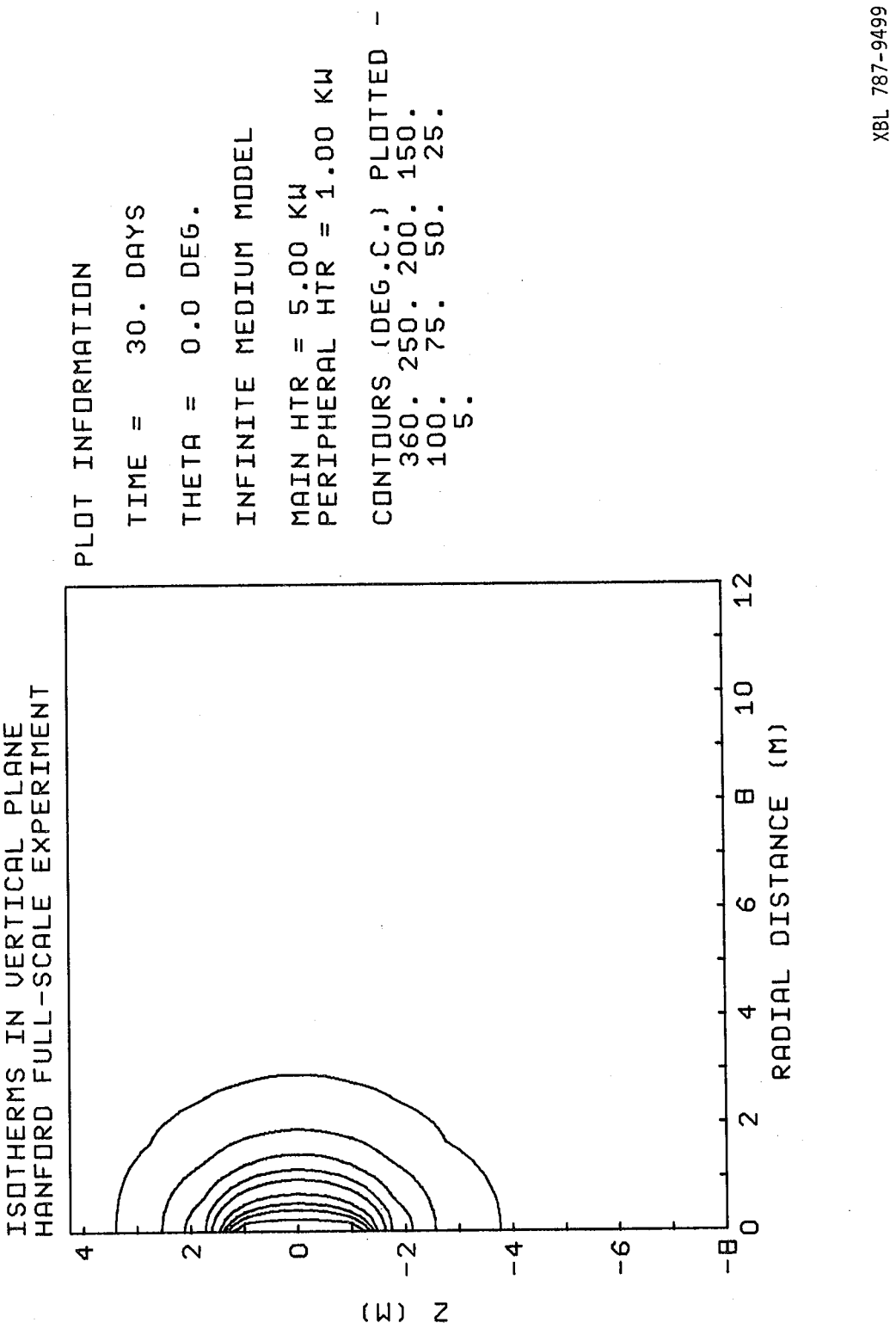
XBL 787-9851

Figure D7f



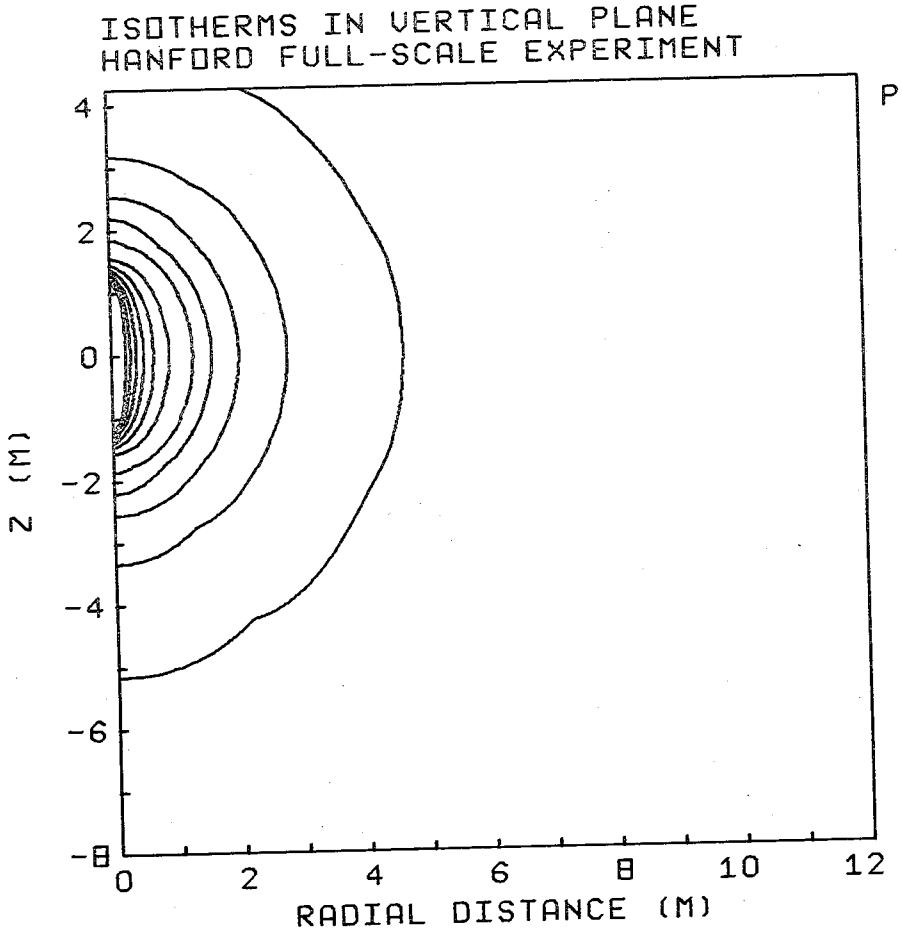
XBL 787-9498

Figure D8a



XBL 787-9499

Figure D8b



PLOT INFORMATION

TIME = 90. DAYS

THETA = 0.0 DEG.

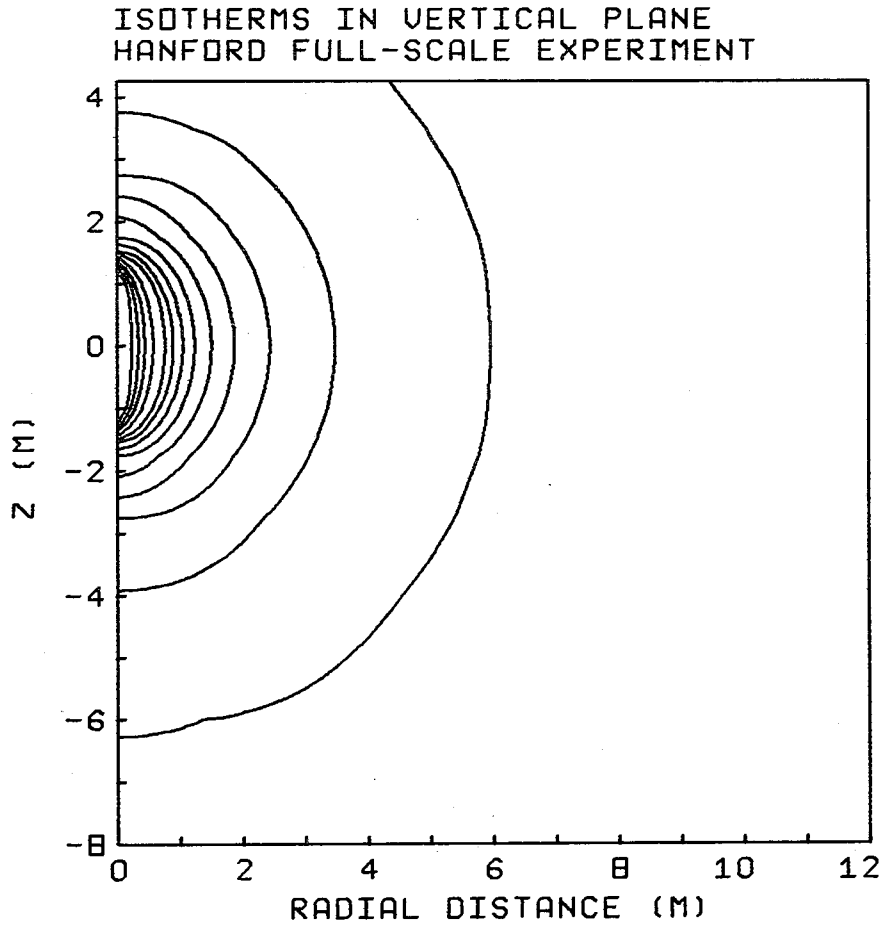
INFINITE MEDIUM MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
408. 350. 300. 250.
200. 150. 100. 75.
50. 25. 5.

XBL 787-9500

Figure D8c



PLOT INFORMATION

TIME = 180. DAYS

THETA = 0.0 DEG.

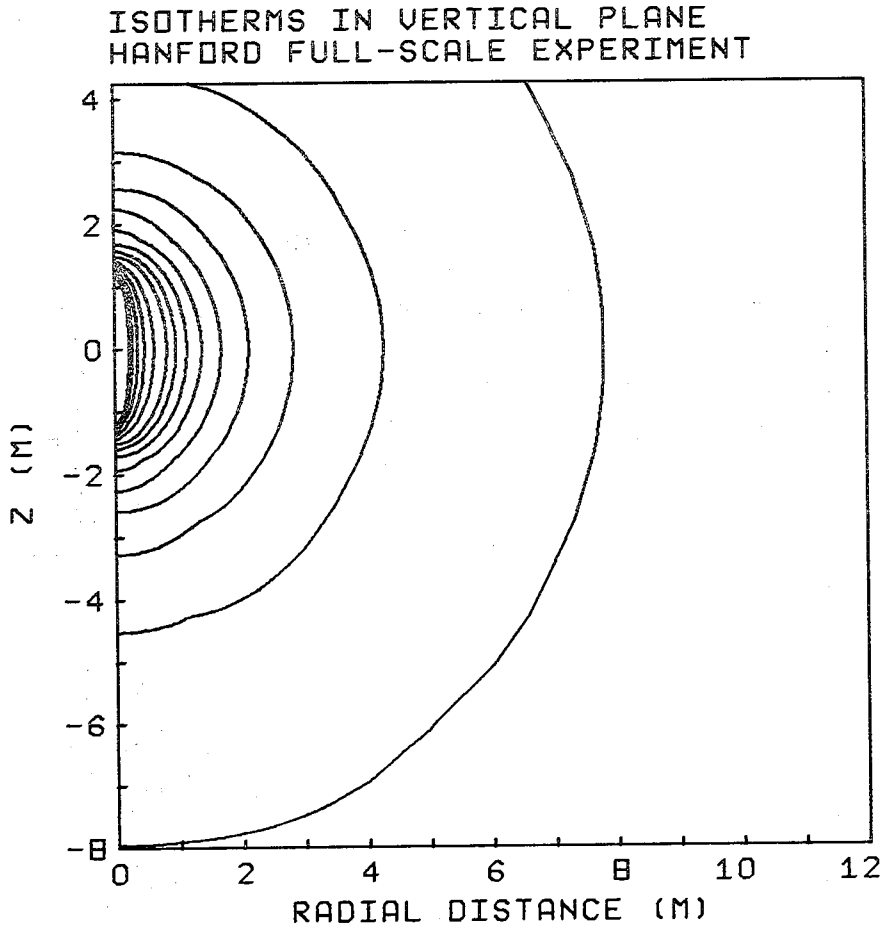
INFINITE MEDIUM MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
428. 350. 300. 250.
200. 175. 150. 125.
100. 75. 50. 25.
5.

XBL 787-9502

Figure D8d



PLOT INFORMATION

TIME = 365. DAYS

THETA = 0.0 DEG.

INFINITE MEDIUM MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
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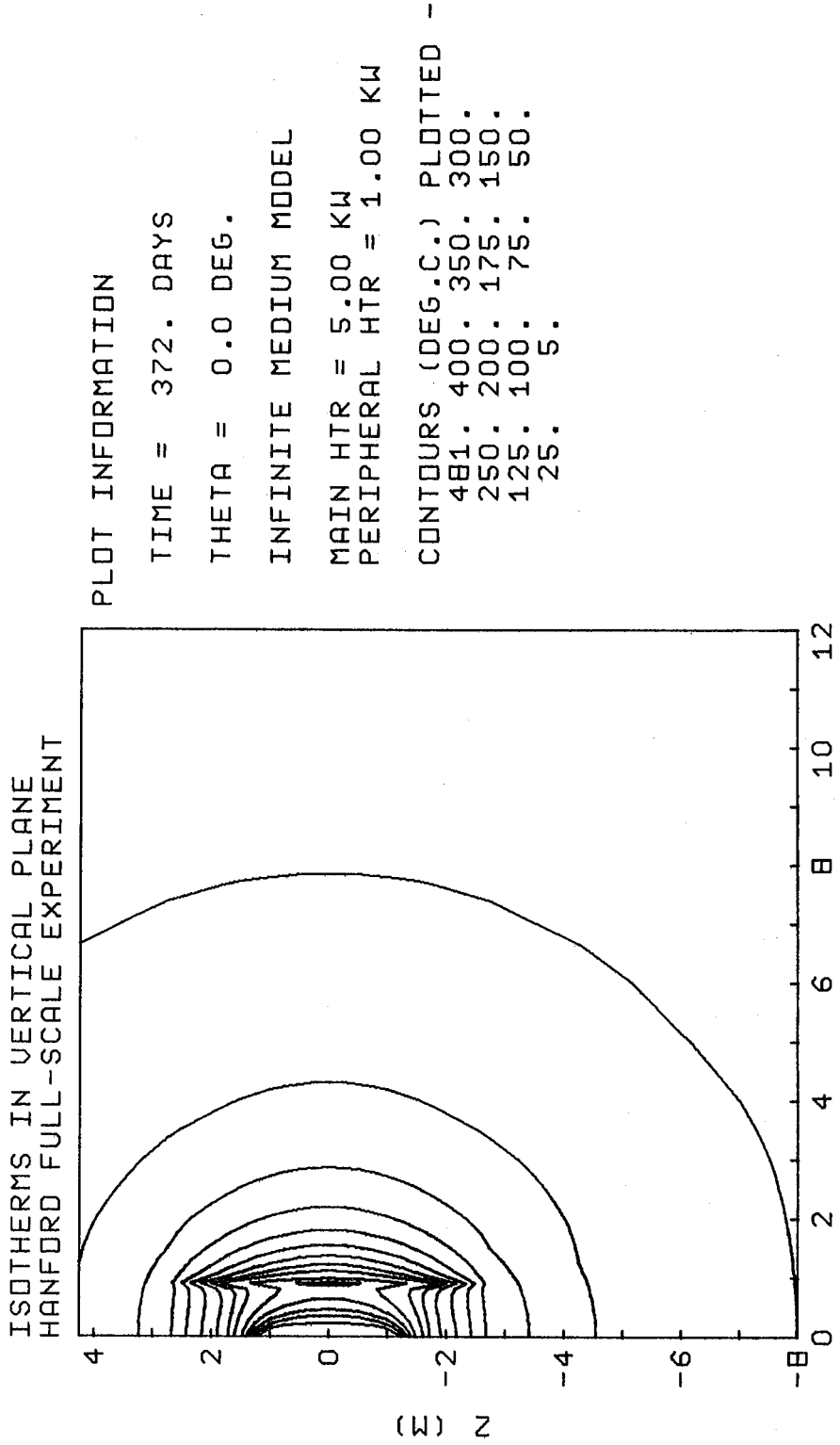
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

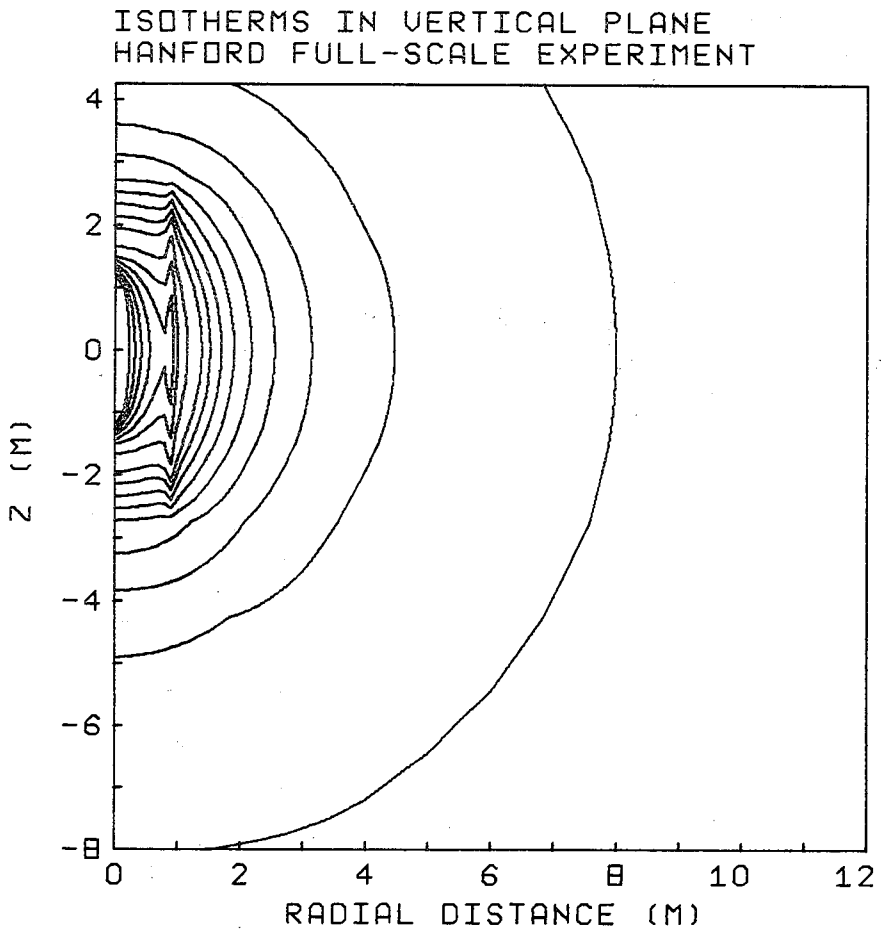
XBL 787-9501

Figure D8e



XBL 787-9510

Figure D8f



PLOT INFORMATION

TIME = 395. DAYS

THETA = 0.0 DEG.

INFINITE MEDIUM MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
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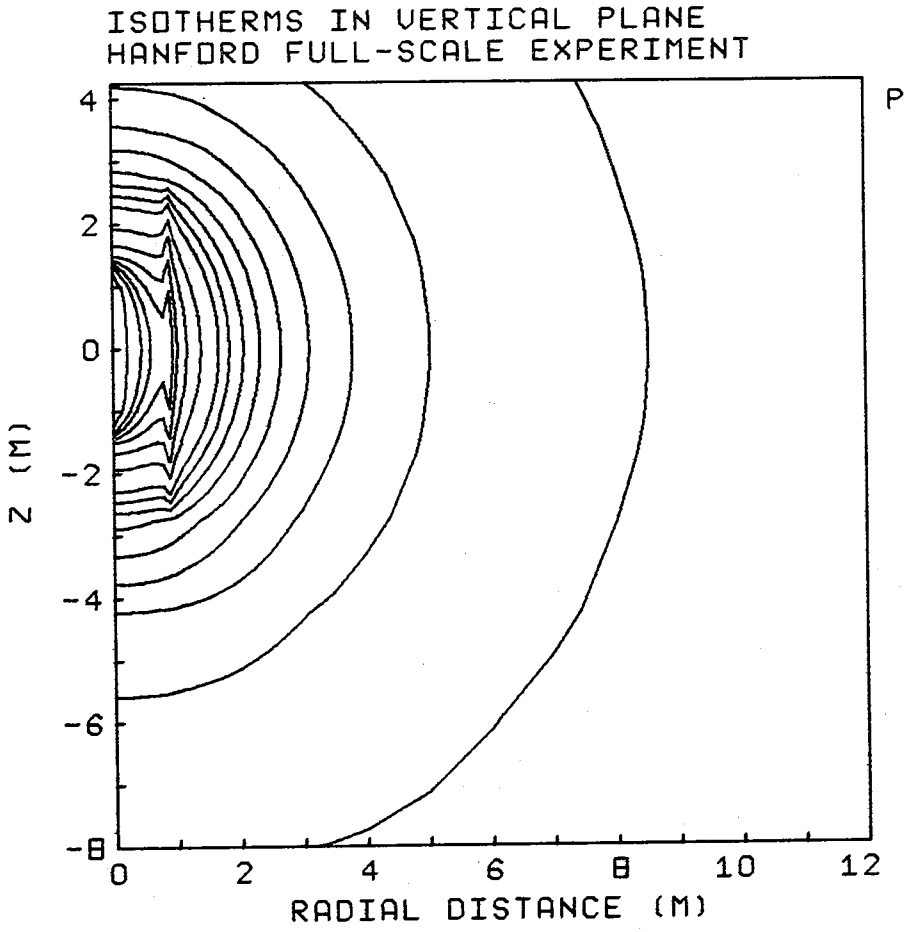
350. 300. 250. 200.
175. 150. 125. 100.
75. 50. 25. 5.

XBL 787-9509

Figure D8g



PLOT INFORMATION

TIME = 455. DAYS

THETA = 0.0 DEG.

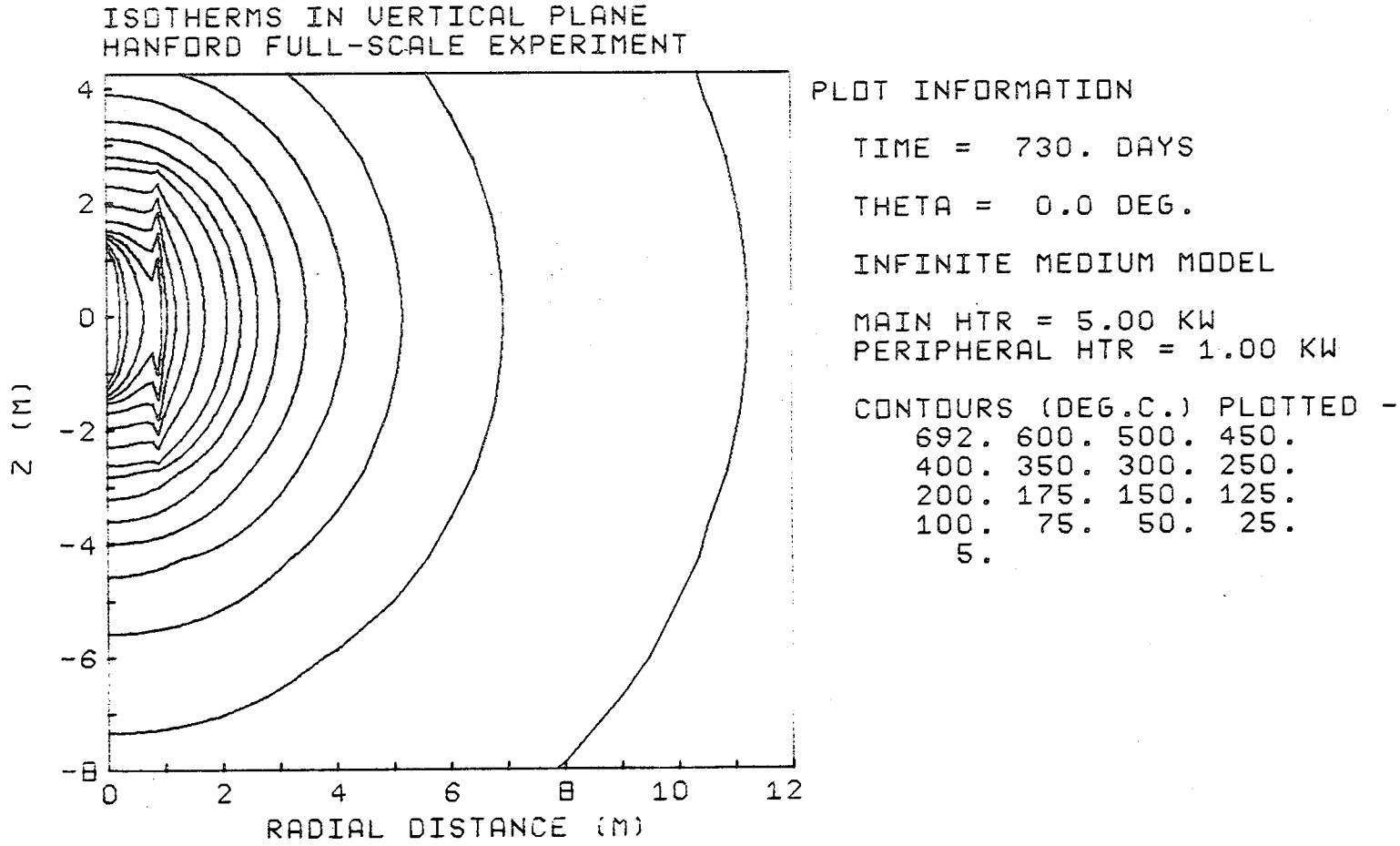
INFINITE MEDIUM MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
633. 500. 450. 400.
350. 300. 250. 200.
175. 150. 125. 100.
75. 50. 25. 5.

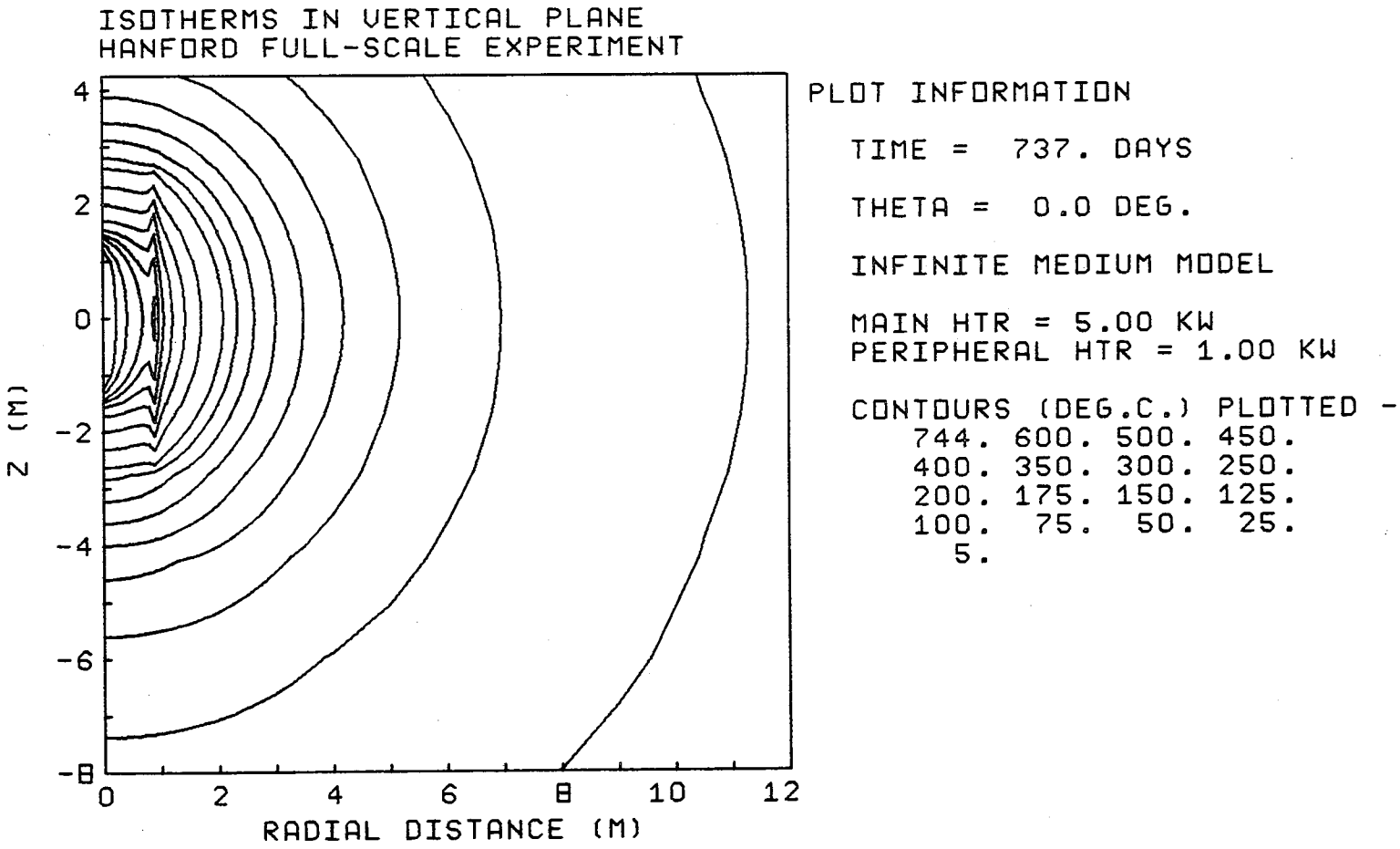
XBL 787-9508

Figure D8h



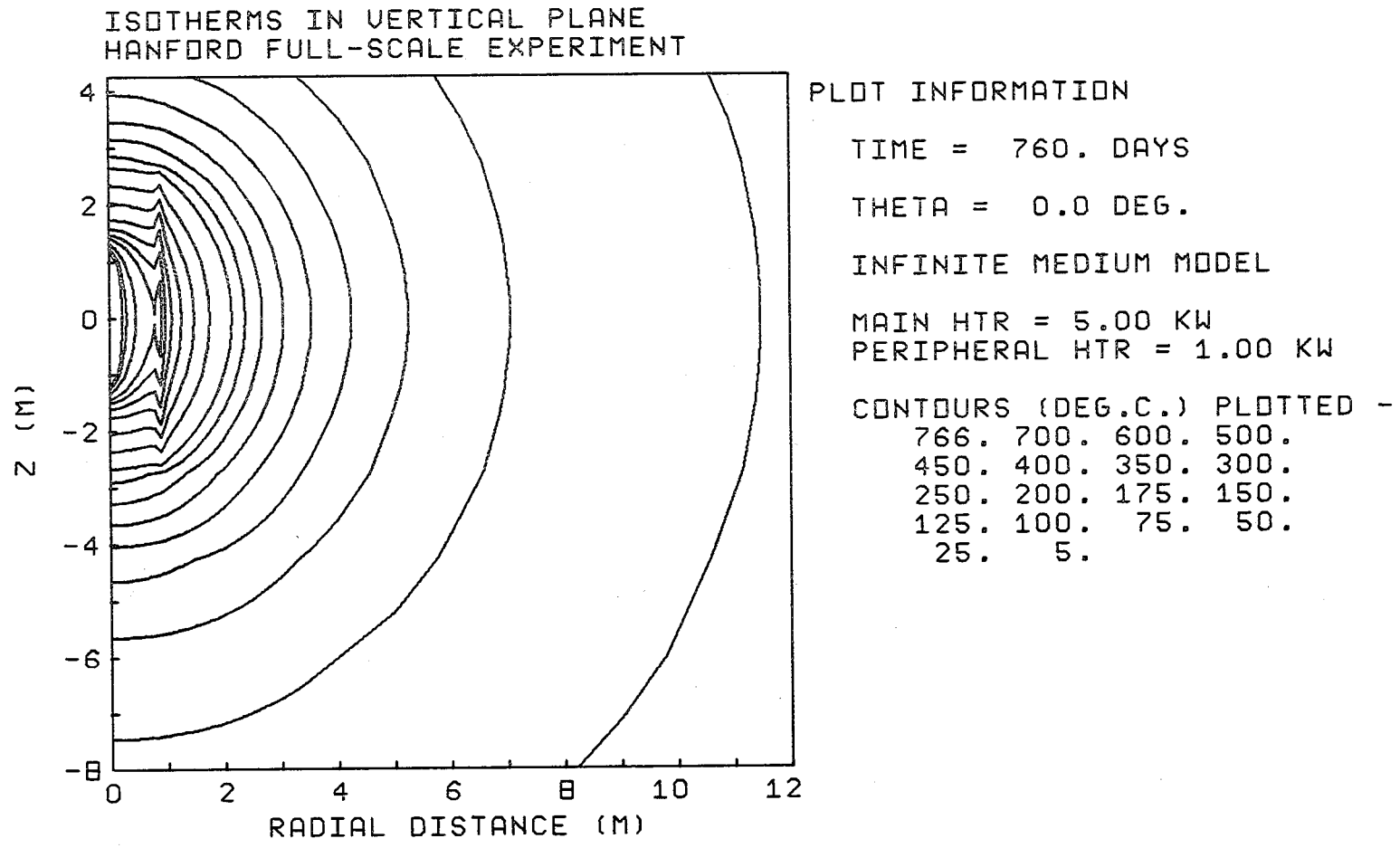
XBL 787-9507

Figure D8i



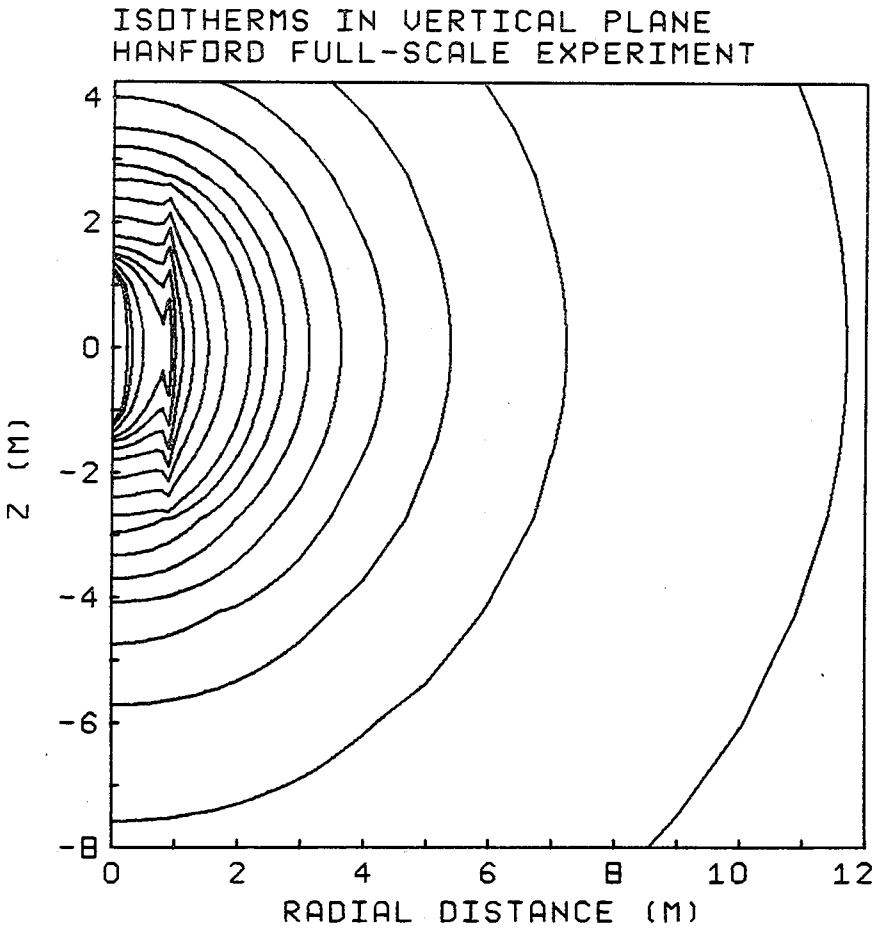
XBL 787-9506

Figure D8j



XBL 787-9505

Figure D8k



PLOT INFORMATION

TIME = 790. DAYS

THETA = 0.0 DEG.

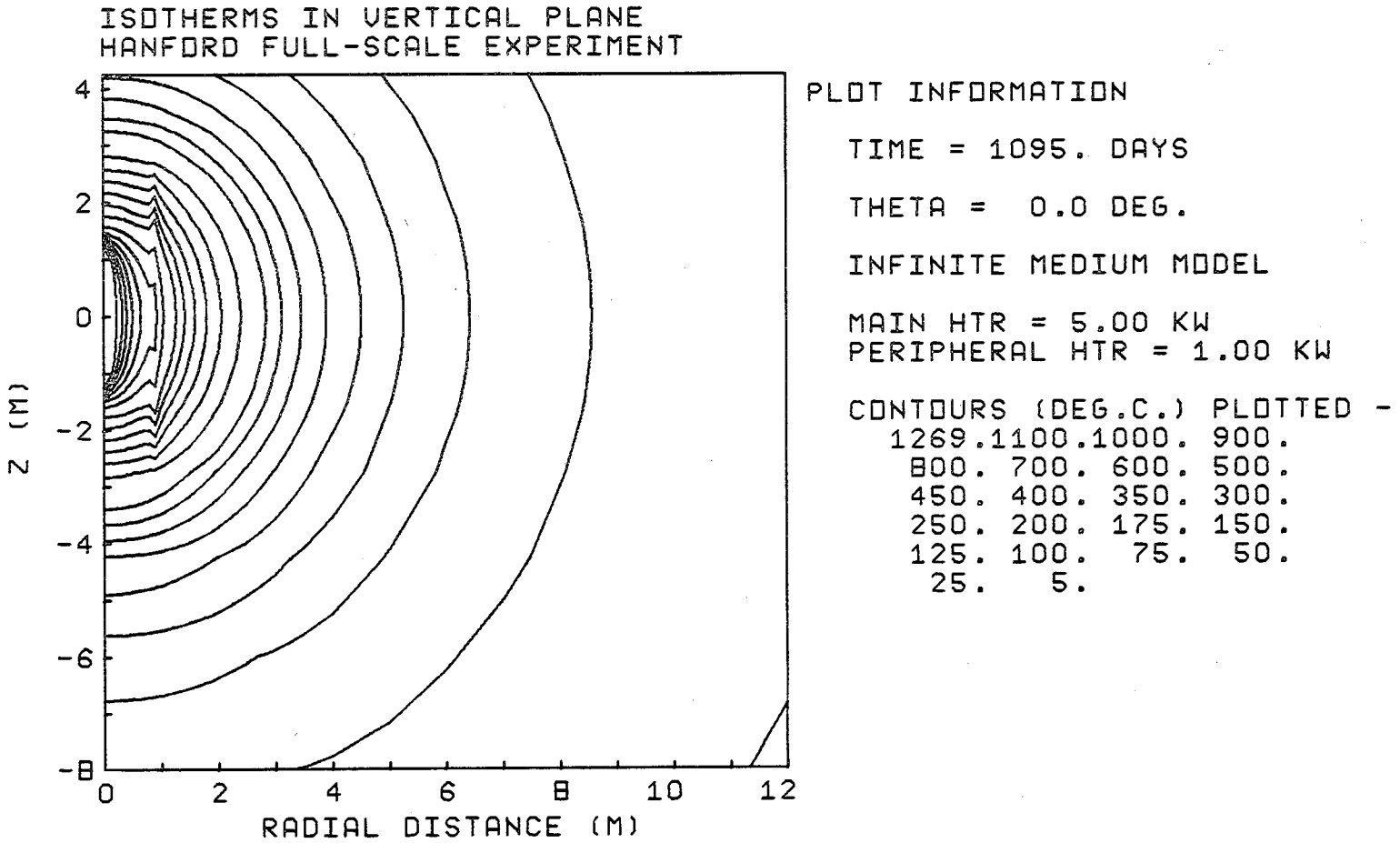
INFINITE MEDIUM MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
775. 700. 600. 500.
450. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

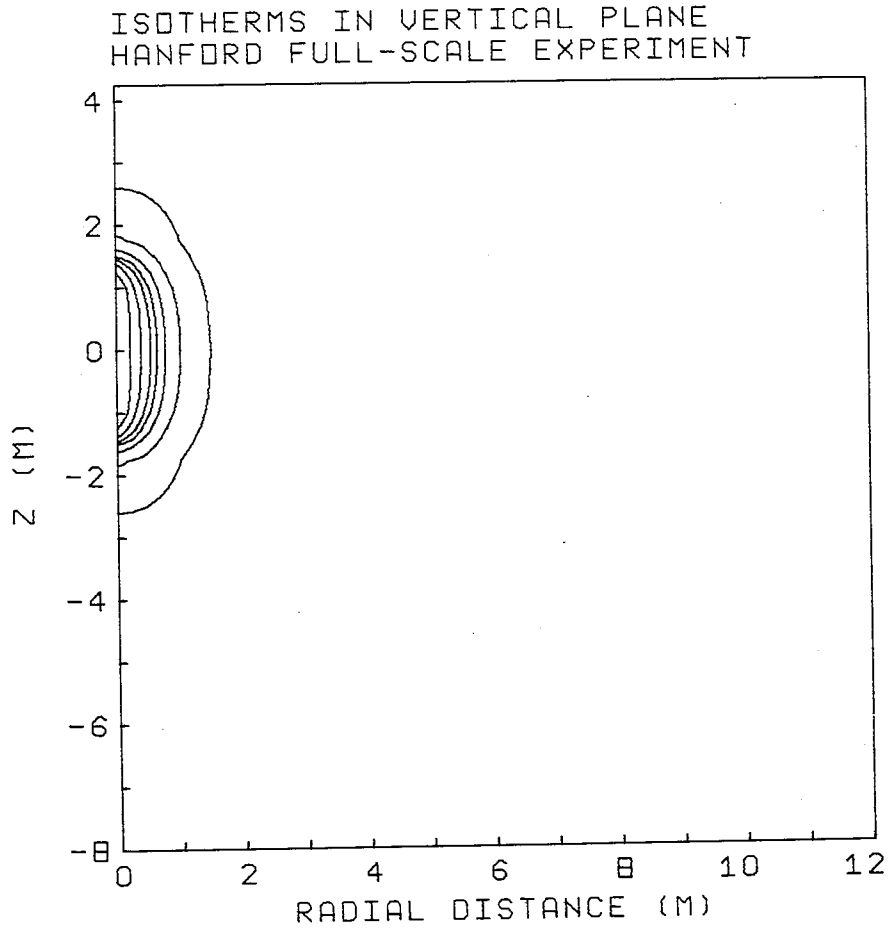
XBL 787-9504

Figure D81



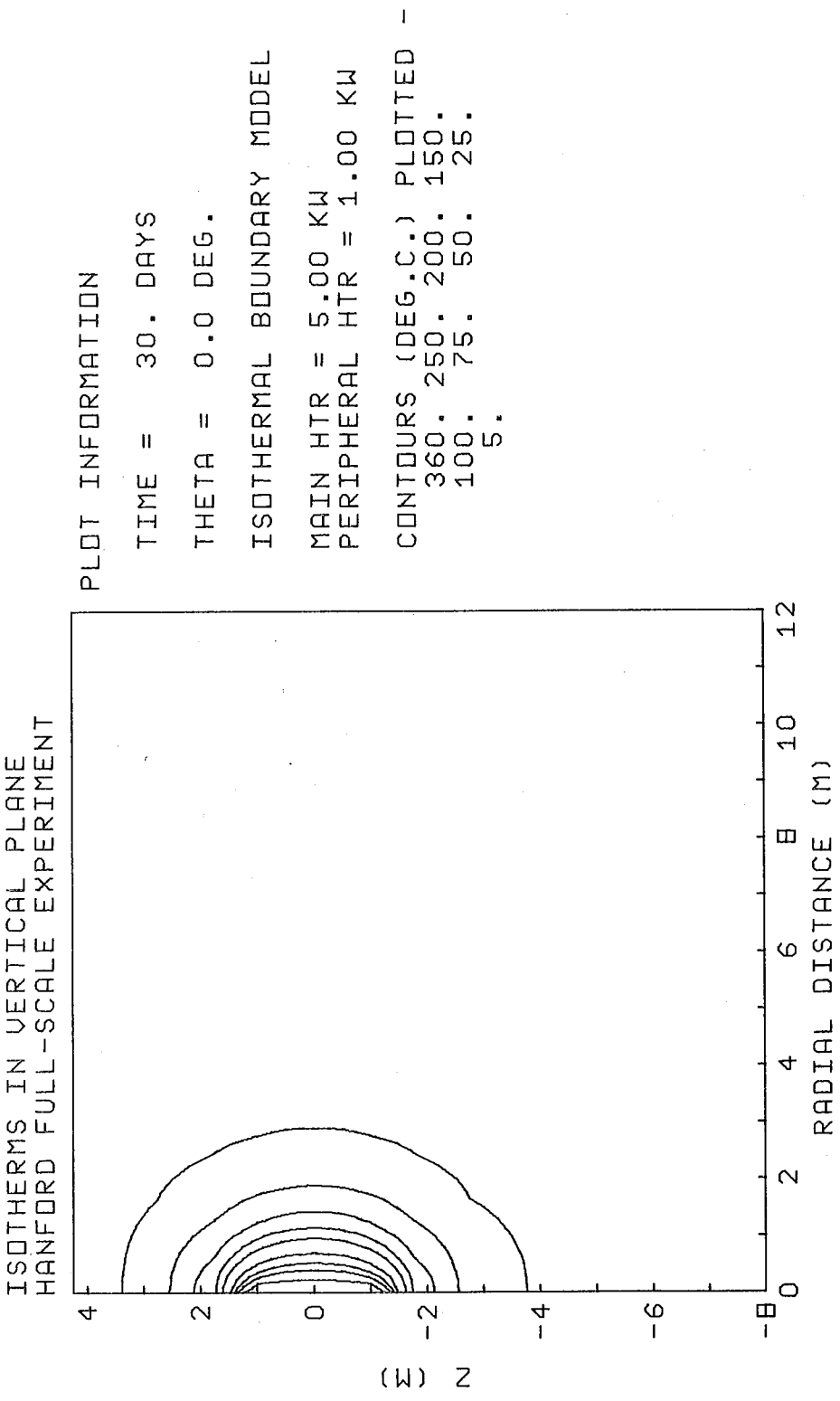
XBL 787-9503

Figure D8m



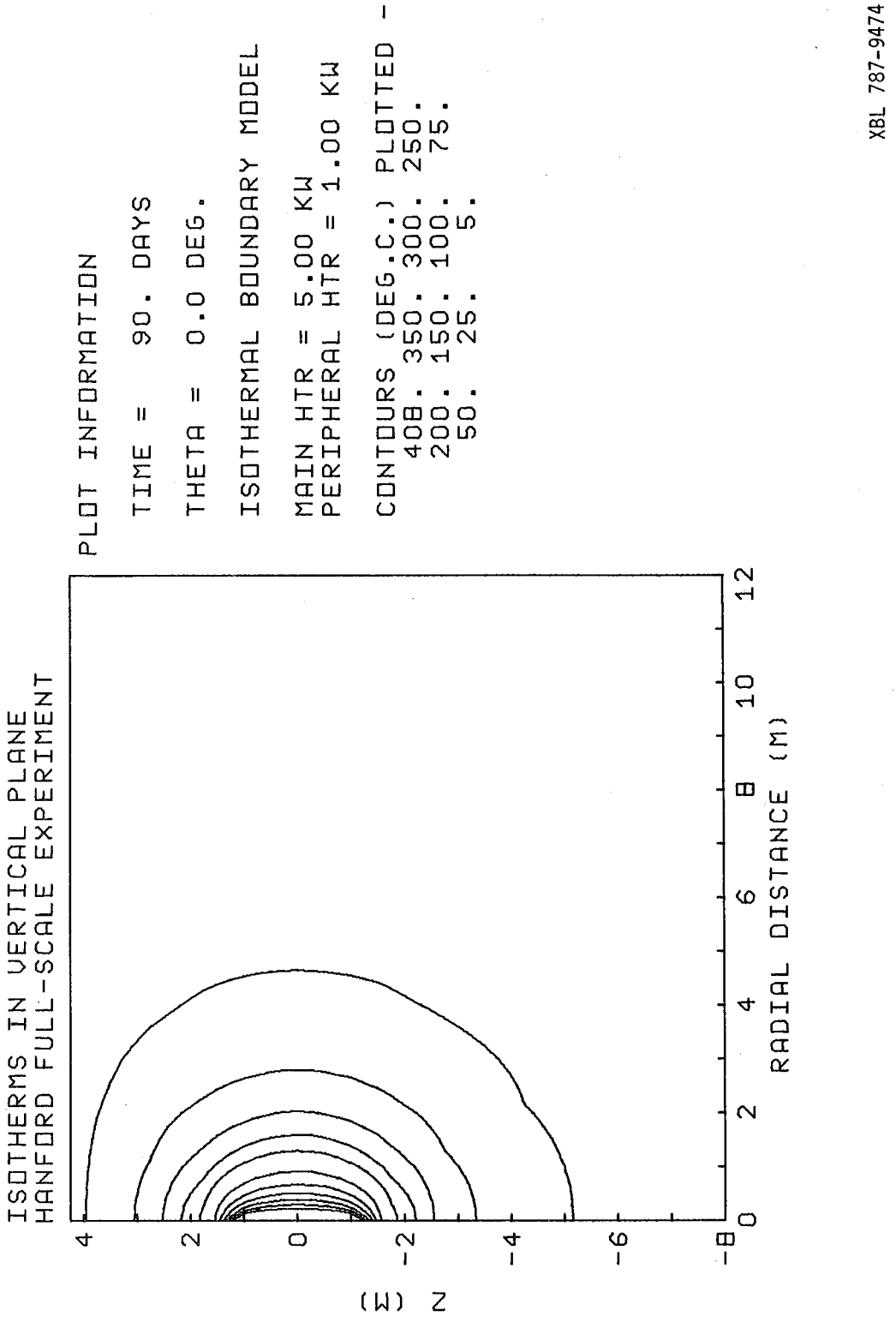
XBL 787-9469

Figure D9a



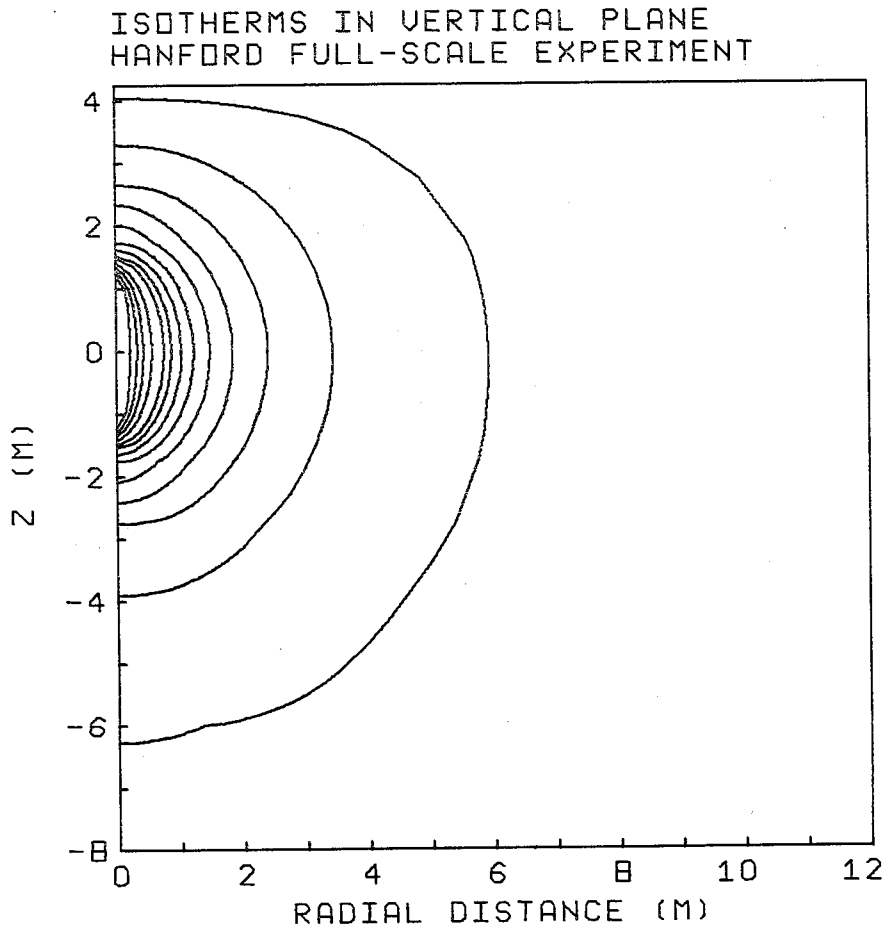
XBL 787-9473

Figure D9b



XBL 787-9474

Figure D9c



PLOT INFORMATION

TIME = 180. DAYS

THETA = 0.0 DEG.

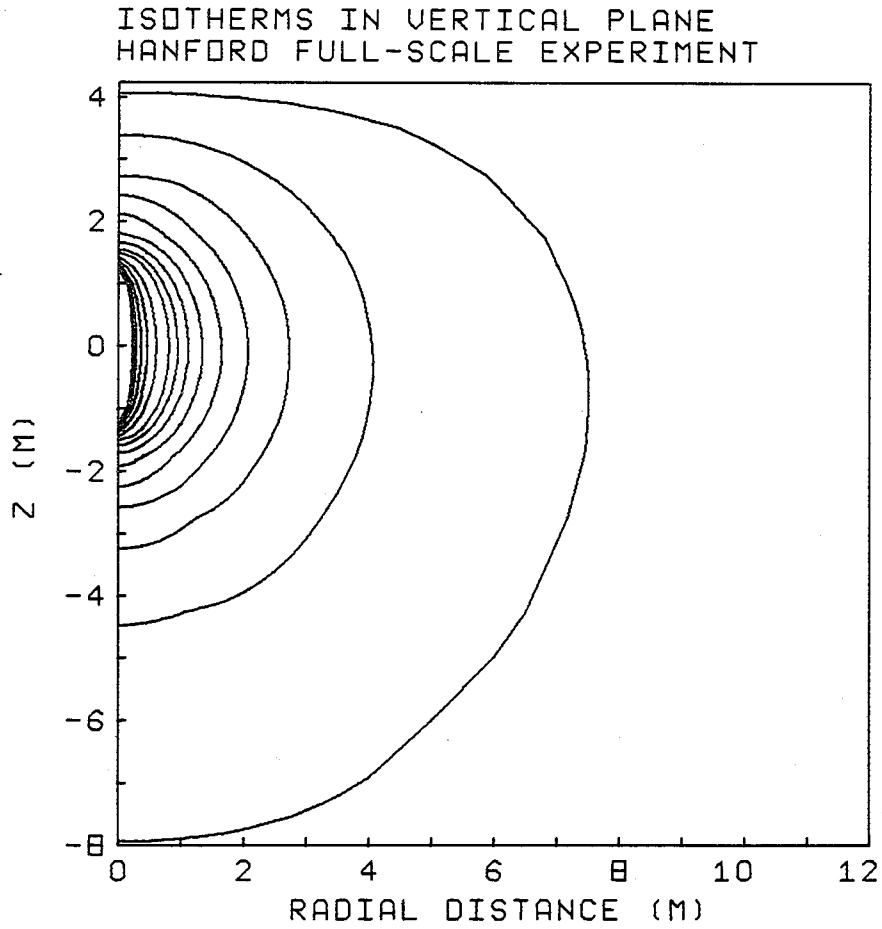
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
427. 350. 300. 250.
200. 175. 150. 125.
100. 75. 50. 25.
5.

XBL 787-9475

Figure D9d



PLOT INFORMATION

TIME = 365. DAYS

THETA = 0.0 DEG.

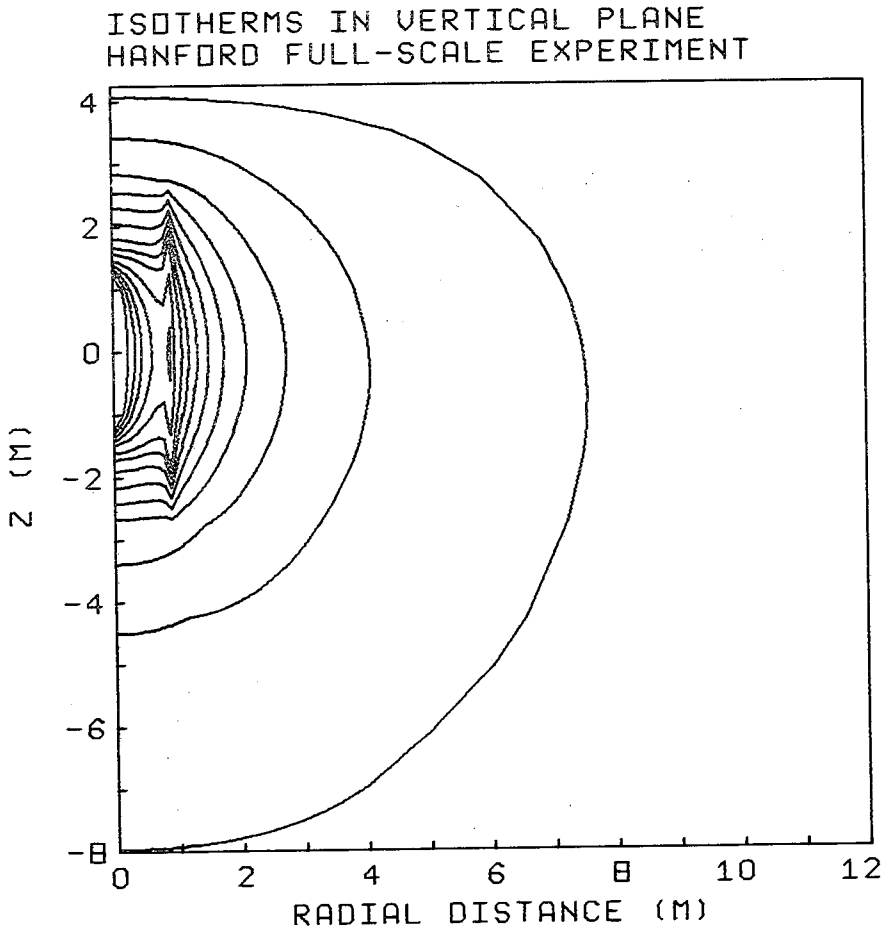
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
440. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

XBL 787-9471

Figure D9e



PLOT INFORMATION

TIME = 372. DAYS

THETA = 0.0 DEG.

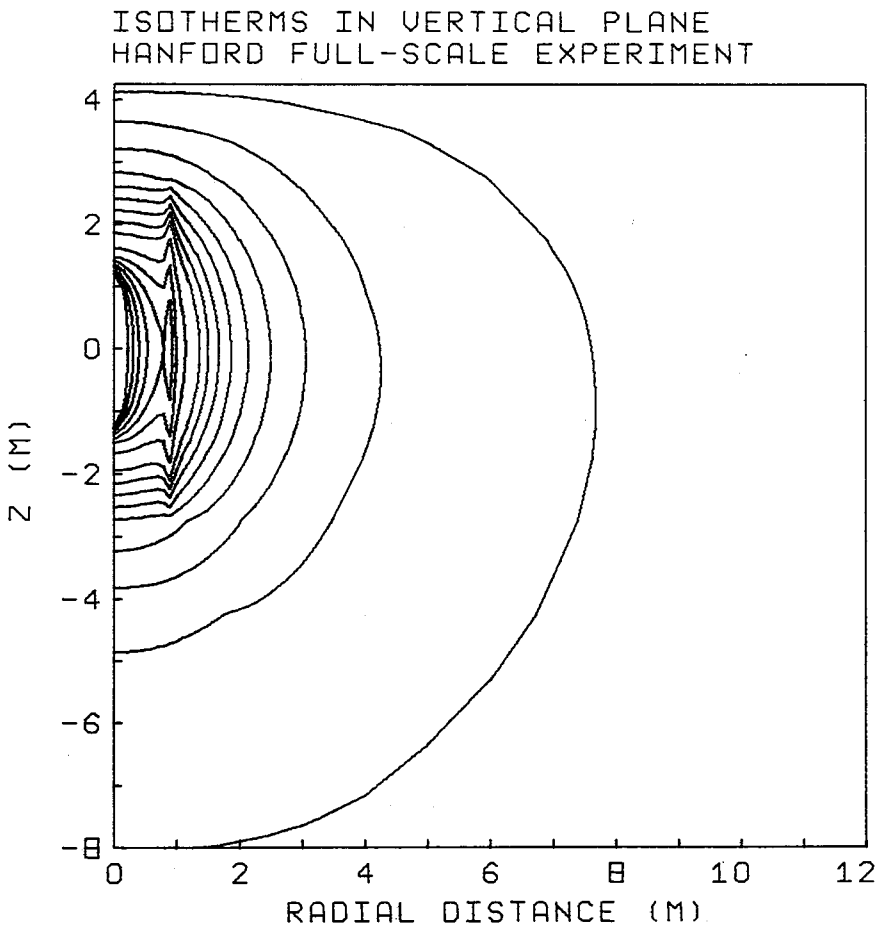
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
477. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

XBL 787-9470

Figure D9f



PLOT INFORMATION

TIME = 395. DAYS

THETA = 0.0 DEG.

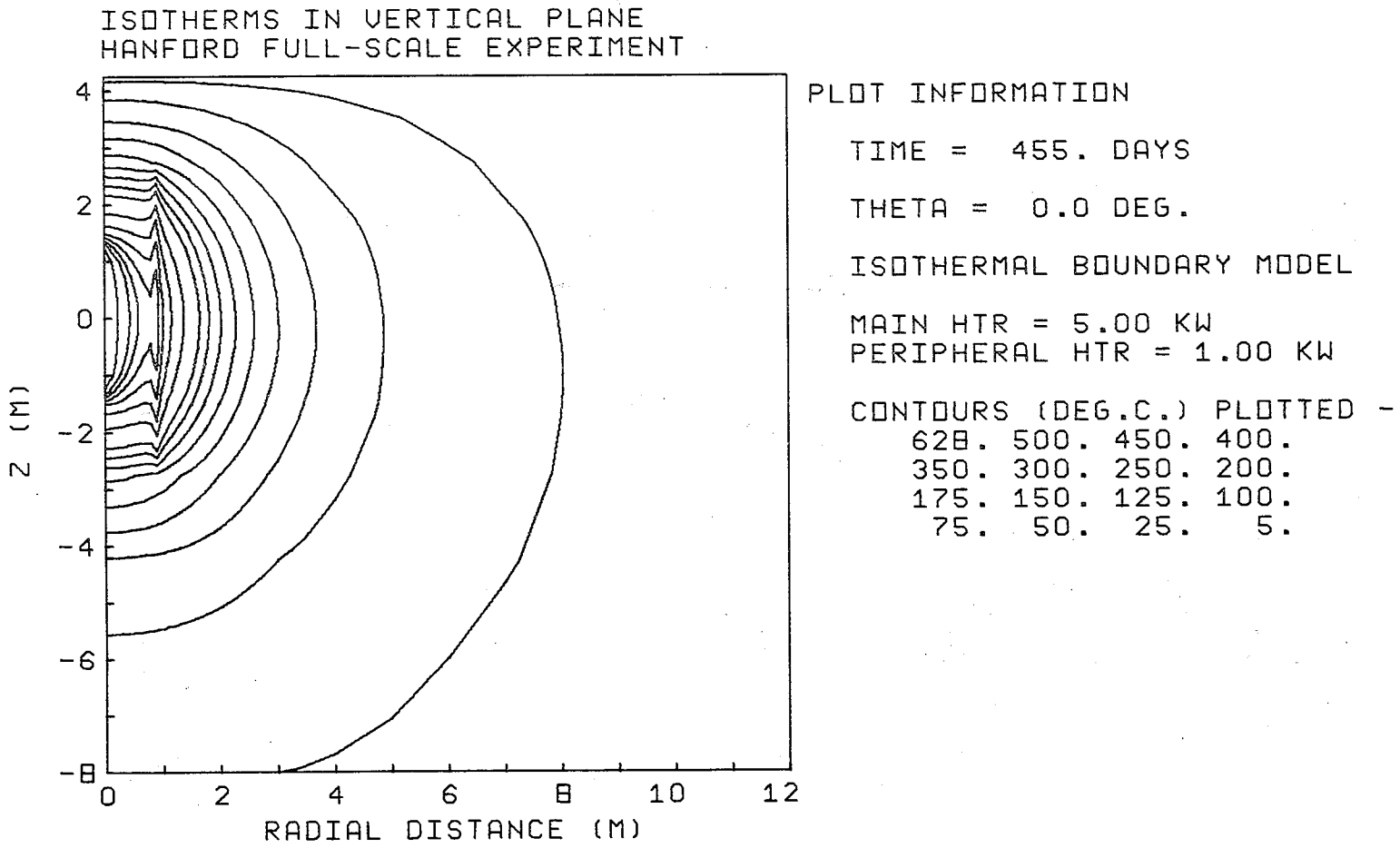
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
563. 500. 450. 400.
350. 300. 250. 200.
175. 150. 125. 100.
75. 50. 25. 5.

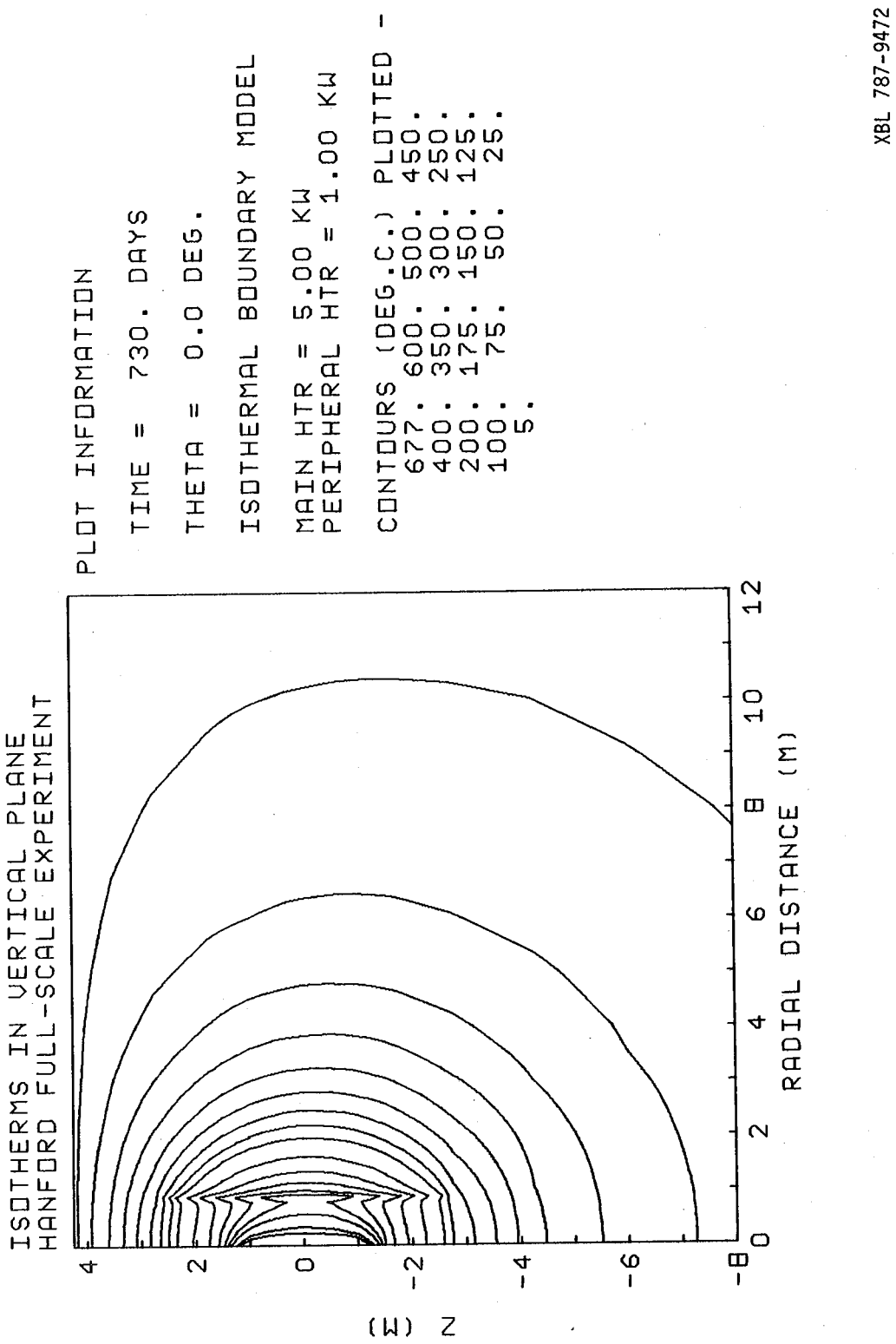
XBL 787-9477

Figure D9g



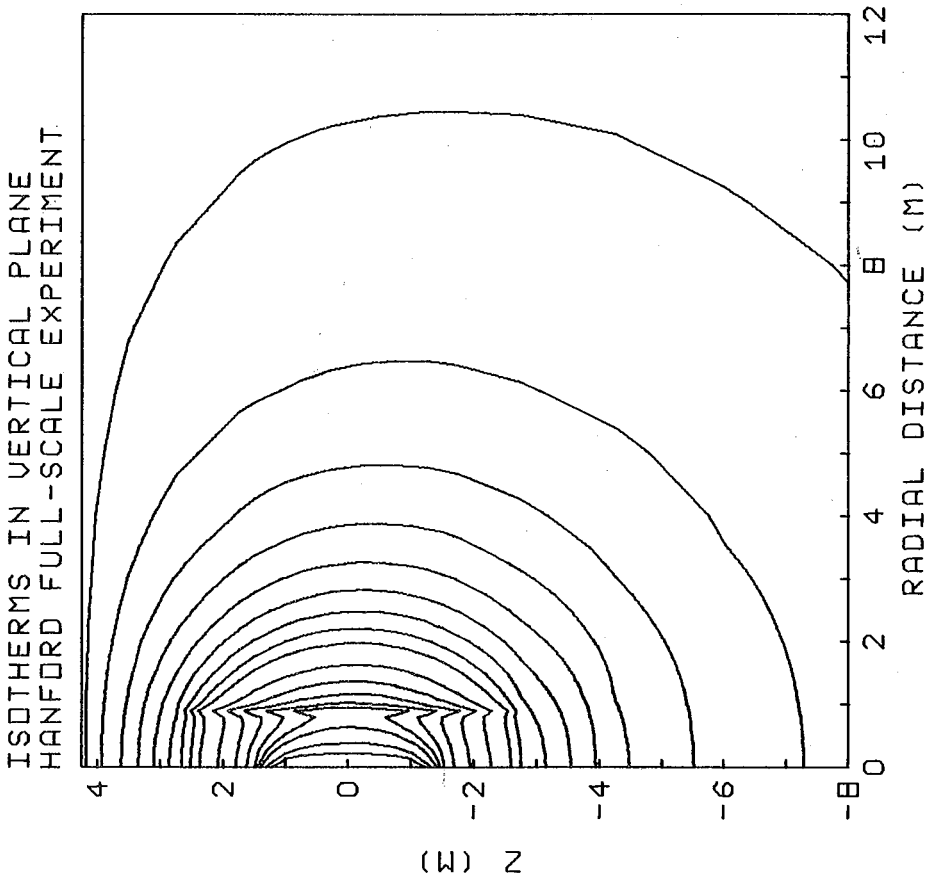
XBL 787-9476

Figure D9h



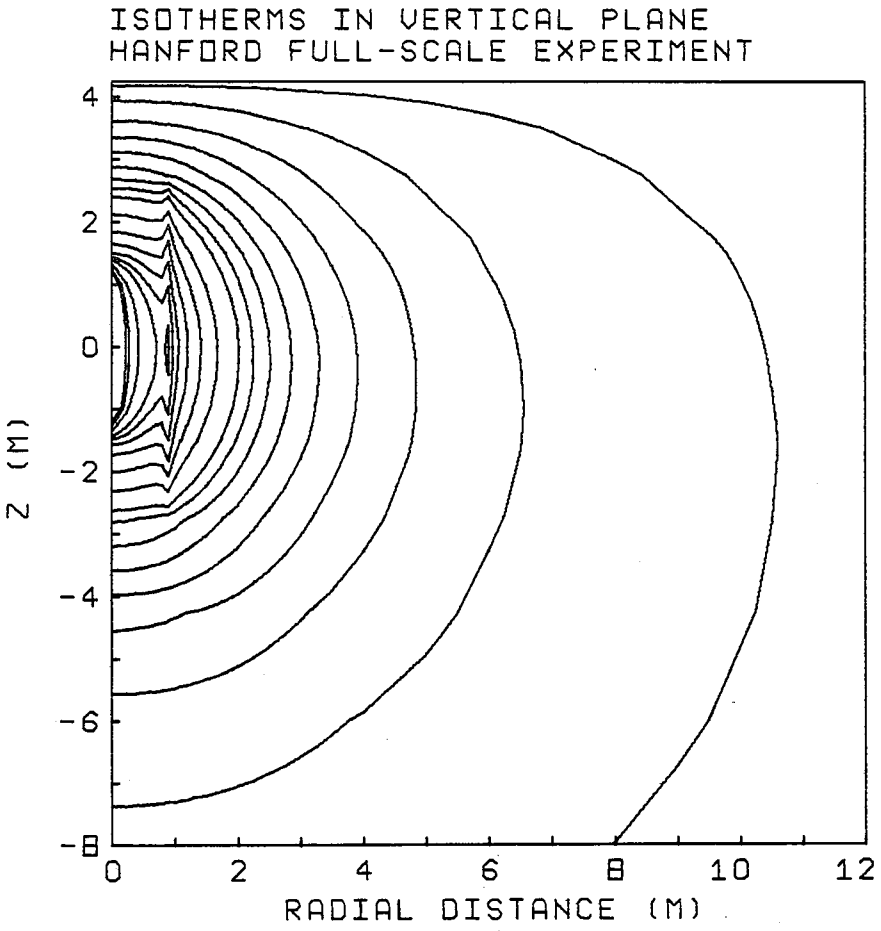
XBL 787-9472

Figure D9i



XBL 787-9468

Figure D9j



PLOT INFORMATION

TIME = 760. DAYS

THETA = 0.0 DEG.

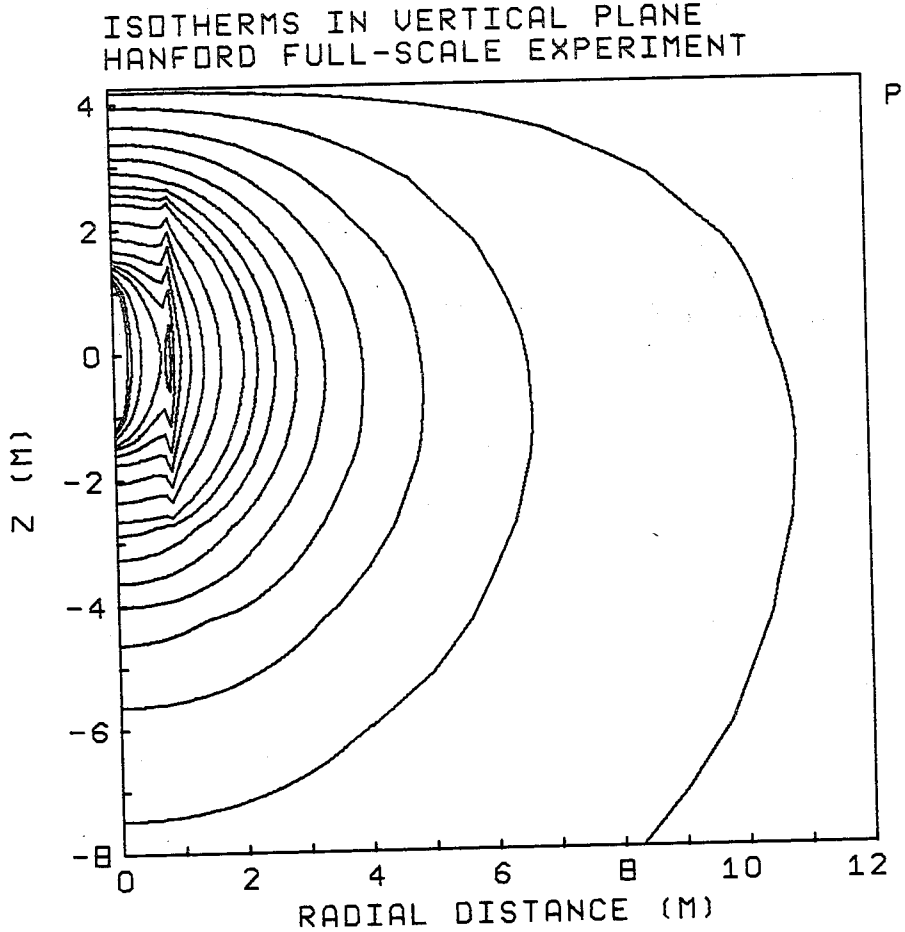
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
751. 700. 600. 500.
450. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

XBL 787-9467

Figure D9k



PLOT INFORMATION

TIME = 790. DAYS

THETA = 0.0 DEG.

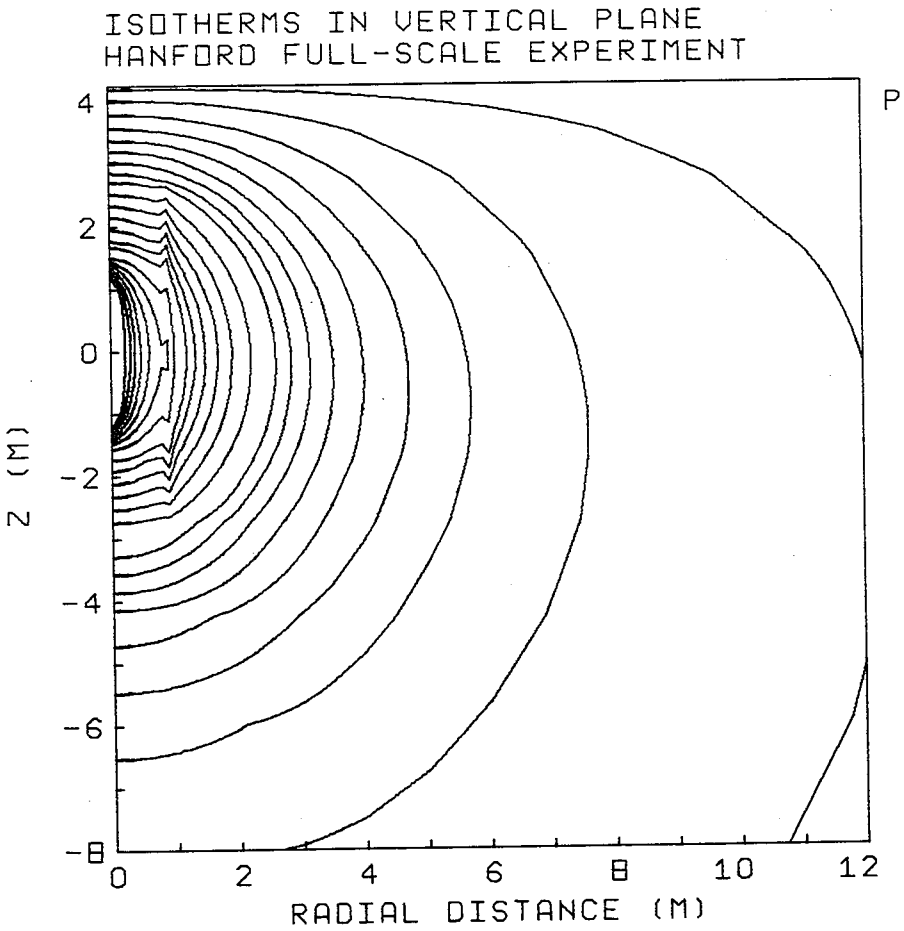
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
759. 700. 600. 500.
450. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

XBL 787-9466

Figure D91



PLOT INFORMATION

TIME = 1095. DAYS

THETA = 0.0 DEG.

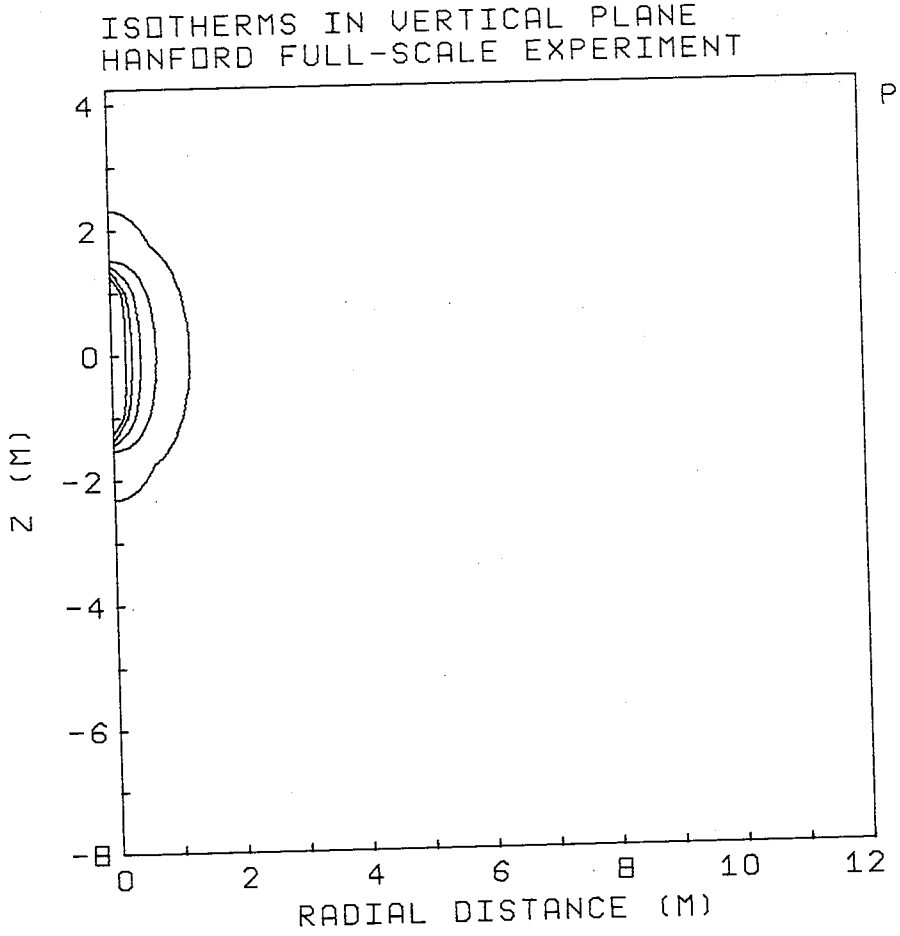
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 5.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
1242.1100.1000. 900.
800. 700. 600. 500.
450. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

XBL 787-9465

Figure D9m



PLOT INFORMATION

TIME = 7. DAYS

THETA = 0.0 DEG.

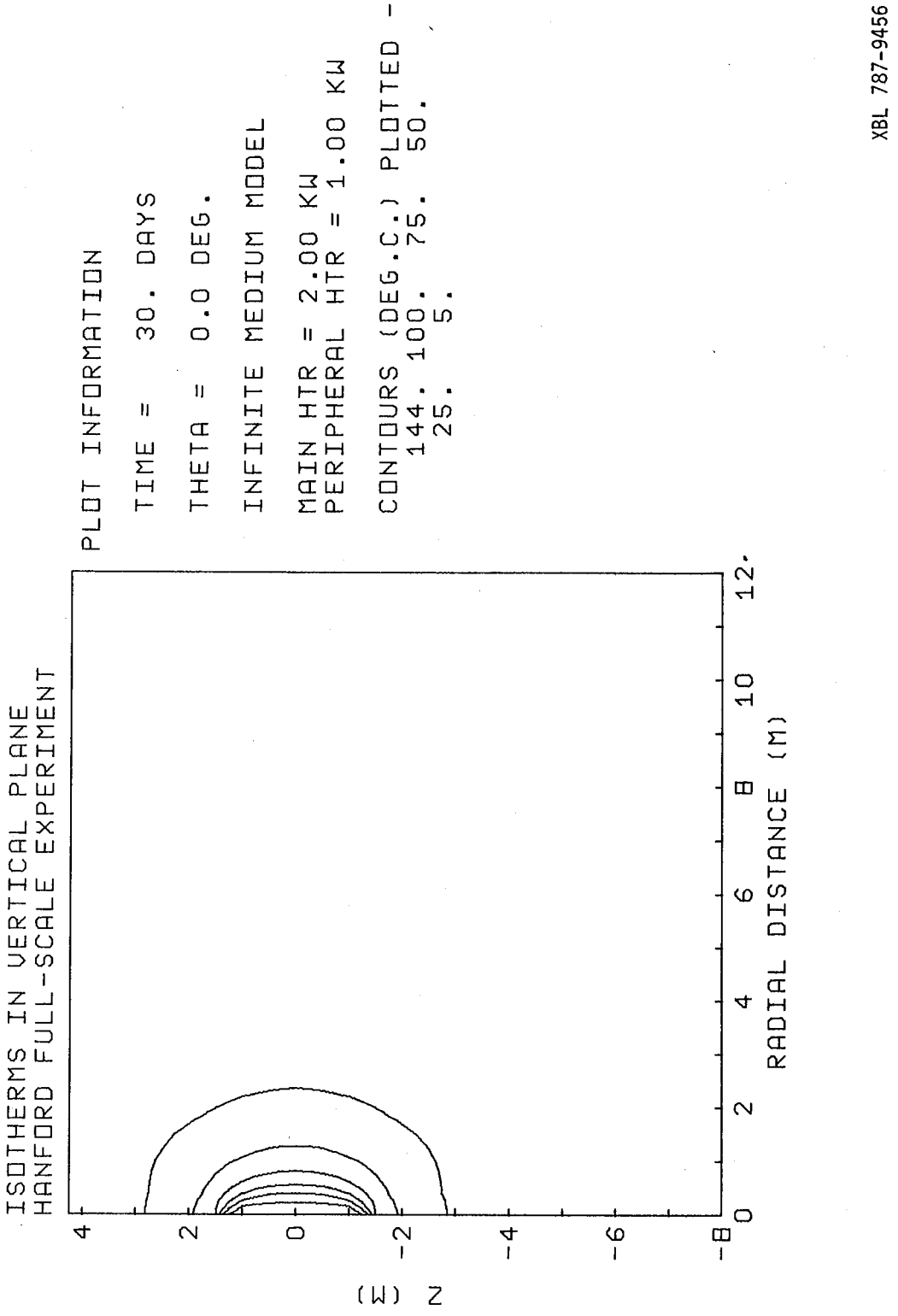
INFINITE MEDIUM MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
102. 75. 50. 25.
5.

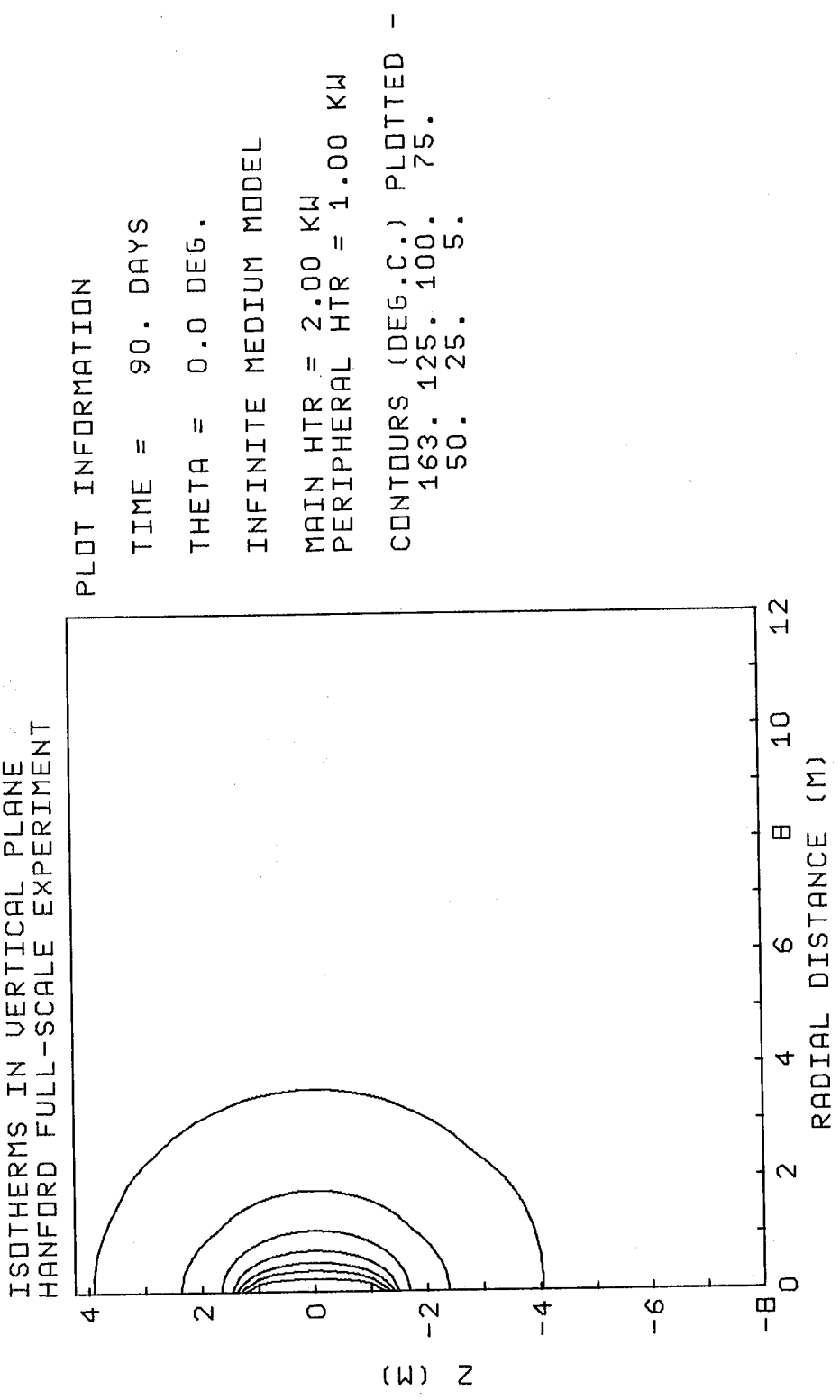
XBL 786-9452

Figure D10a



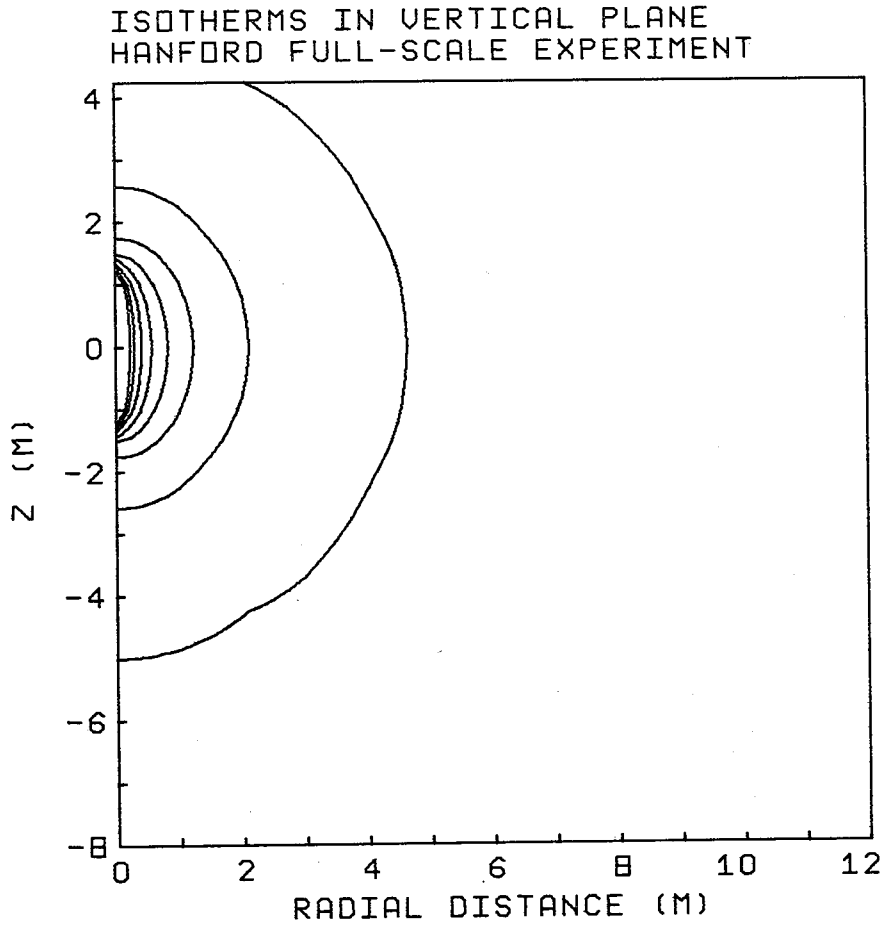
XBL 787-9456

Figure D10b



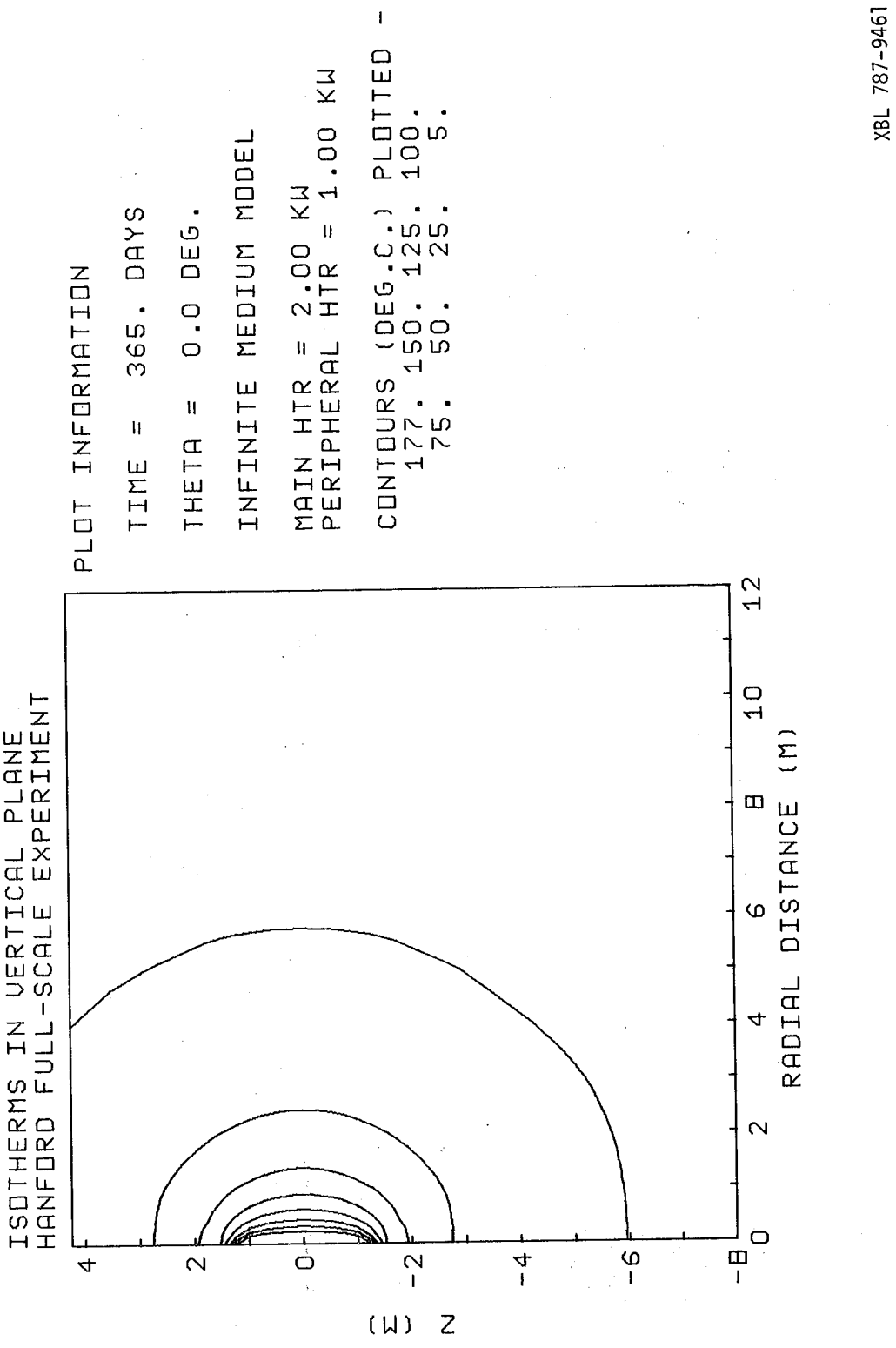
XBL 787-9457

Figure D10c



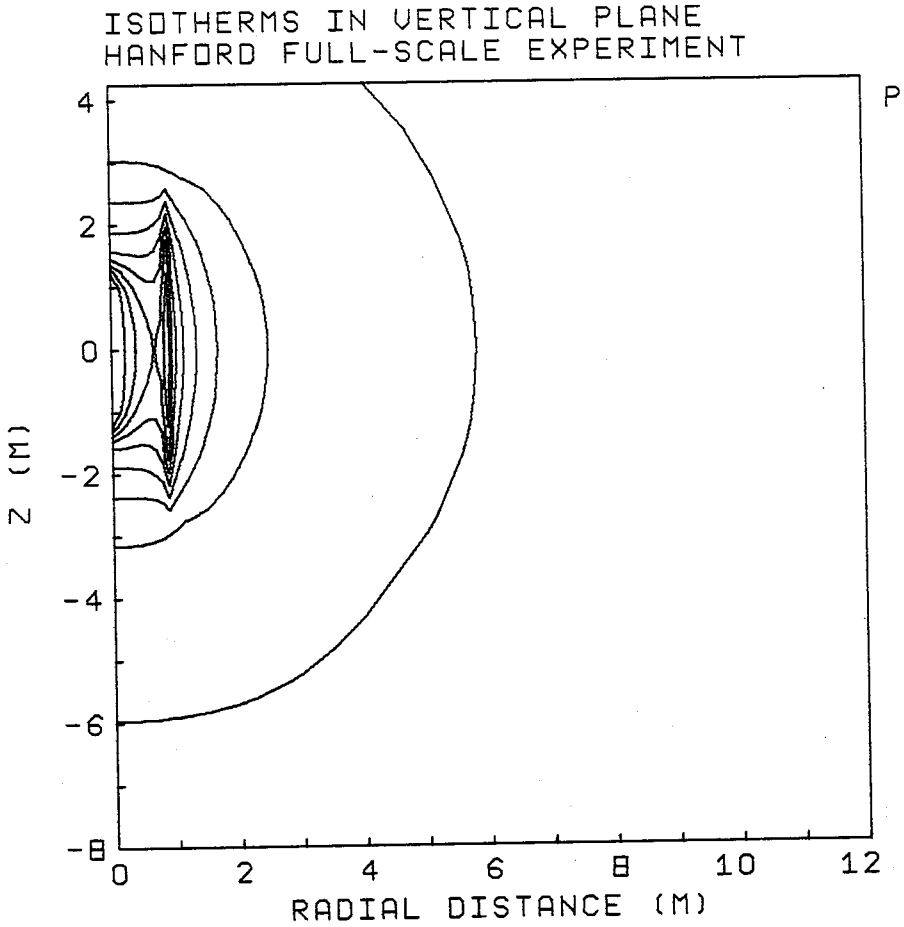
XBL 787-9458

Figure D10d



XBL 787-9461

Figure D10e



PLOT INFORMATION

TIME = 372. DAYS

THETA = 0.0 DEG.

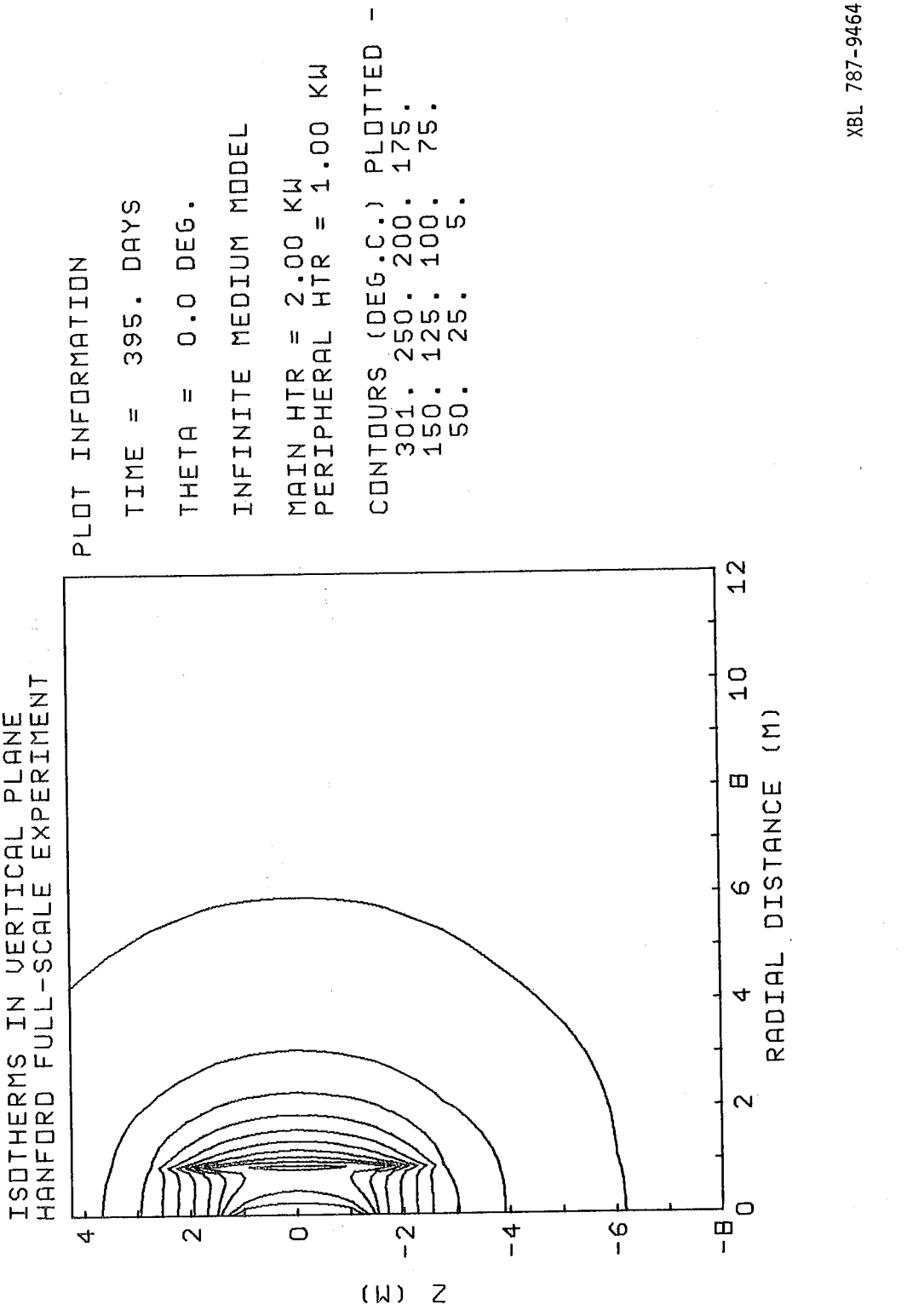
INFINITE MEDIUM MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
215. 175. 150. 125.
100. 75. 50. 25.
5.

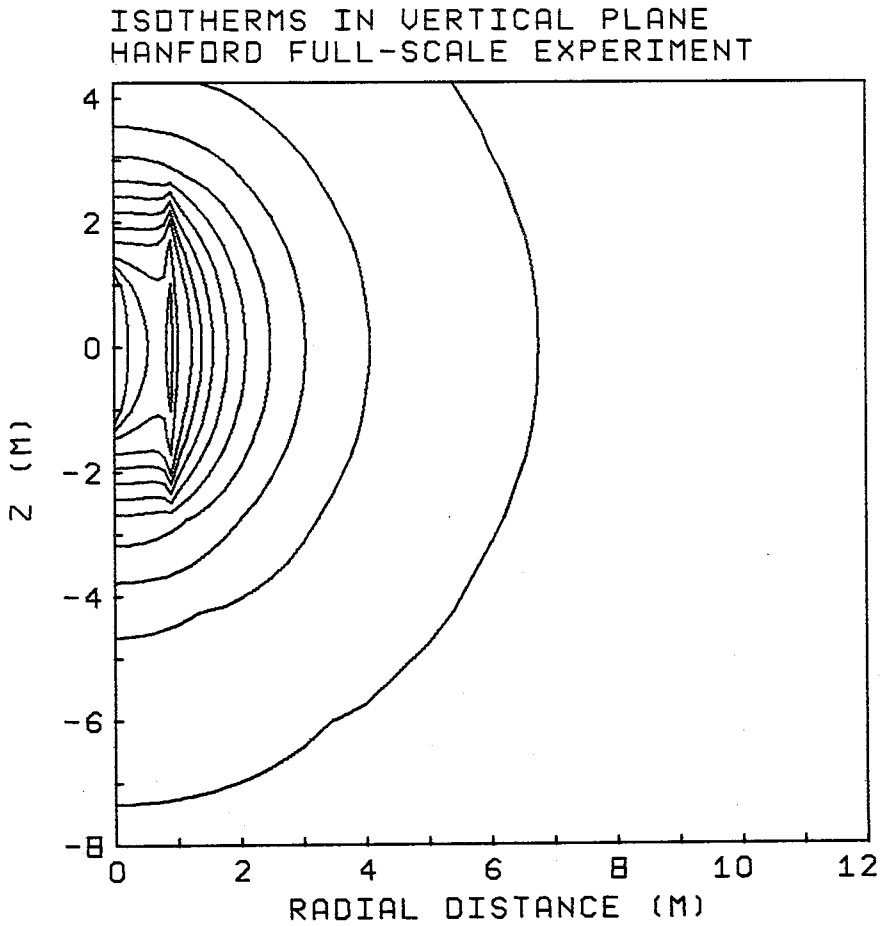
XBL 787-9463

Figure D10f



XBL 787-9464

Figure D10g



PLOT INFORMATION

TIME = 455. DAYS

THETA = 0.0 DEG.

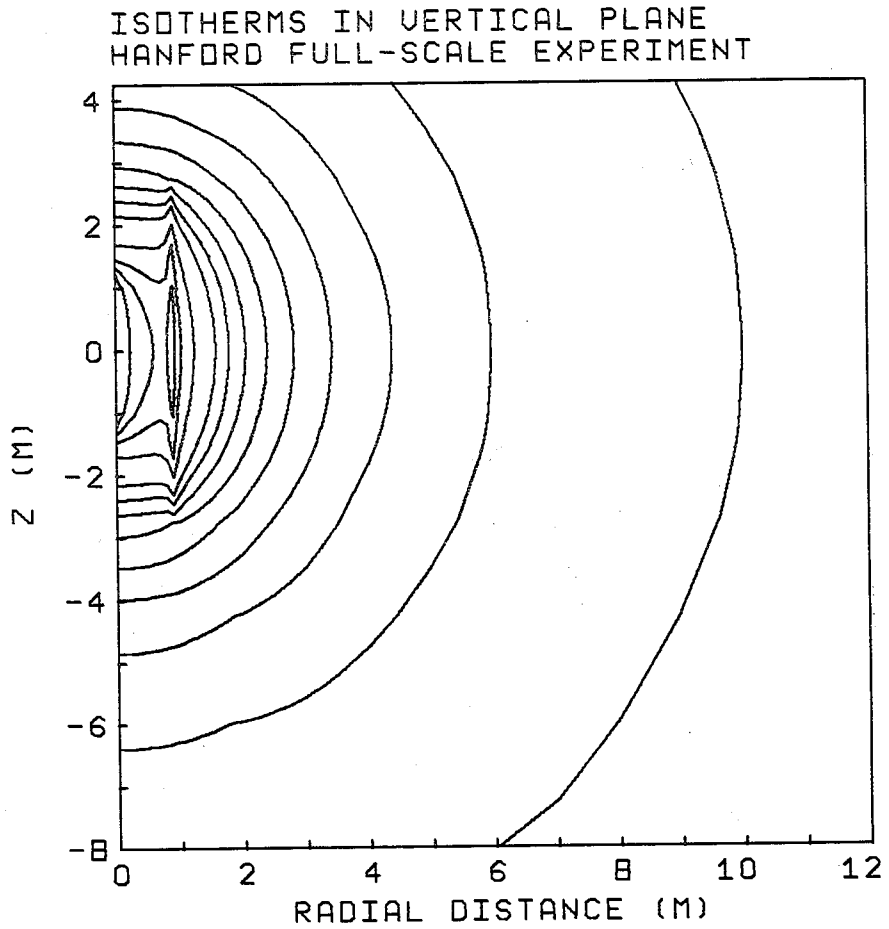
INFINITE MEDIUM MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
365. 300. 250. 200.
175. 150. 125. 100.
75. 50. 25. 5.

XBL 787-9462

Figure D10h



PLOT INFORMATION

TIME = 730. DAYS

THETA = 0.0 DEG.

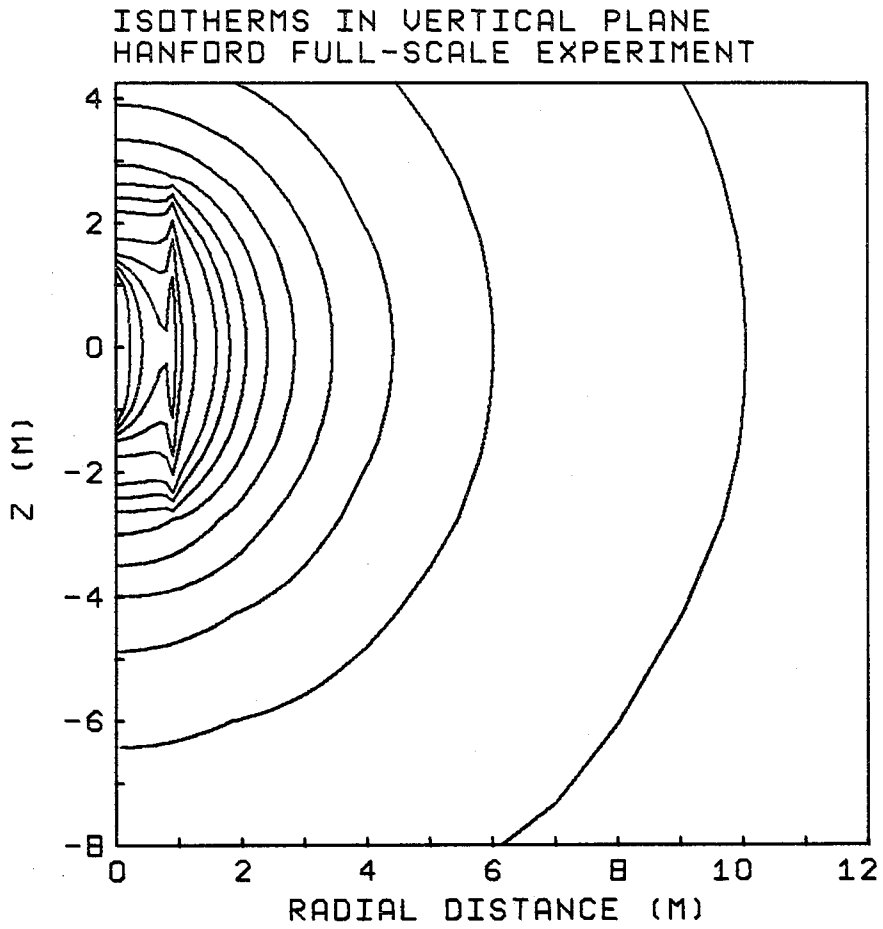
INFINITE MEDIUM MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
420. 350. 300. 250.
200. 175. 150. 125.
100. 75. 50. 25.
5.

XBL 787-9460

Figure D10i



PLOT INFORMATION

TIME = 737. DAYS

THETA = 0.0 DEG.

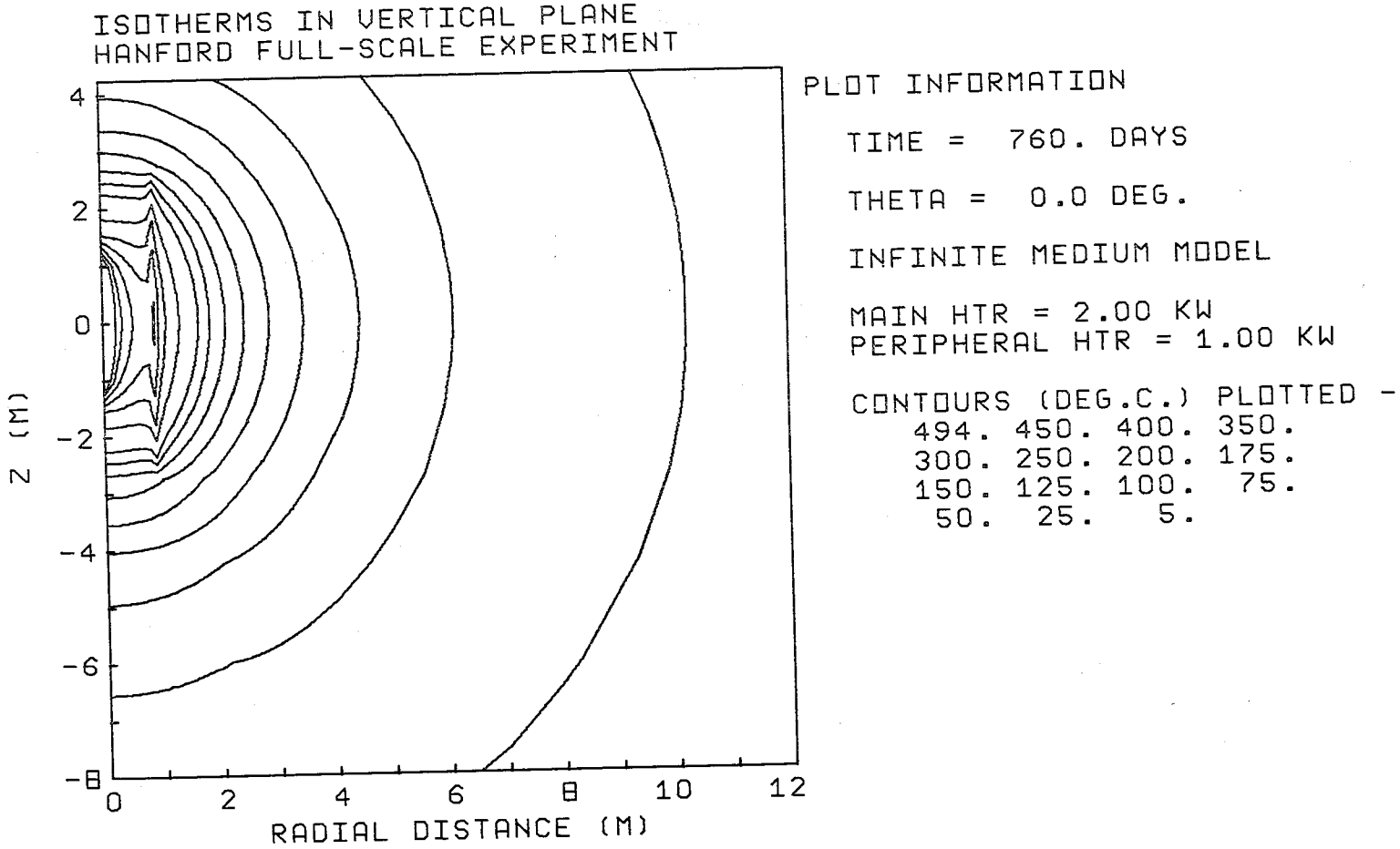
INFINITE MEDIUM MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
472. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

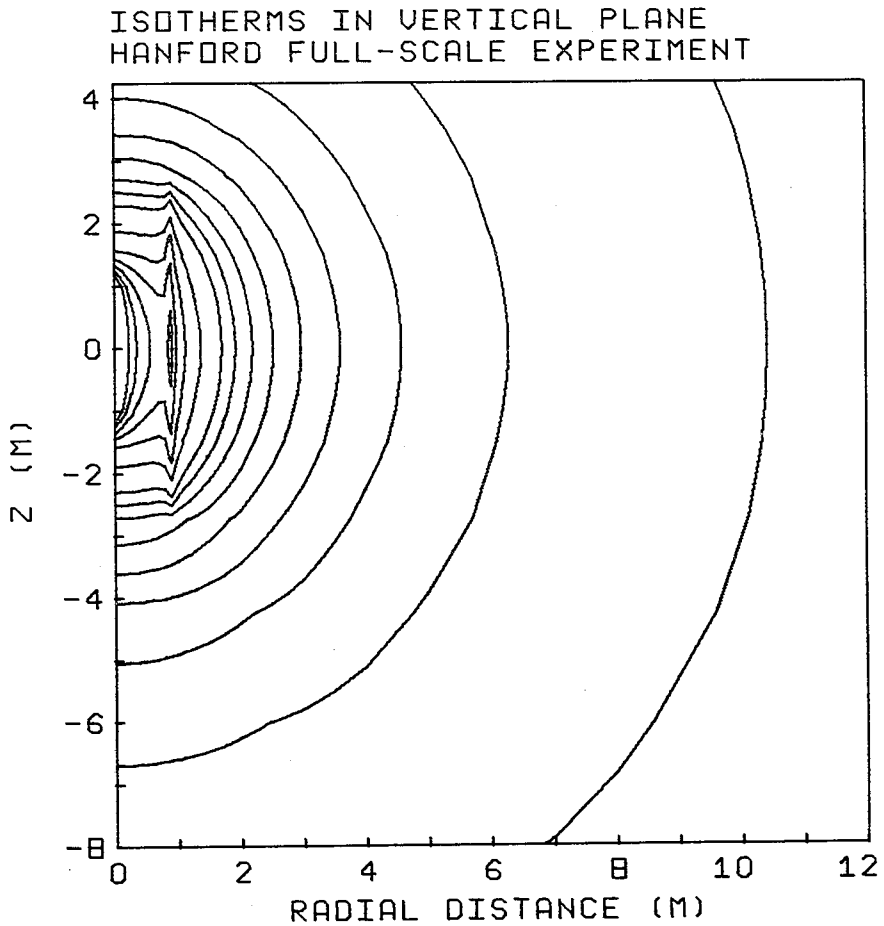
XBL 787-9459

Figure D10j



XBL 787-9455

Figure D10k



PLOT INFORMATION

TIME = 790. DAYS

THETA = 0.0 DEG.

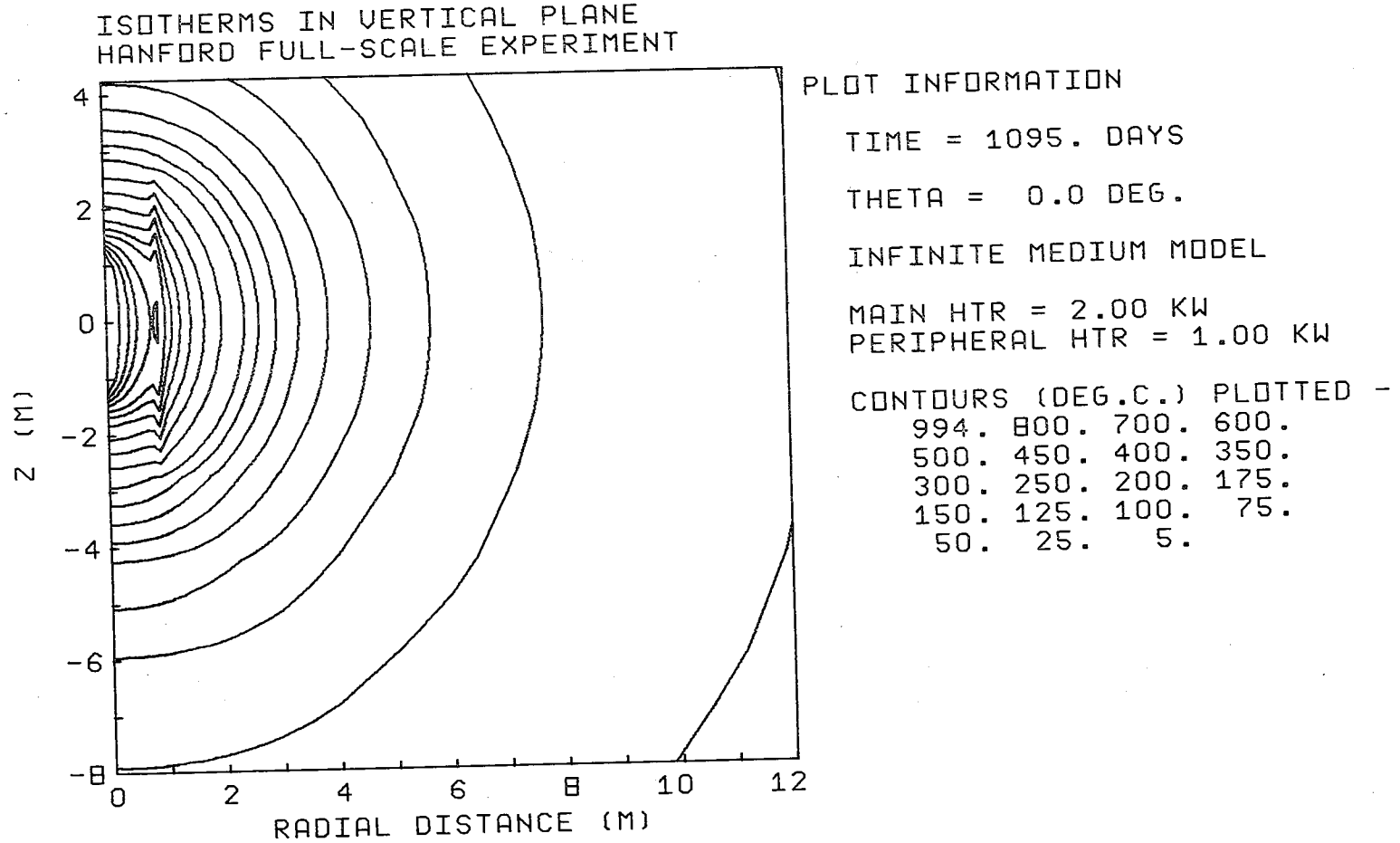
INFINITE MEDIUM MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
503. 450. 400. 350.
300. 250. 200. 175.
150. 125. 100. 75.
50. 25. 5.

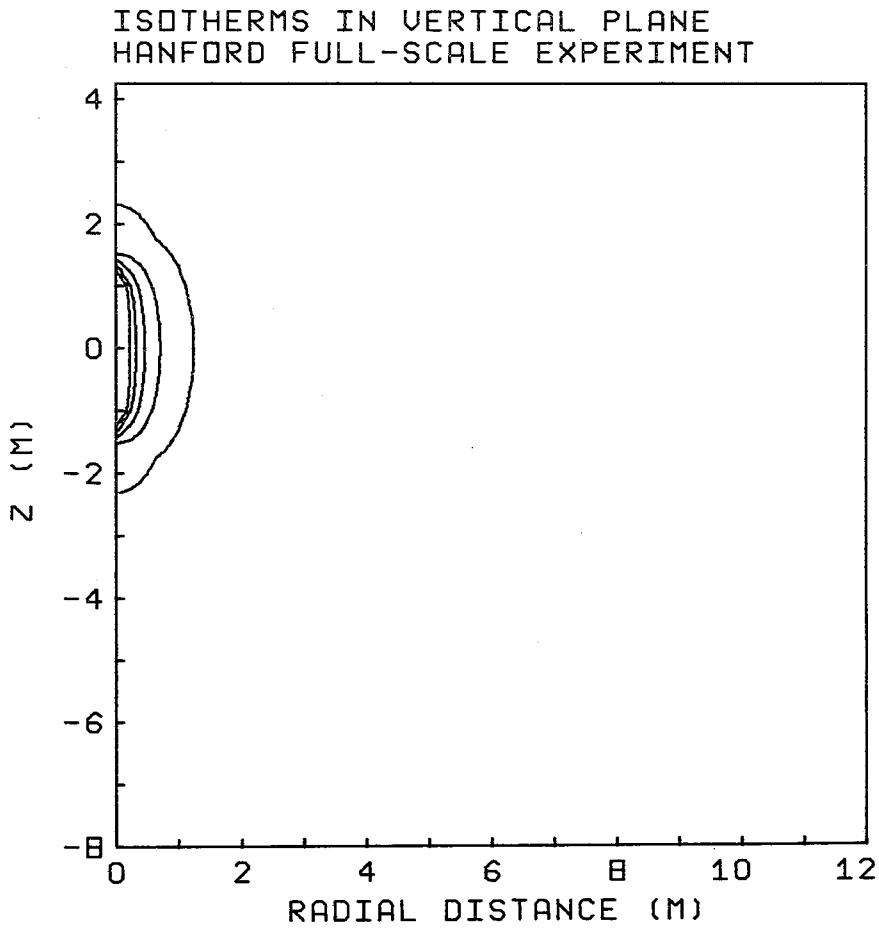
XBL 787-9454

Figure D101



XBL 786-9453

Figure D10m



PLOT INFORMATION

TIME = 7. DAYS

THETA = 0.0 DEG.

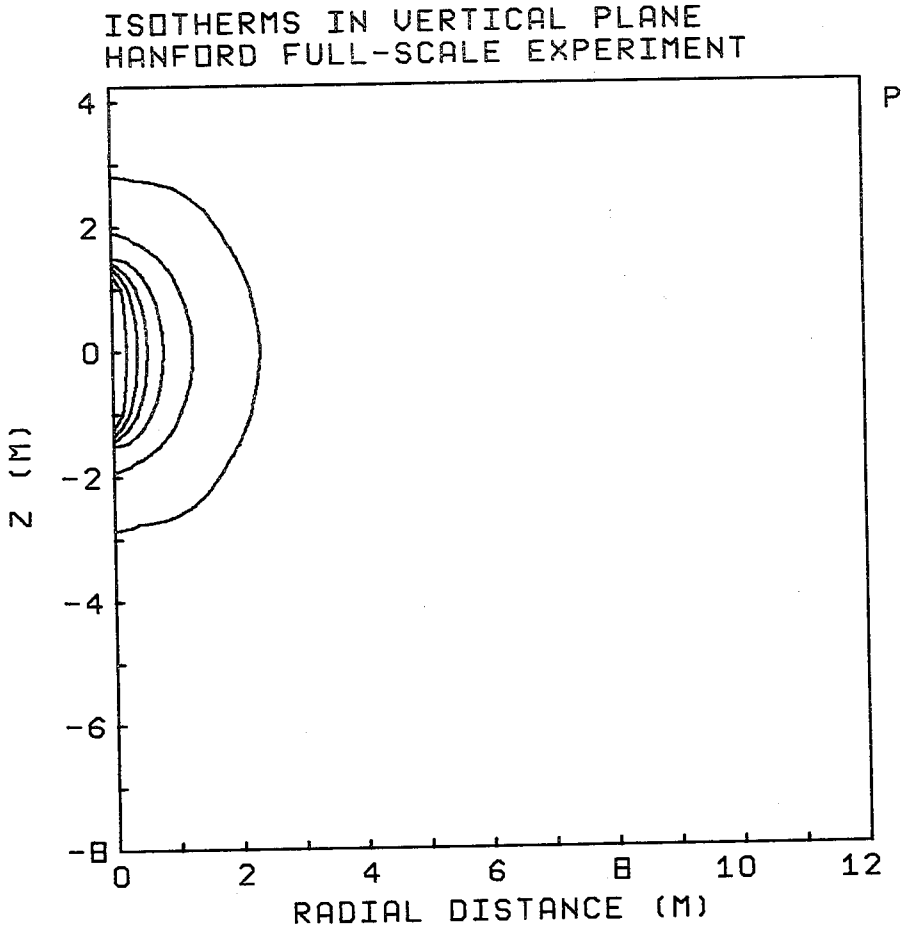
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
102. 75. 50. 25.
5.

XBL 787-9489

Figure D11a



PLOT INFORMATION

TIME = 30. DAYS

THETA = 0.0 DEG.

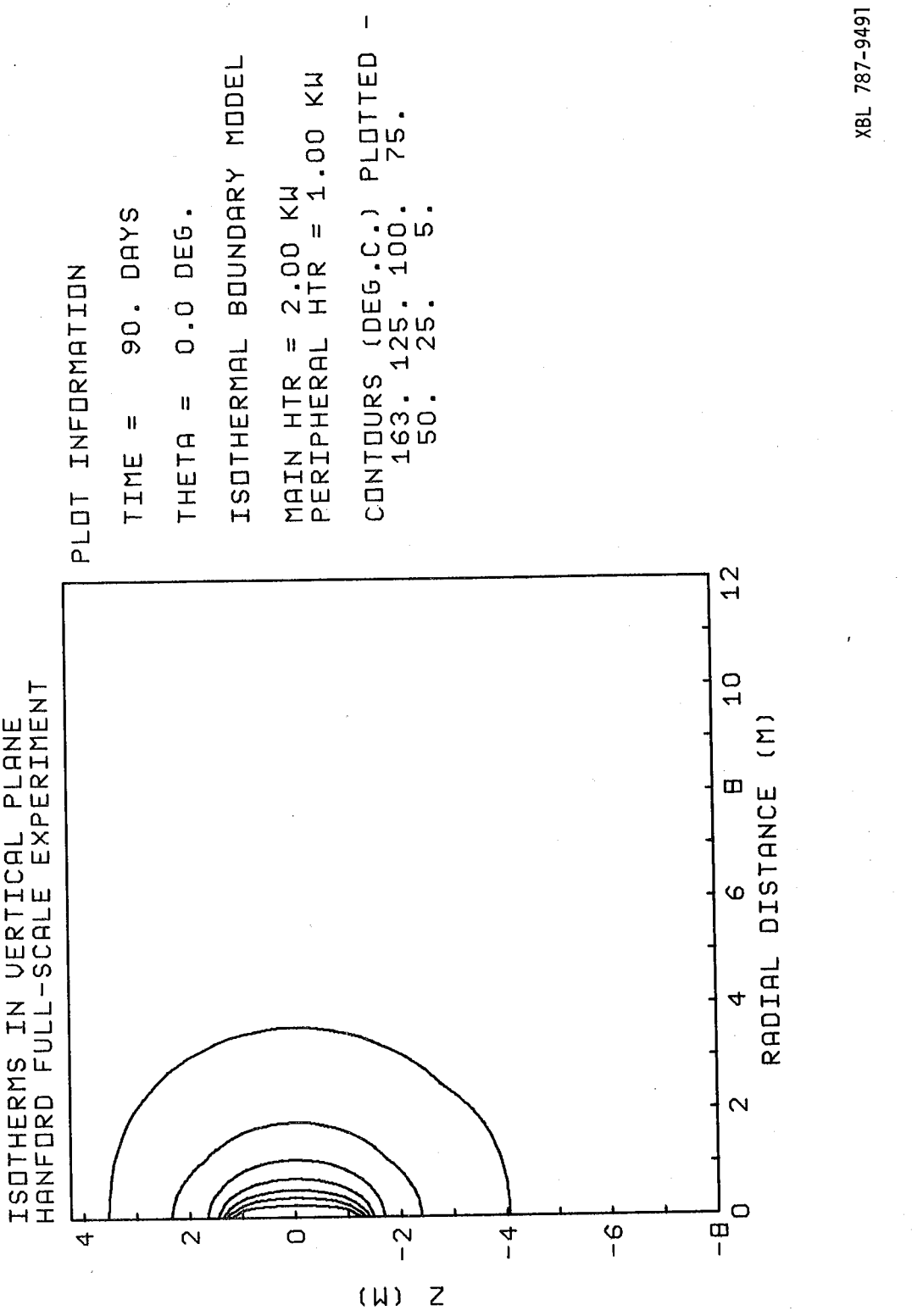
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
143. 100. 75. 50.
25. 5.

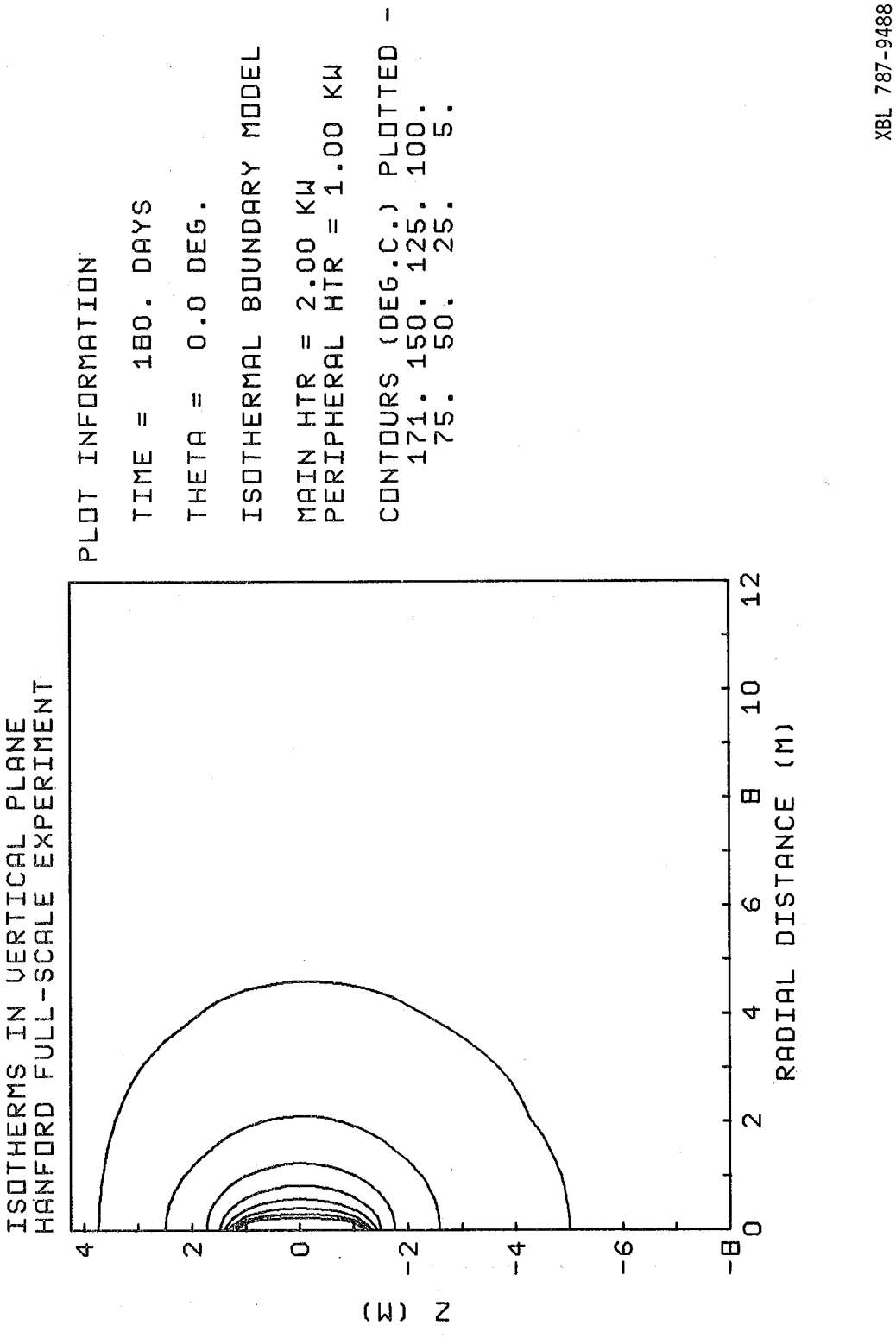
XBL 787-9490

Figure D11b



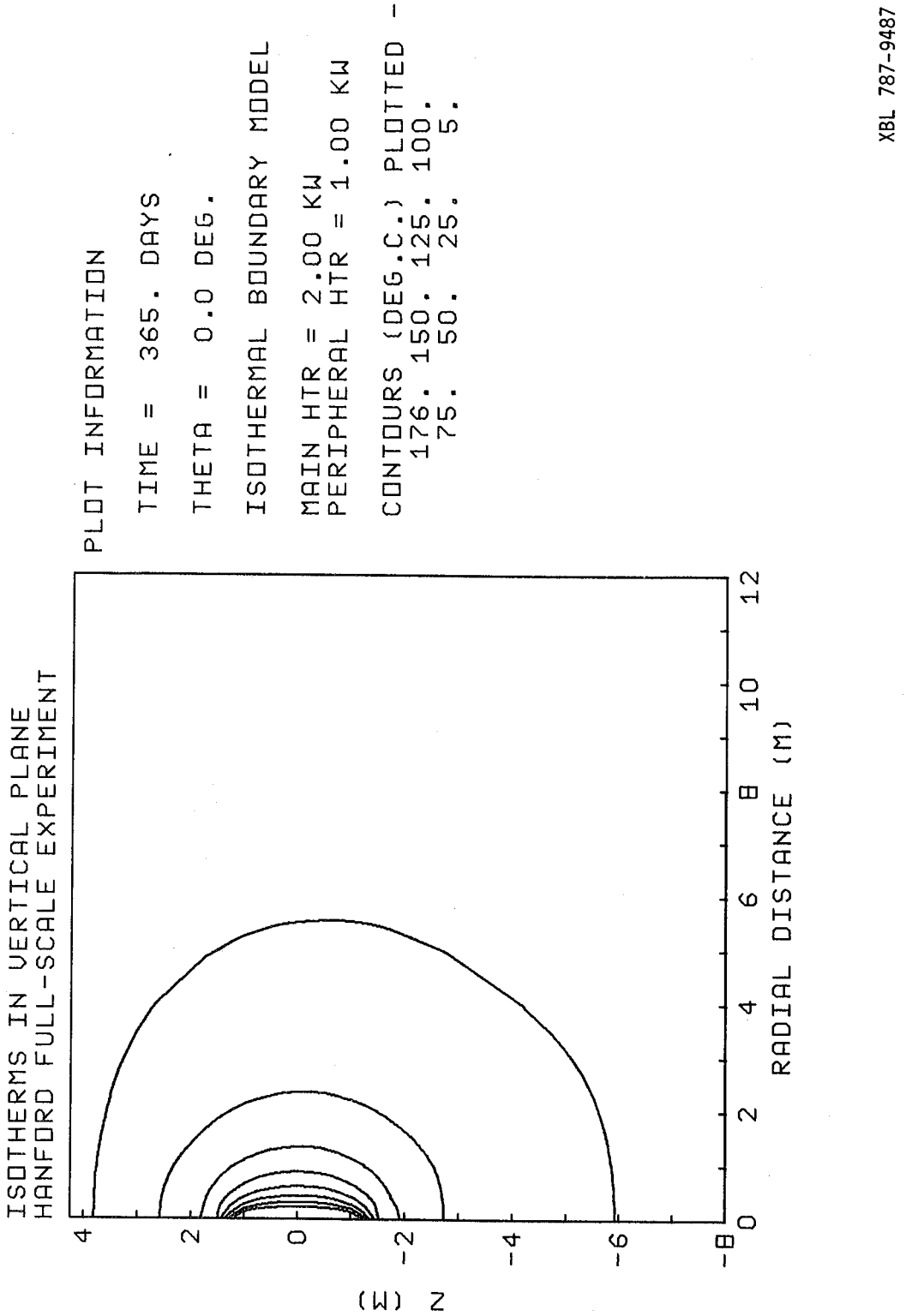
XBL 787-9491

Figure D11c



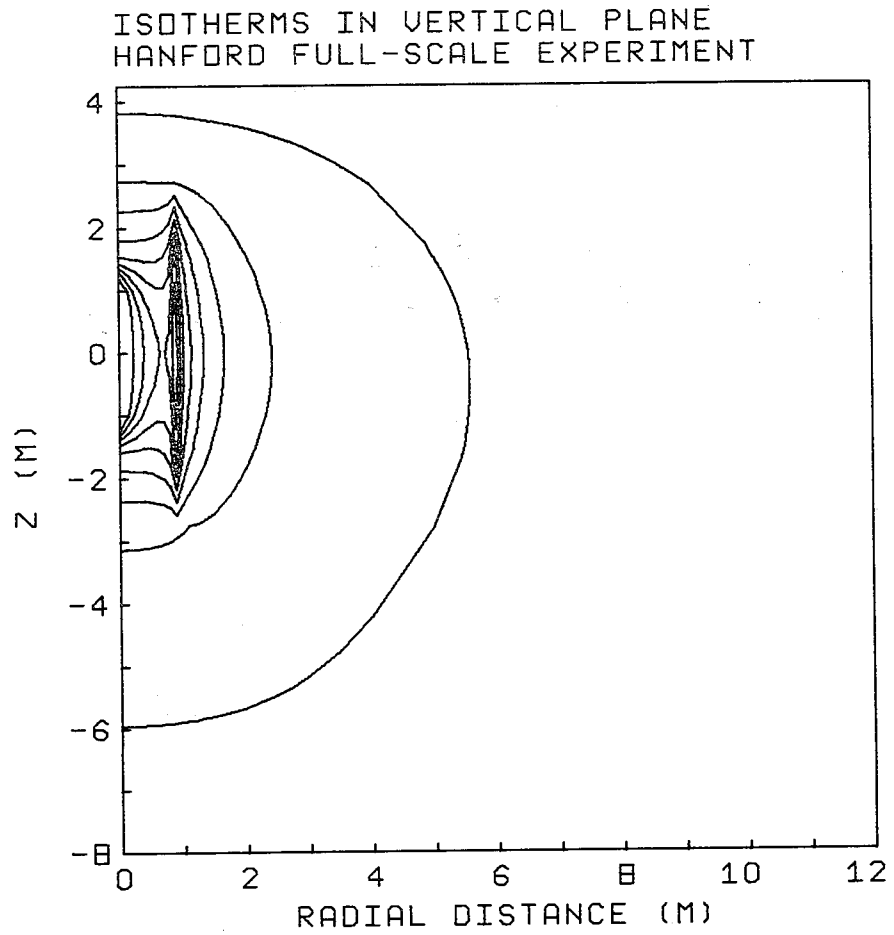
XBL 787-9488

Figure D11d



XBL 787-9487

Figure D11e



PLOT INFORMATION

TIME = 372. DAYS

THETA = 0.0 DEG.

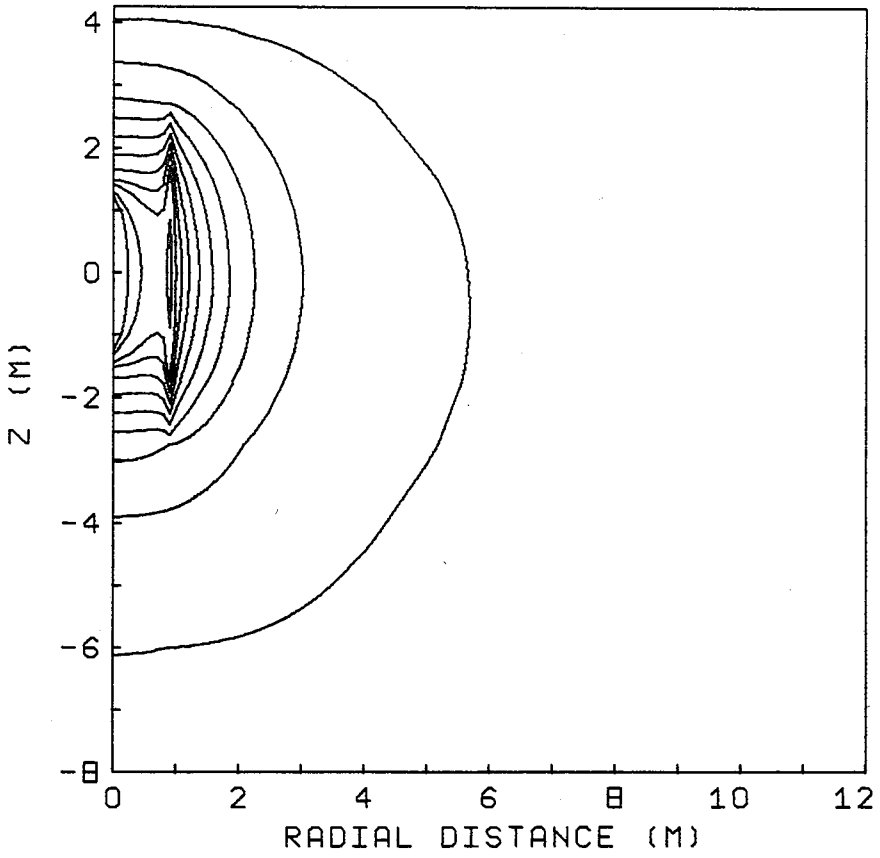
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
213. 175. 150. 125.
100. 75. 50. 25.
5.

XBL 787-9486

Figure D11f



PLOT INFORMATION

TIME = 395. DAYS

THETA = 0.0 DEG.

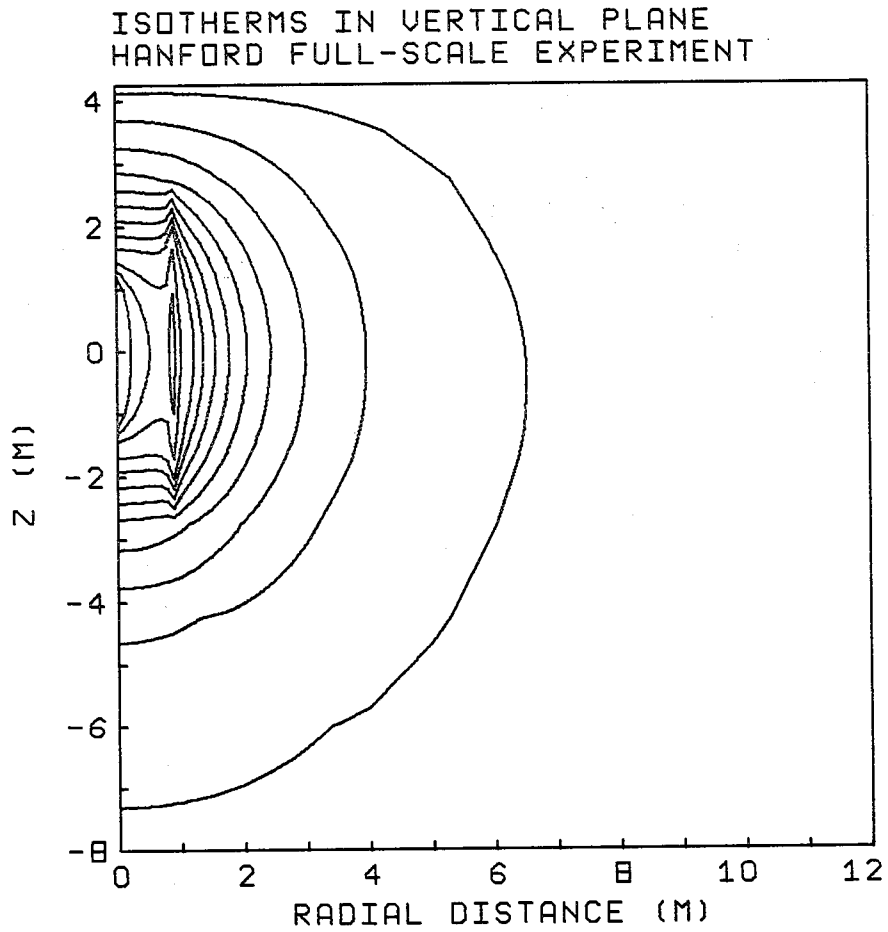
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
299. 250. 200. 175.
150. 125. 100. 75.
50. 25. 5.

XBL 787-9485

Figure D11g



PLOT INFORMATION

TIME = 455. DAYS

THETA = 0.0 DEG.

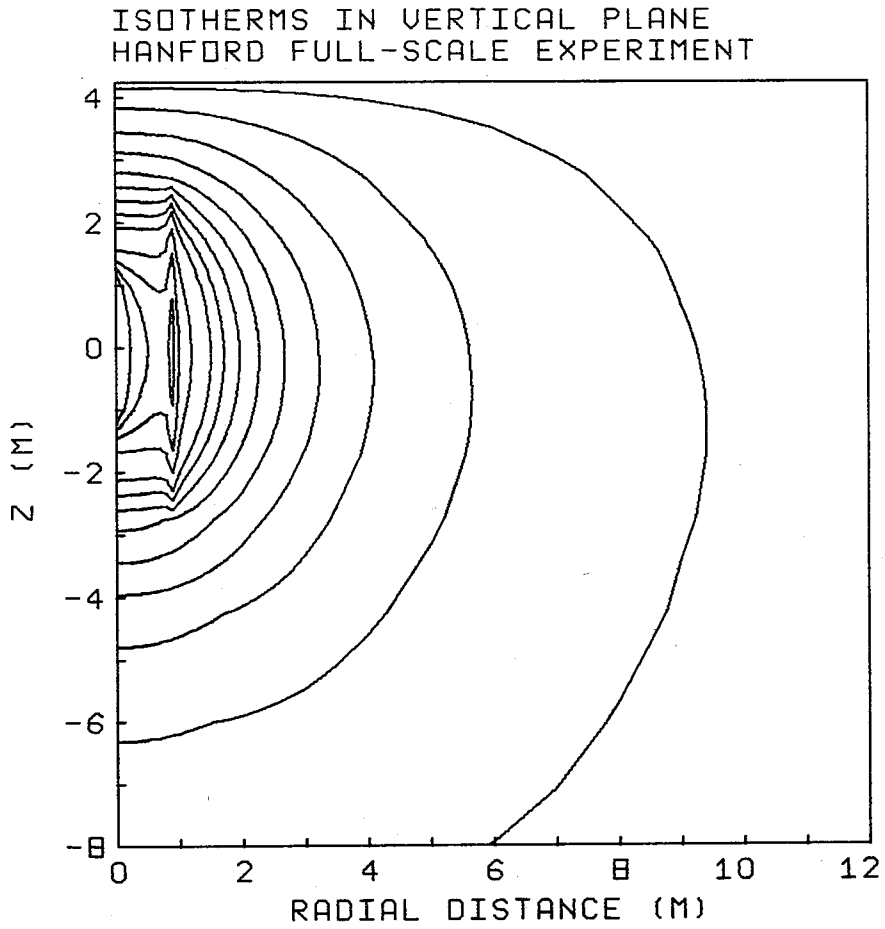
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
363. 300. 250. 200.
175. 150. 125. 100.
75. 50. 25. 5.

XBL 787-9484

Figure D11h



PLOT INFORMATION

TIME = 730. DAYS

THETA = 0.0 DEG.

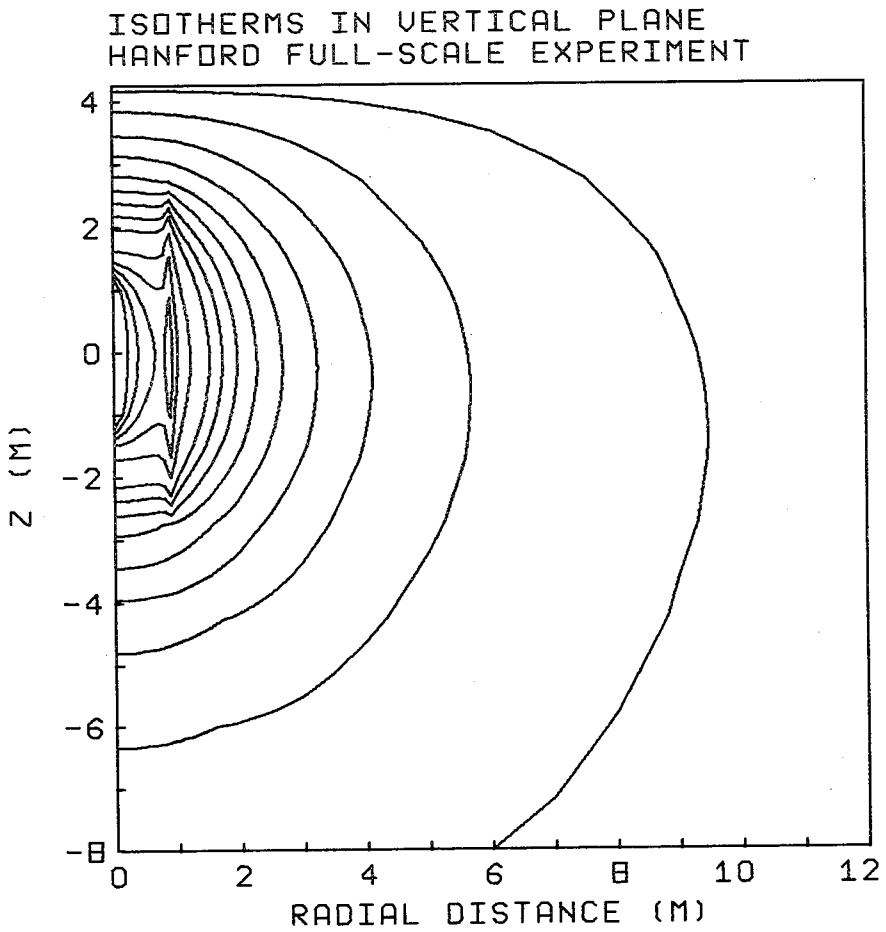
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
410. 350. 300. 250.
200. 175. 150. 125.
100. 75. 50. 25.
5.

XBL 787-9483

Figure D11i



PLOT INFORMATION

TIME = 737. DAYS

THETA = 0.0 DEG.

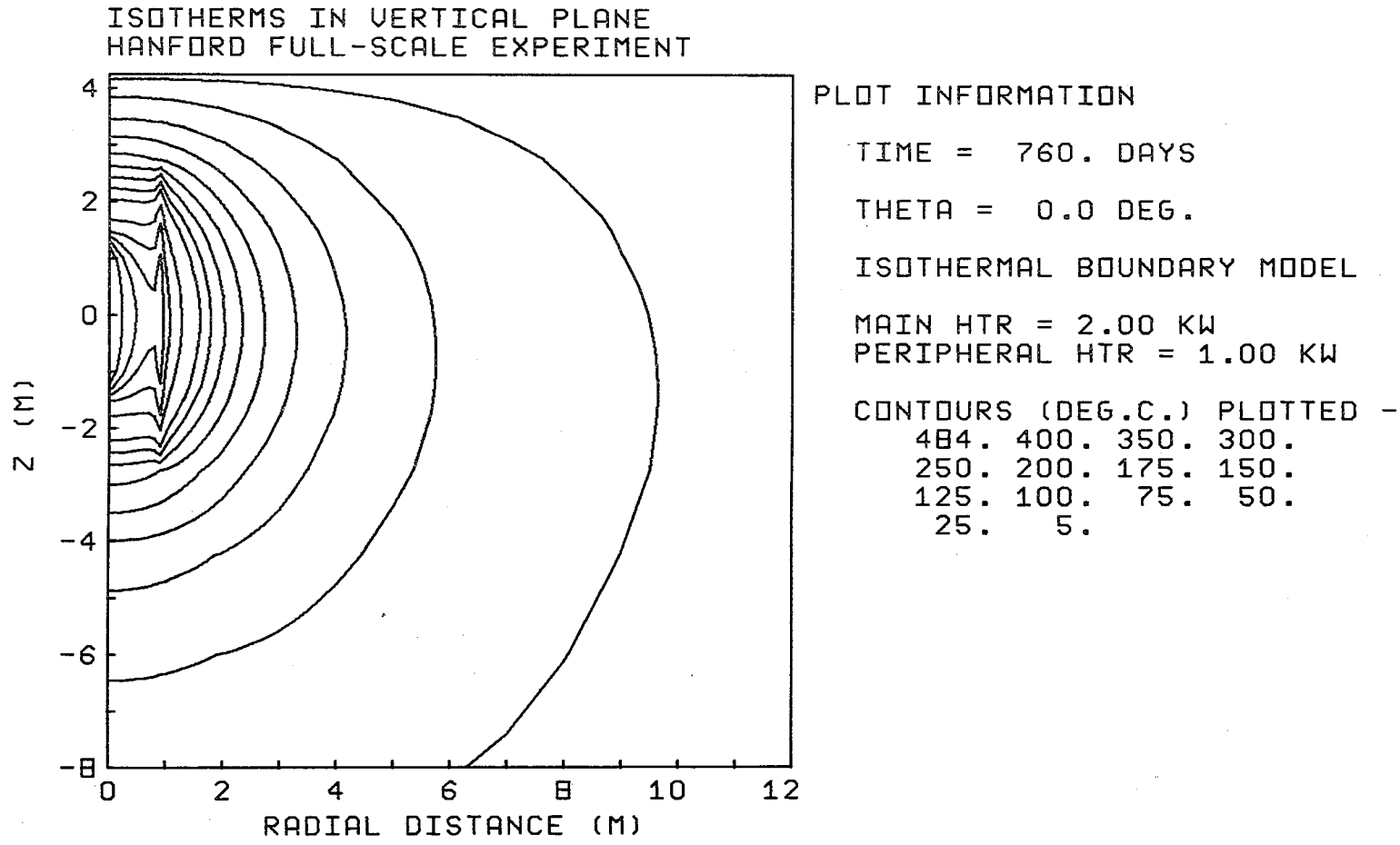
ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
461. 400. 350. 300.
250. 200. 175. 150.
125. 100. 75. 50.
25. 5.

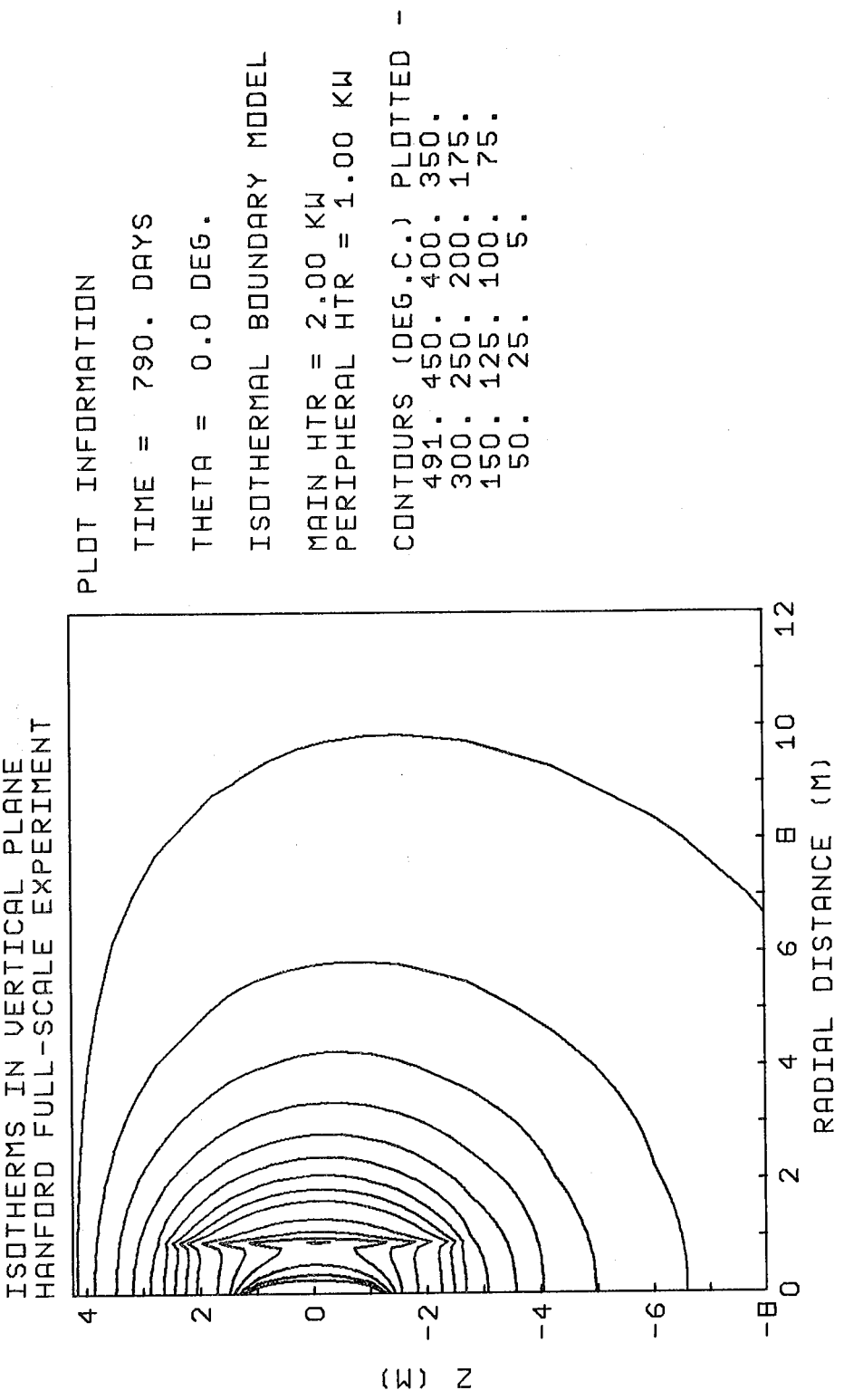
XBL 787-9482

Figure D11j



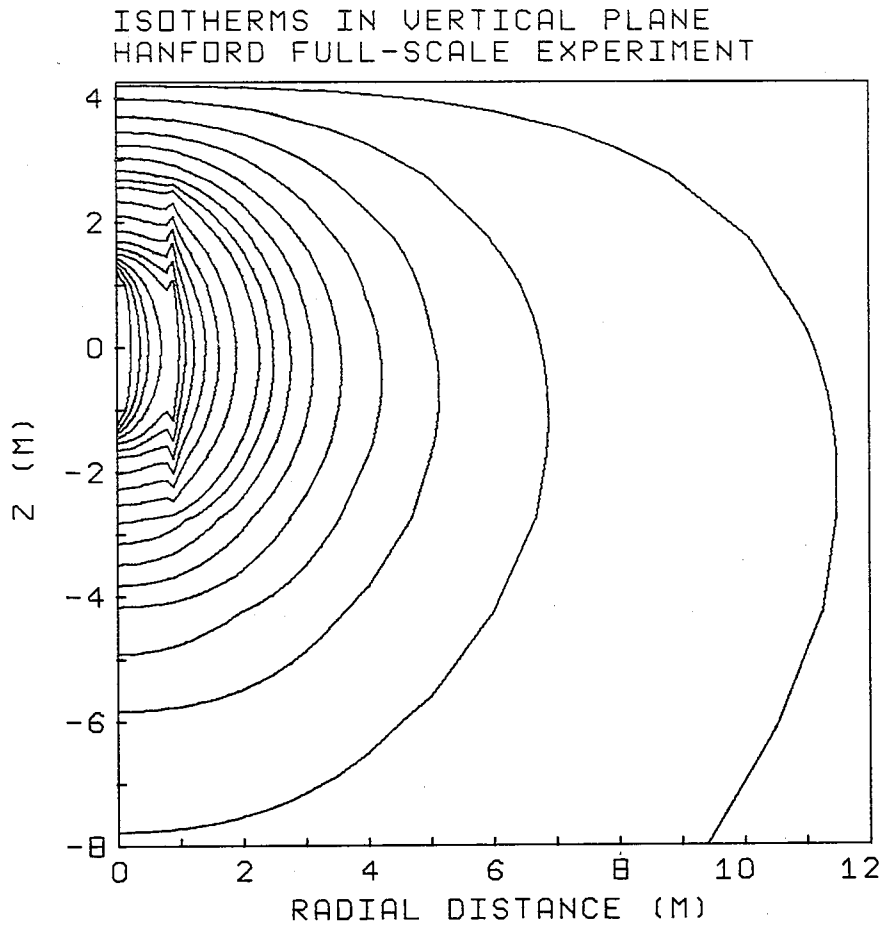
XBL 787-9481

Figure D11k



XBL 787-9480

Figure D11



PLOT INFORMATION

TIME = 1095. DAYS

THETA = 0.0 DEG.

ISOTHERMAL BOUNDARY MODEL

MAIN HTR = 2.00 KW
PERIPHERAL HTR = 1.00 KW

CONTOURS (DEG.C.) PLOTTED -
974. 800. 700. 600.
500. 450. 400. 350.
300. 250. 200. 175.
150. 125. 100. 75.
50. 25. 5.

XBL 787-9478

Figure D11m

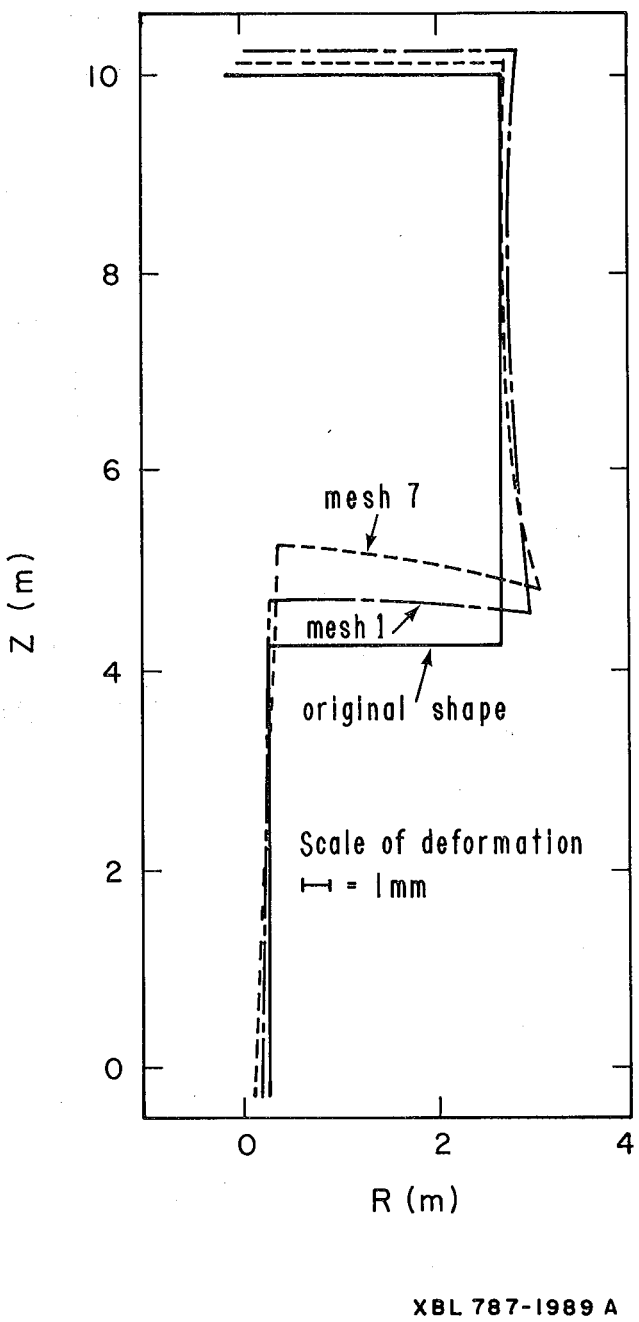

HANFORD FULL-SCALE EXPERIMENT
Power schedule 1A
Deformation drift and borehole
730 days
10
8
6
4
2
0
Z (m)
mesh 7
mesh 1
original shape
Scale of deformation
⊢ = 1mm
0
2
4
R (m)
XBL 787-1989 A

Figure D12a

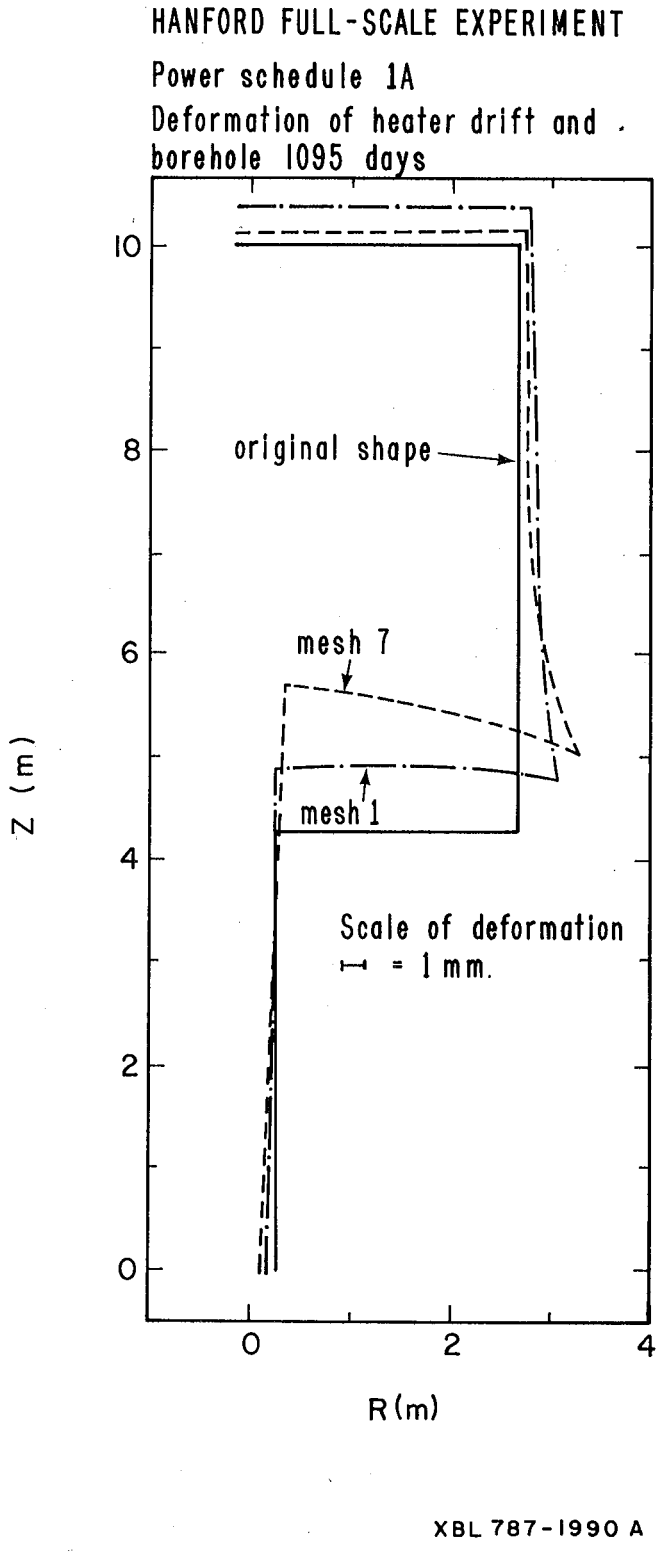

HANFORD FULL-SCALE EXPERIMENT
Power schedule 1A
Deformation of heater drift and borehole 1095 days
original shape
mesh 7
mesh 1
Scale of deformation
⊢ = 1 mm.
Z (m)
R(m)
0
2
4
6
8
10
0
2
4
XBL 787-1990 A

Figure D12b

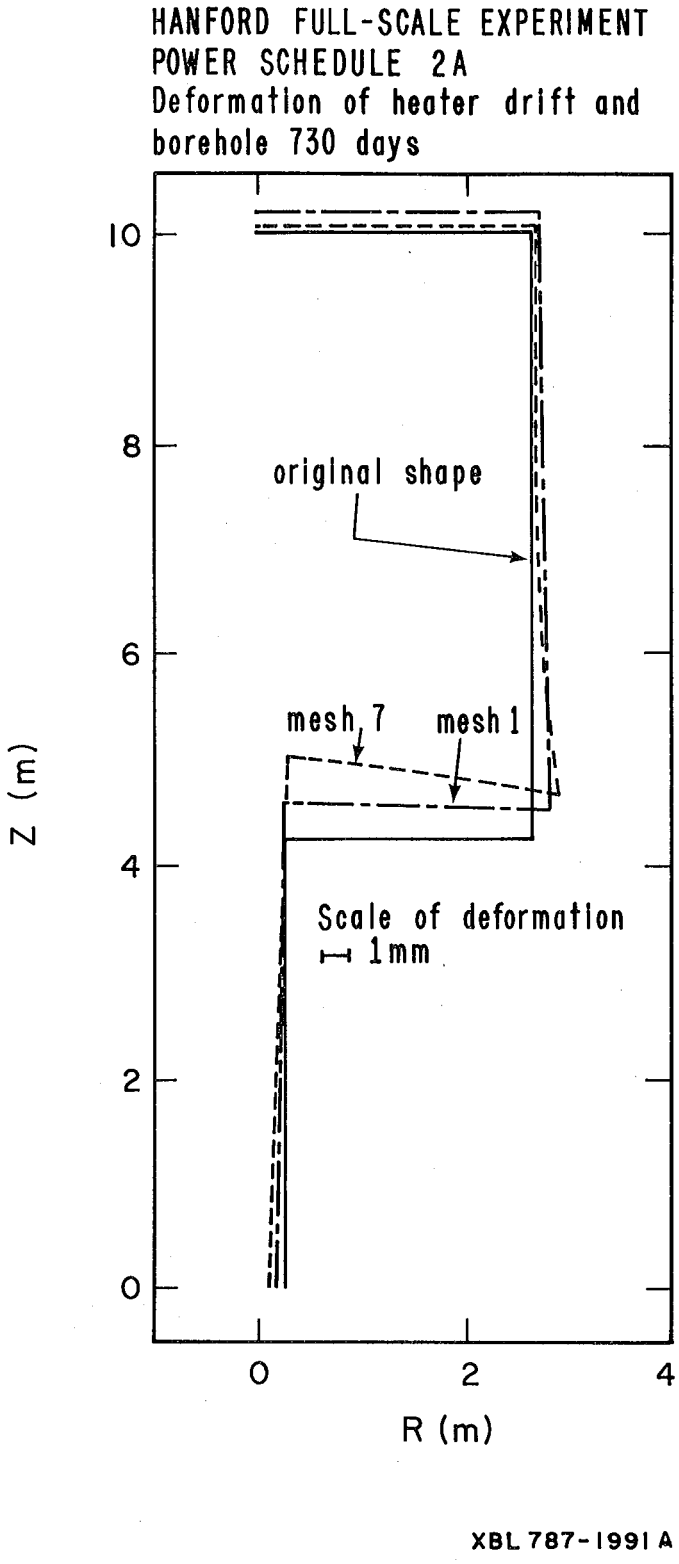

HANFORD FULL-SCALE EXPERIMENT
POWER SCHEDULE 2A
Deformation of heater drift and borehole 730 days
original shape
mesh 7
mesh 1
Scale of deformation
1mm
Z (m)
R (m)
0
2
4
6
8
10
0
2
4
XBL 787-1991 A

Figure D13a

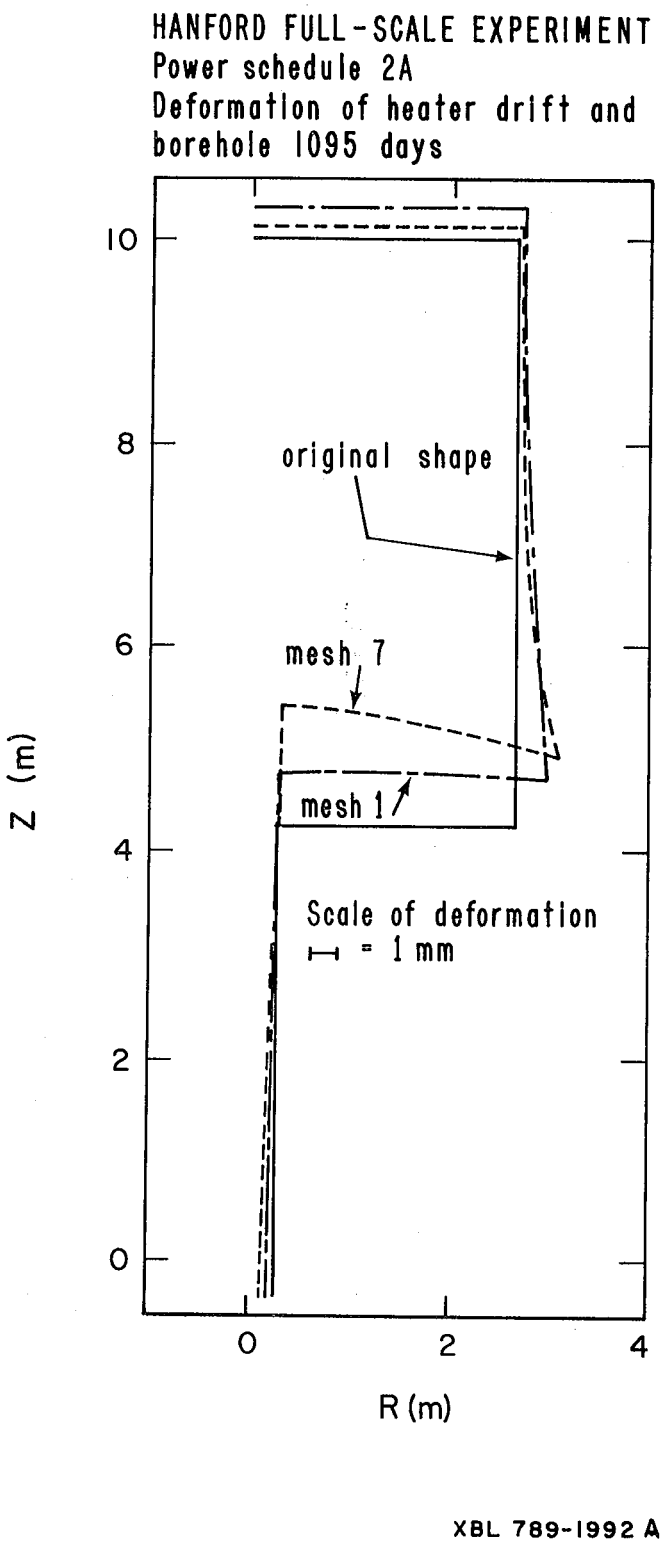

HANFORD FULL-SCALE EXPERIMENT
Power schedule 2A
Deformation of heater drift and
borehole 1095 days
original shape
mesh 7
mesh 1
Scale of deformation
⊢ = 1 mm
Z (m)
R (m)
0
2
4
6
8
10
0
2
4
XBL 789-1992 A

Figure D13b

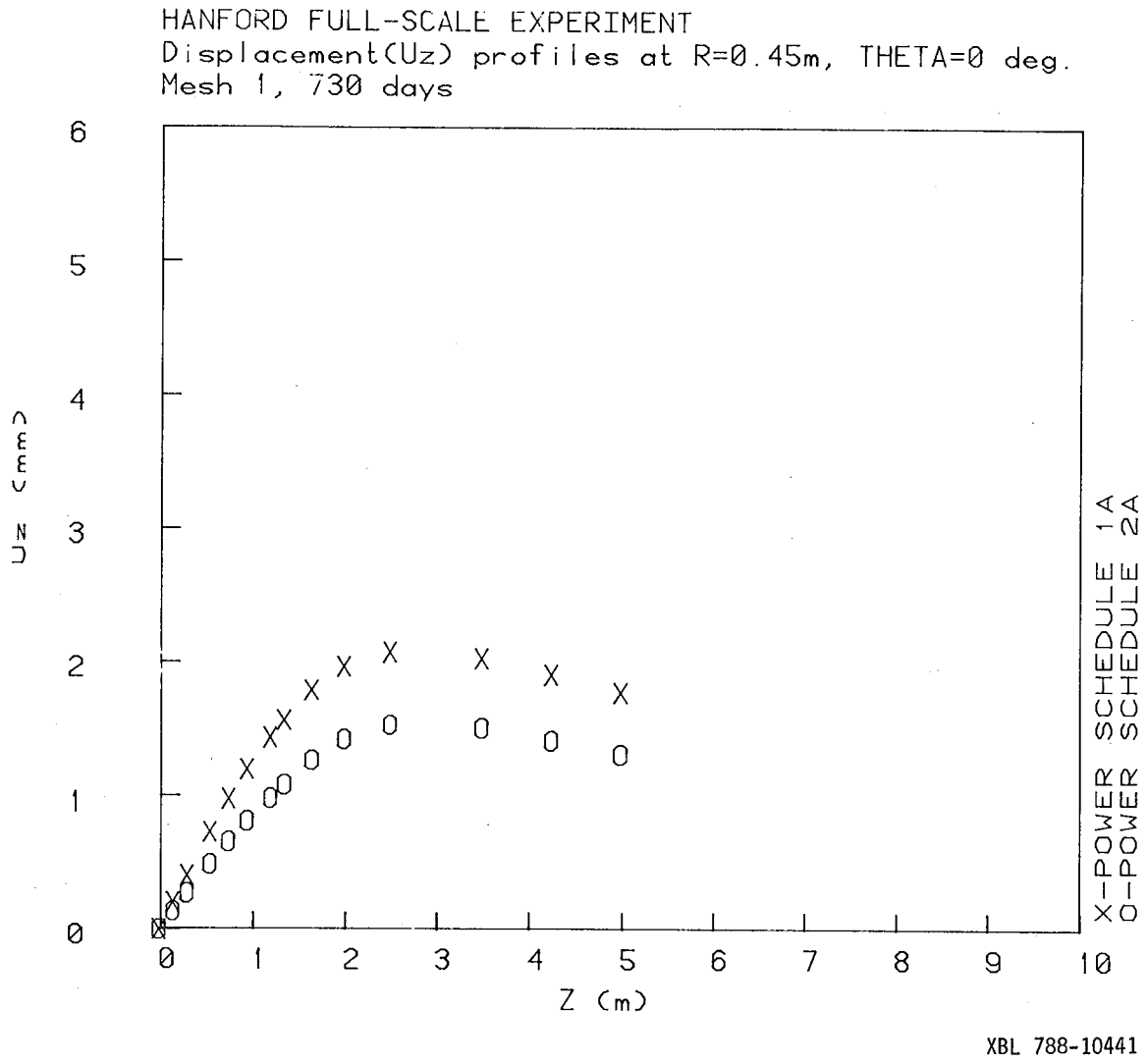

HANFORD FULL-SCALE EXPERIMENT
Displacement(Uz) profiles at R=0.45m, THETA=0 deg.
Mesh 1, 730 days
Uz (mm)
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10441

Figure D14a

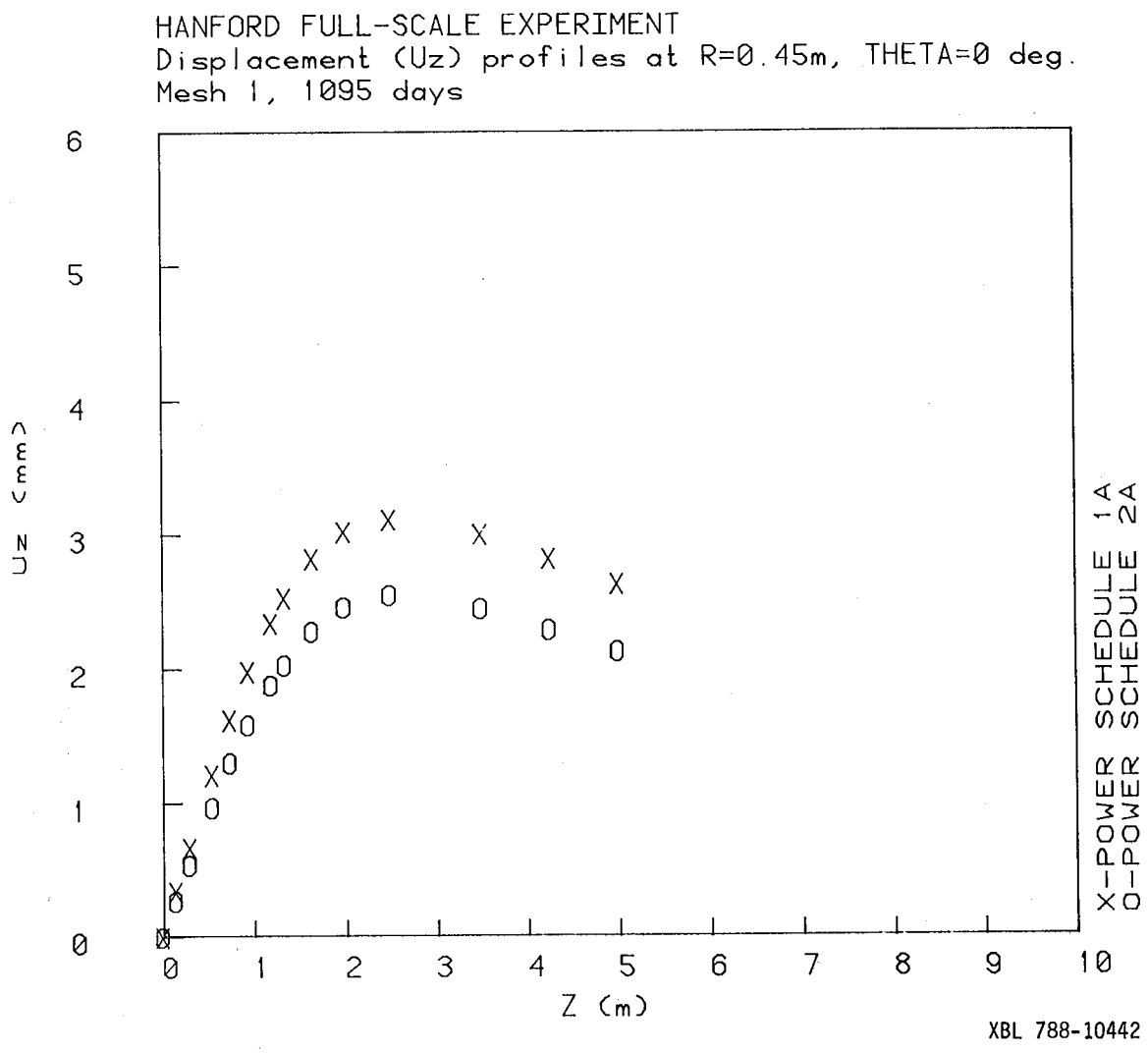

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=0.45m, THETA=0 deg.
Mesh 1, 1095 days
UN (mm)
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10442

Figure D14b

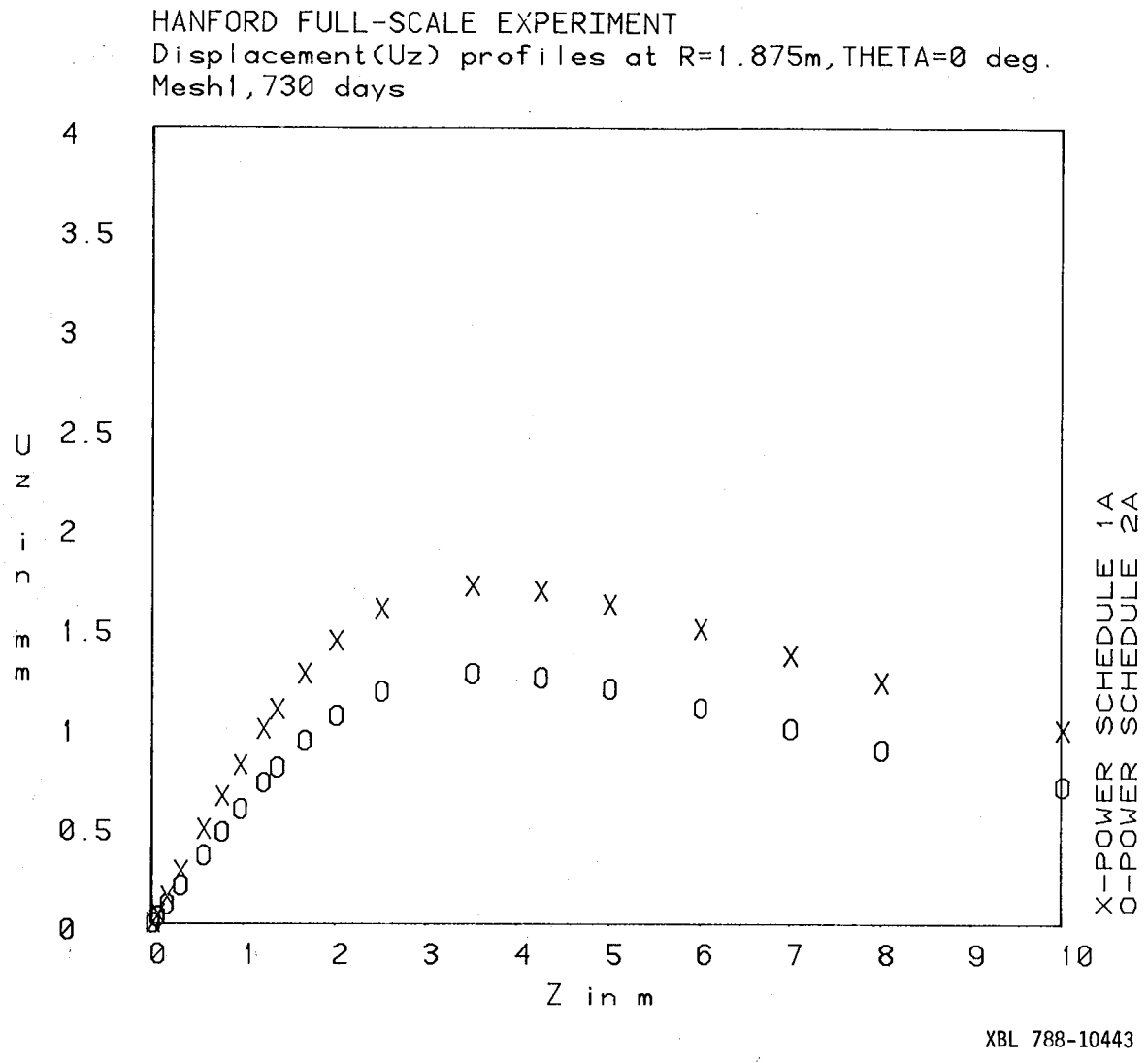

HANFORD FULL-SCALE EXPERIMENT
Displacement(Uz) profiles at R=1.875m, THETA=0 deg.
Mesh1, 730 days
4
3.5
3
2.5
2
1.5
1
0.5
0
m m in Uz
0
1
2
3
4
5
6
7
8
9
10
Z in m
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10443

Figure D15a

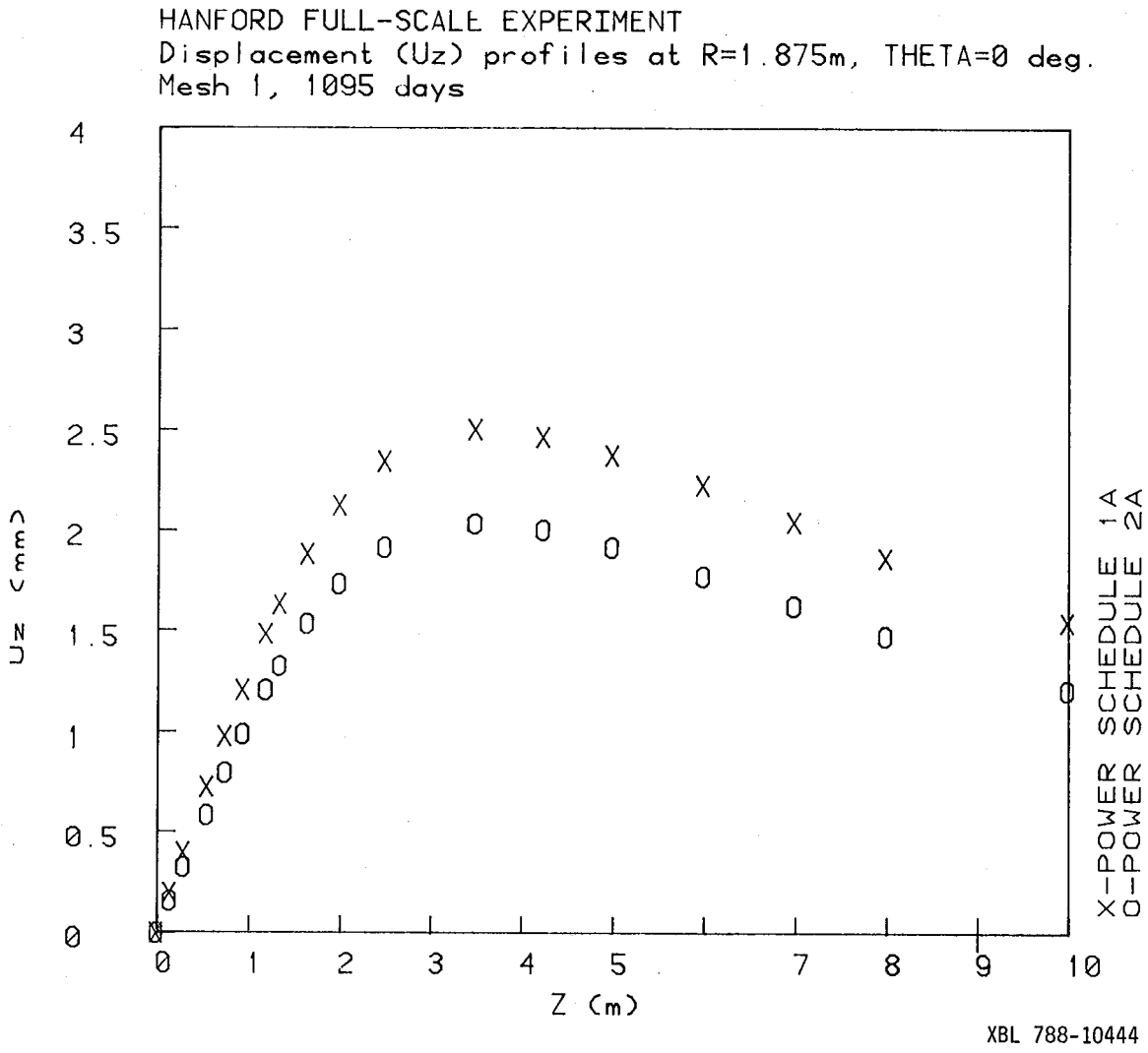

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=1.875m, THETA=0 deg.
Mesh 1, 1095 days
Uz (mm)
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10444

Figure D15b

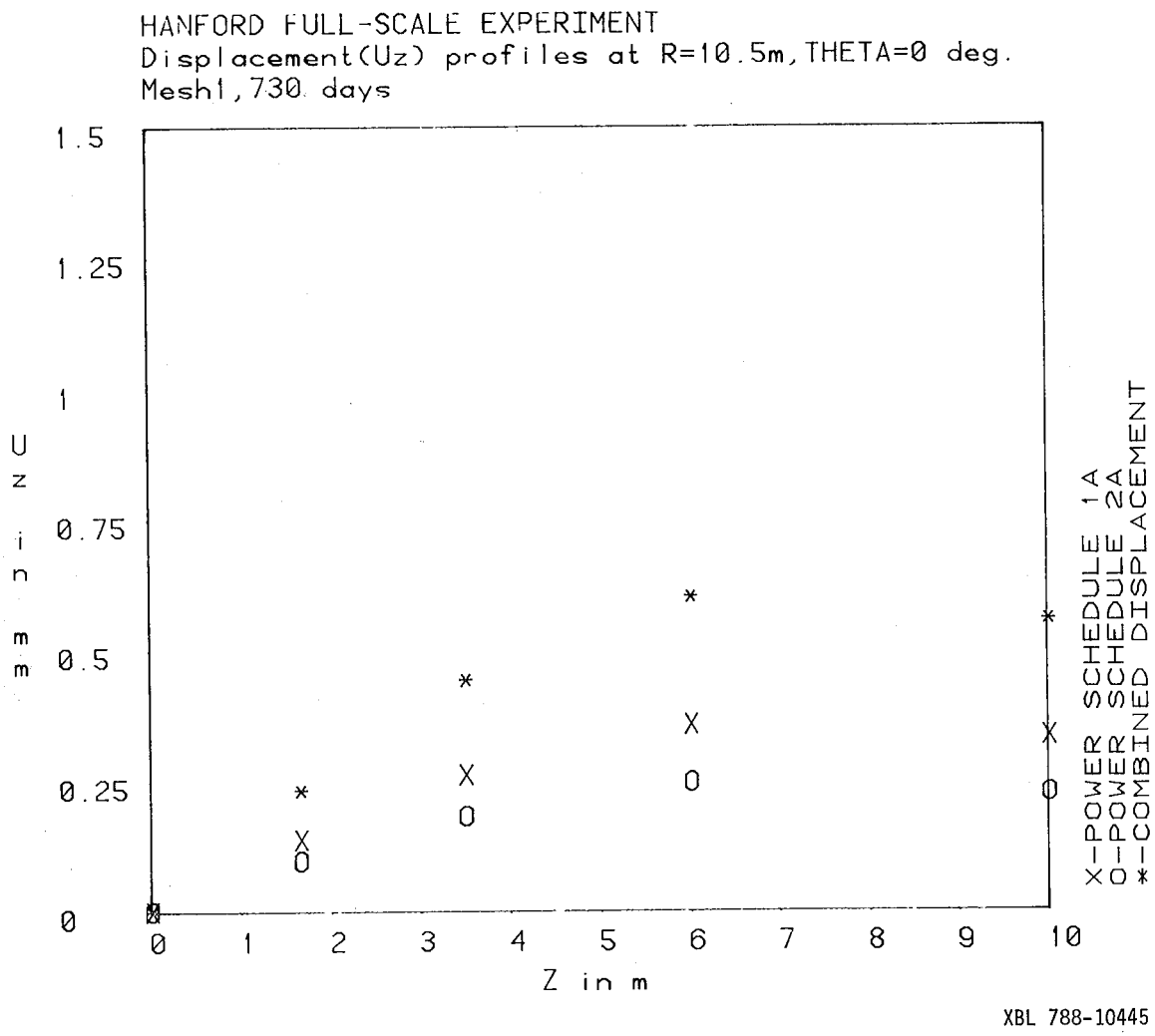

HANFORD FULL-SCALE EXPERIMENT
Displacement(Uz) profiles at R=10.5m, THETA=0 deg.
Mesh1, 730 days
1.5
1.25
1
0.75
0.5
0.25
0
U z in m
0
1
2
3
4
5
6
7
8
9
10
Z in m
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
*-COMBINED DISPLACEMENT
XBL 788-10445

Figure D16a

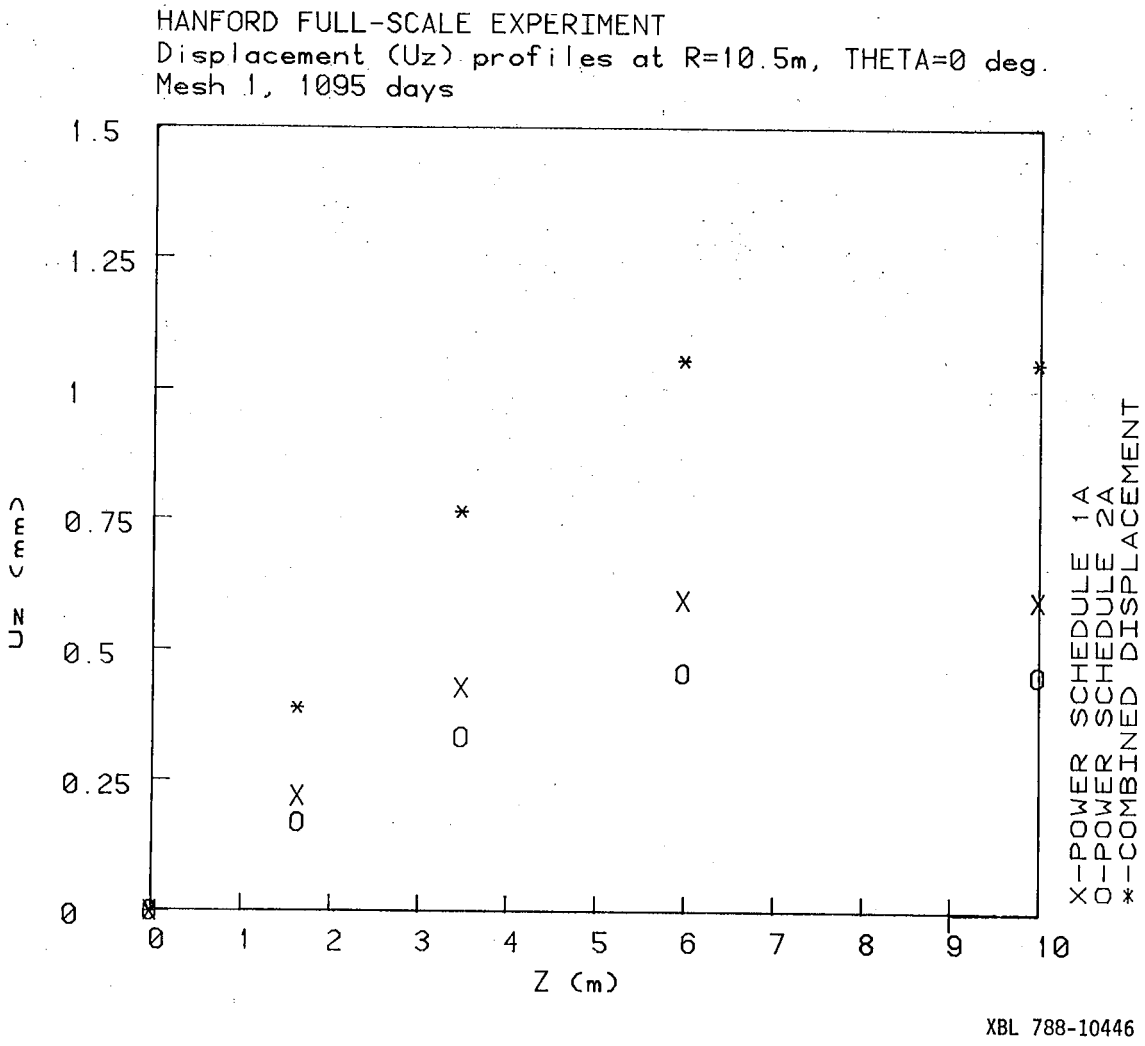

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=10.5m, THETA=0 deg.
Mesh 1, 1095 days
1.5
1.25
1
0.75
0.5
0.25
0
UN (mm)
0
1
2
3
4
5
6
7
8
9
10
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
*-COMBINED DISPLACEMENT
XBL 788-10446

Figure D16b

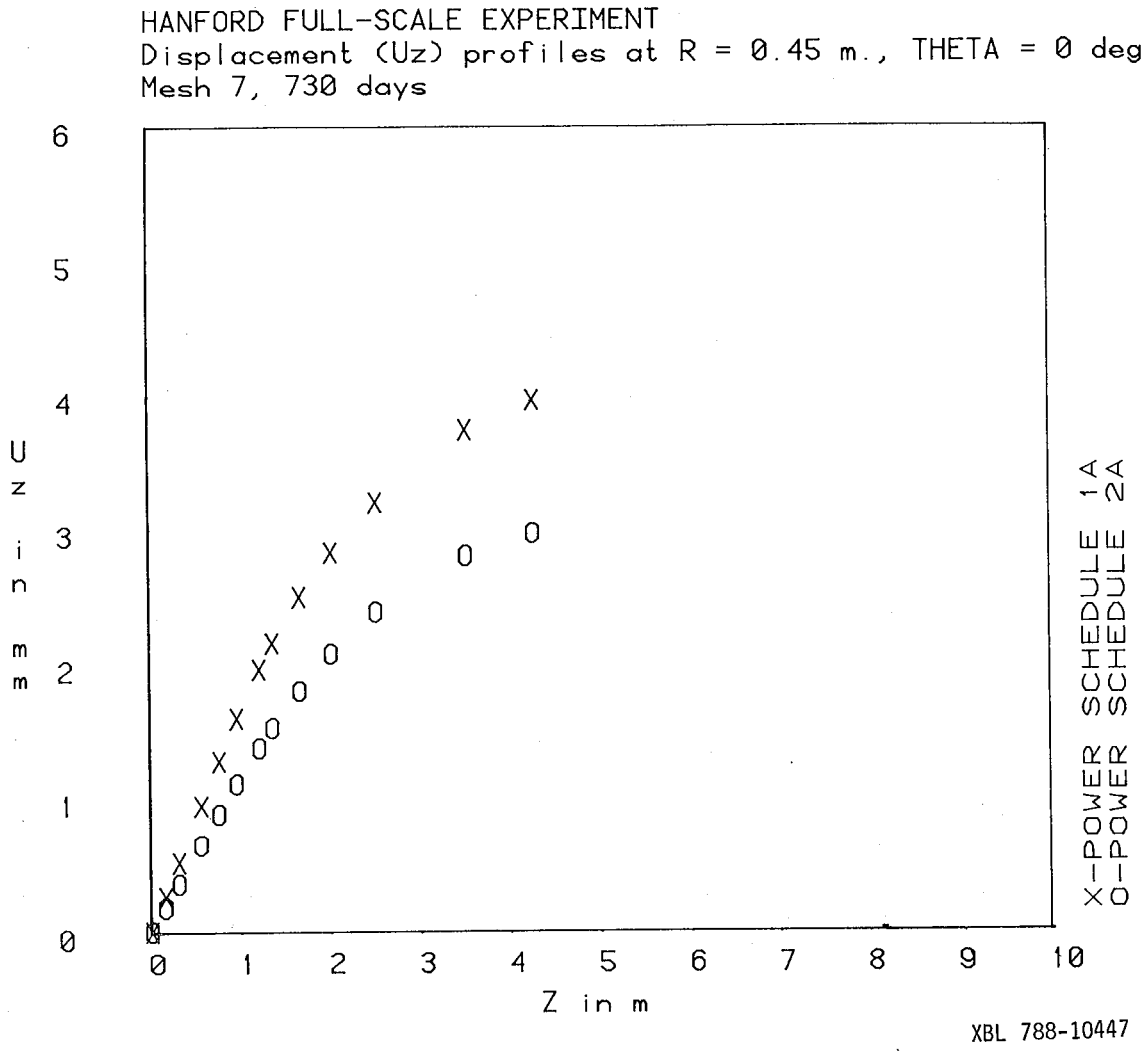

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R = 0.45 m., THETA = 0 deg.
Mesh 7, 730 days
Uz in mm
Z in m
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10447

Figure D17a

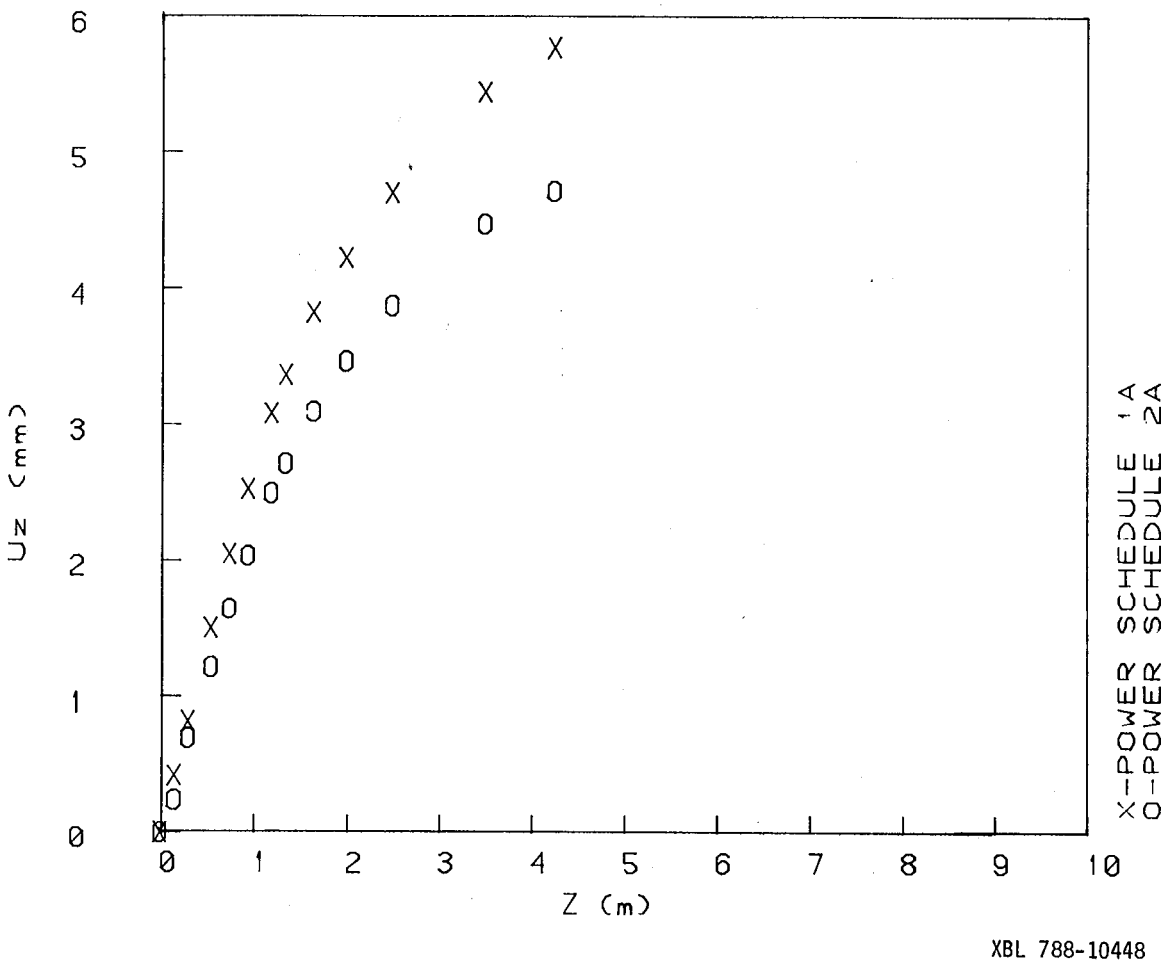

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=0.15m, THETA=0 deg.
Mesh 7, 1095 days
UN (mm)
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10448

Figure D17b

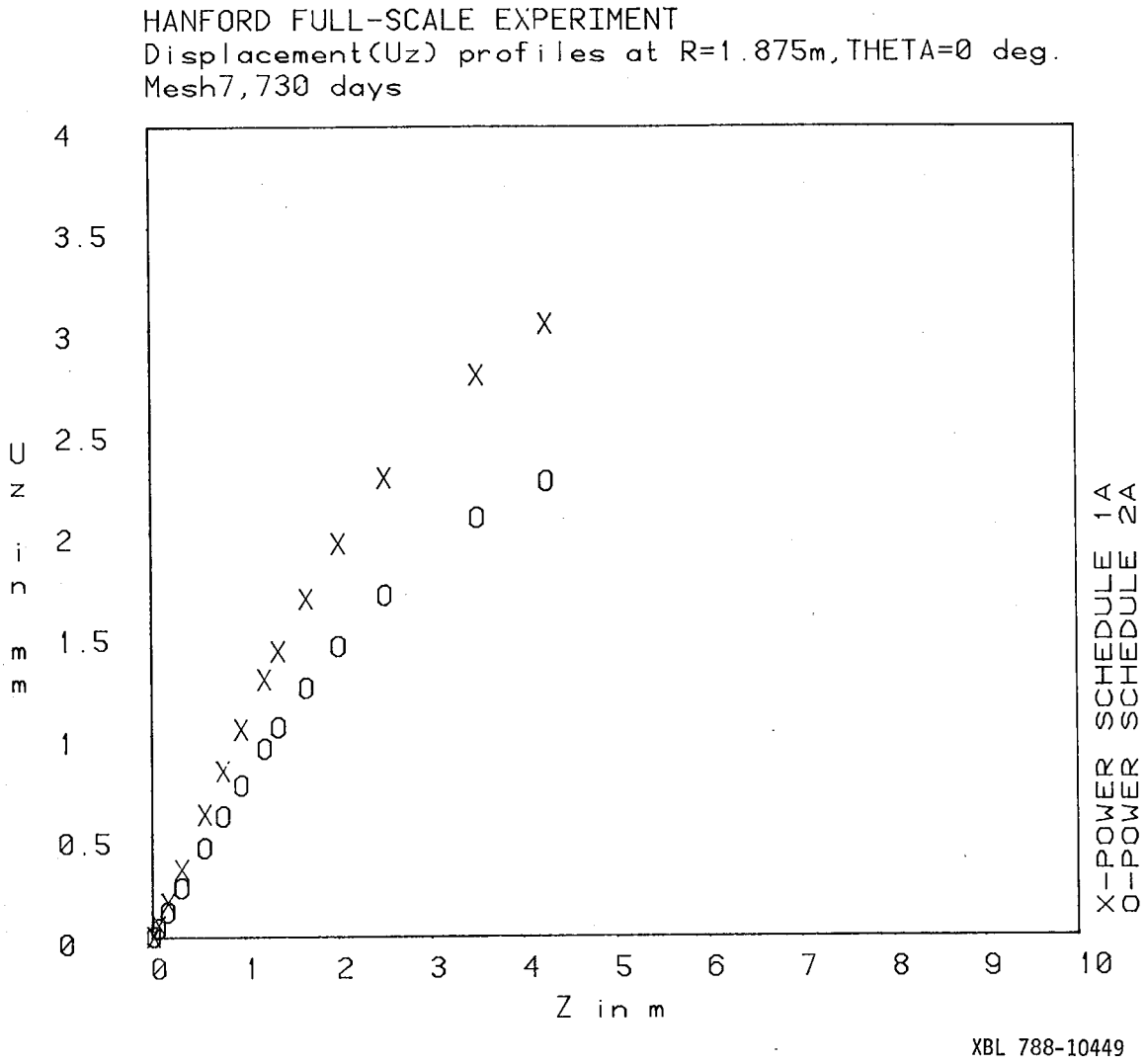

HANFORD FULL-SCALE EXPERIMENT
Displacement(Uz) profiles at R=1.875m,THETA=0 deg.
Mesh7,730 days
mm in Uz
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9
10
Z in m
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10449

Figure D18a

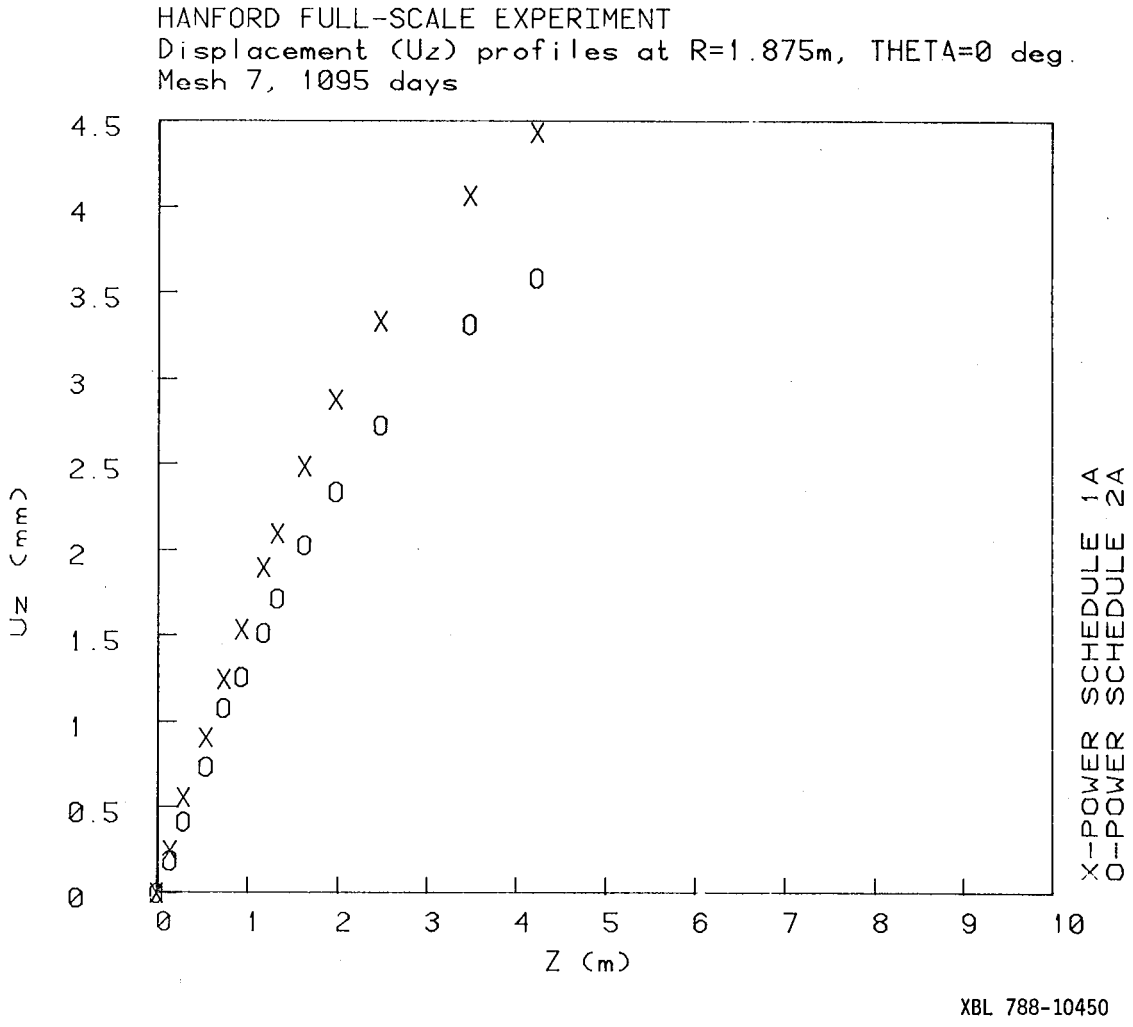

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=1.875m, THETA=0 deg.
Mesh 7, 1095 days
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
UZ (mm)
0
1
2
3
4
5
6
7
8
9
10
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10450

Figure D18b

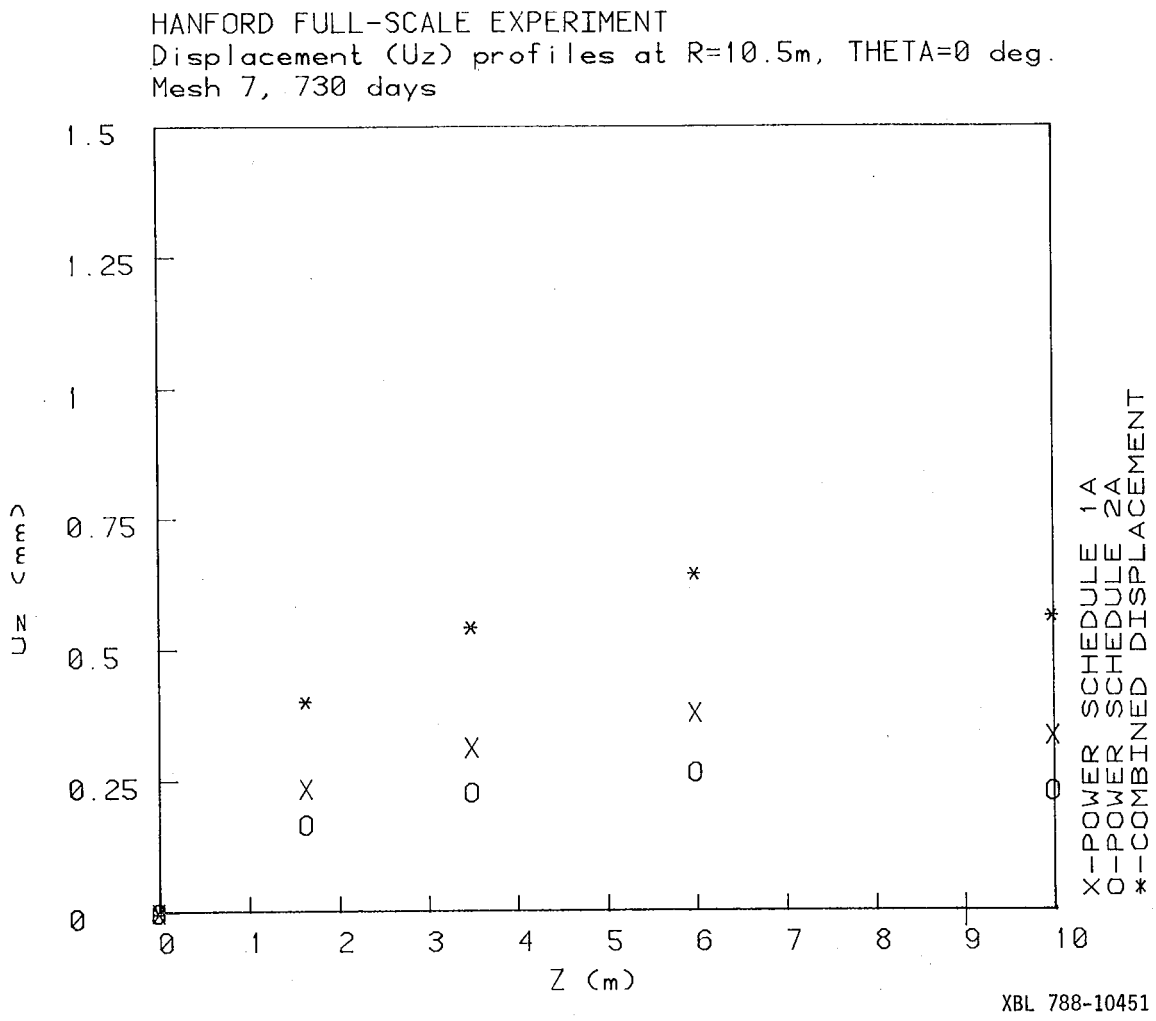

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=10.5m, THETA=0 deg.
Mesh 7, 730 days
1.5
1.25
1
0.75
0.5
0.25
0
UN (cm)
0
1
2
3
4
5
6
7
8
9
10
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
*-COMBINED DISPLACEMENT
XBL 788-10451

Figure D19a

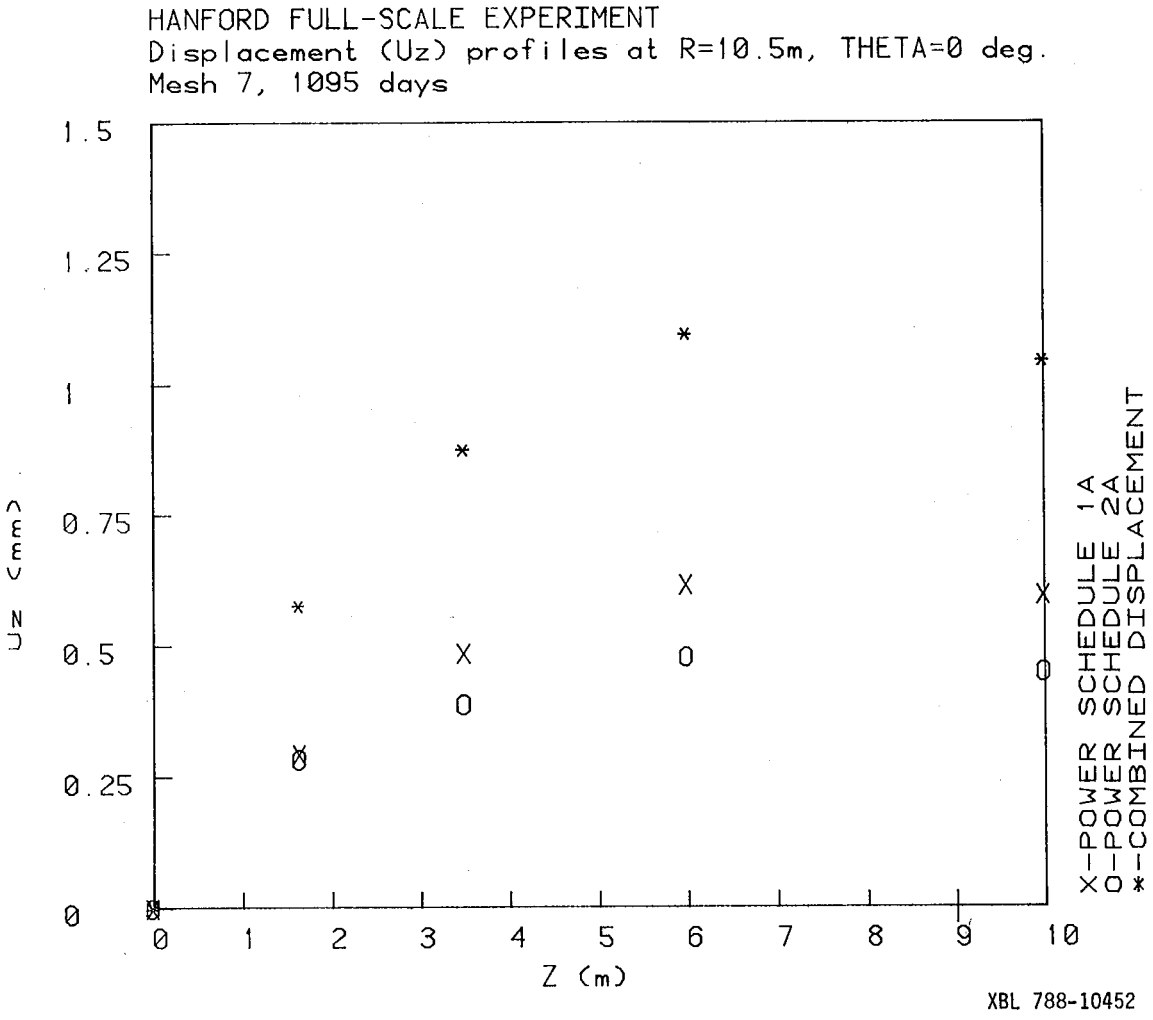
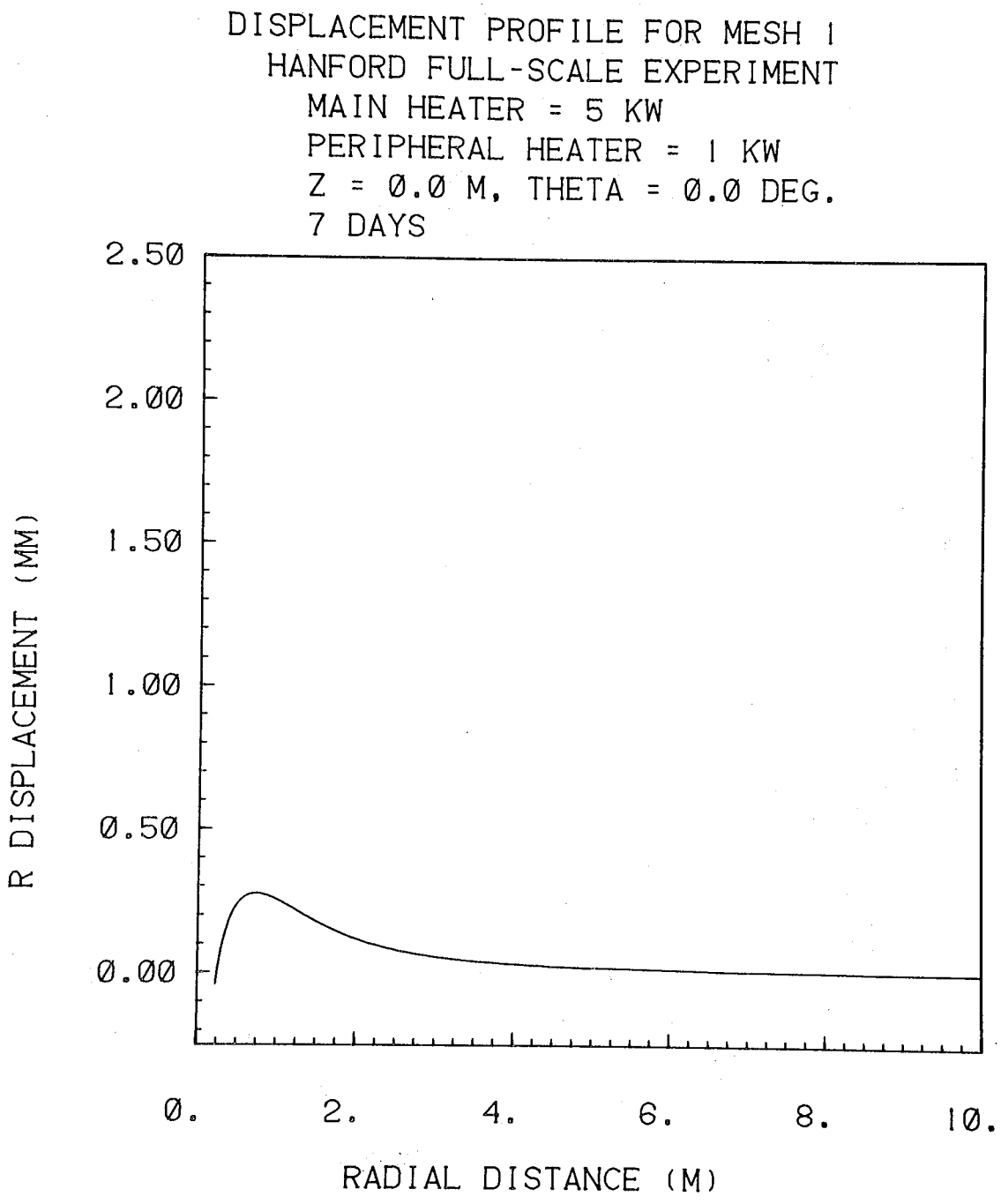
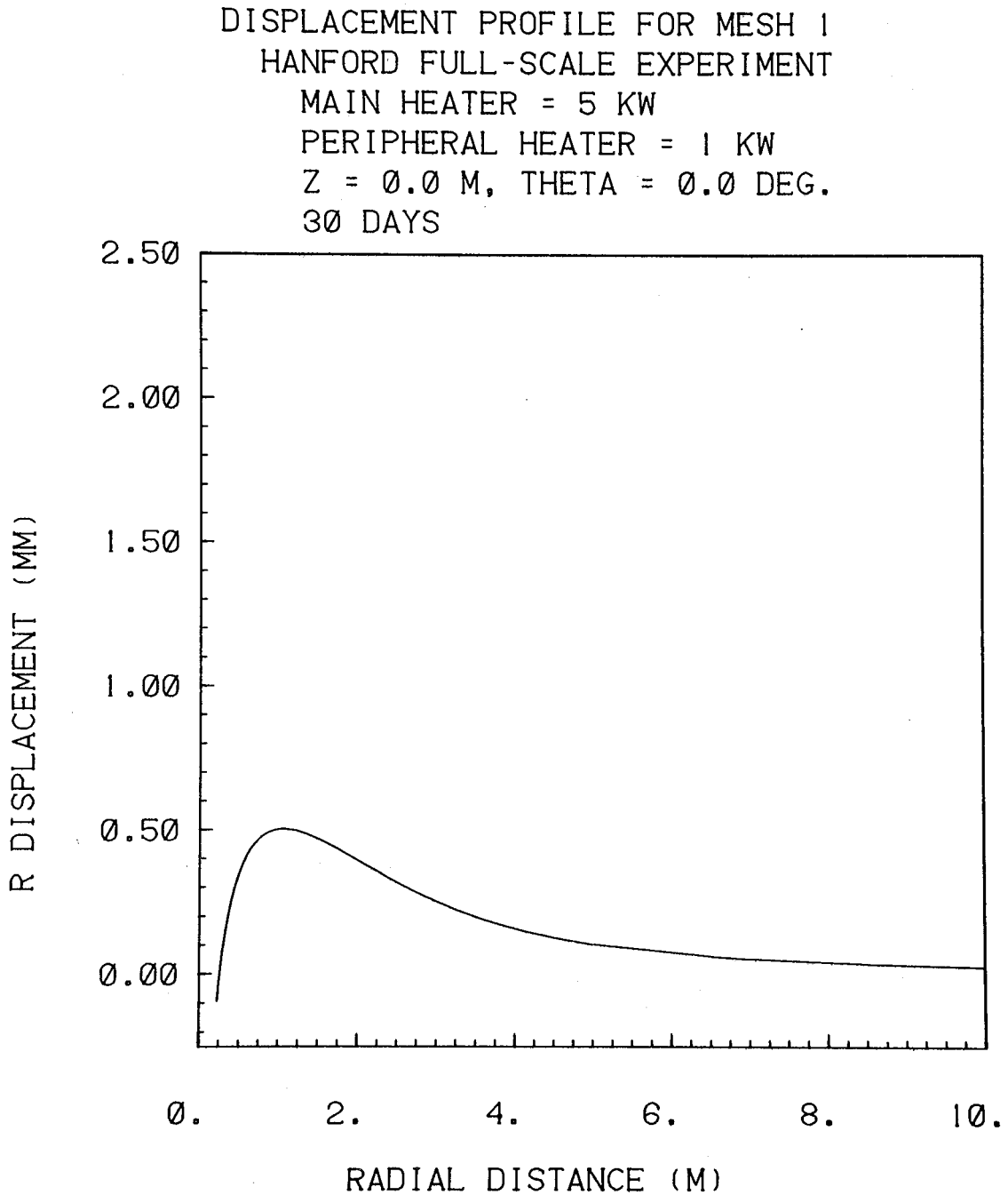

HANFORD FULL-SCALE EXPERIMENT
Displacement (Uz) profiles at R=10.5m, THETA=0 deg.
Mesh 7, 1095 days
1.5
1.25
1
0.75
0.5
0.25
0
UN (mm)
0
1
2
3
4
5
6
7
8
9
10
Z (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
*-COMBINED DISPLACEMENT
XBL 788-10452

Figure D19b



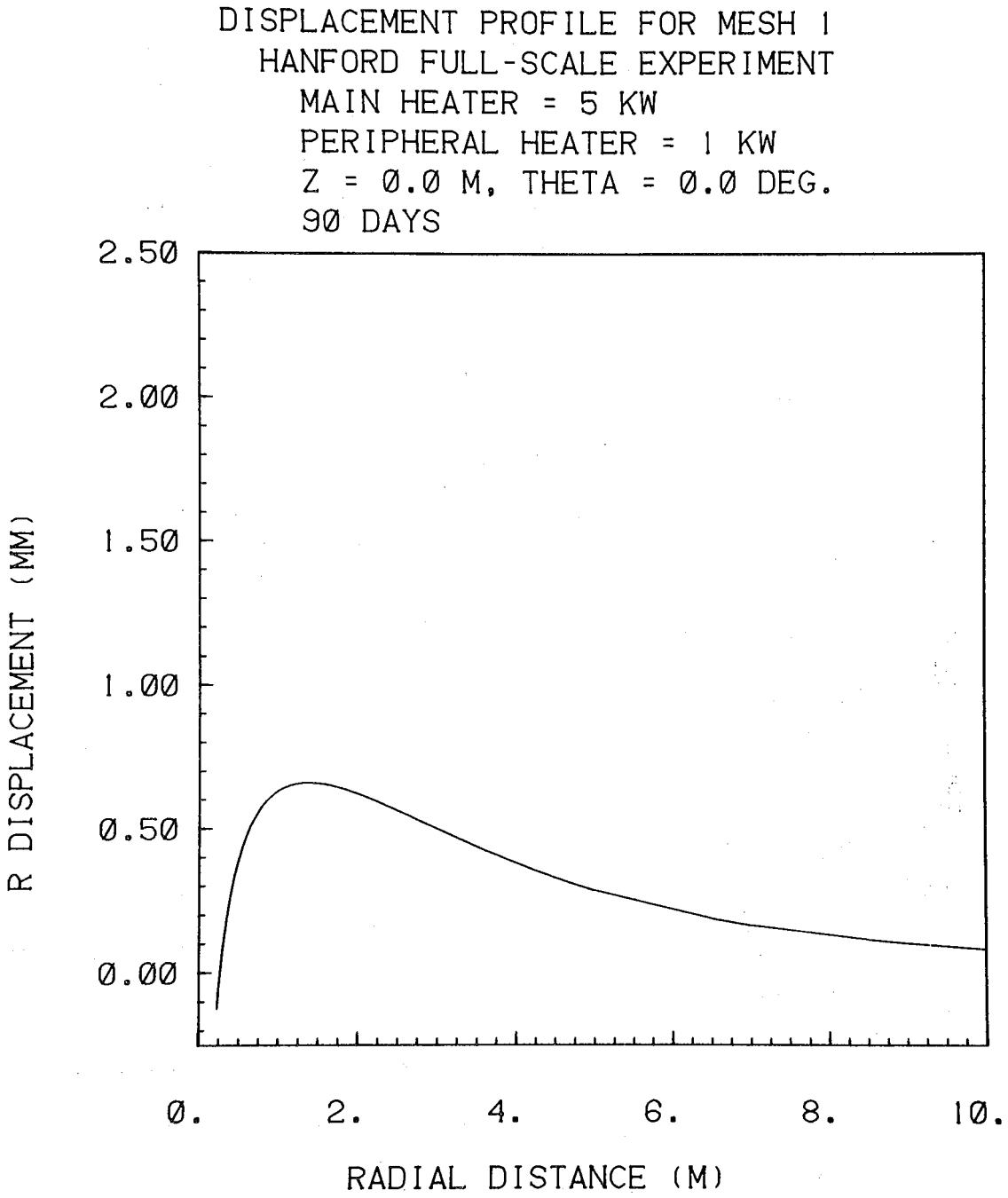
XBL 787-9748

Figure D20a



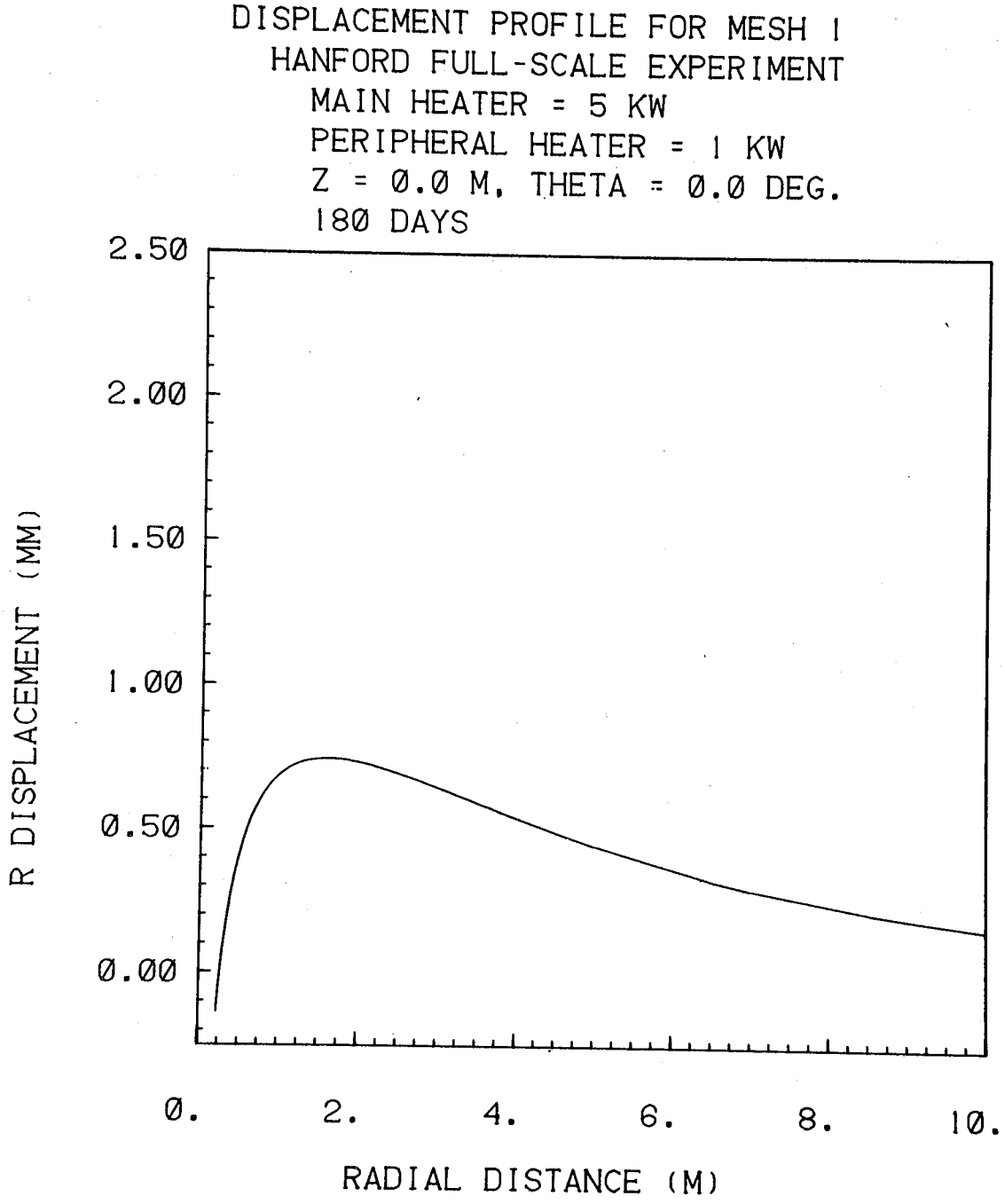
XBL 787-9749

Figure D20b



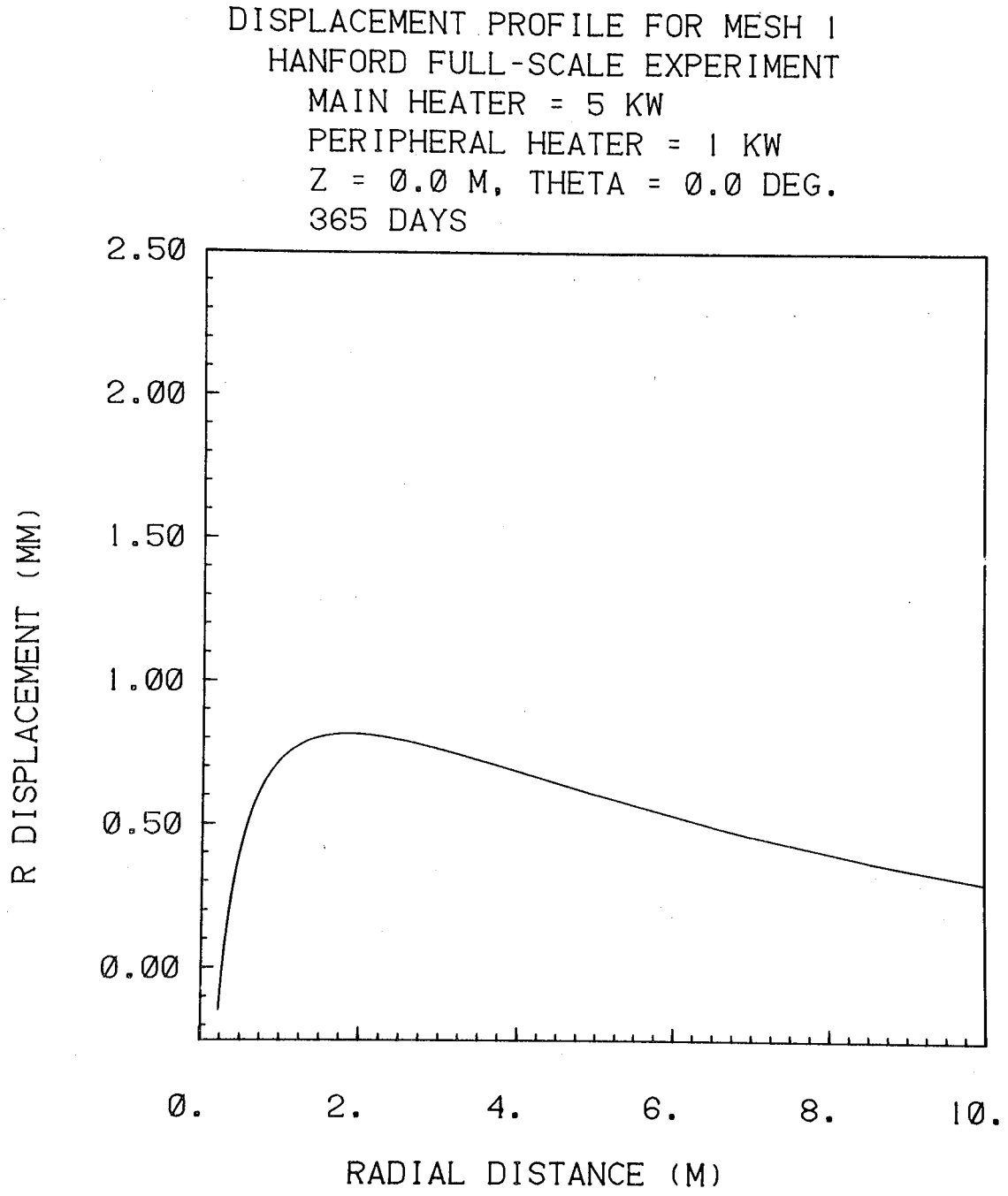
XBL 787-9747

Figure D20c



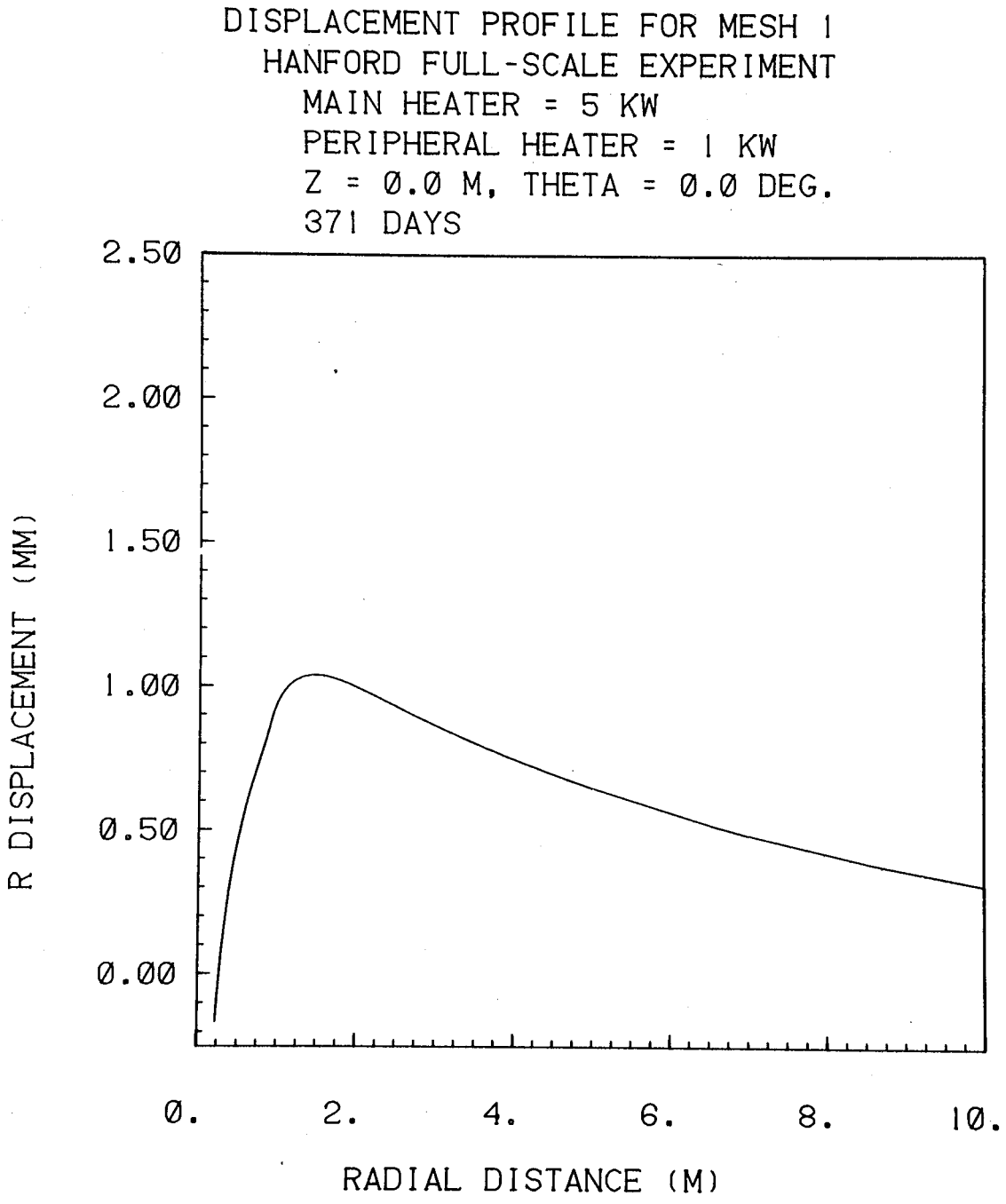
XBL 787-9746

Figure D20d



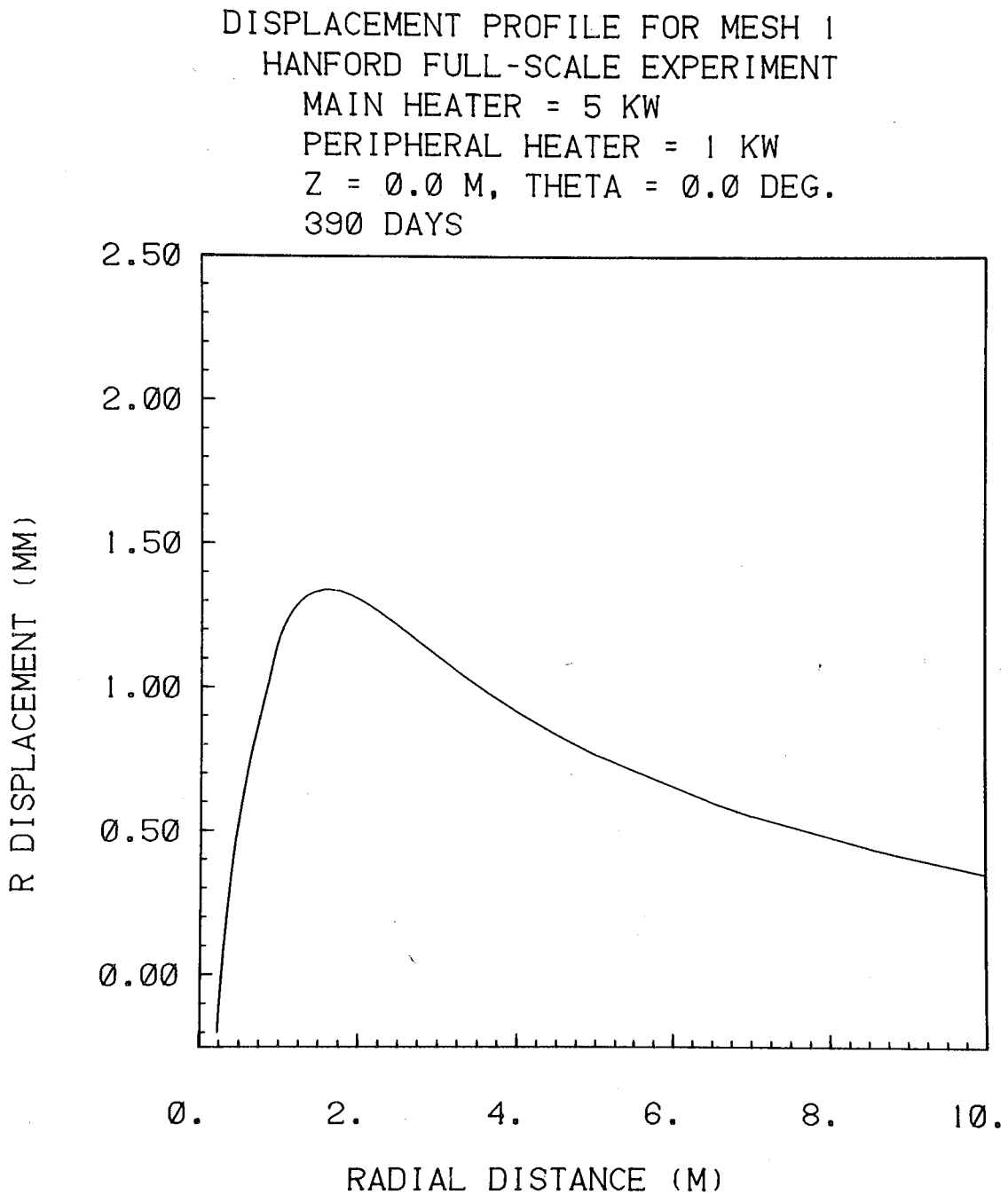
XBL 787-9745

Figure D20e



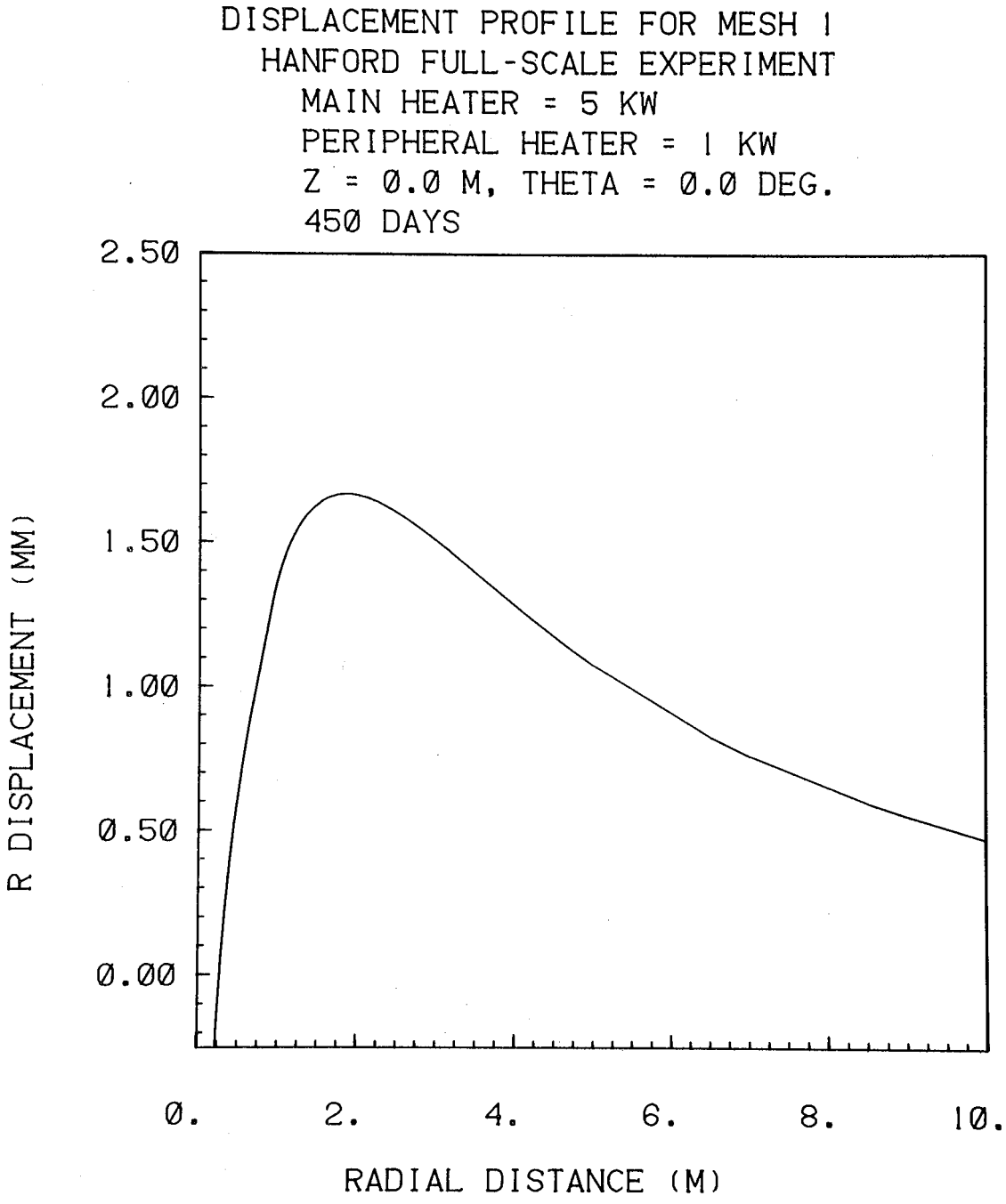
XBL 787-9744

Figure D20f



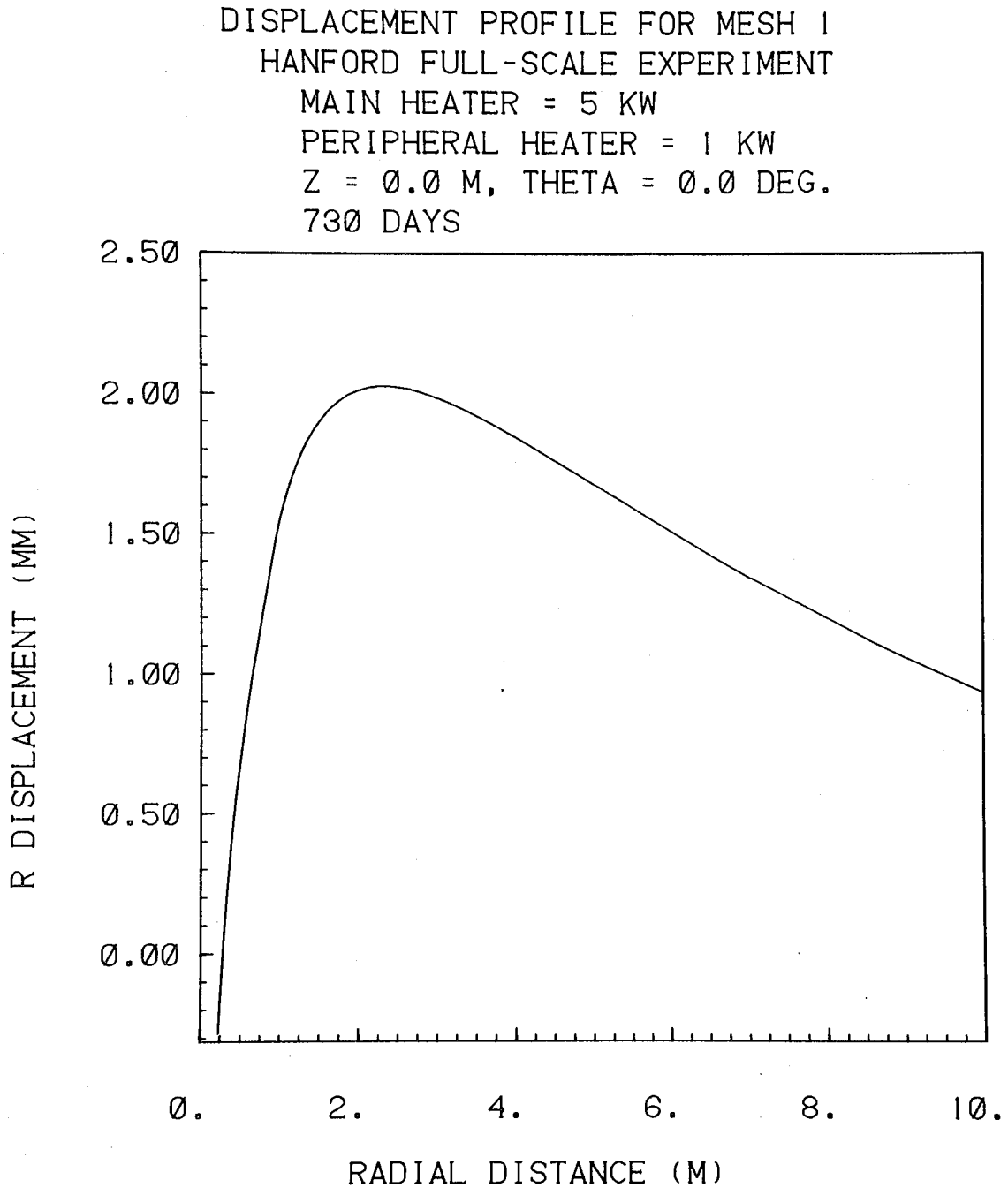
XBL 787-9743

Figure D20g



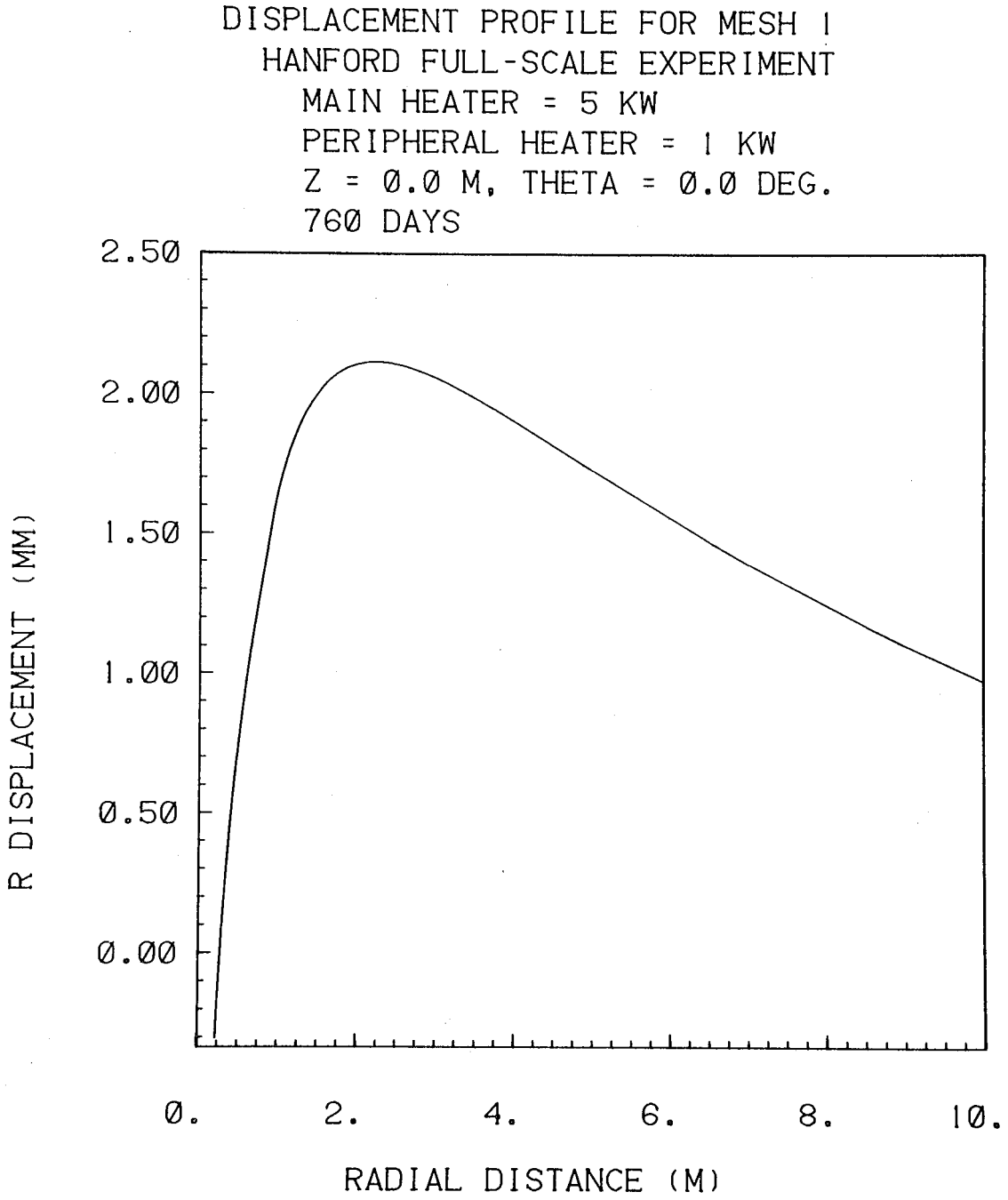
XBL 787-9742

Figure D20h



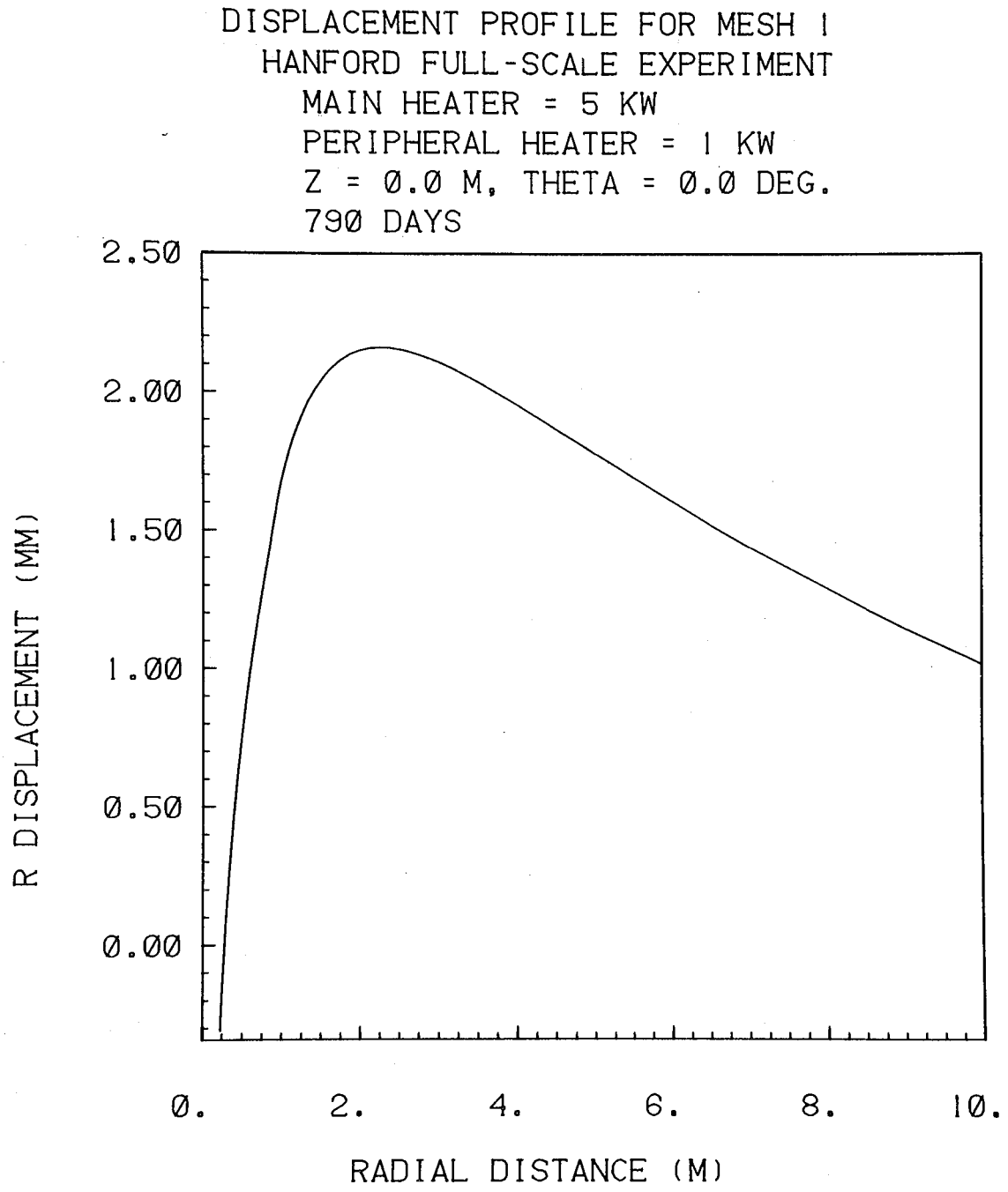
XBL 787-9741

Figure D20i



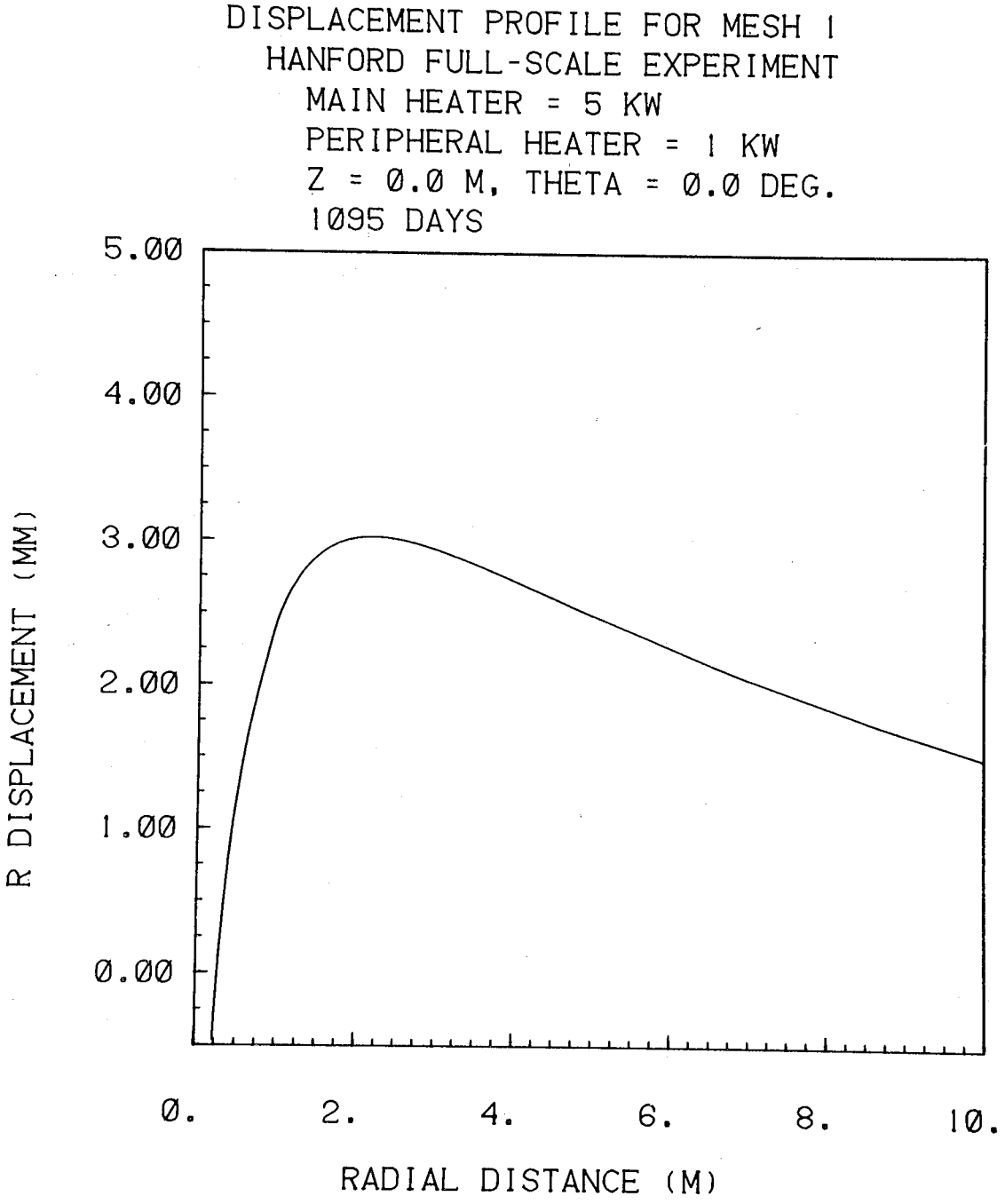
XBL 787-9740

Figure D20j



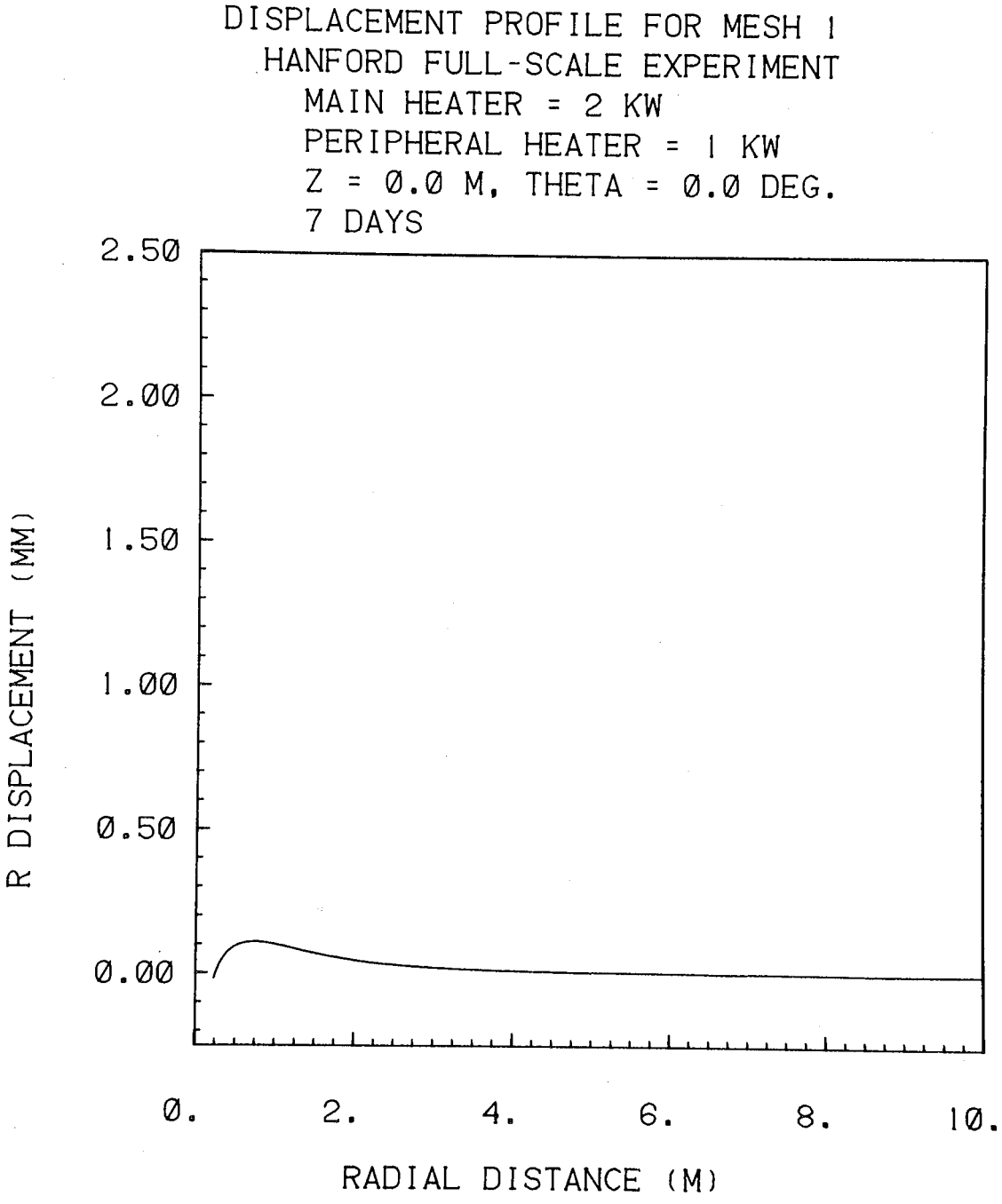
XBL 787-9739

Figure D20k



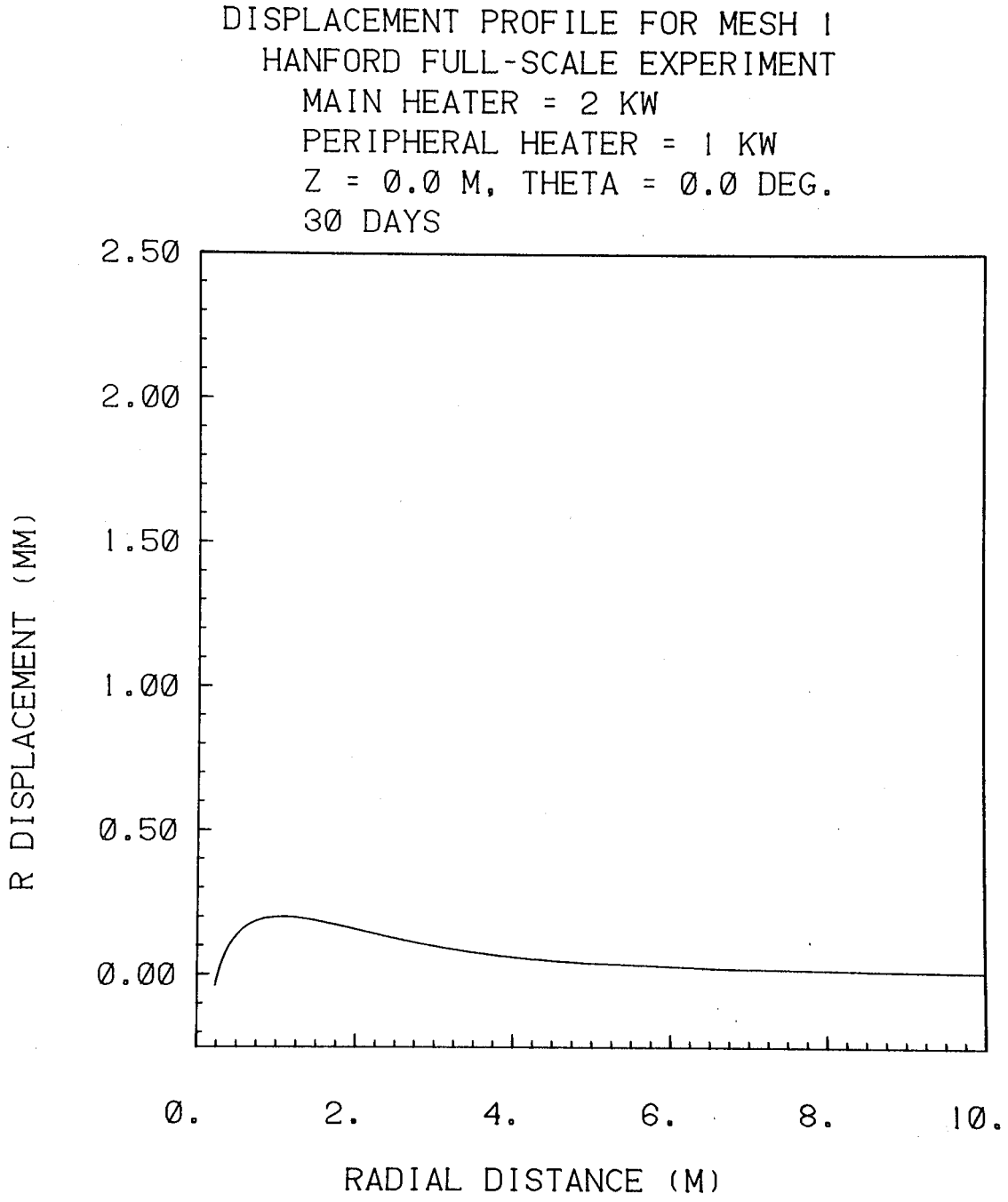
XBL 787-9738

Figure D201



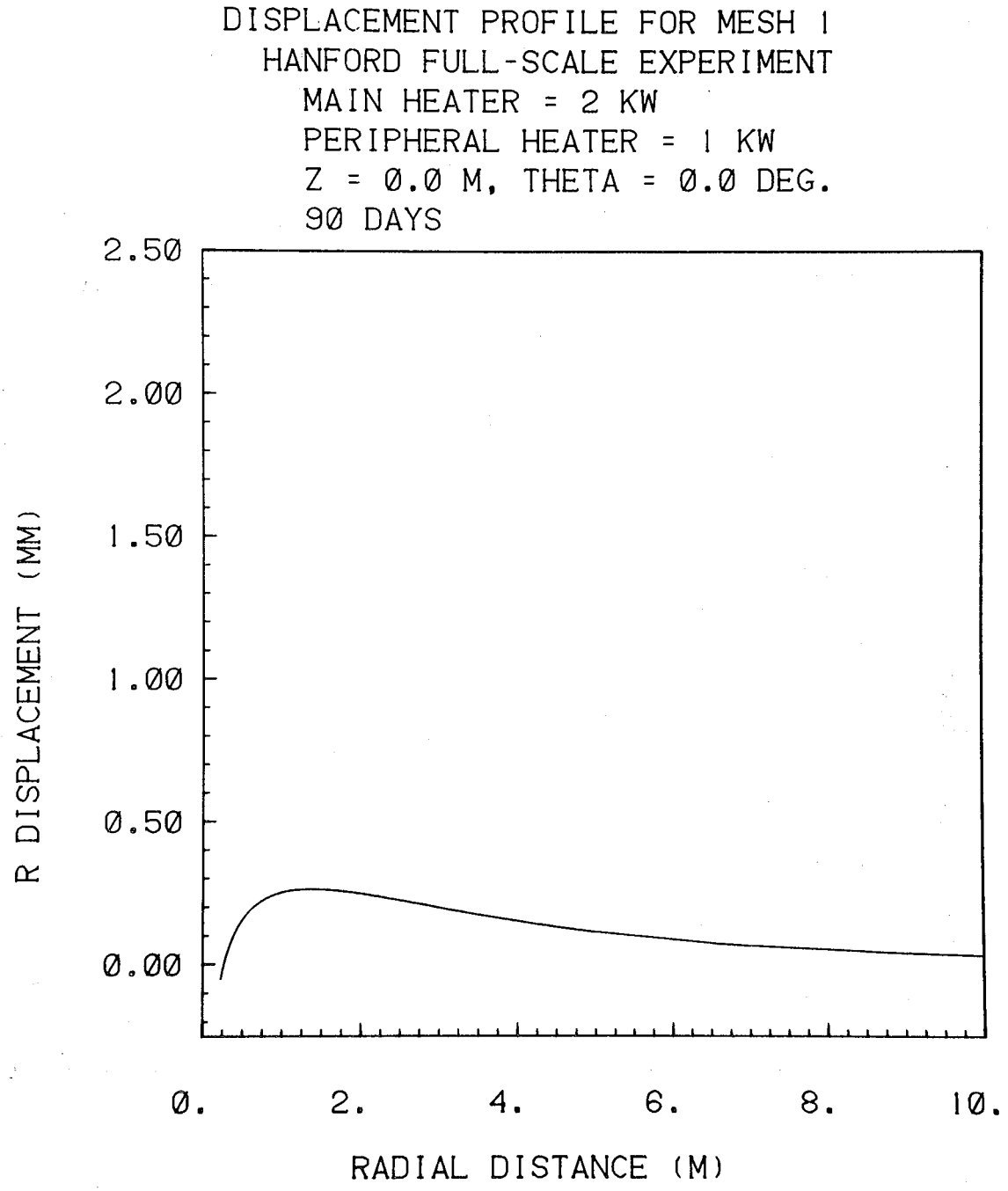
XBL 787-9716

Figure D21a



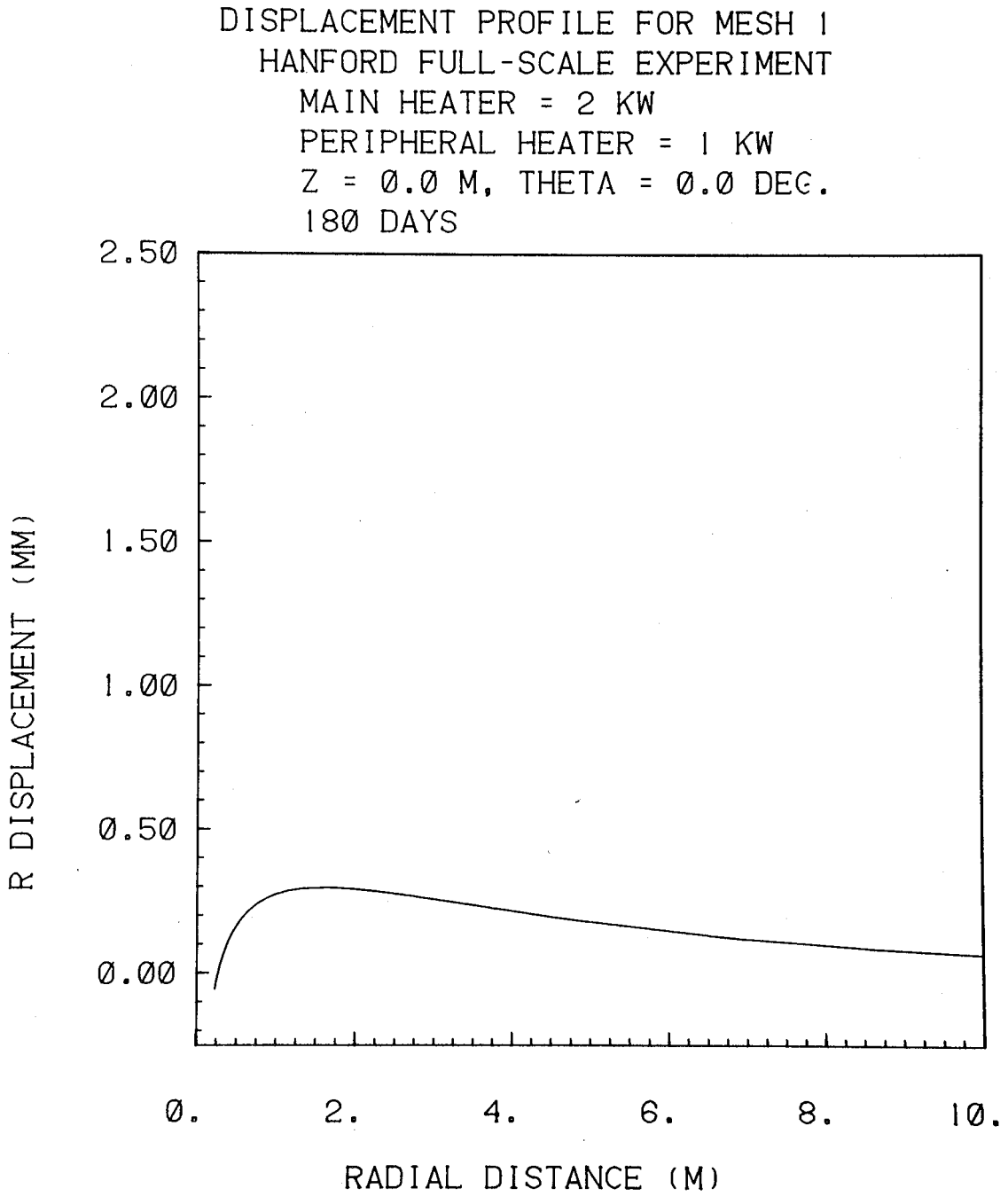
XBL 787-9715

Figure D21b



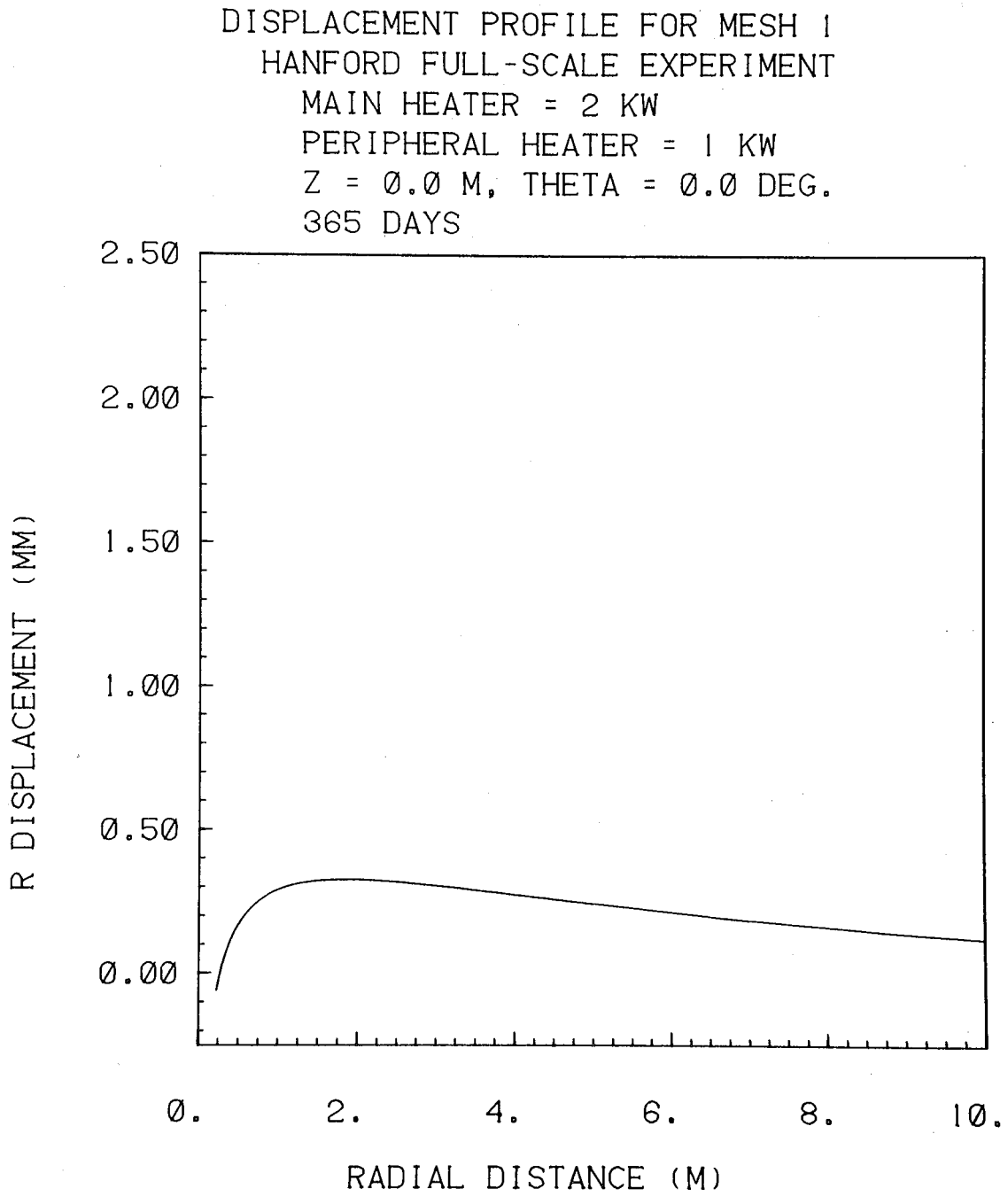
XBL 787-9714

Figure D21c



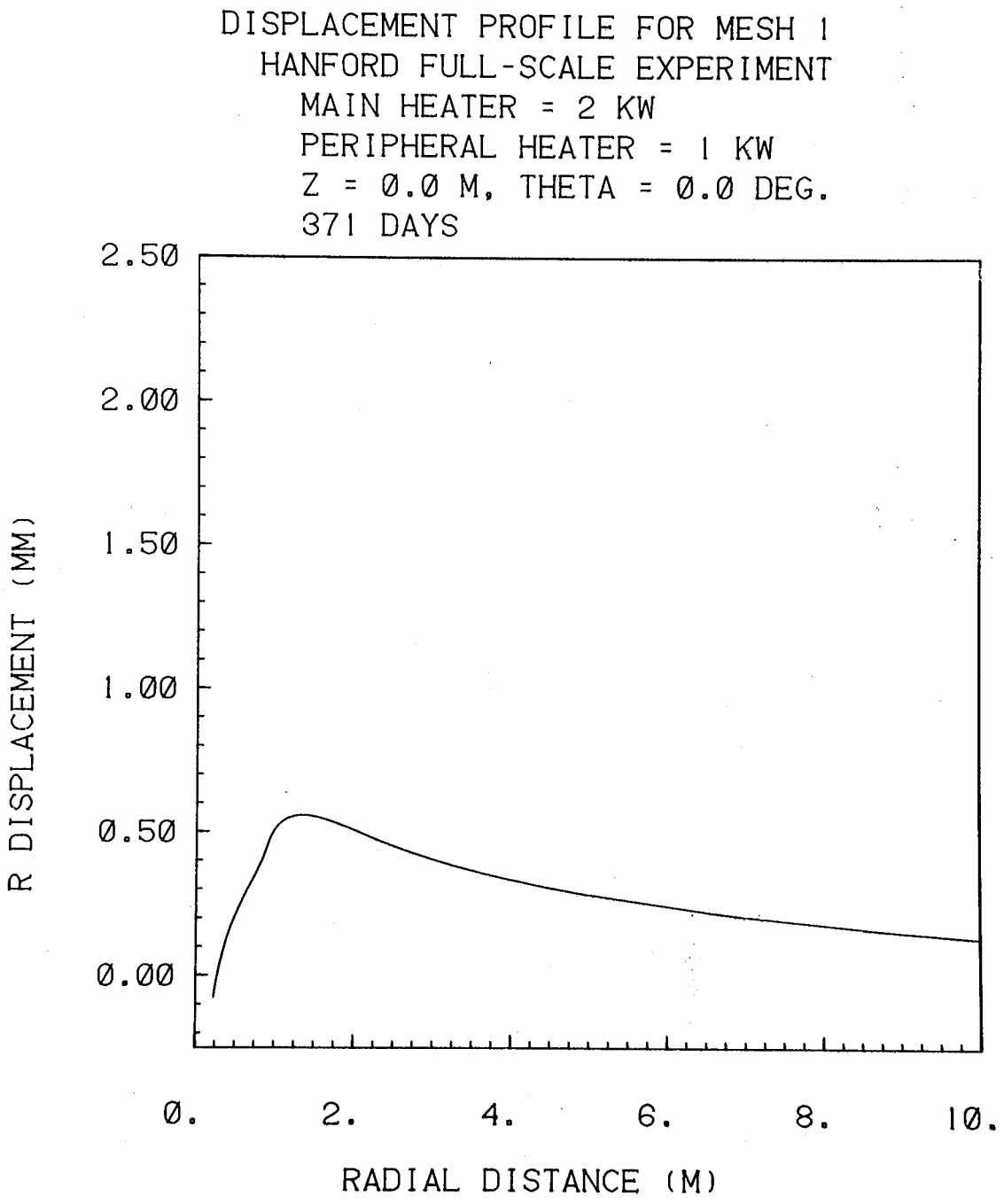
XBL 787-9713

Figure D21d



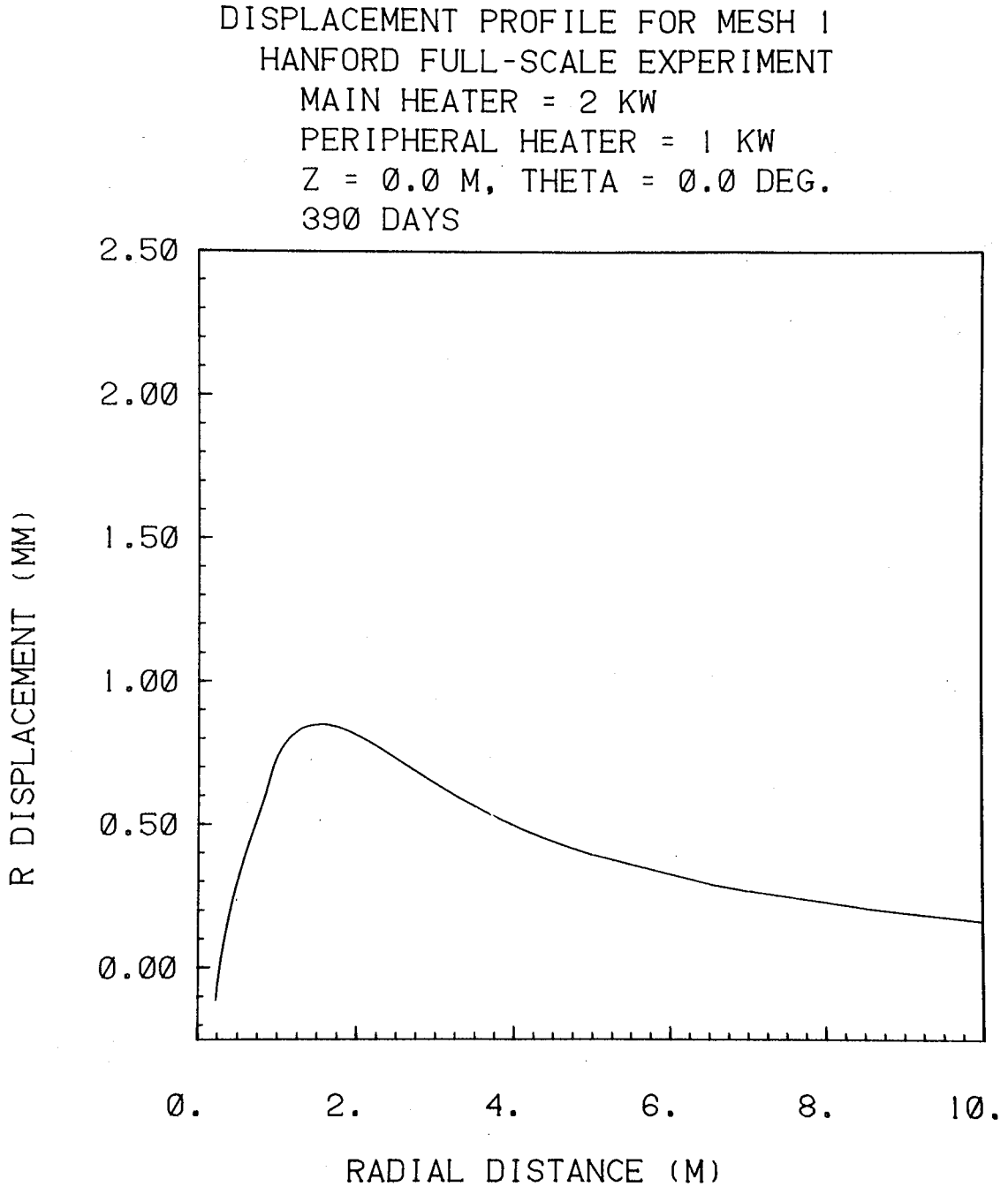
XBL 787-9712

Figure D21e



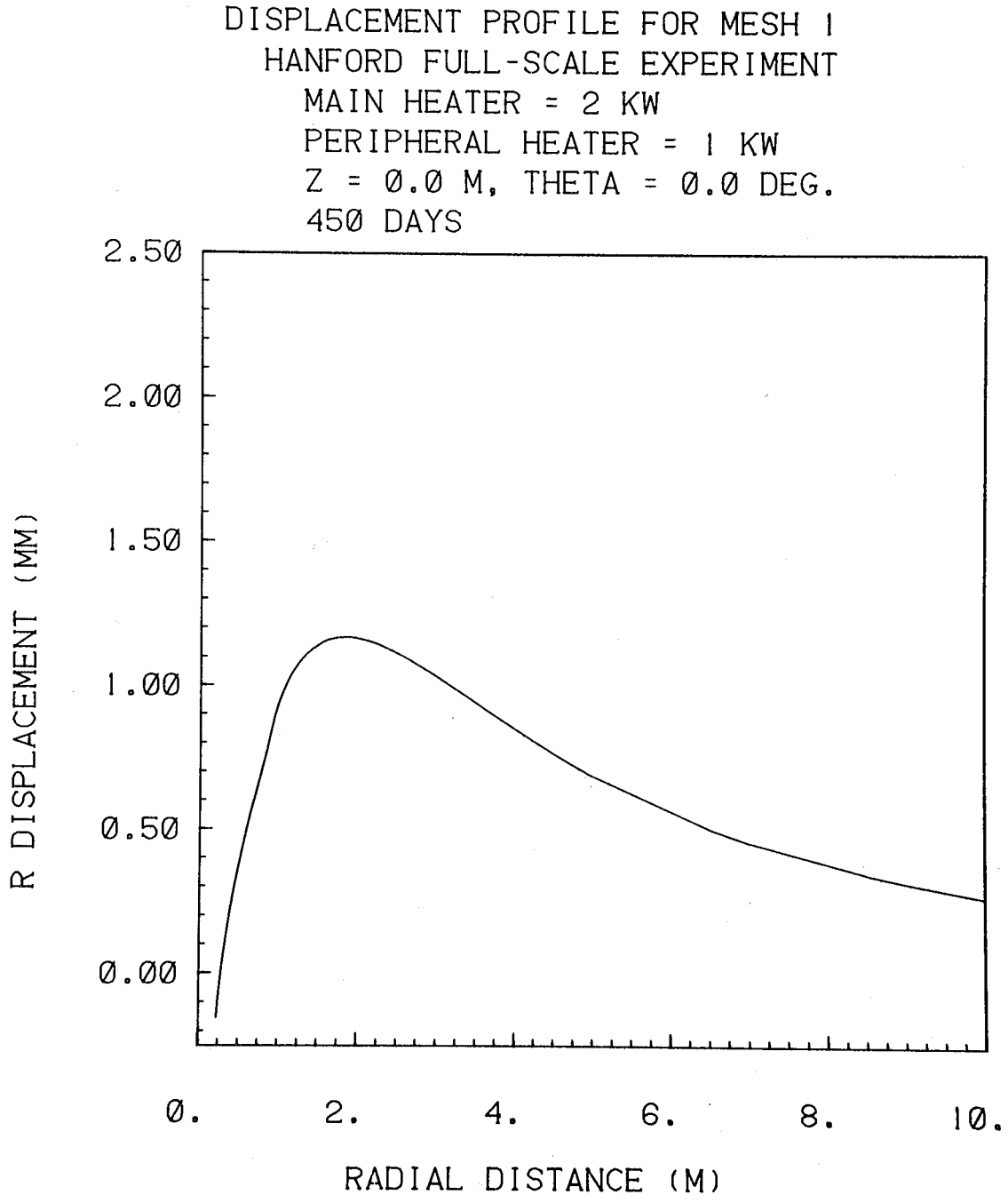
XBL 787-9711

Figure D21f



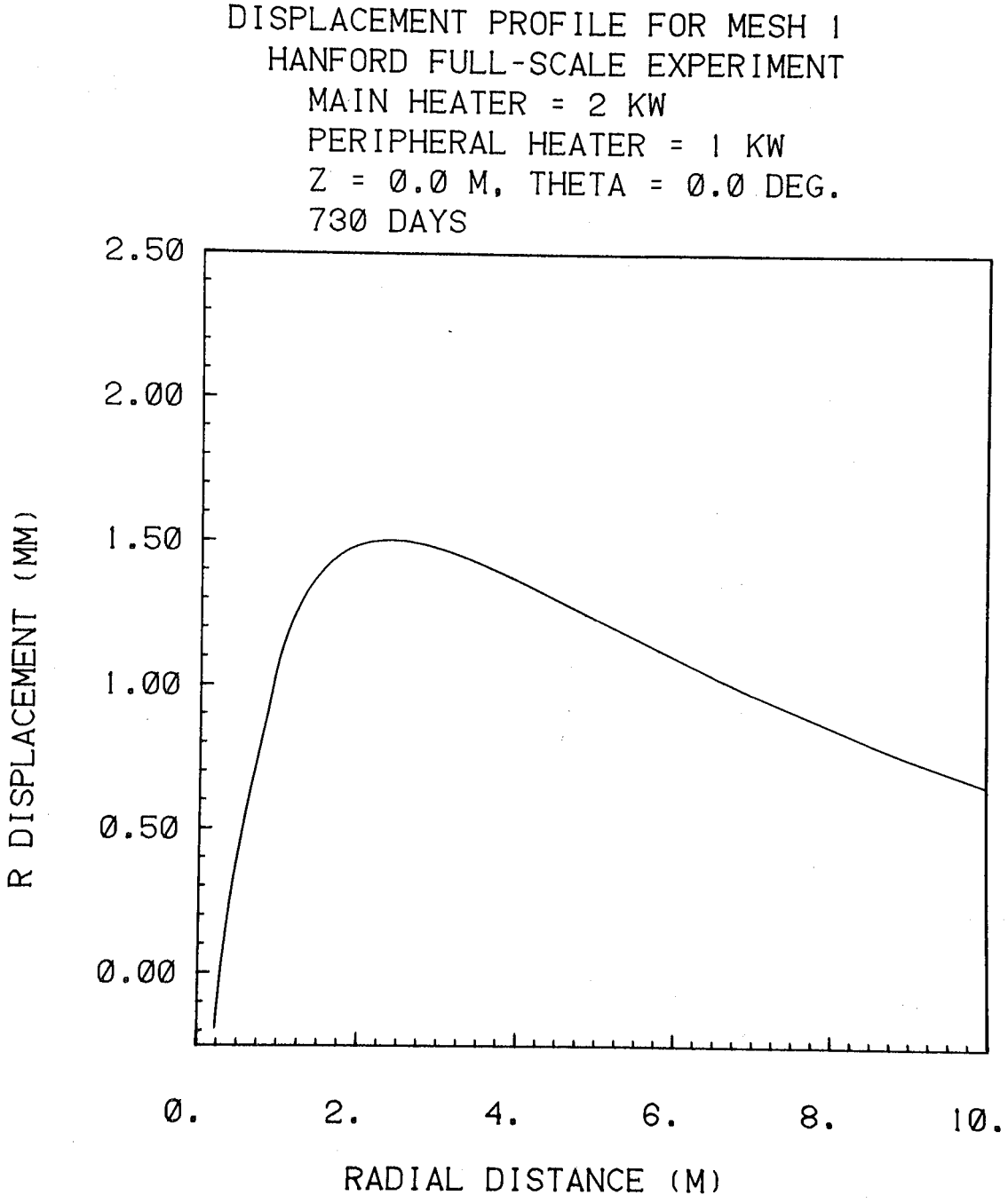
XBL 787-9710

Figure D21g



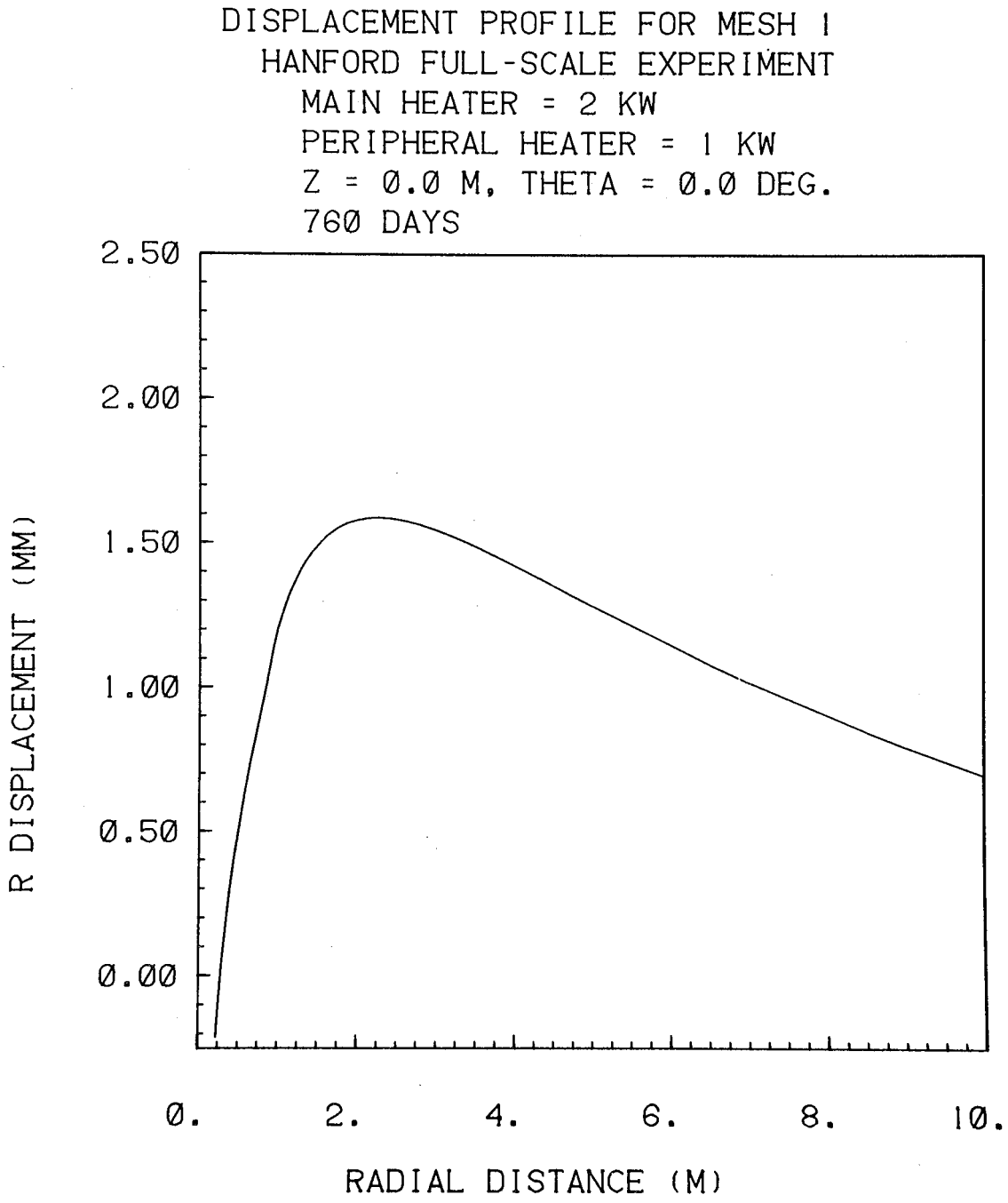
XBL 787-9709

Figure D21h



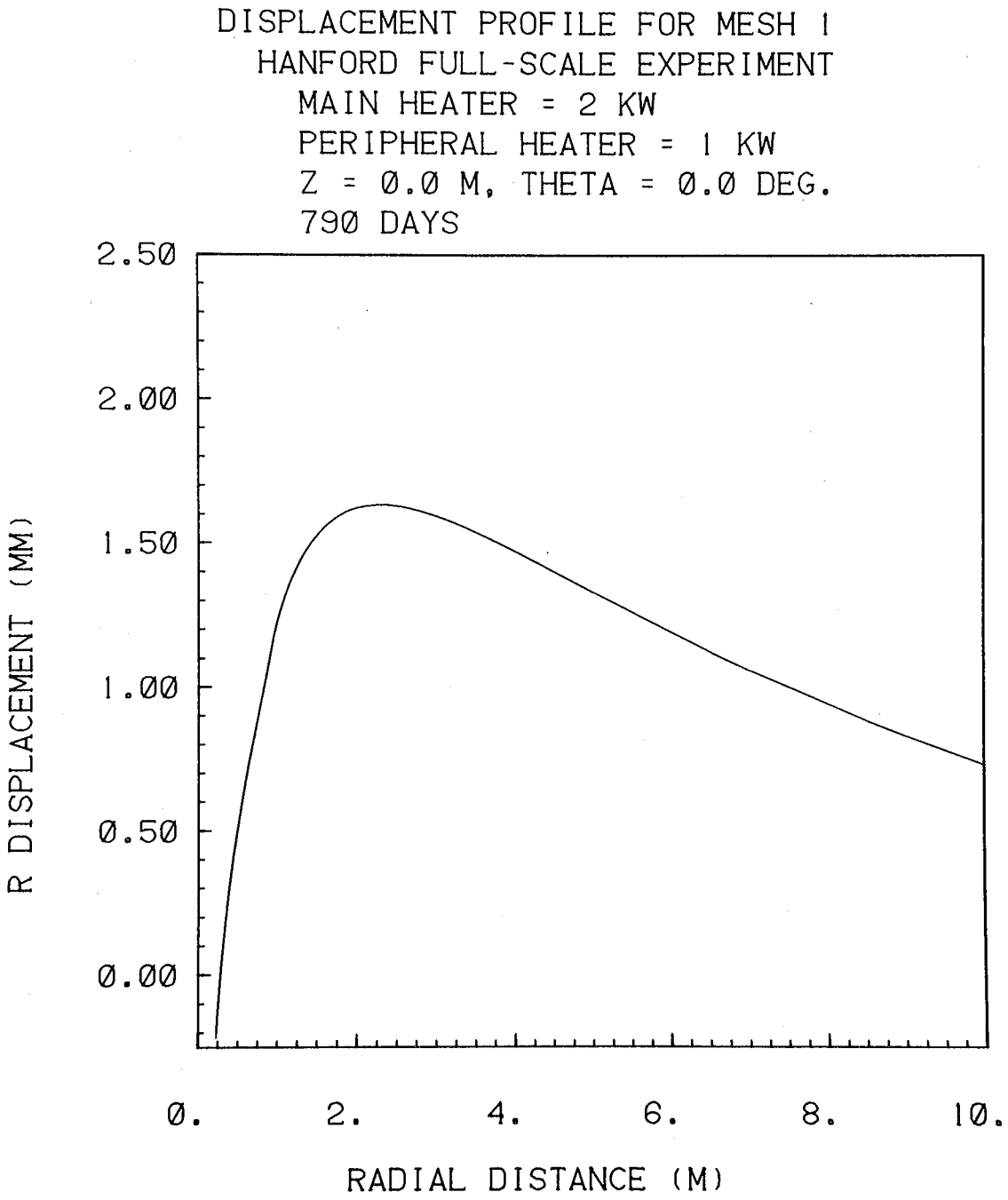
XBL 787-9708

Figure D21i



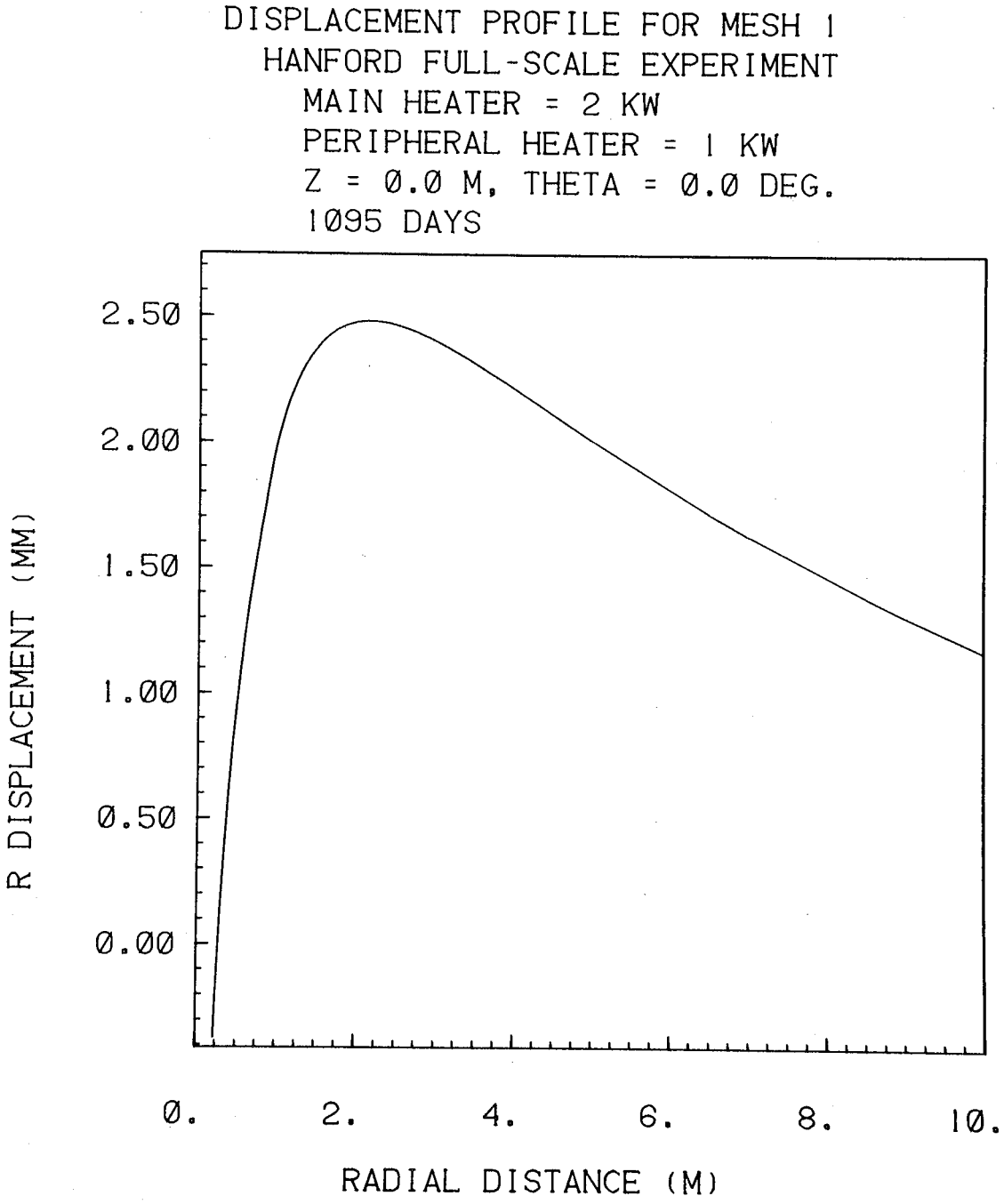
XBL 787-9707

Figure D21j



XBL 787-9706

Figure D21k



XBL 787-9705

Figure D211

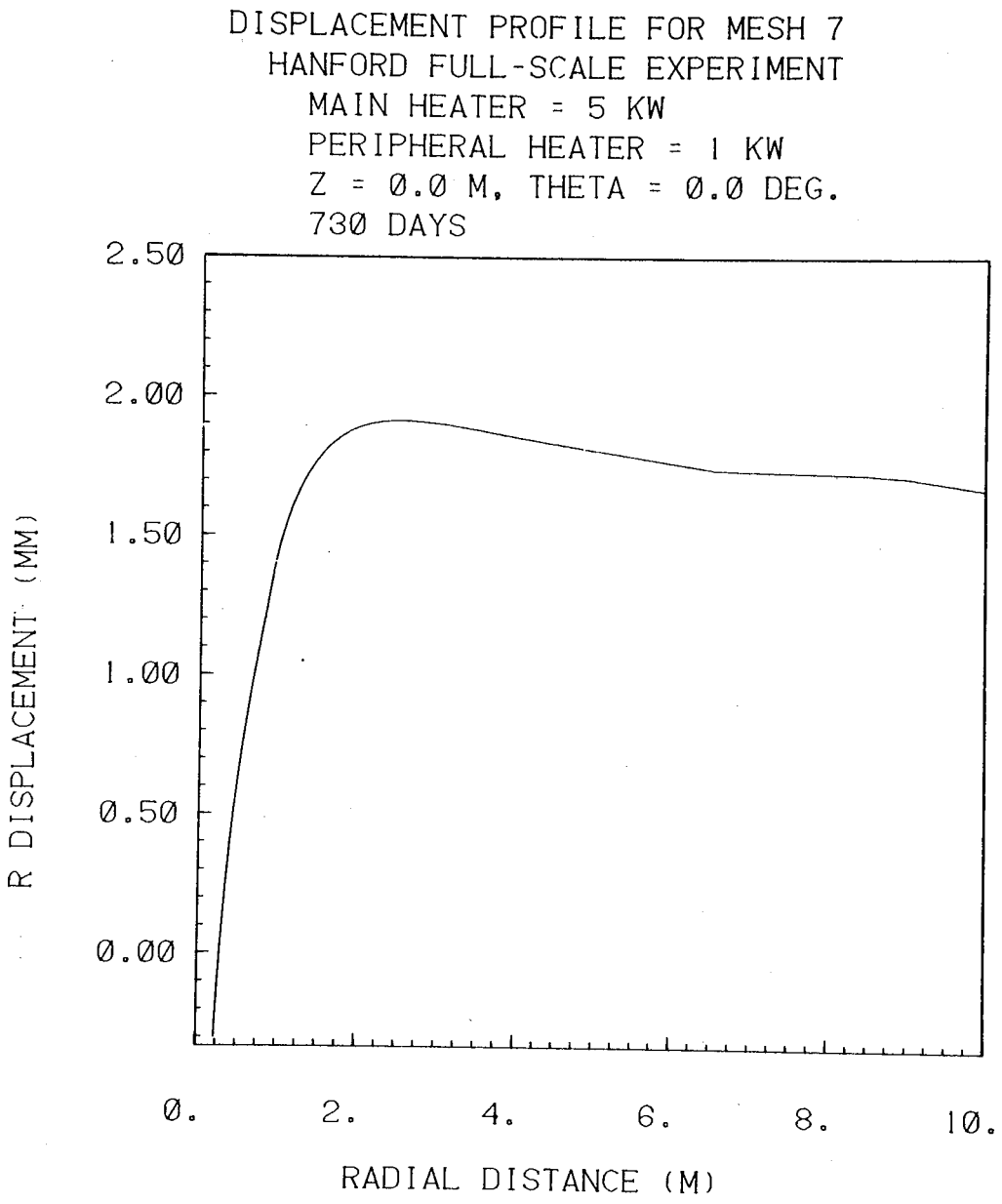
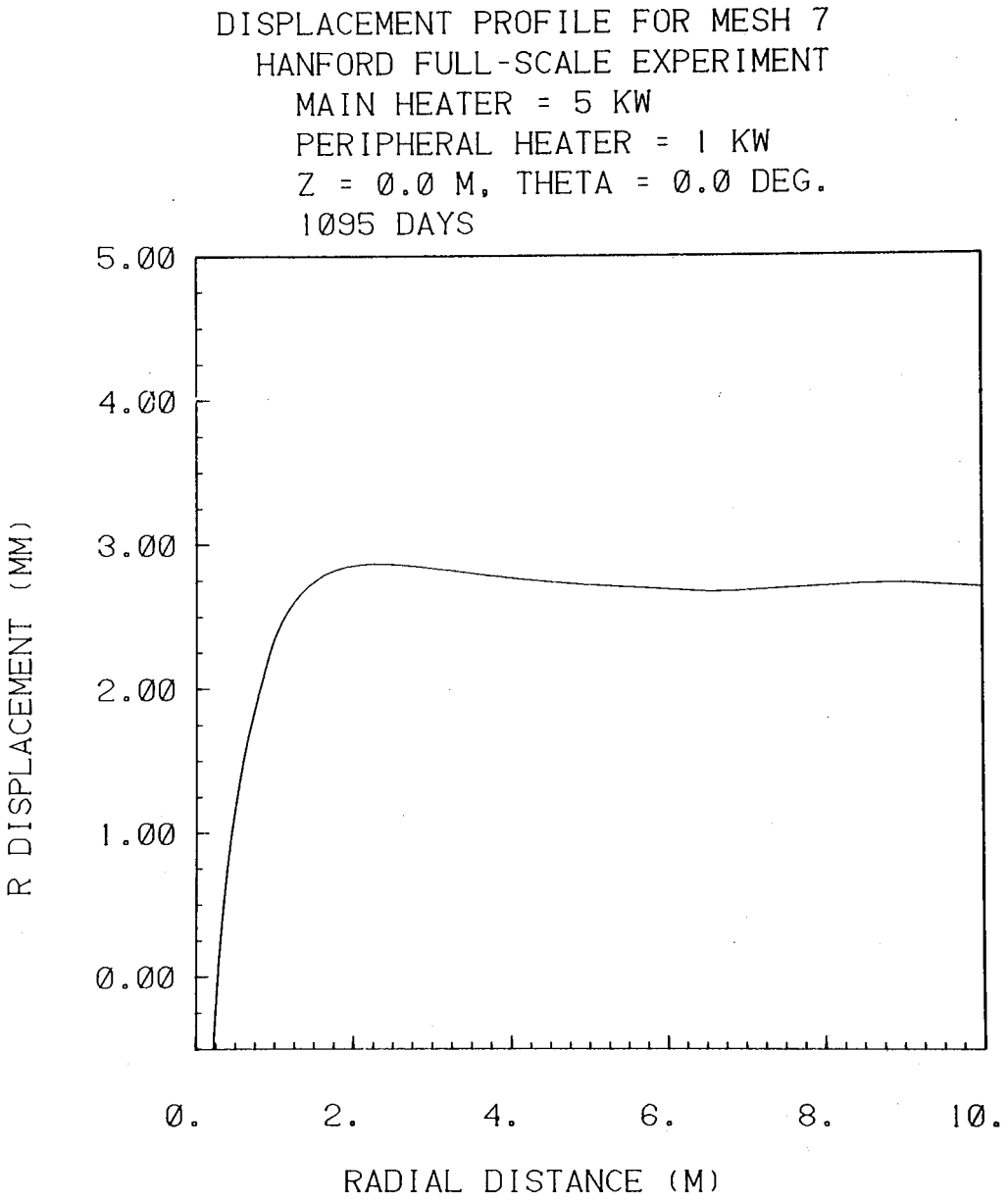
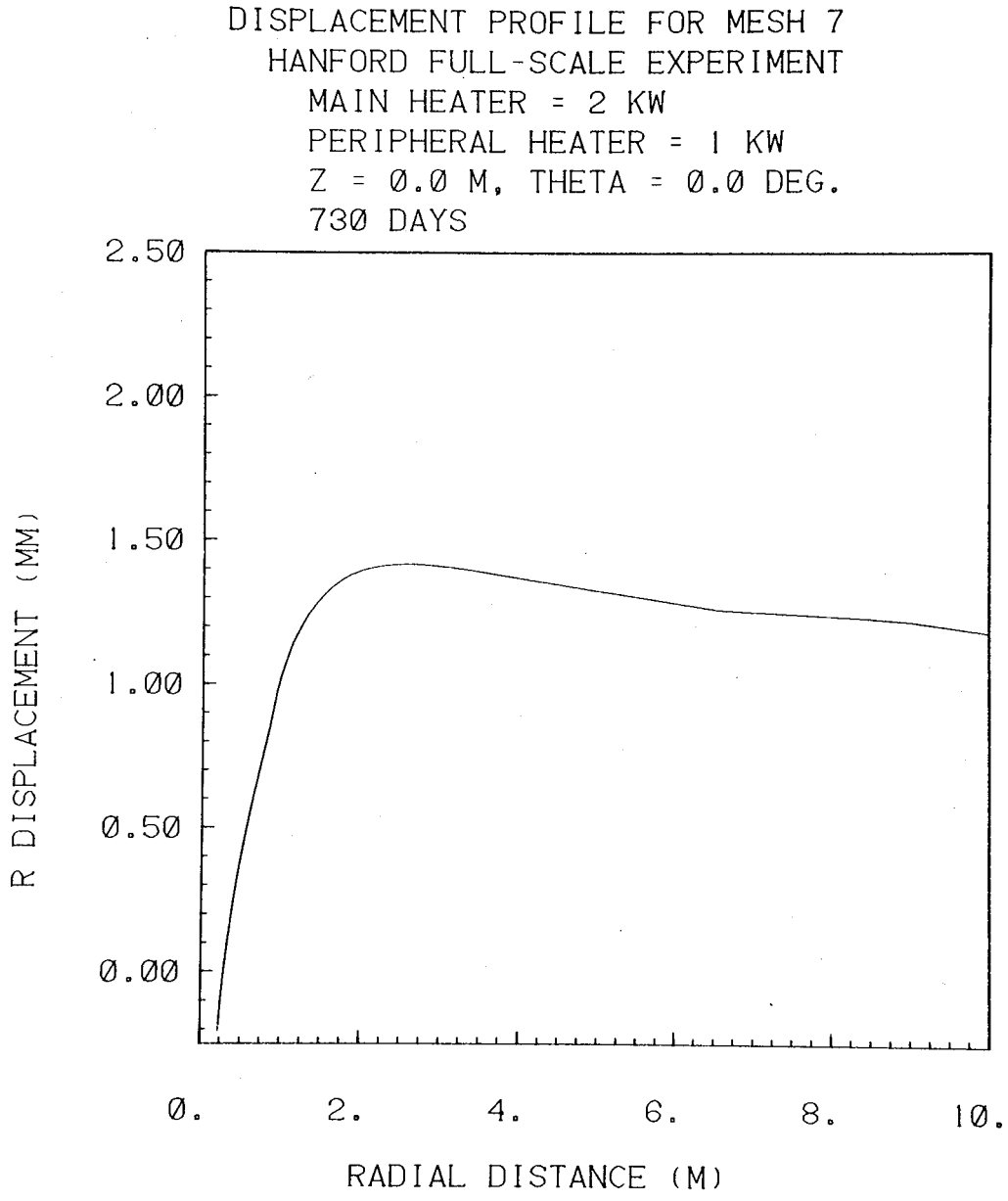

DISPLACEMENT PROFILE FOR MESH 7
HANFORD FULL-SCALE EXPERIMENT
MAIN HEATER = 5 KW
PERIPHERAL HEATER = 1 KW
Z = 0.0 M, THETA = 0.0 DEG.
730 DAYS
2.50
2.00
1.50
1.00
0.50
0.00
R DISPLACEMENT (MM)
0.
2.
4.
6.
8.
10.
RADIAL DISTANCE (M)
XBL 788-10467

Figure D22a



XBL 788-10468

Figure D22b



XBL 788-10470

Figure D23a

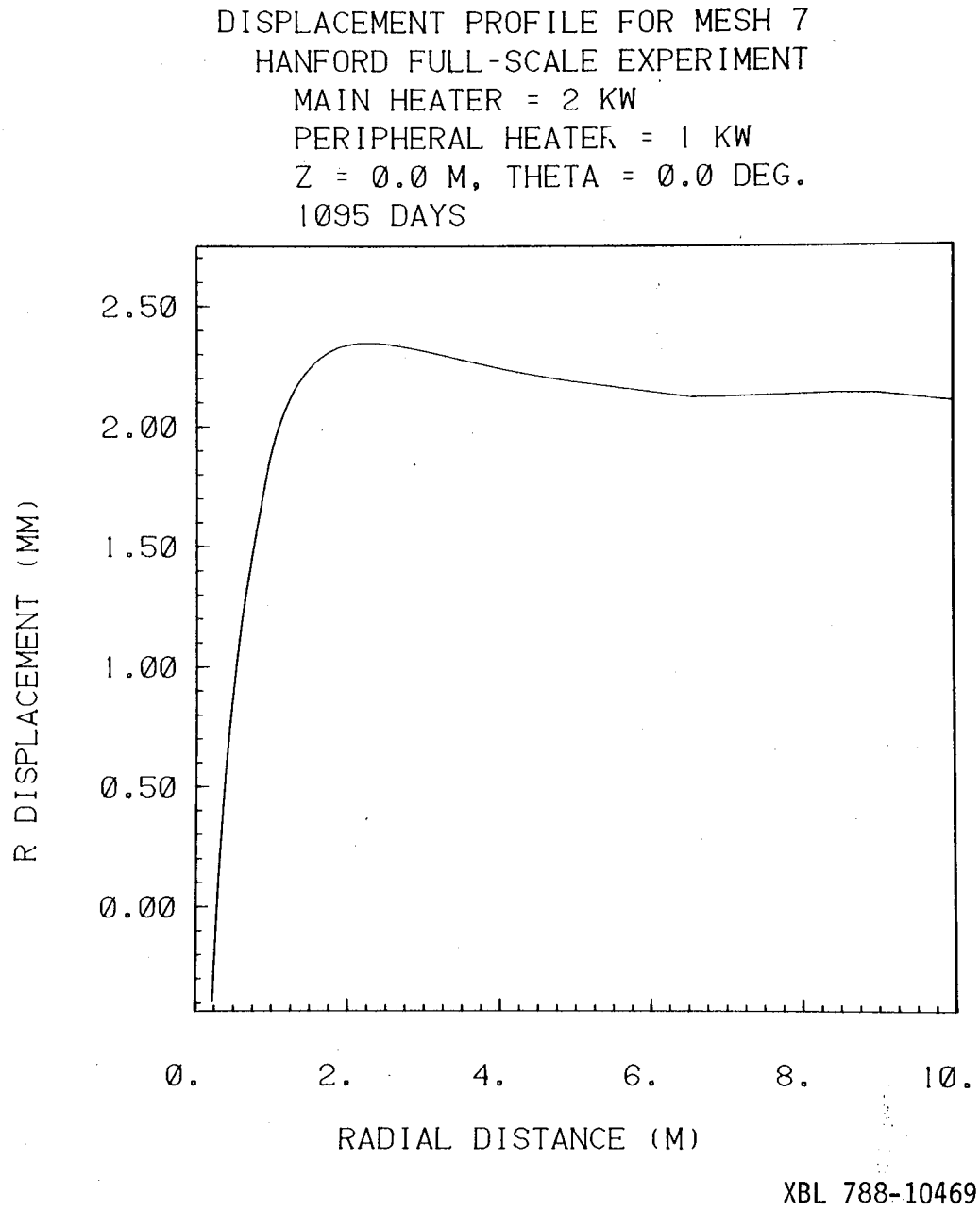
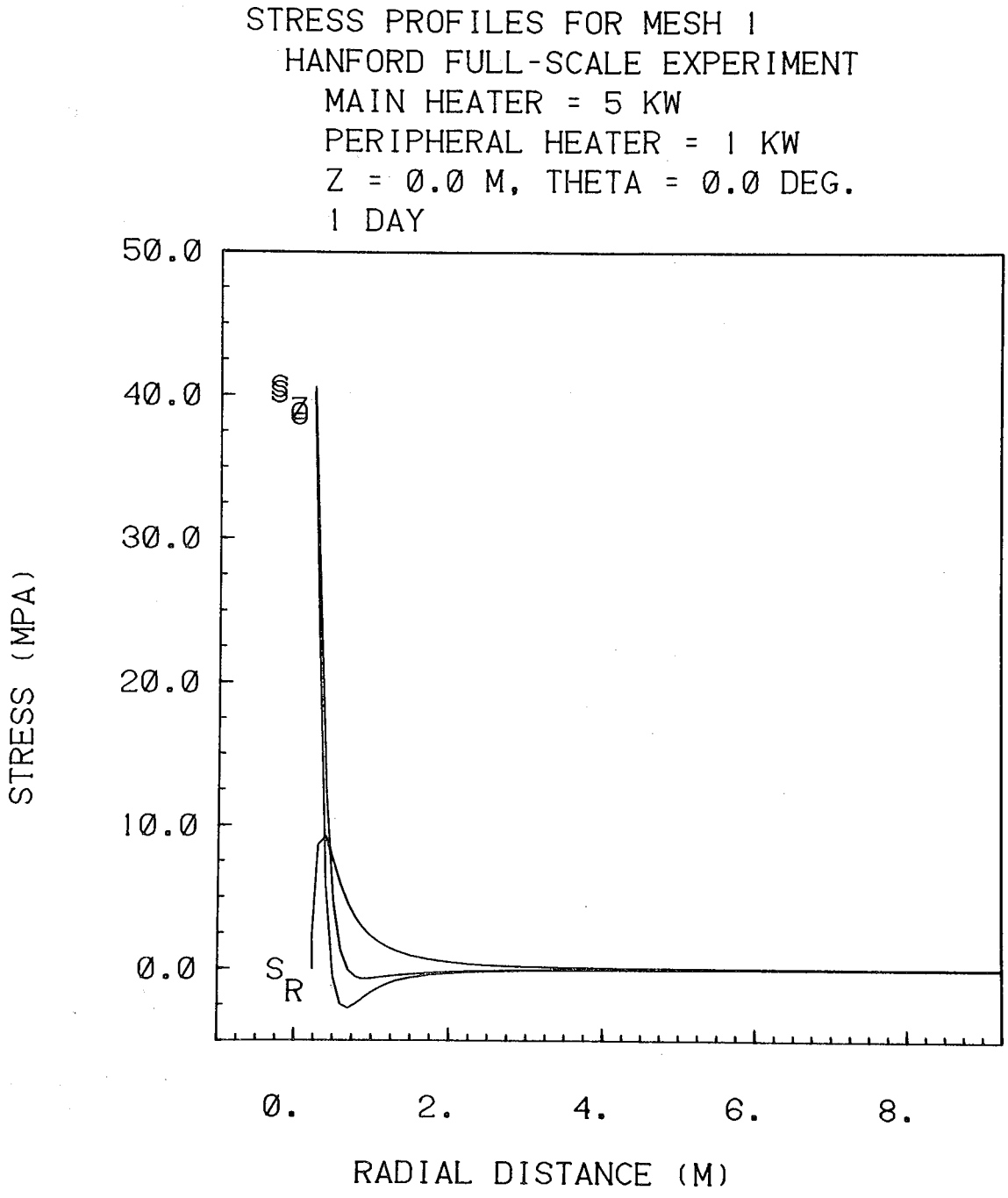
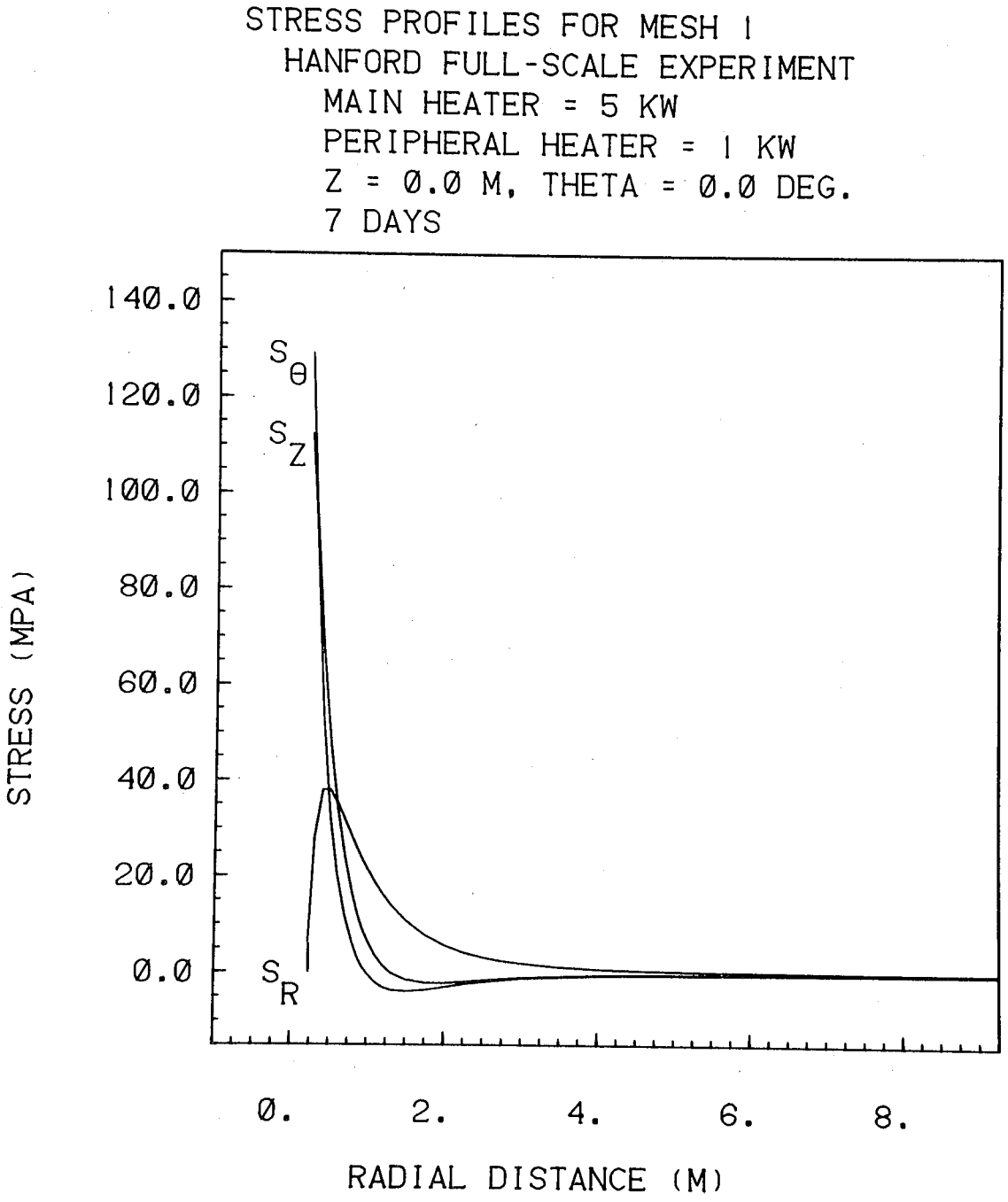

DISPLACEMENT PROFILE FOR MESH 7
HANFORD FULL-SCALE EXPERIMENT
MAIN HEATER = 2 KW
PERIPHERAL HEATER = 1 KW
Z = 0.0 M, THETA = 0.0 DEG.
1095 DAYS
R DISPLACEMENT (MM)
2.50
2.00
1.50
1.00
0.50
0.00
0.
2.
4.
6.
8.
10.
RADIAL DISTANCE (M)
XBL 788-10469

Figure D23b



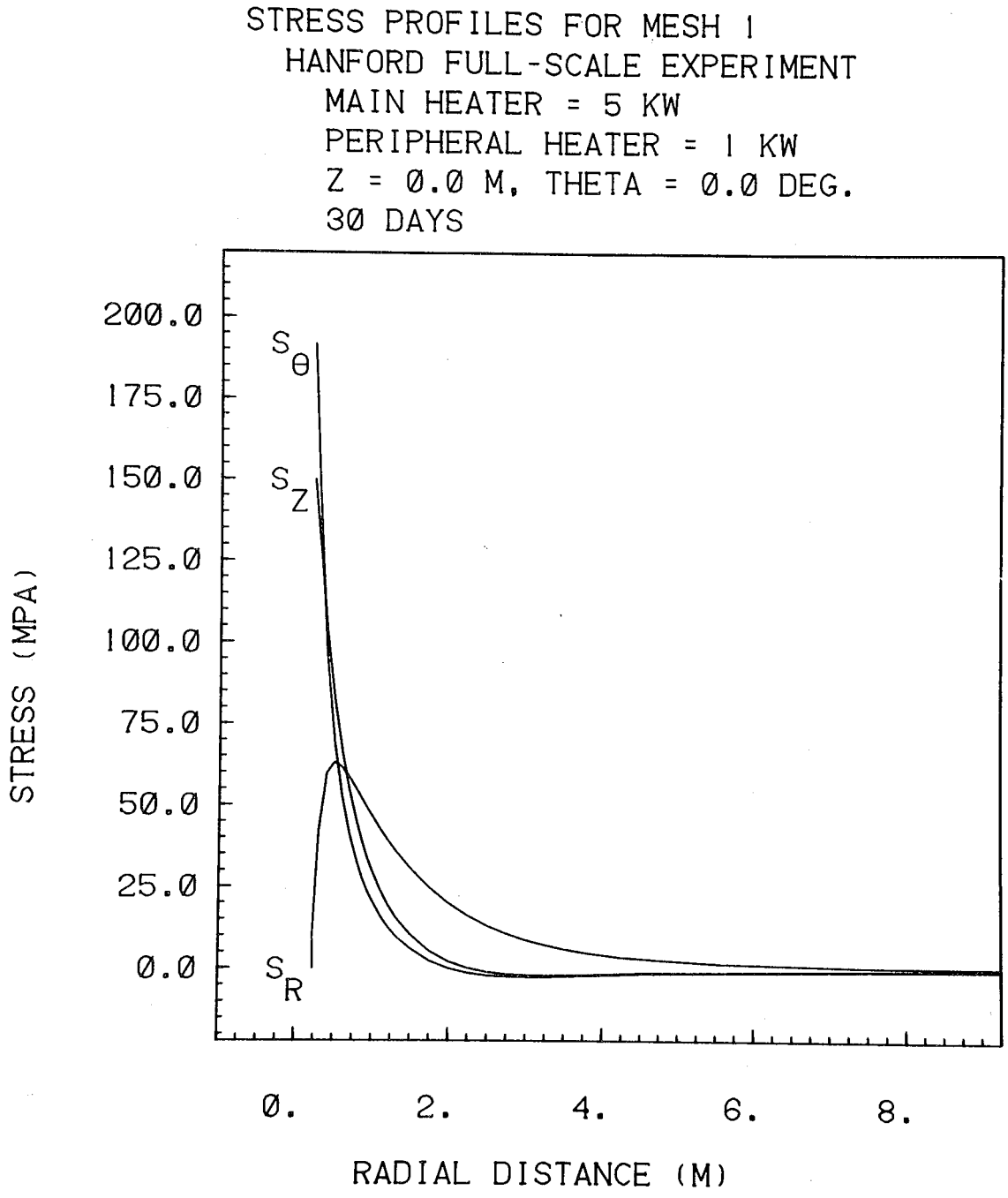
XBL 788-9862

Figure D24a



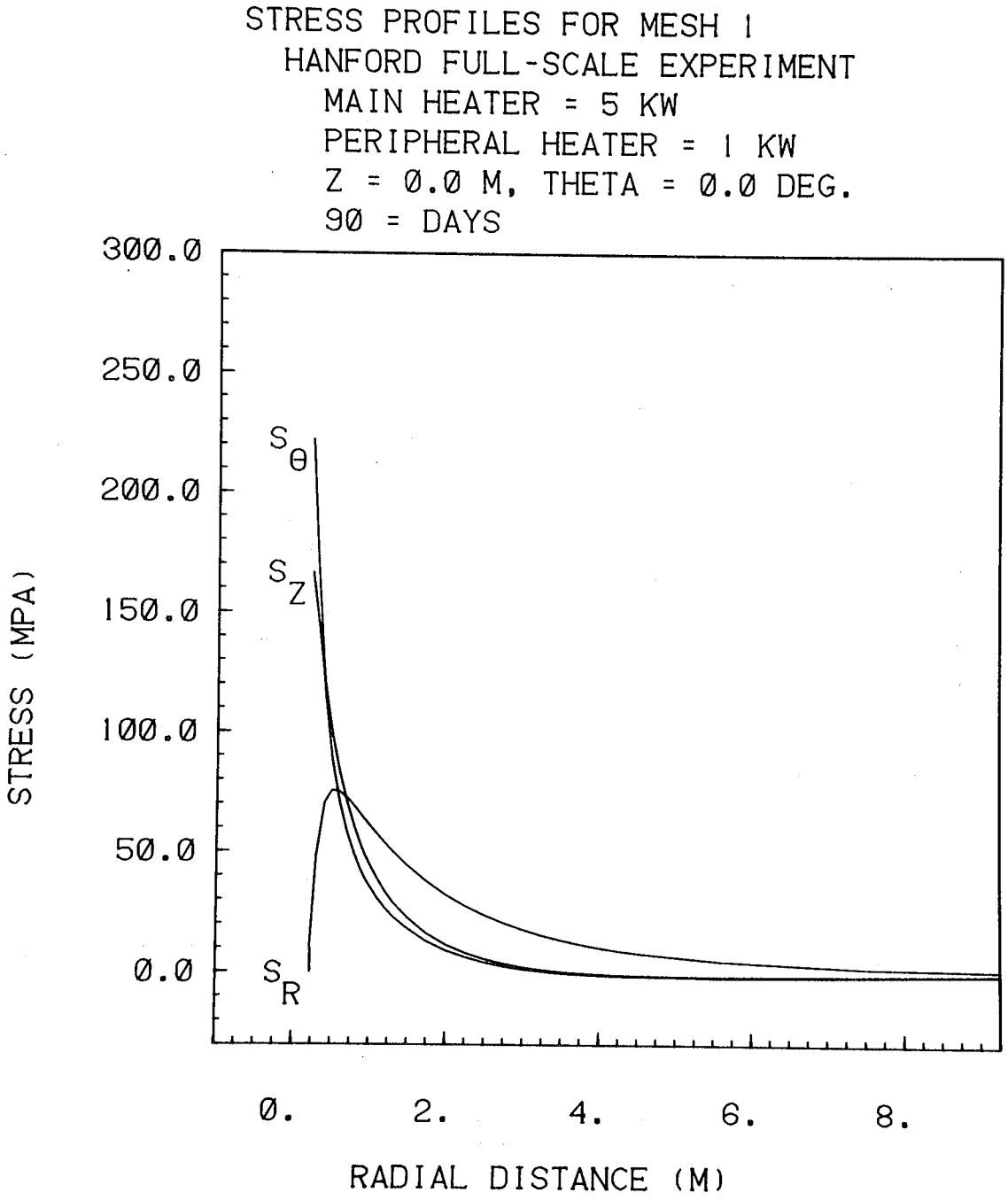
XBL 787-9737

Figure D24b



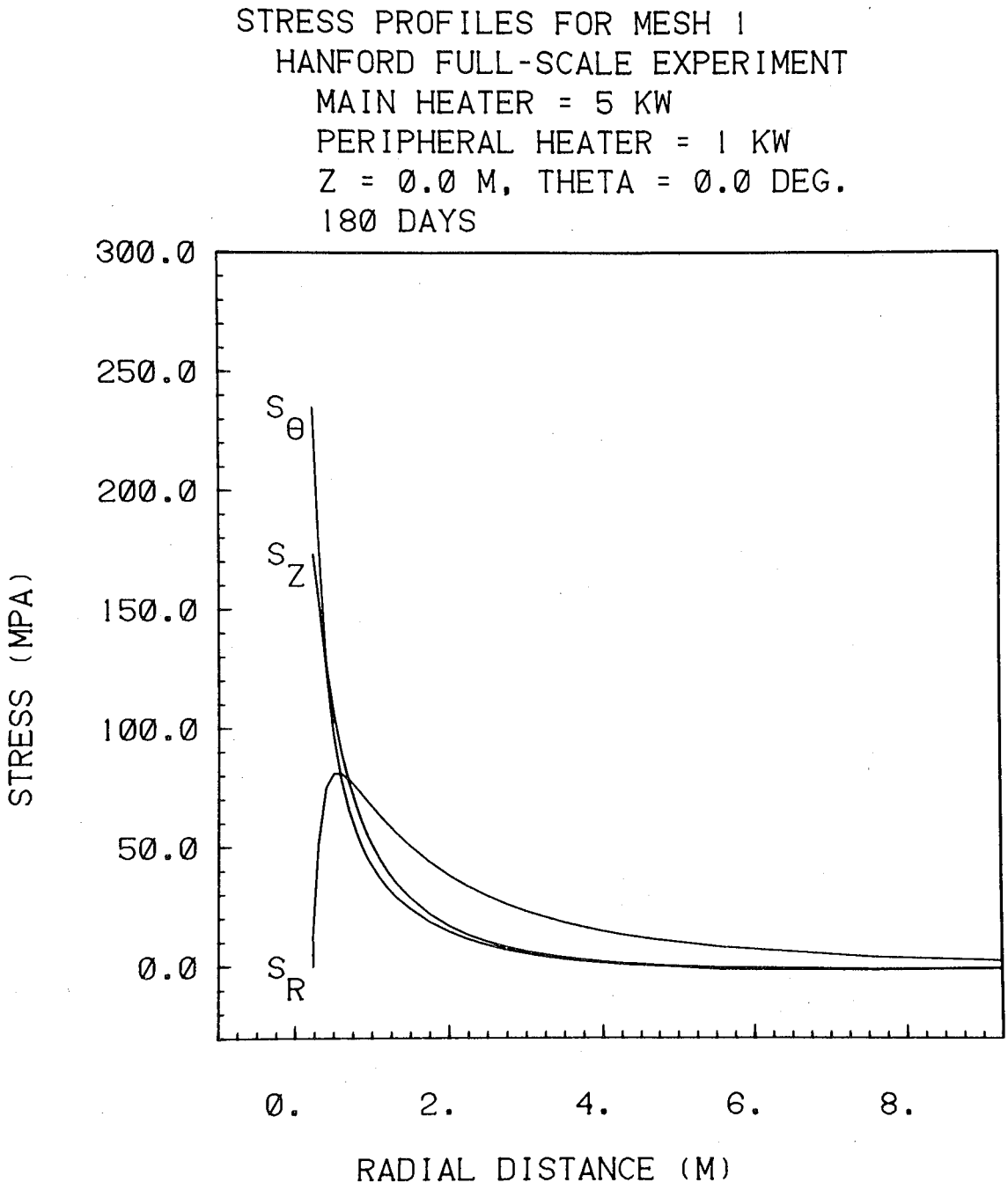
XBL 787-9736

Figure D24c



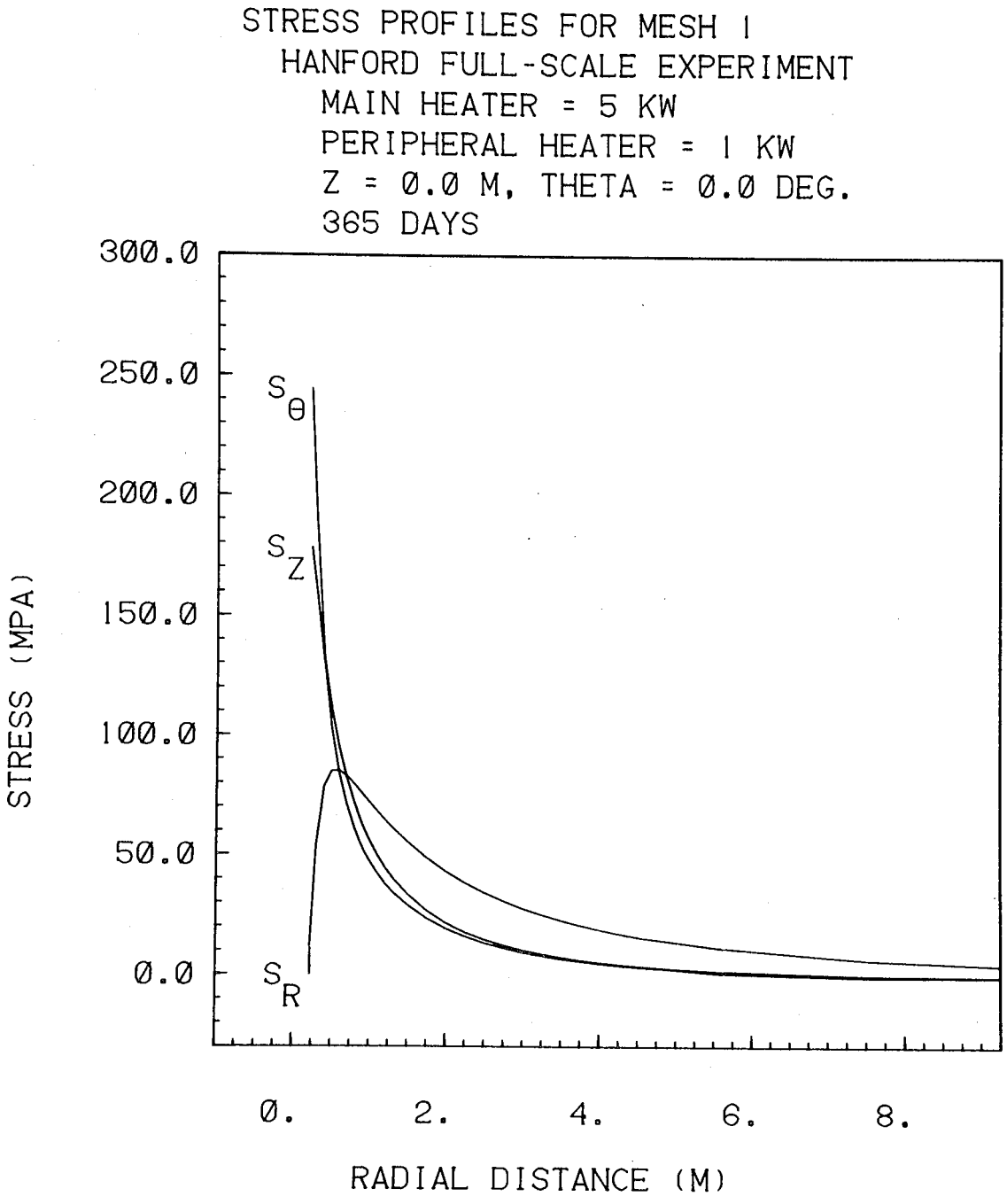
XBL 787-9735

Figure D24d



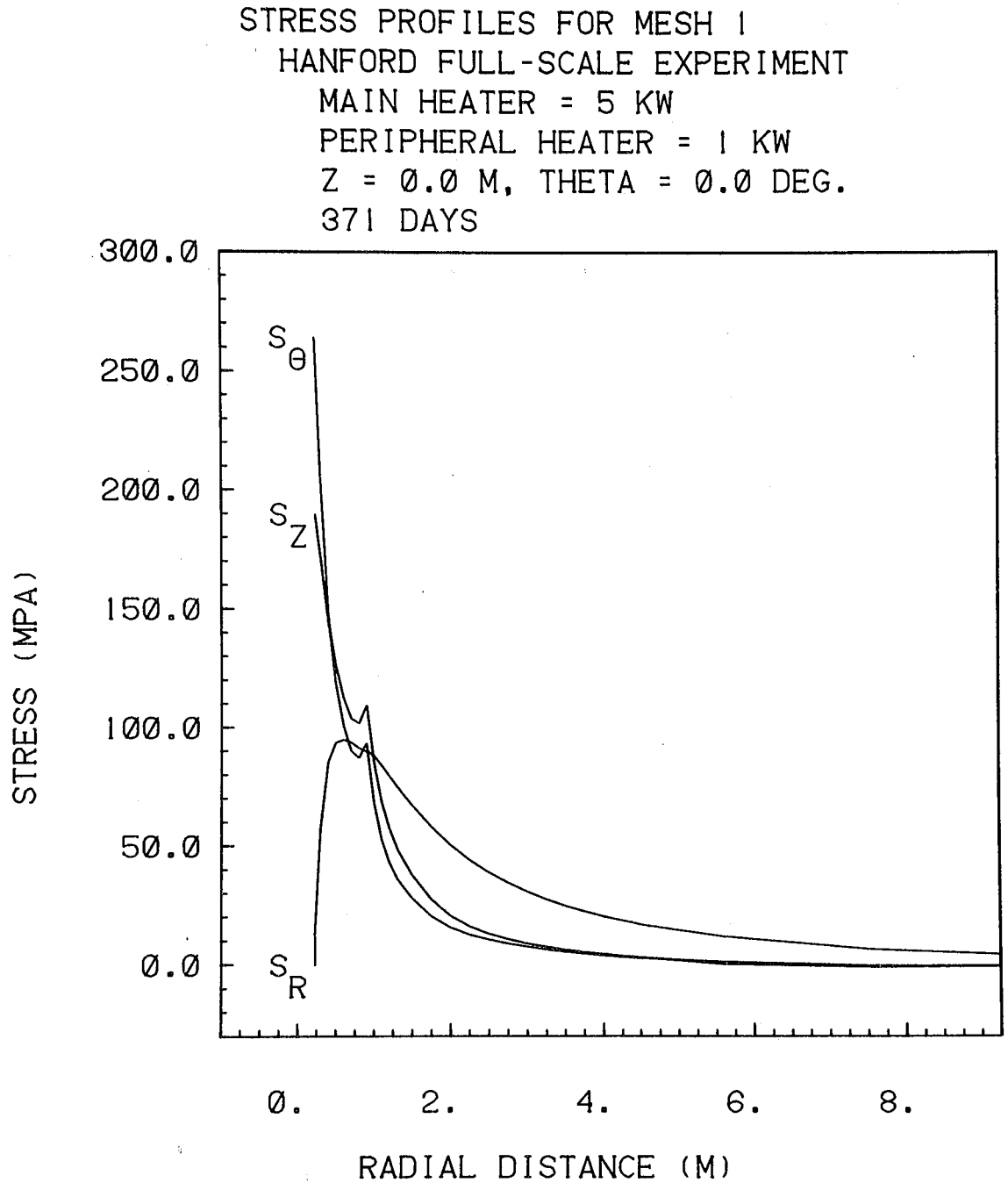
XBL 787-9734

Figure D24e



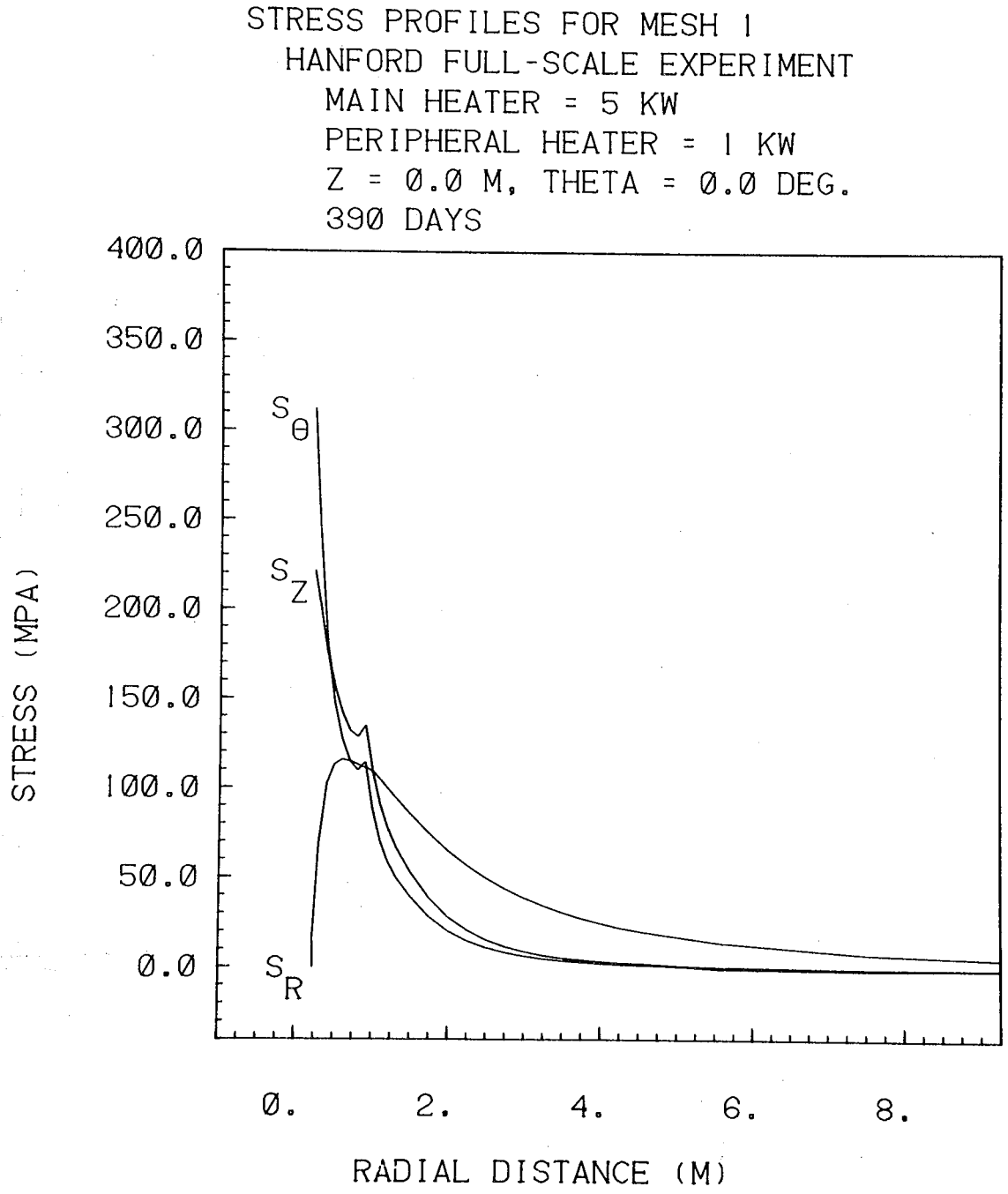
XBL 787-9697

Figure D24f



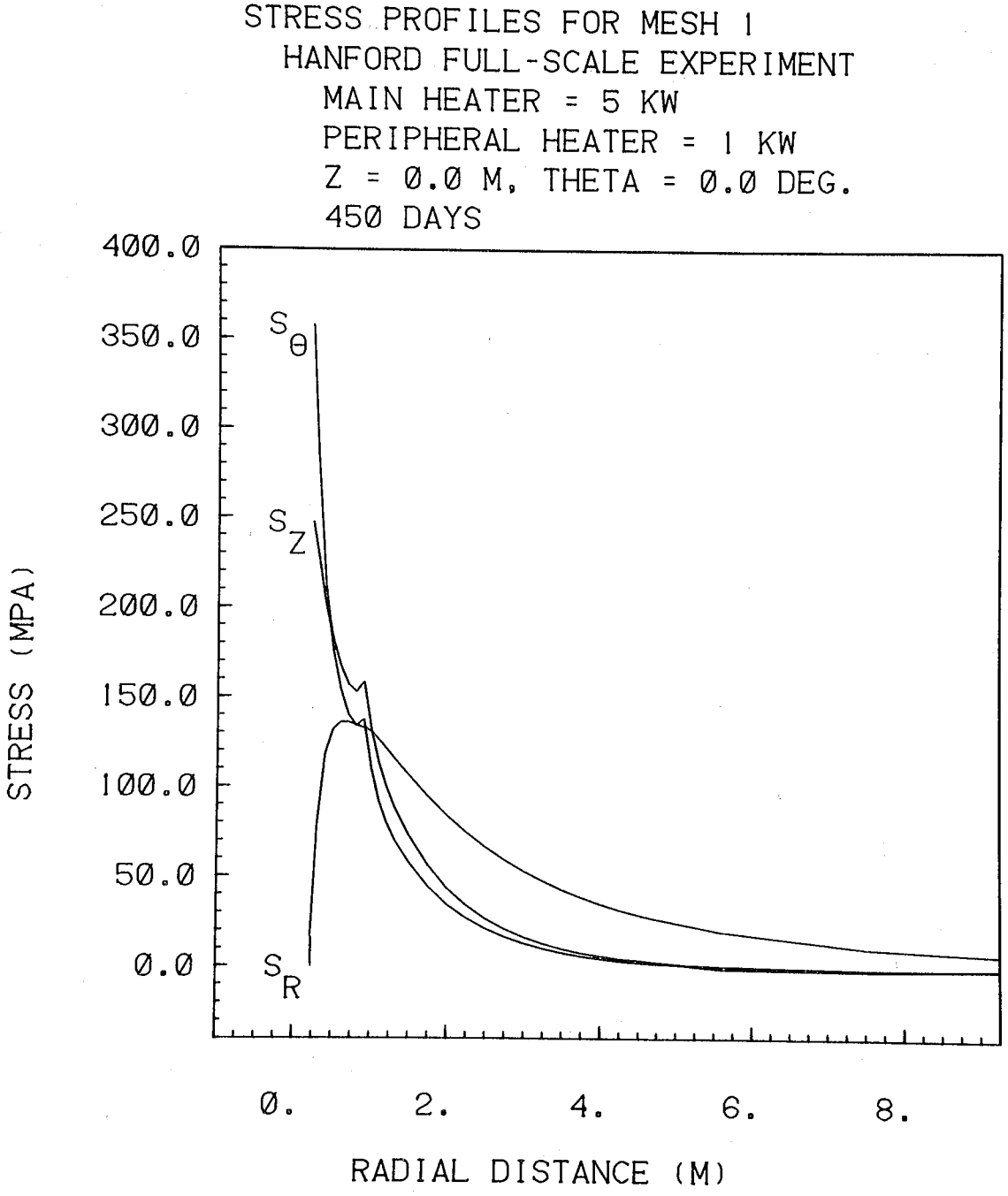
XBL 787-9698

Figure D24g



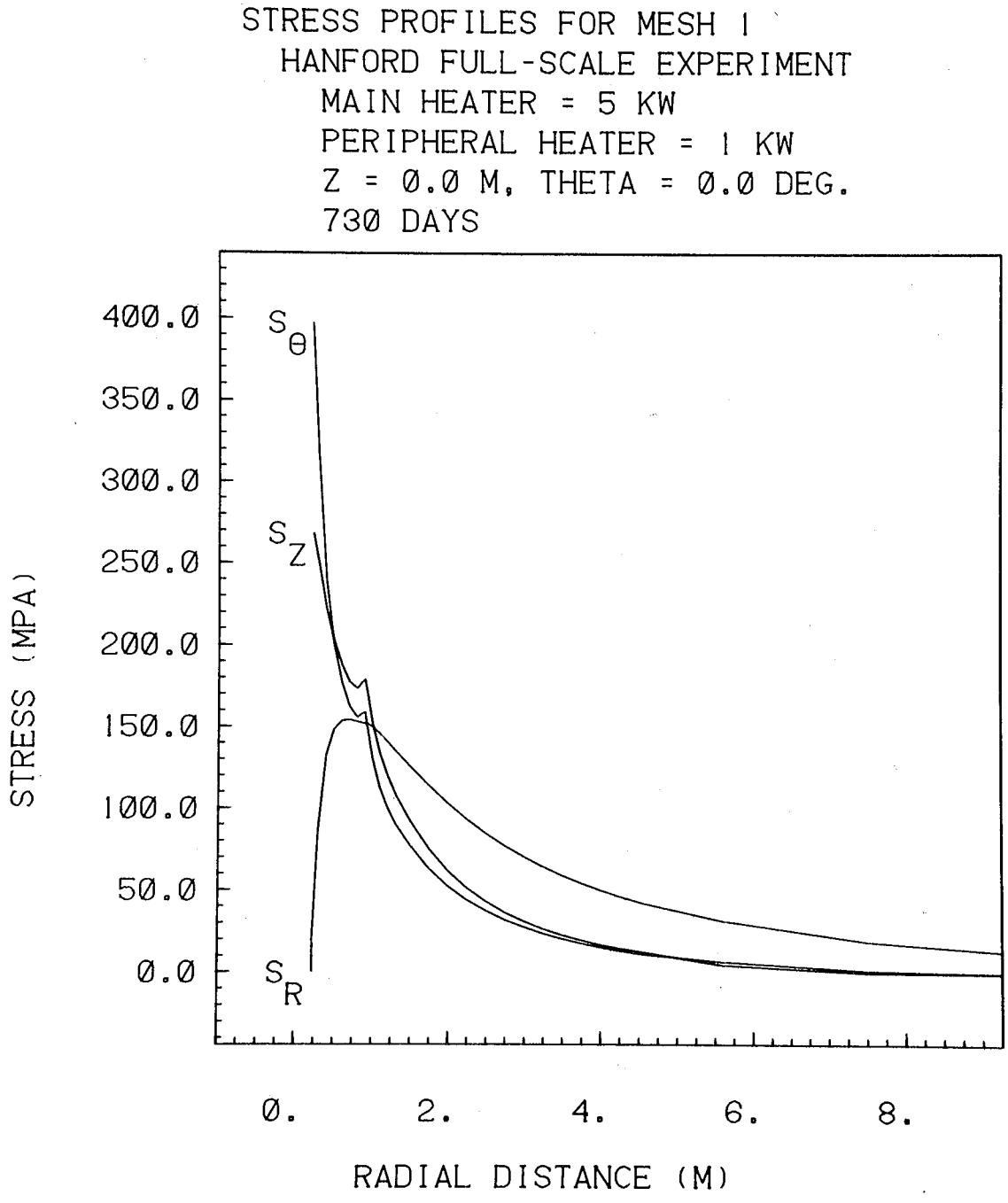
XBL 787-9699

Figure D24h



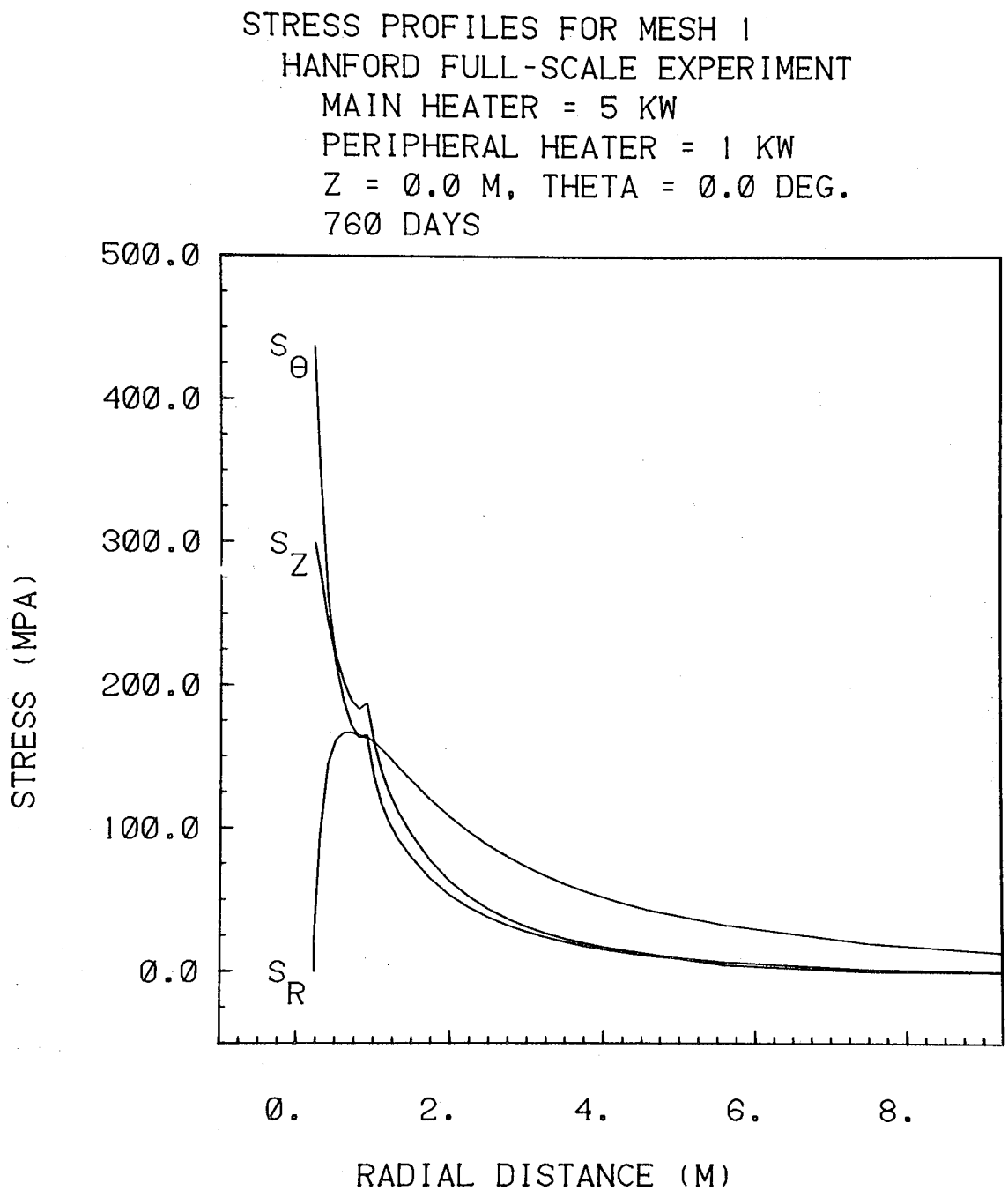
XBL 787-9700

Figure D24i



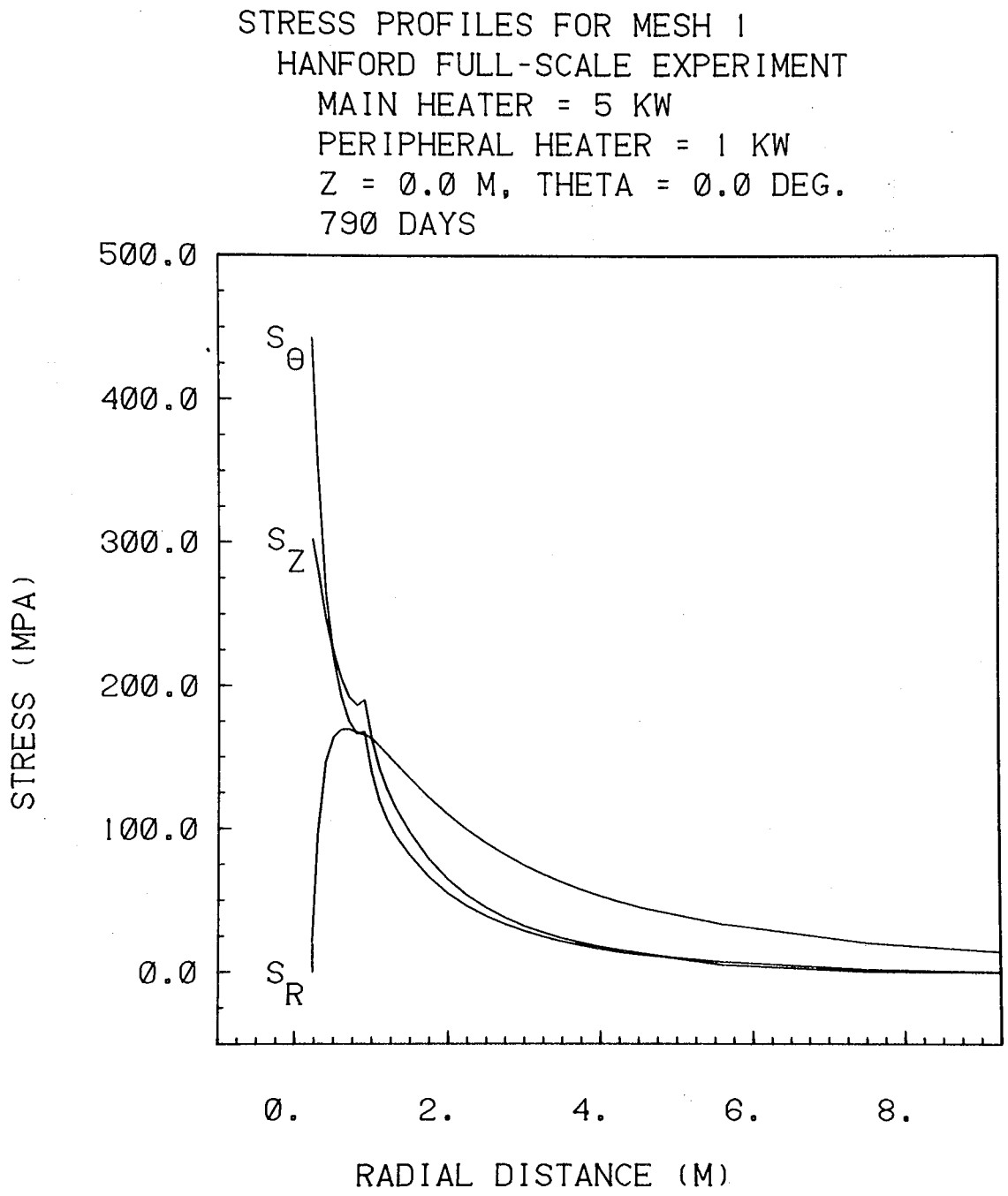
XBL 787-9701

Figure D24j



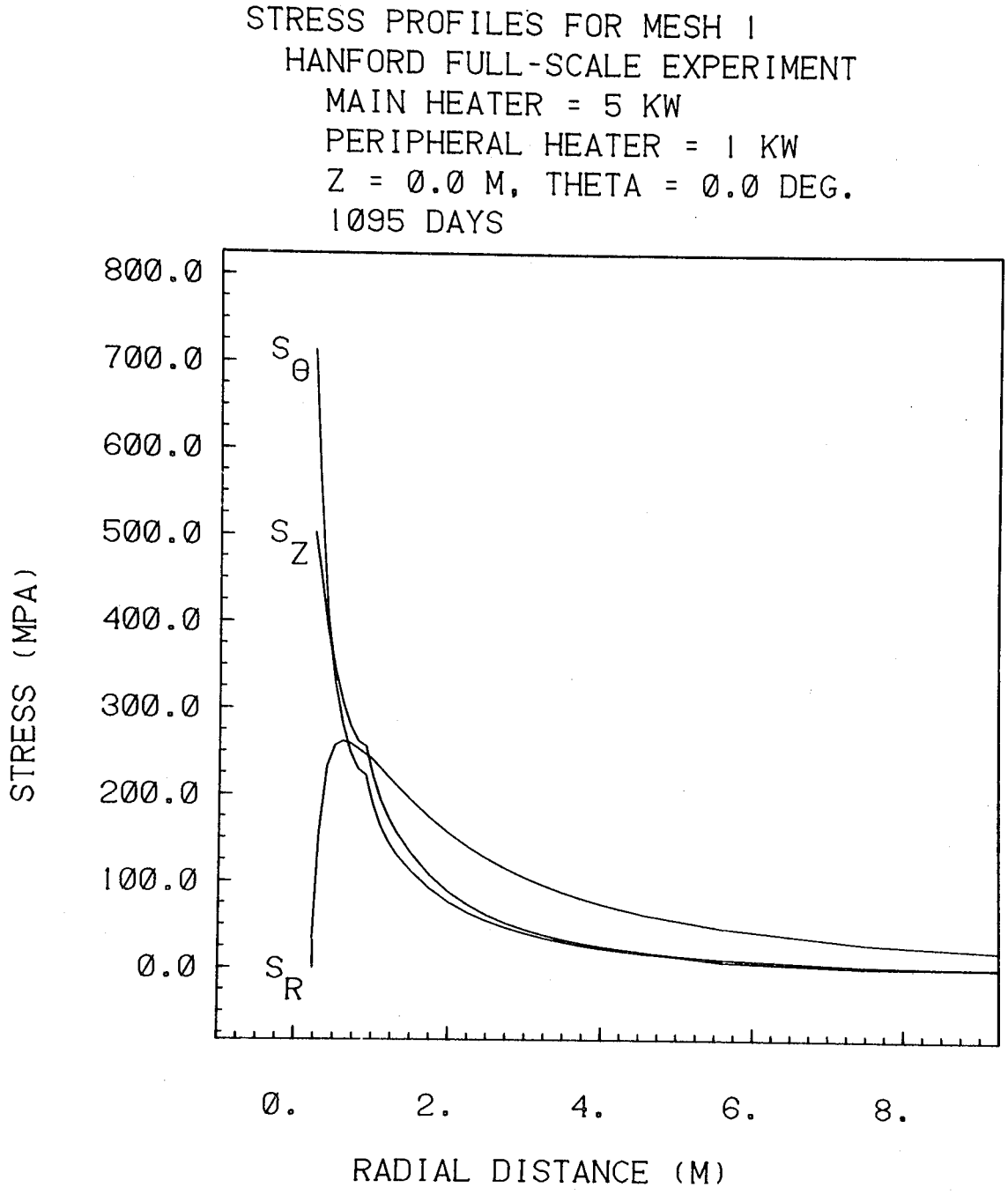
XBL 787-9702

Figure D24k



XBL 787-9703

Figure D241



XBL 787-9704

Figure D24m

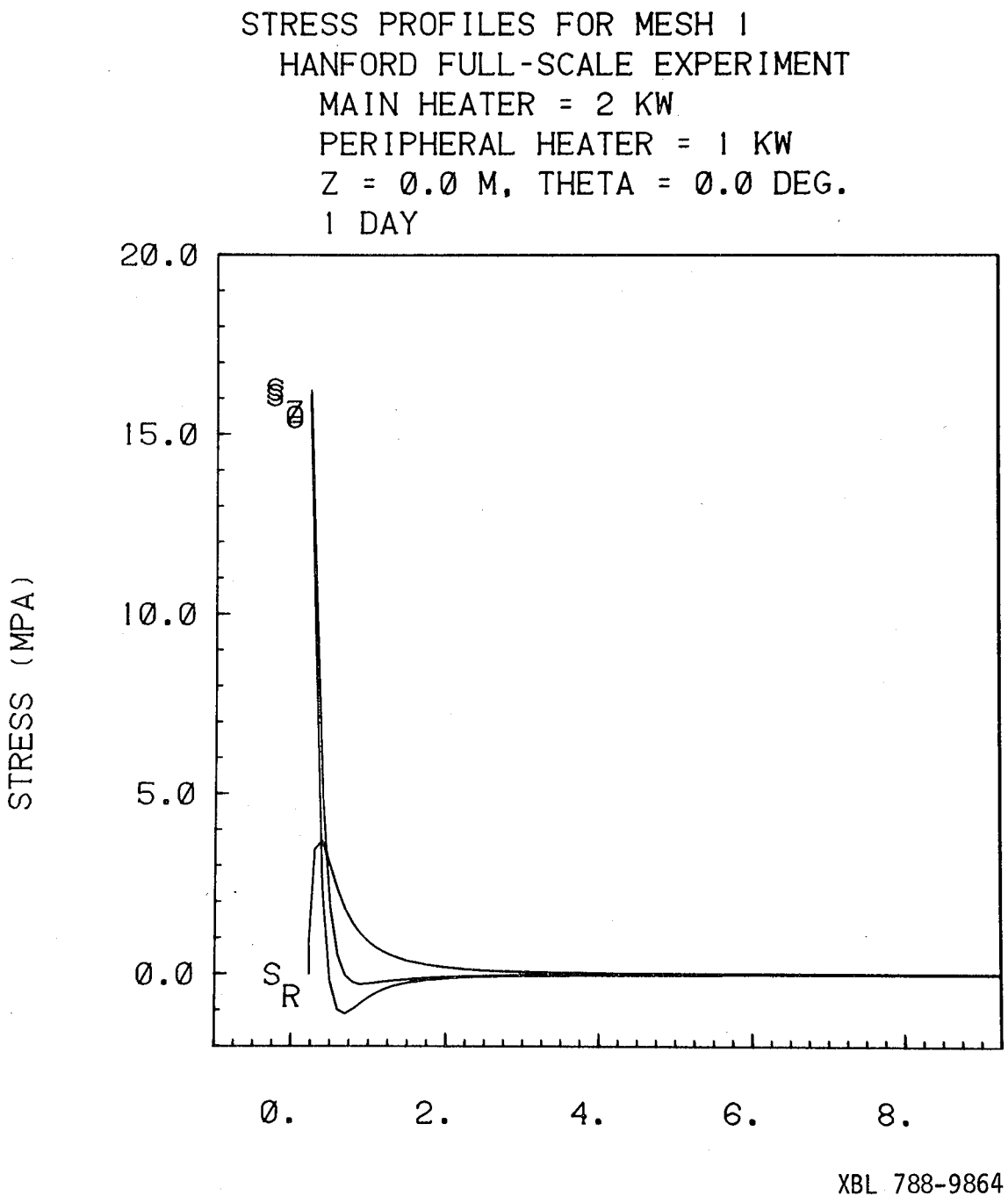
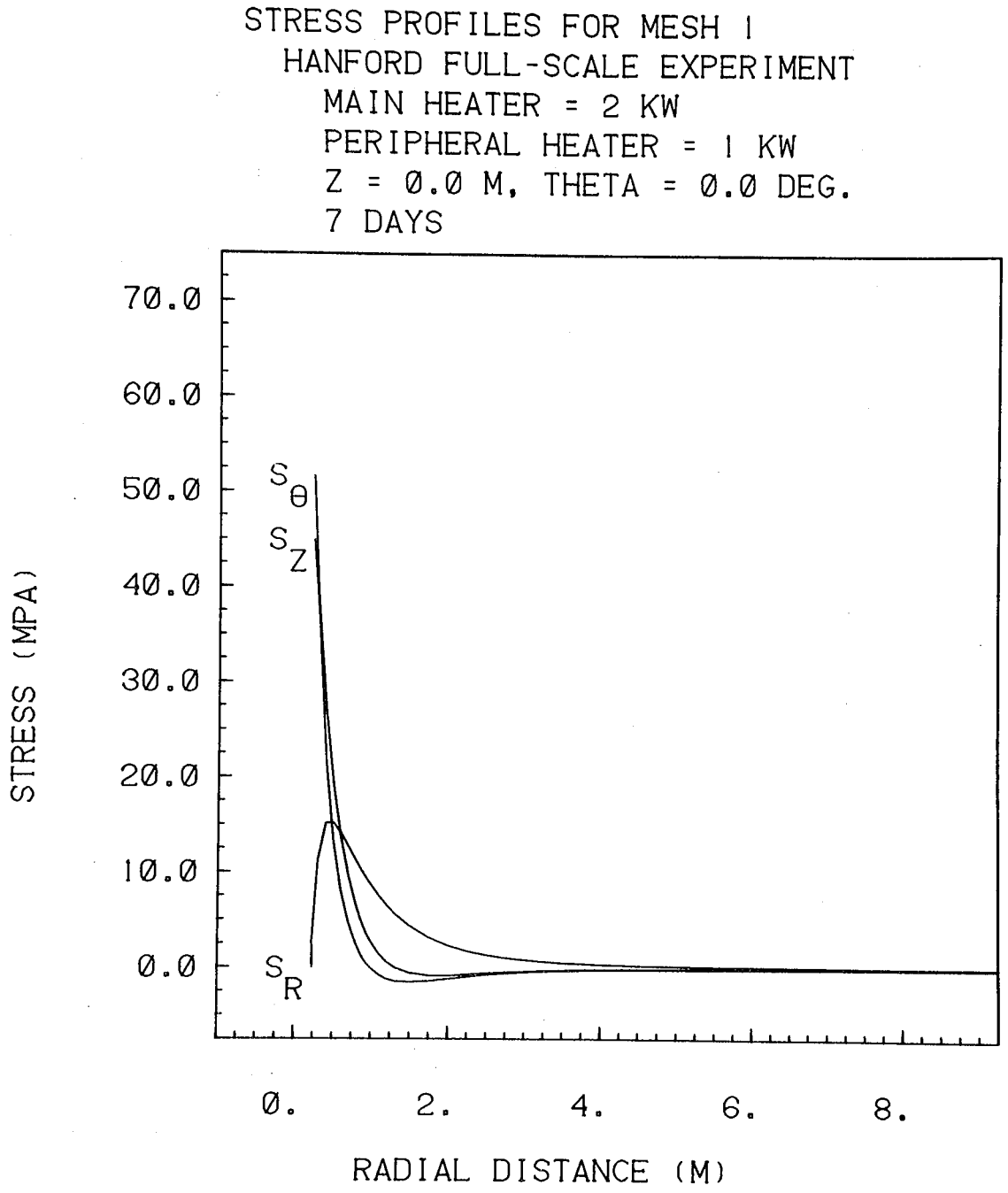
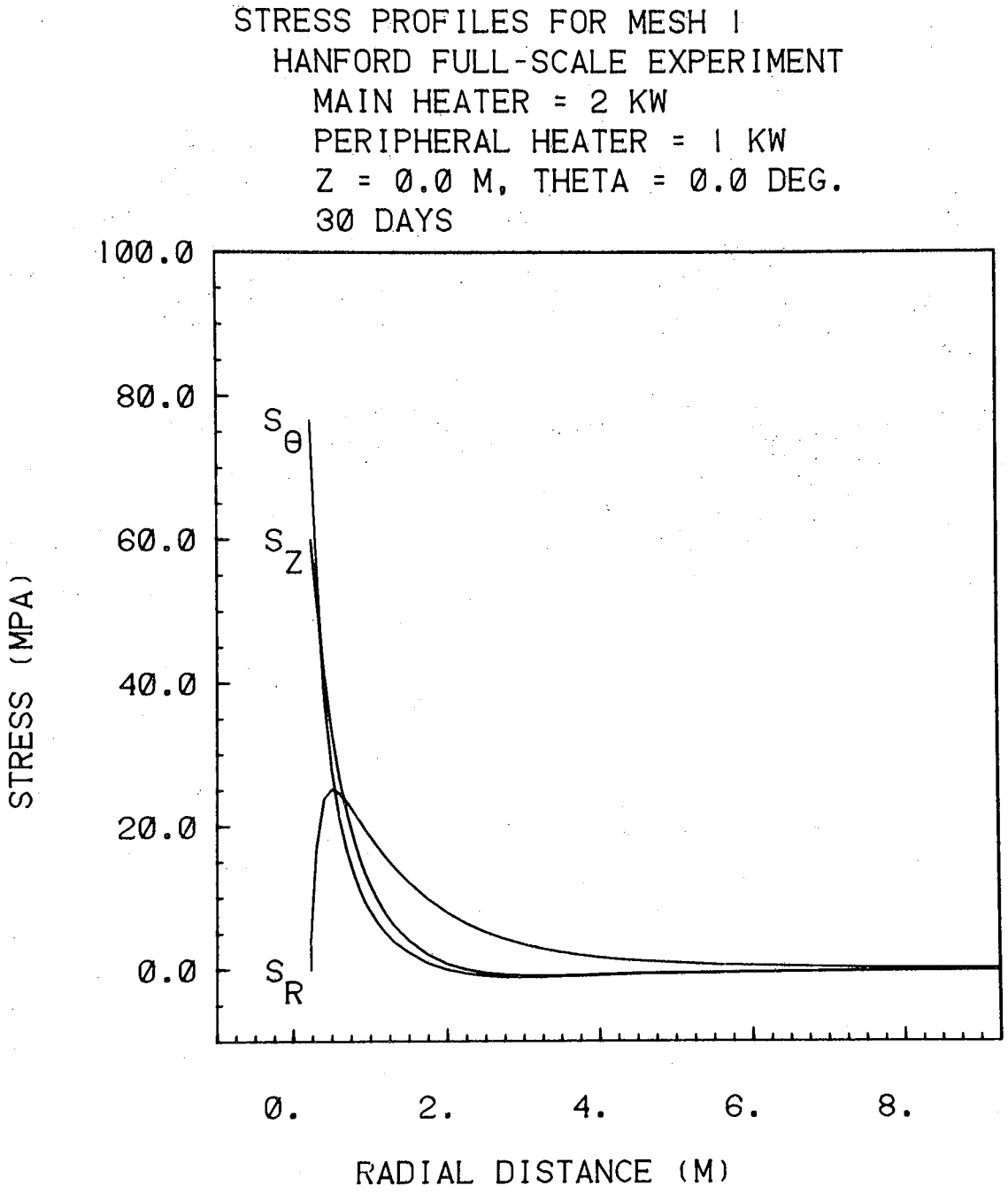

STRESS PROFILES FOR MESH 1
HANFORD FULL-SCALE EXPERIMENT
MAIN HEATER = 2 KW
PERIPHERAL HEATER = 1 KW
Z = 0.0 M, THETA = 0.0 DEG.
1 DAY
STRESS (MPA)
20.0
15.0
10.0
5.0
0.0
S_θ
S_R
0.
2.
4.
6.
8.
XBL 788-9864

Figure D25a



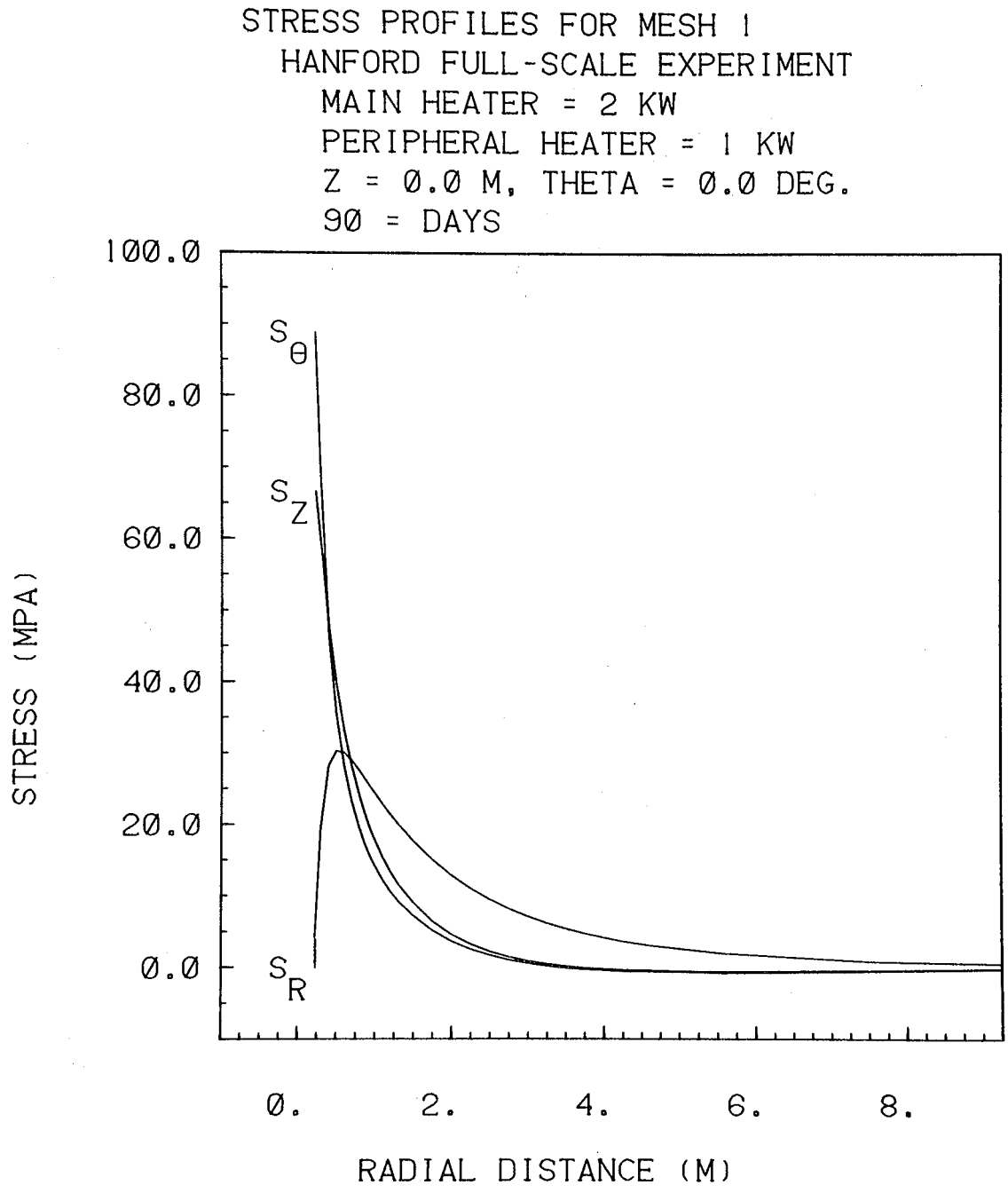
XBL 787-9717

Figure D25b



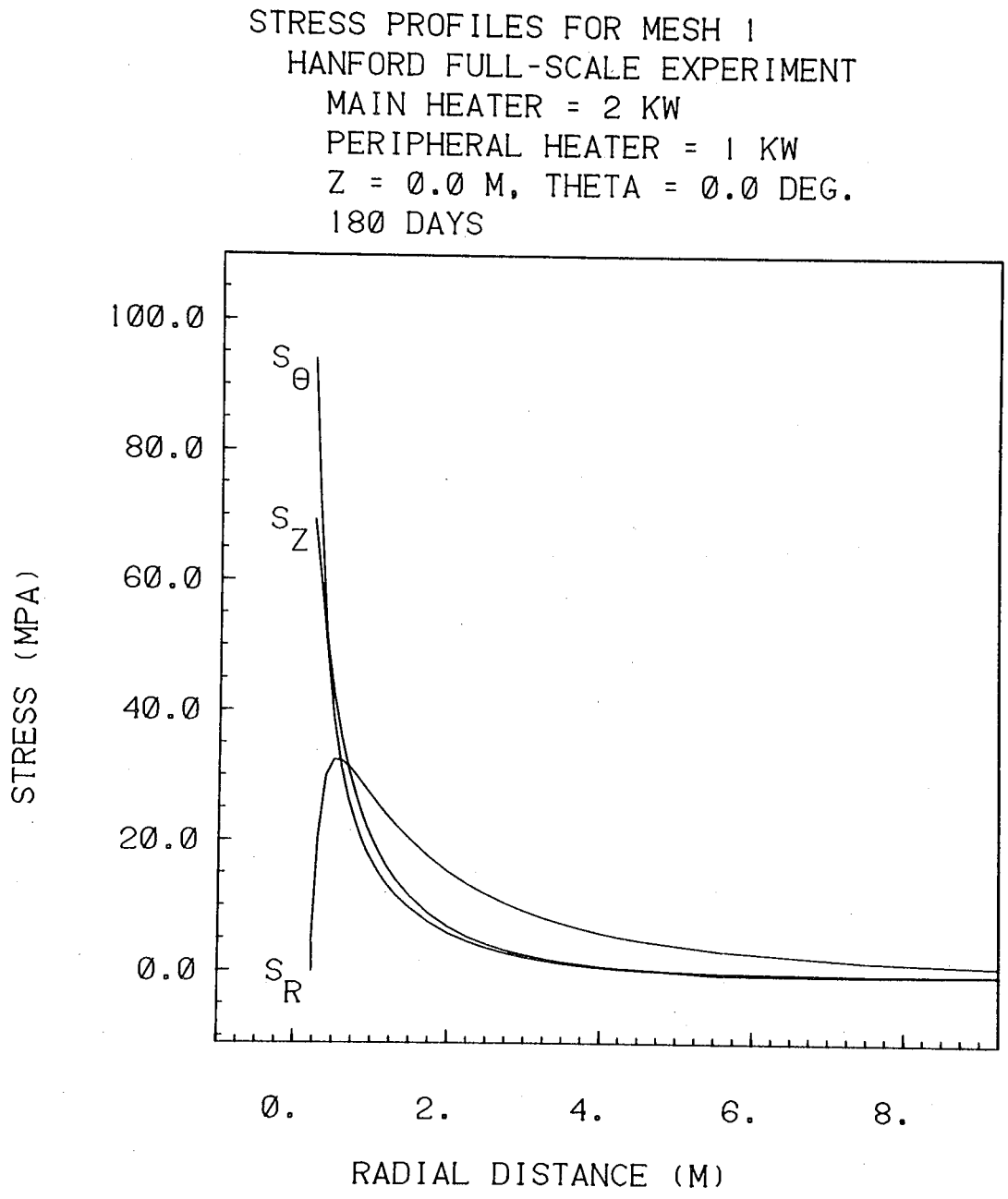
XBL 787-9718

Figure D25c



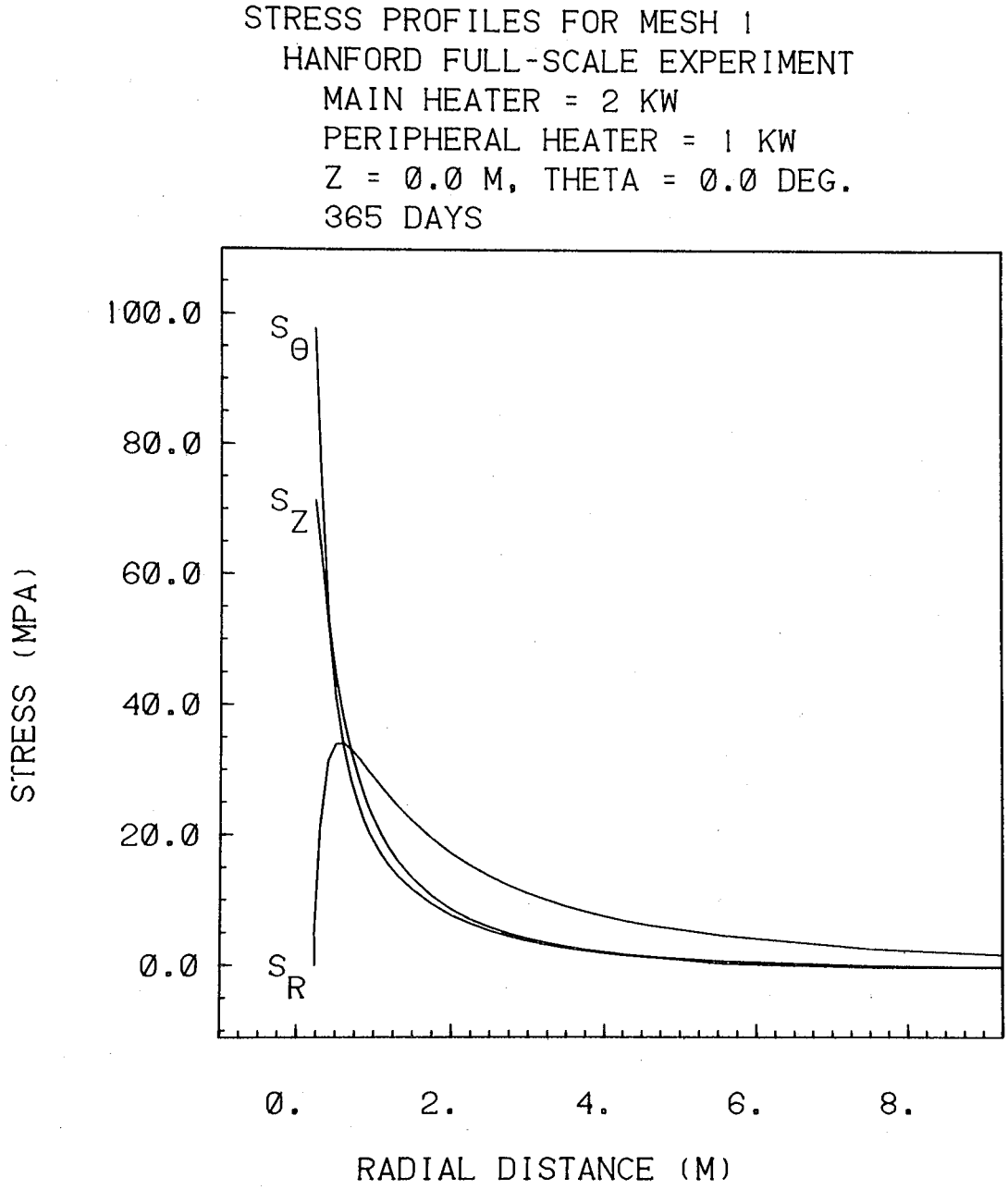
XBL 787-9719

Figure D25d



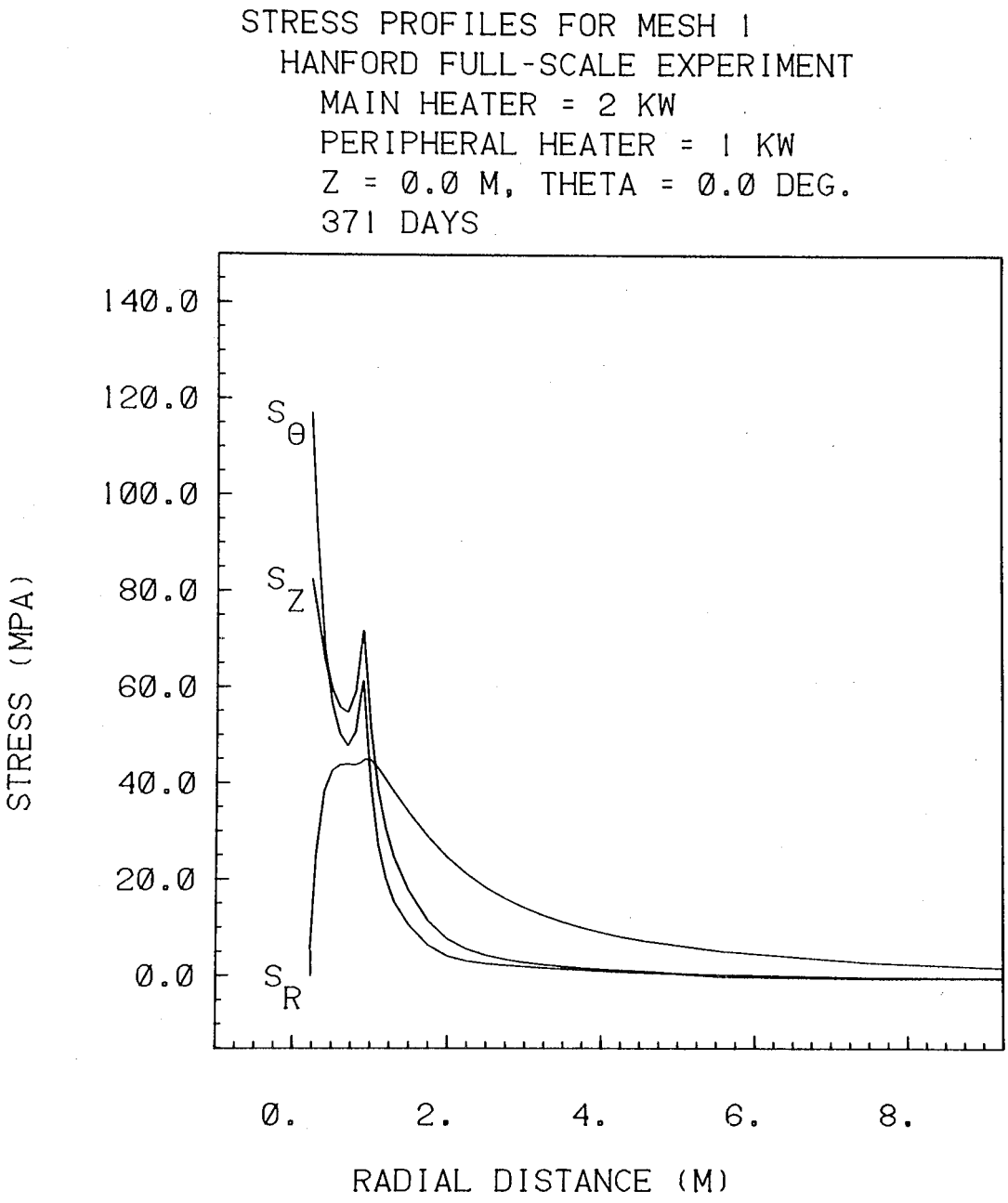
XBL 787-9720

Figure D25e



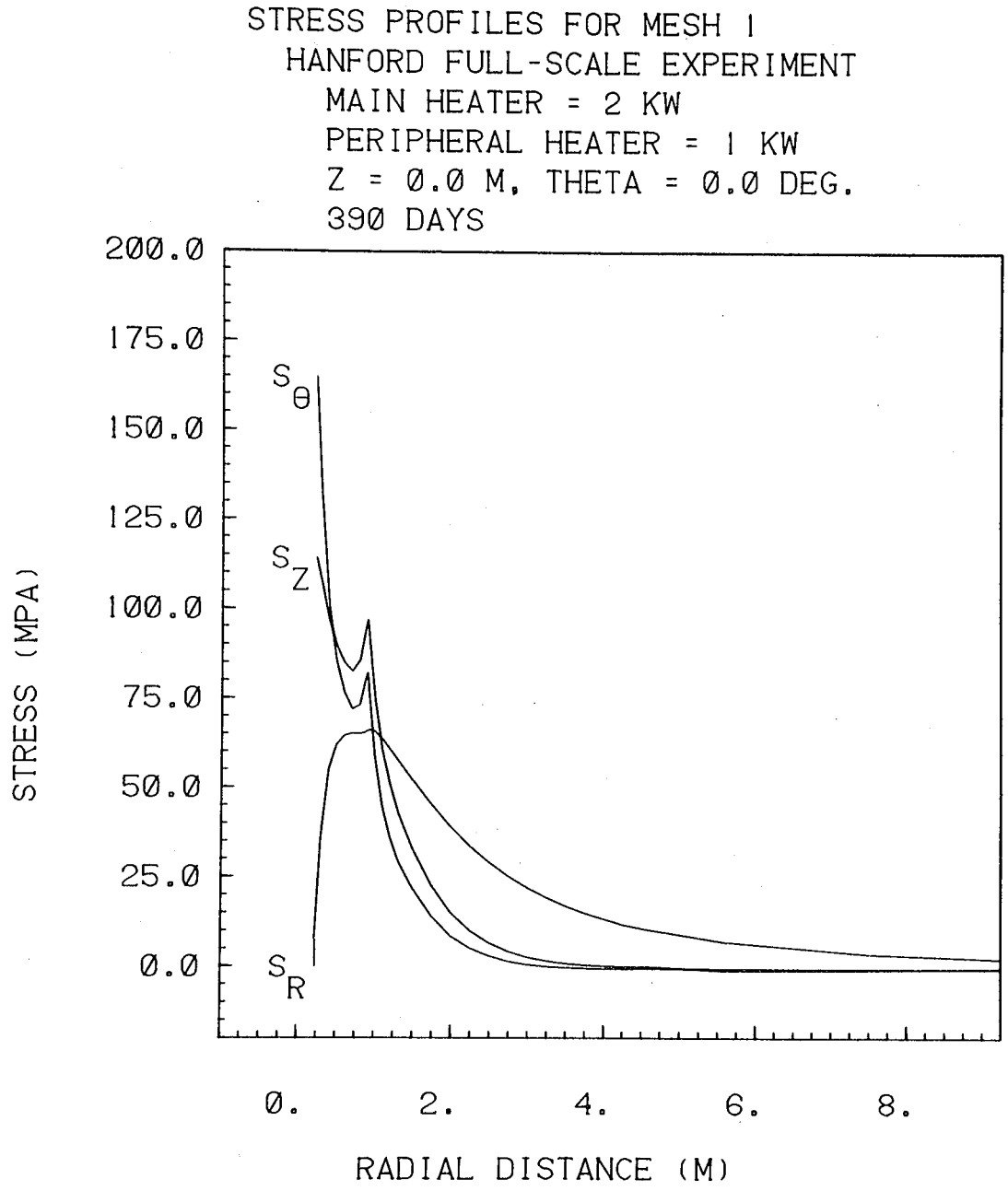
XBL 787-9721

Figure D25f



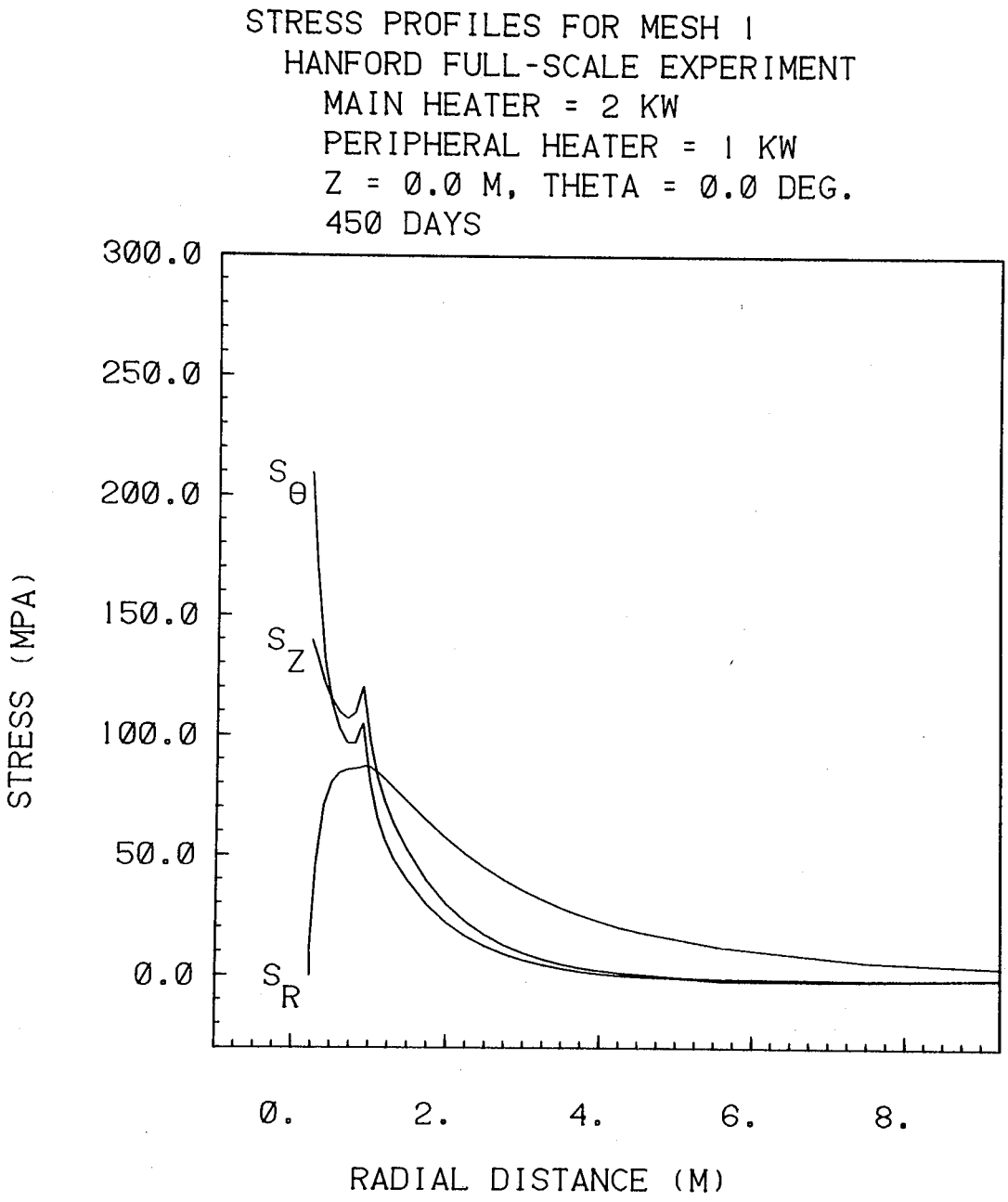
XBL 787-9722

Figure D25g



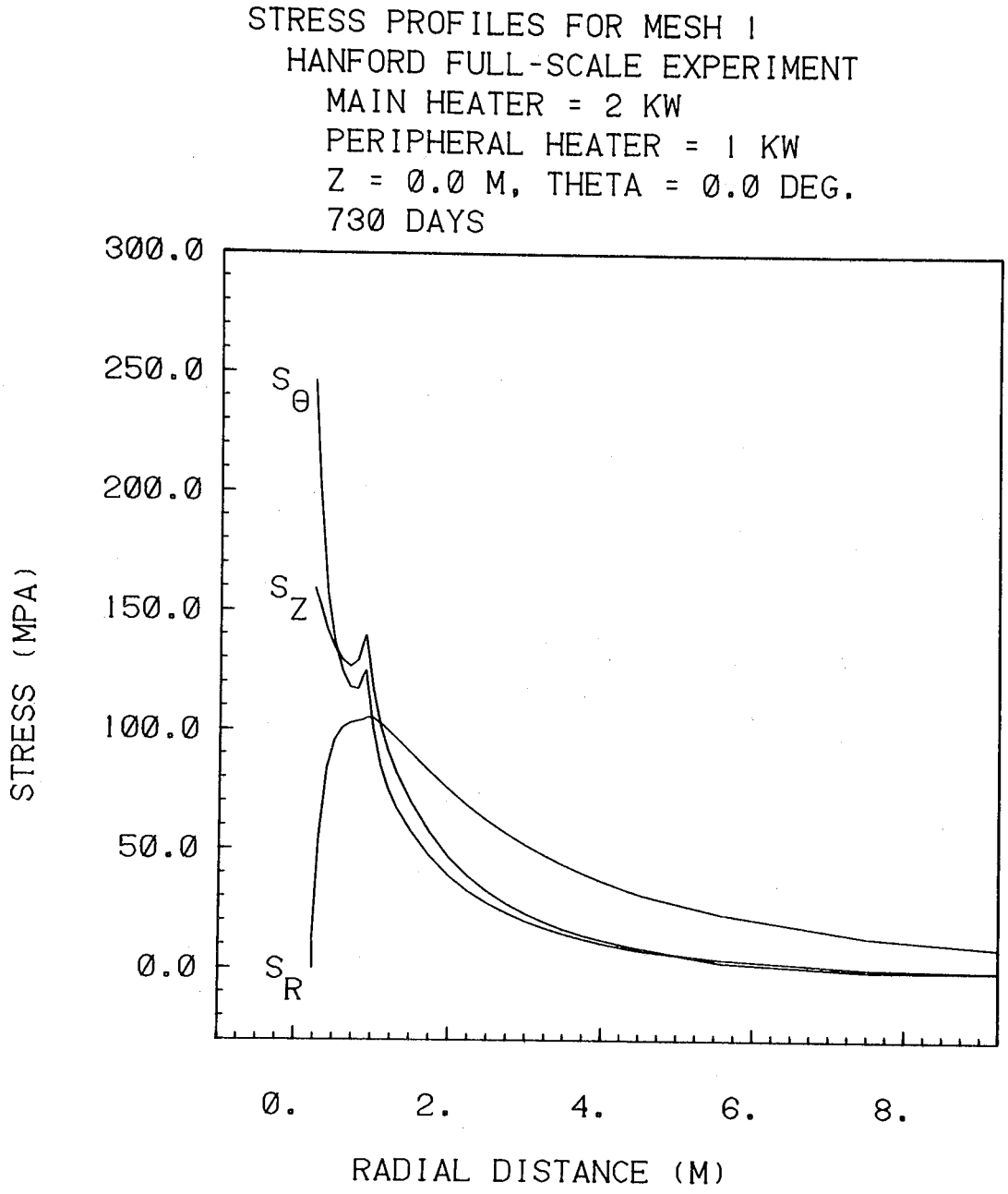
XBL 787-9723

Figure D25h



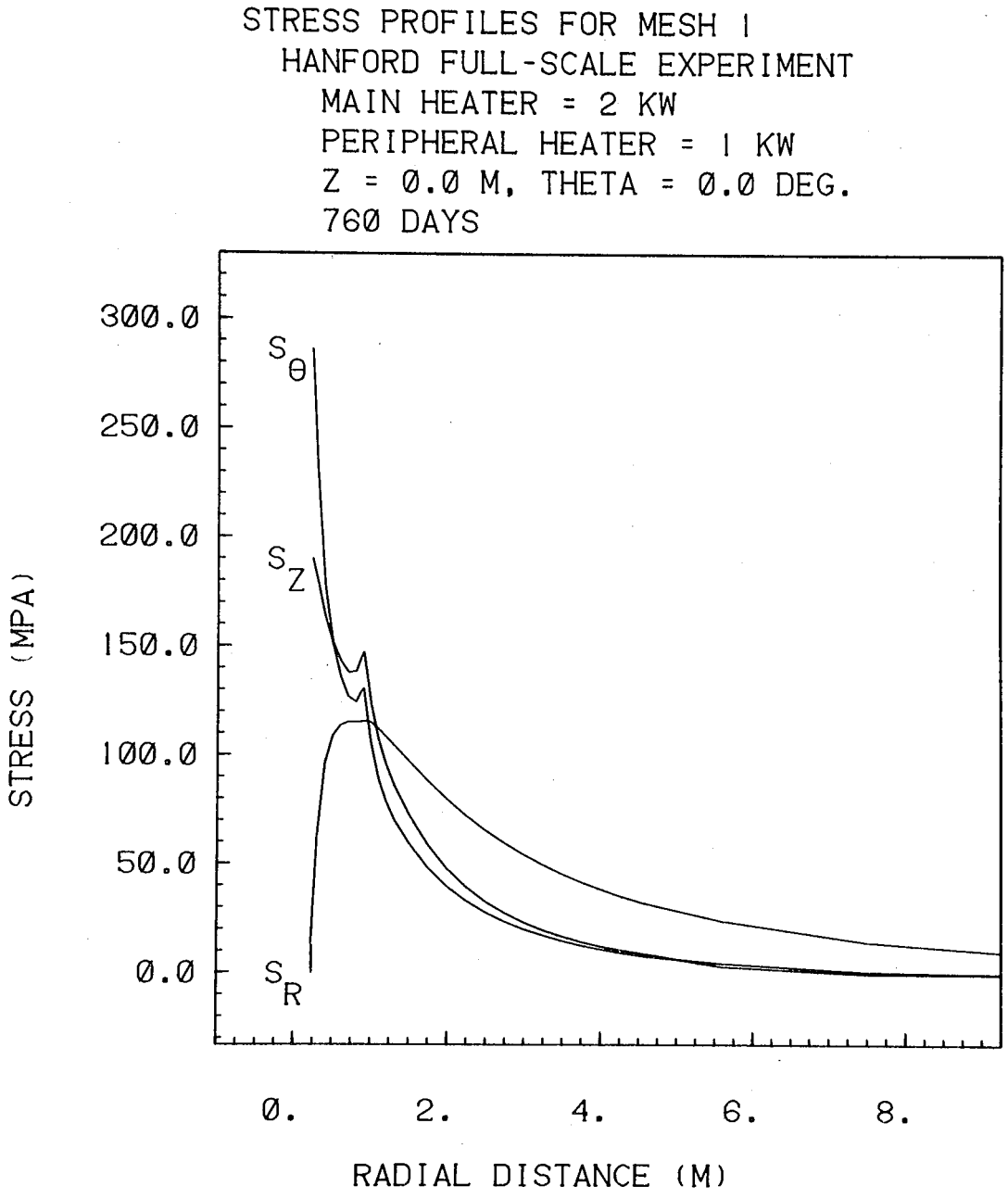
XBL 787-9724

Figure D25i



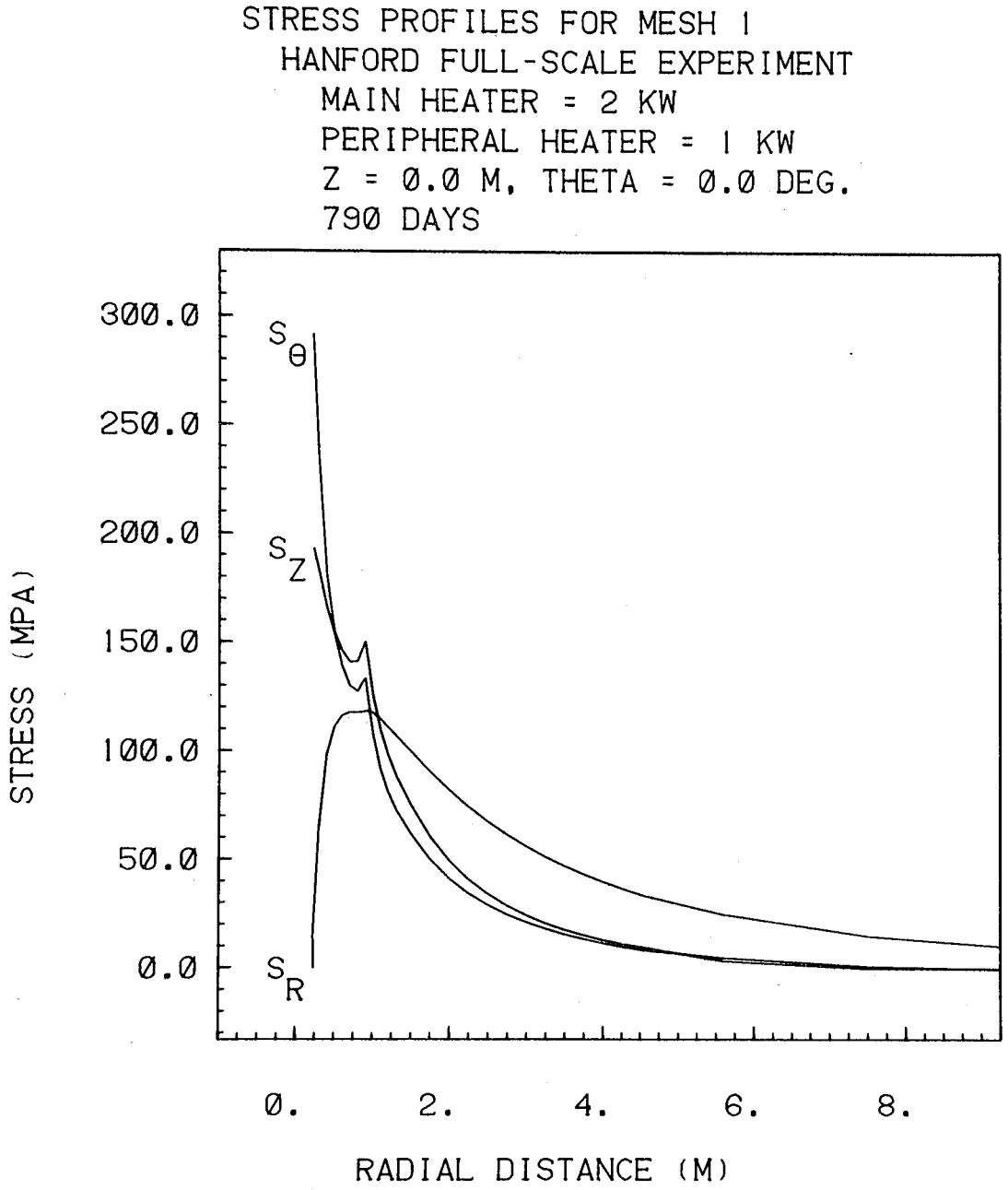
XBL 787-9725

Figure D25j



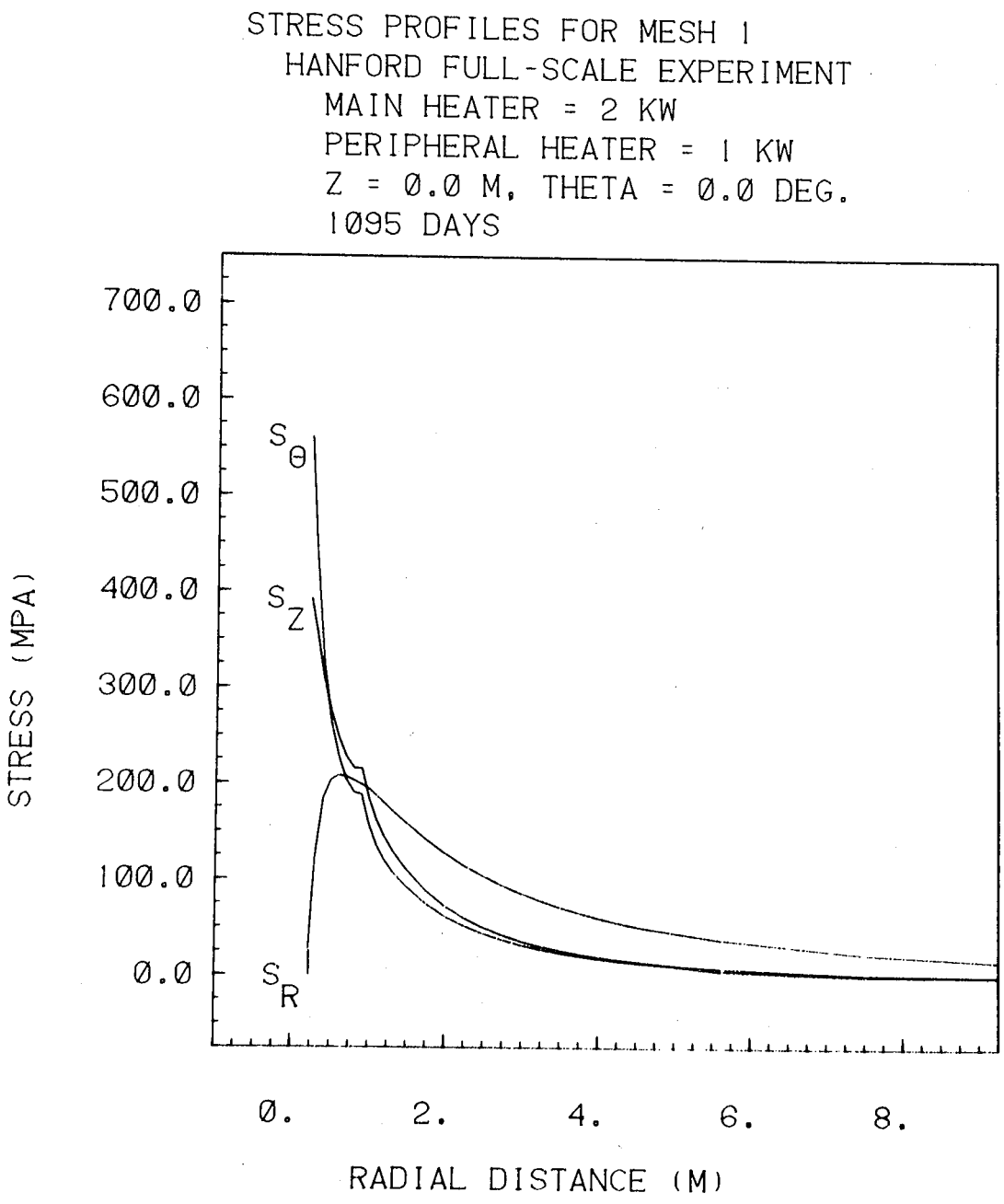
XBL 787-9726

Figure D25k



XBL 787-9727

Figure D251



XBL 787-9728

Figure D25m

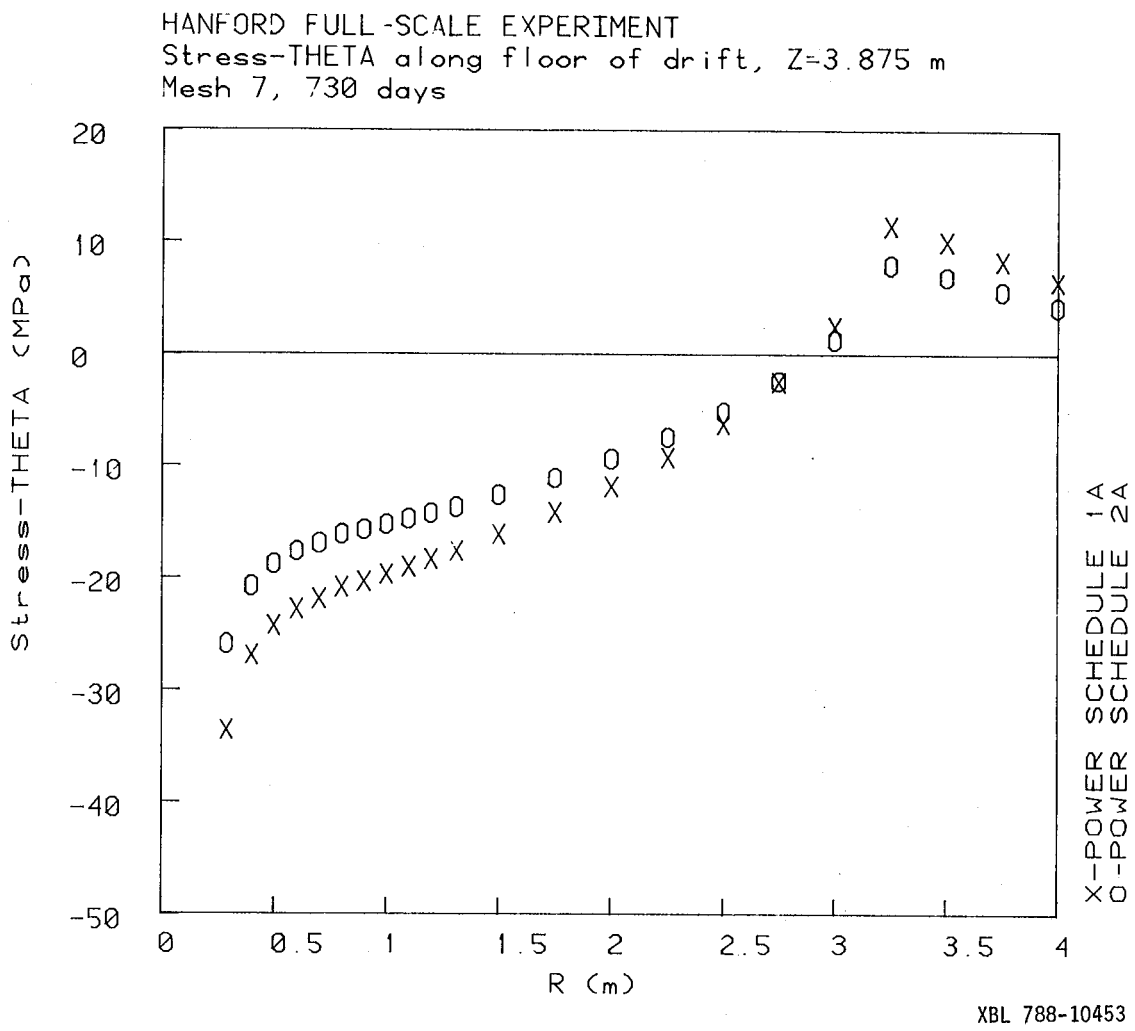

HANFORD FULL-SCALE EXPERIMENT
Stress-THETA along floor of drift, Z=3.875 m
Mesh 7, 730 days
Stress-THETA (MPa)
20
10
0
-10
-20
-30
-40
-50
0
0.5
1
1.5
2
2.5
3
3.5
4
R (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10453

Figure D26a

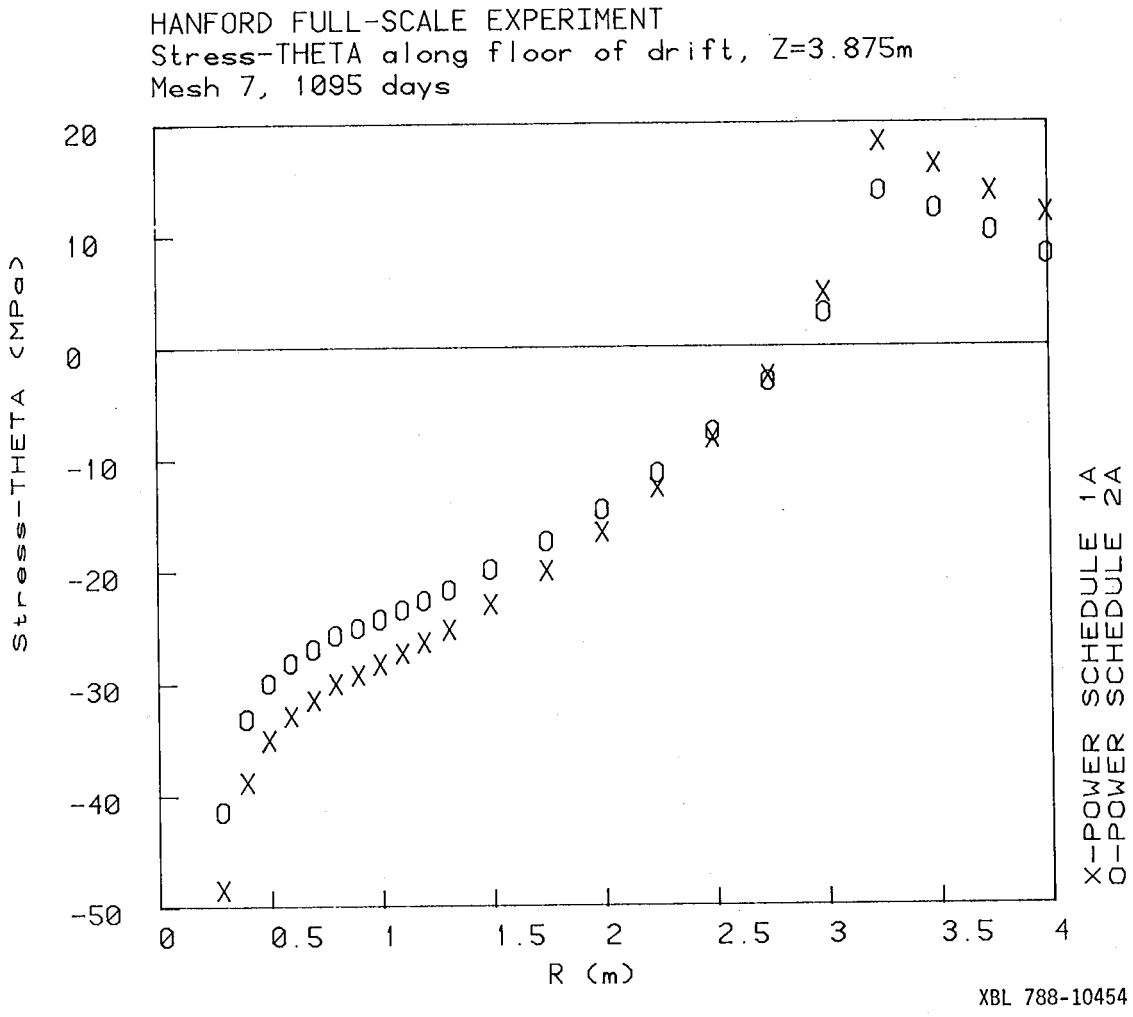

HANFORD FULL-SCALE EXPERIMENT
Stress-THETA along floor of drift, Z=3.875m
Mesh 7, 1095 days
Stress-THETA (MPa)
20
10
0
-10
-20
-30
-40
-50
0
0.5
1
1.5
2
2.5
3
3.5
4
R (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
XBL 788-10454

Figure D26b

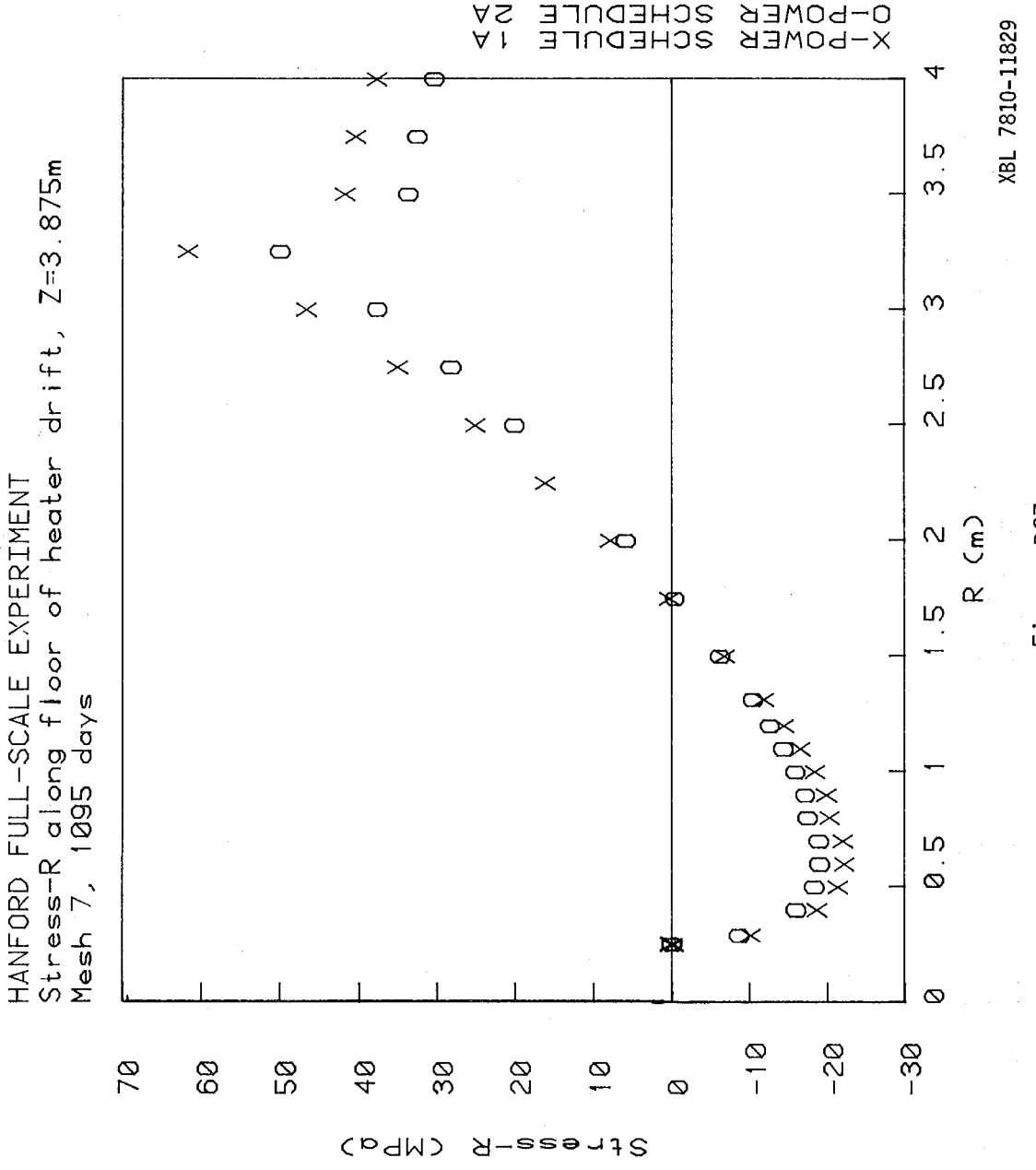

HANFORD FULL-SCALE EXPERIMENT
Stress-R along floor of heater drift, Z=3.875m
Mesh 7, 1095 days
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
Stress-R (MPa)
R (m)
70
60
50
40
30
20
10
0
-10
-20
-30
0
0.5
1
1.5
2
2.5
3
3.5
4
XBL 7810-11829

Figure D27a

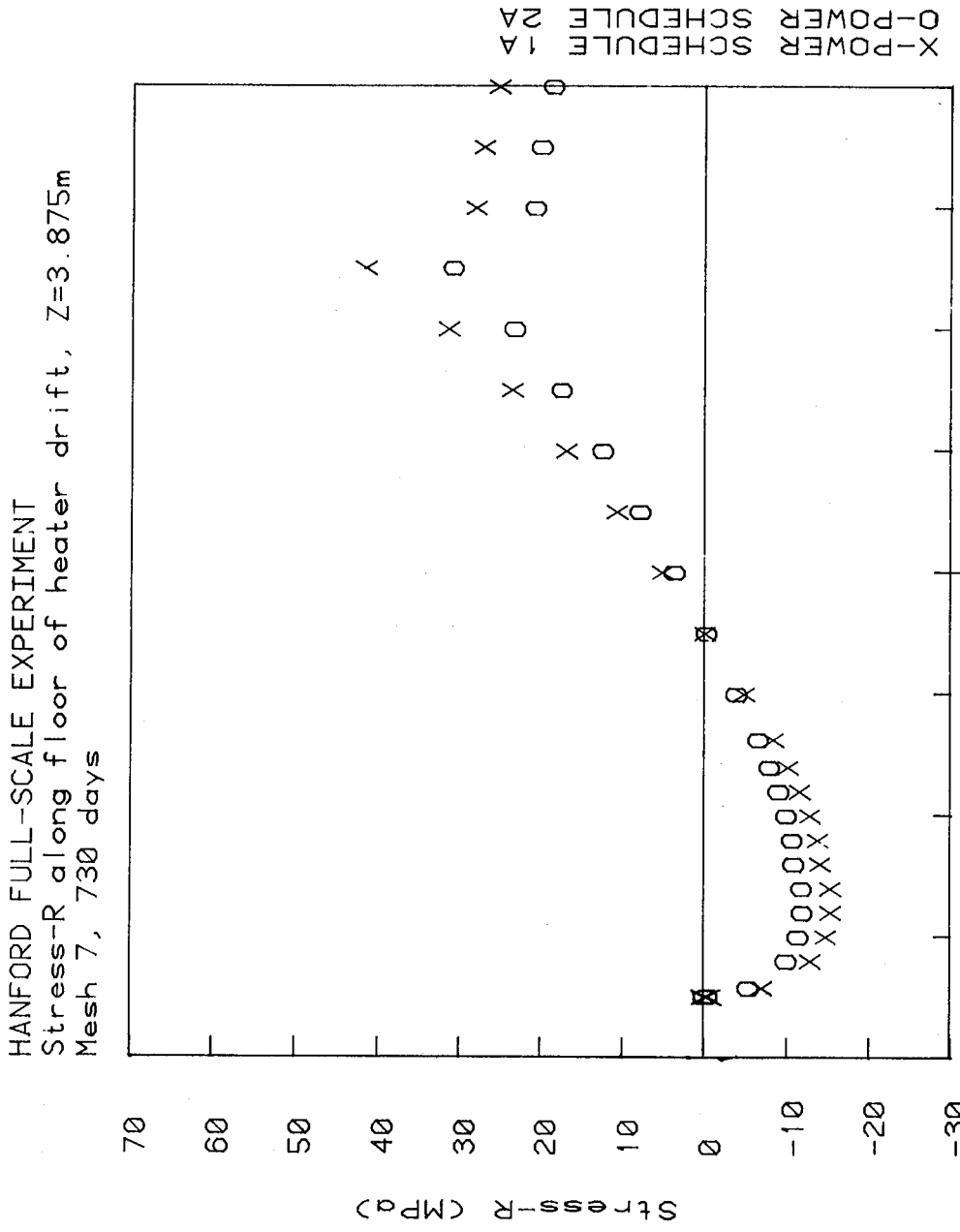

HANFORD FULL-SCALE EXPERIMENT
Stress-R along floor of heater drift, Z=3.875m
Mesh 7, 730 days
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
Stress-R (MPa)
R (m)
70
60
50
40
30
20
10
0
-10
-20
-30
0
0.5
1
1.5
2
2.5
3
3.5
4
XBL 7810-11828

Figure D27b

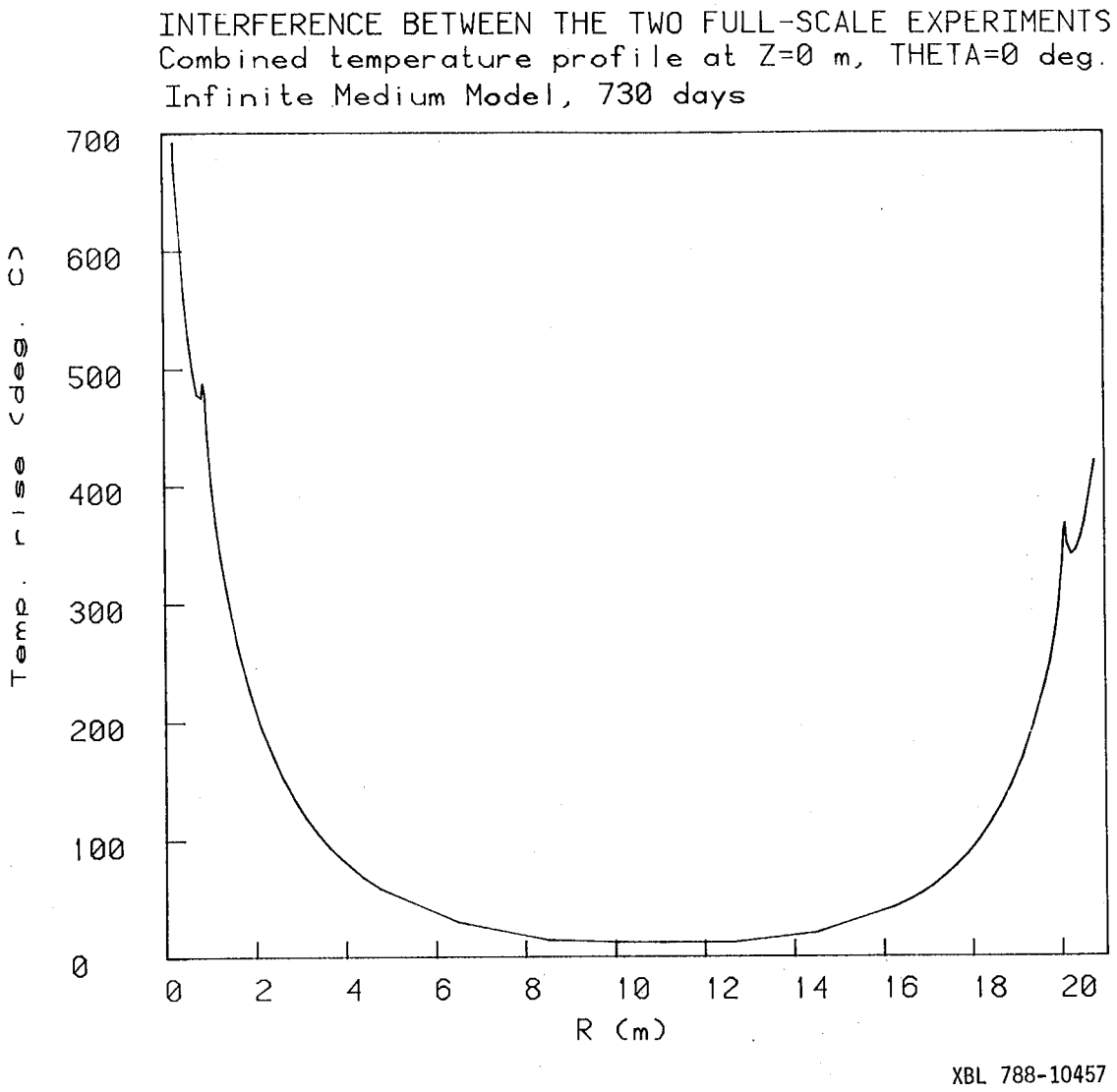

INTERFERENCE BETWEEN THE TWO FULL-SCALE EXPERIMENTS
Combined temperature profile at Z=0 m, THETA=0 deg.
Infinite Medium Model, 730 days
Temp. rise (deg. C)
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
R (m)
XBL 788-10457

Figure D28a

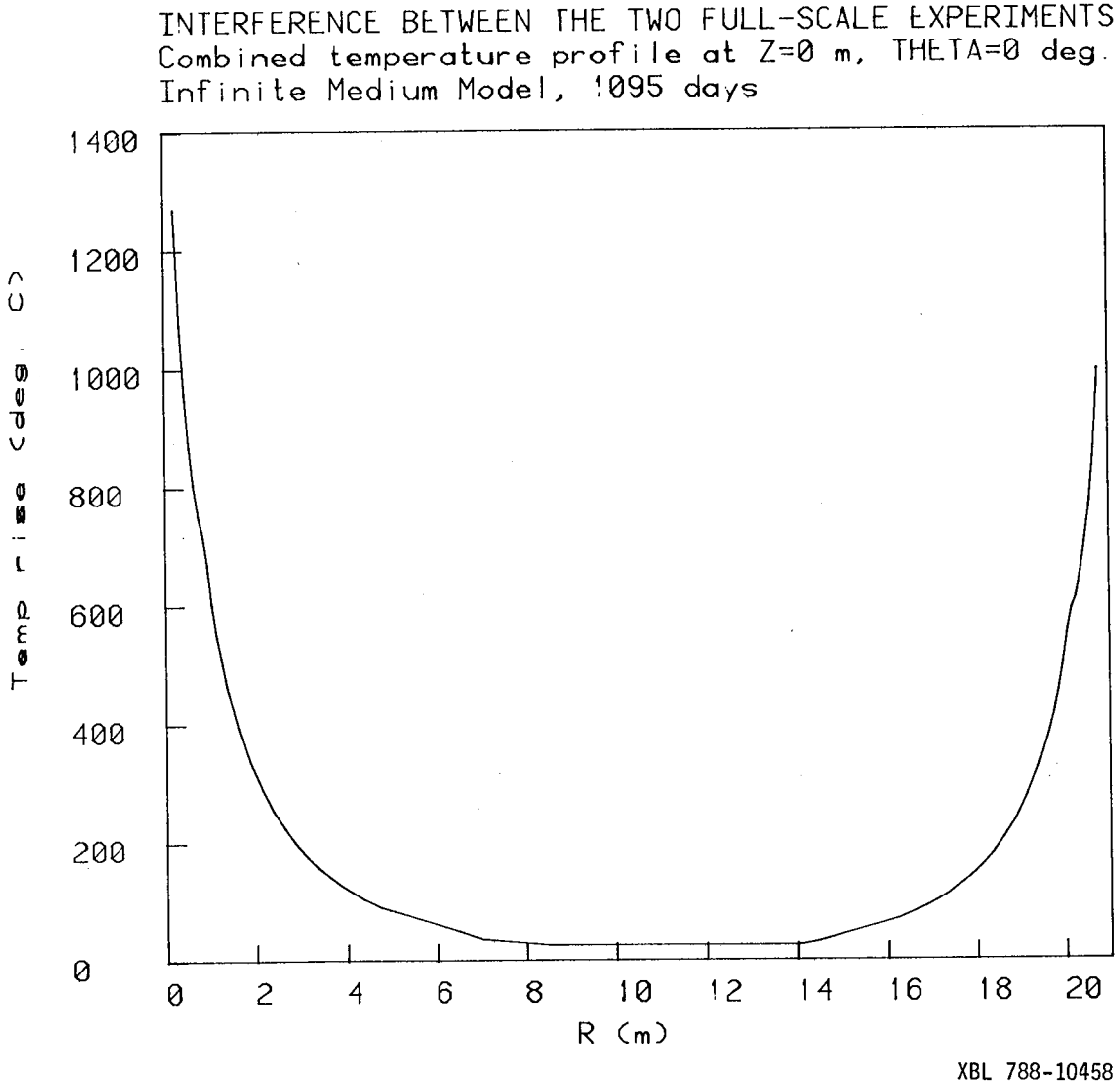

INTERFERENCE BETWEEN THE TWO FULL-SCALE EXPERIMENTS
Combined temperature profile at Z=0 m, THETA=0 deg.
Infinite Medium Model, 1095 days
Temp rise (deg. C)
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
16
18
20
R (m)
XBL 788-10458

Figure D28b

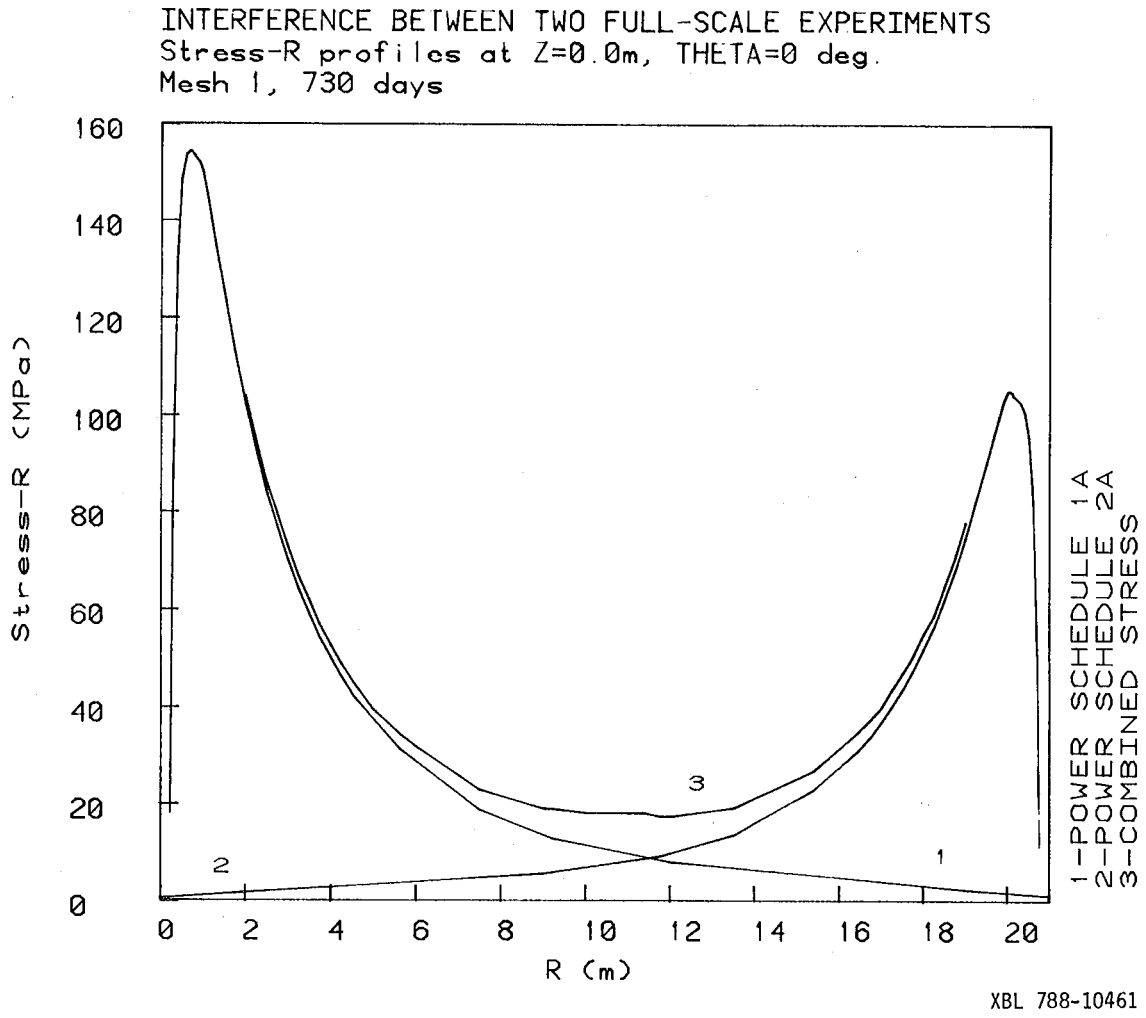

INTERFERENCE BETWEEN TWO FULL-SCALE EXPERIMENTS
Stress-R profiles at Z=0.0m, THETA=0 deg.
Mesh 1, 730 days
Stress-R (MPa)
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18
20
R (m)
1
2
3
1-POWER SCHEDULE 1A
2-POWER SCHEDULE 2A
3-COMBINED STRESS
XBL 788-10461

Figure D29a

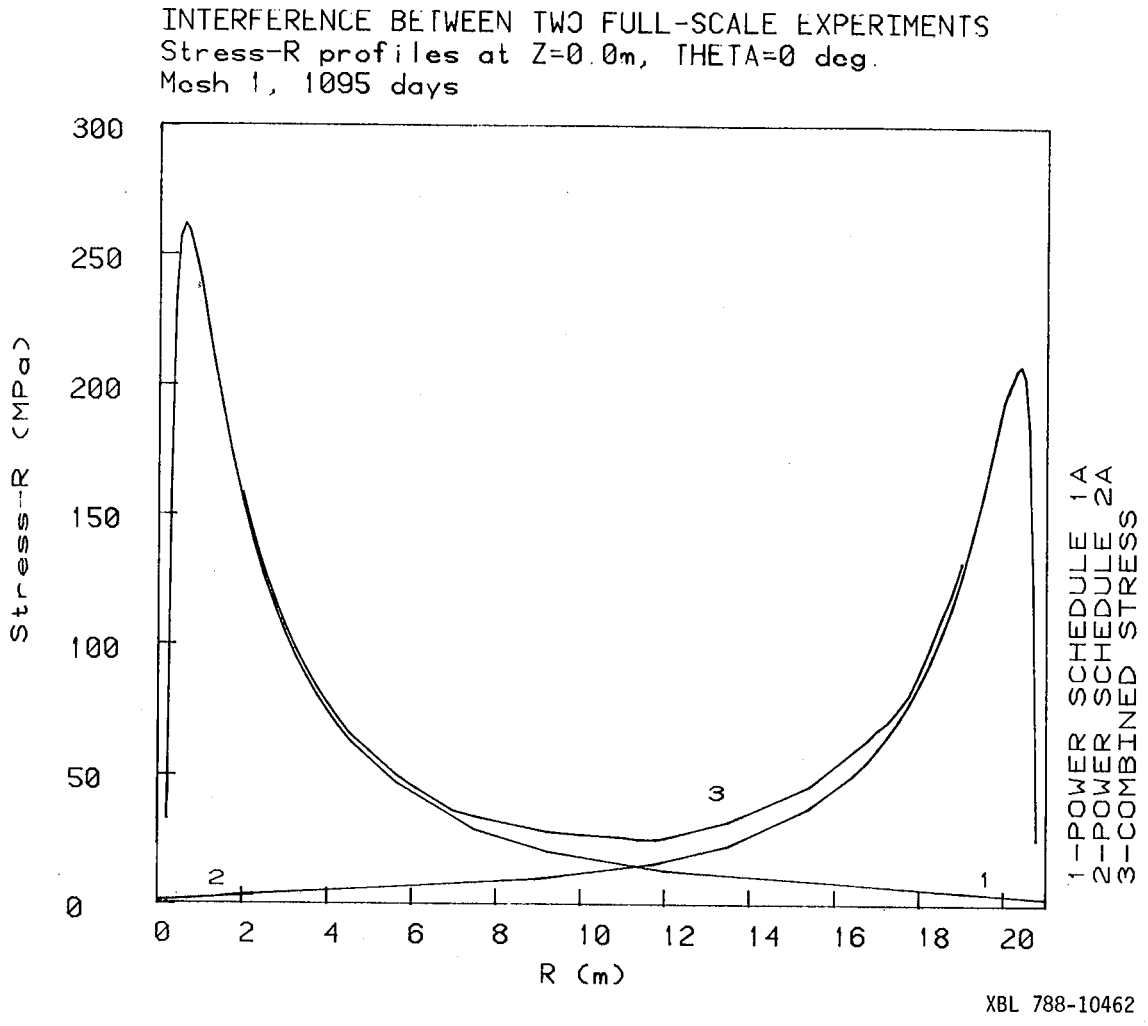

INTERFERENCE BETWEEN TWO FULL-SCALE EXPERIMENTS
Stress-R profiles at Z=0.0m, THETA=0 deg.
Mesh 1, 1095 days
Stress-R (MPa)
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20
R (m)
1
2
3
1-POWER SCHEDULE 1A
2-POWER SCHEDULE 2A
3-COMBINED STRESS
XBL 788-10462

Figure D29b

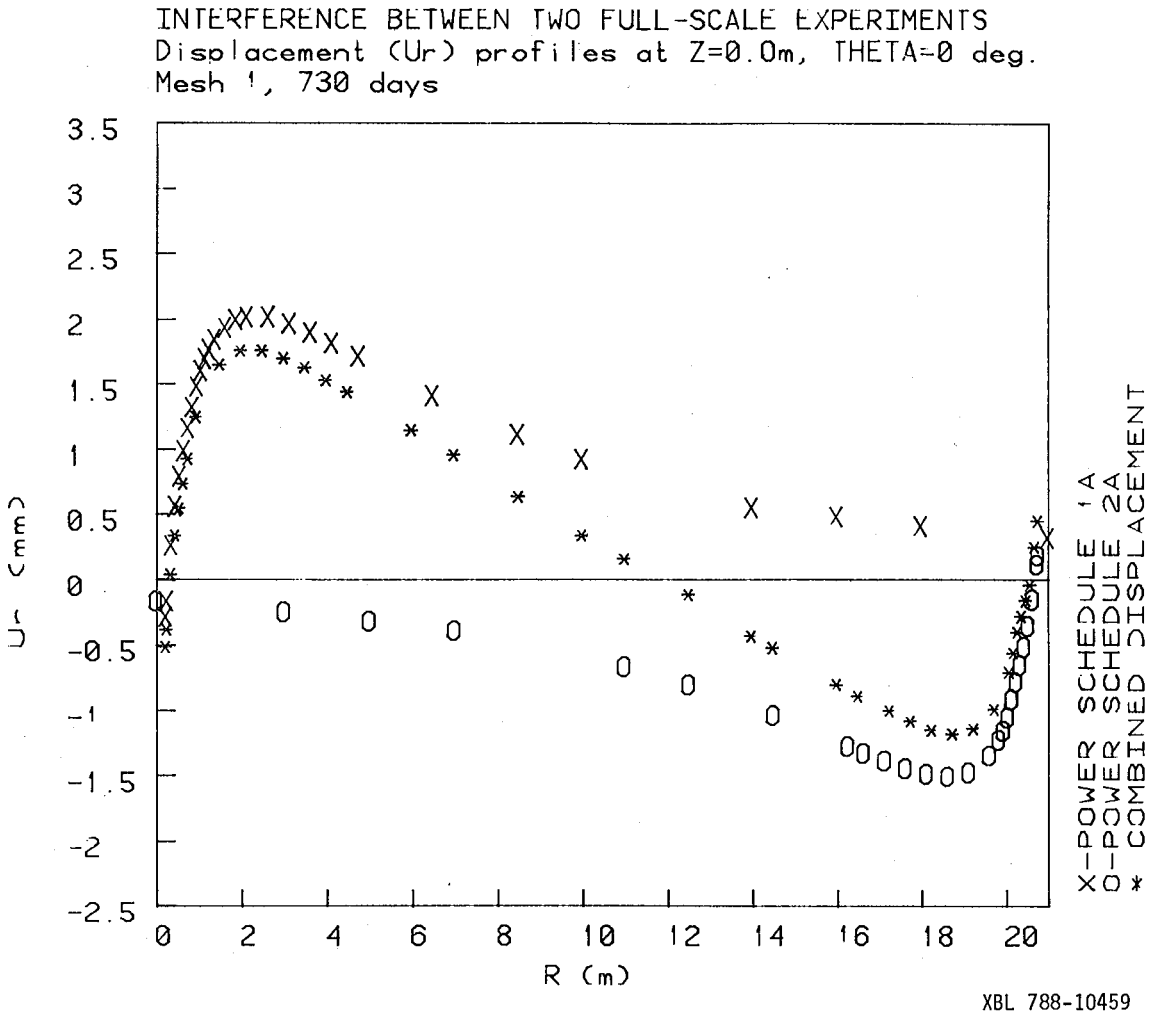

INTERFERENCE BETWEEN TWO FULL-SCALE EXPERIMENTS
Displacement (Ur) profiles at Z=0.0m, THETA=0 deg.
Mesh 1, 730 days
Ur (mm)
R (m)
X-POWER SCHEDULE 1A
O-POWER SCHEDULE 2A
* COMBINED DISPLACEMENT
XBL 788-10459

Figure D30a

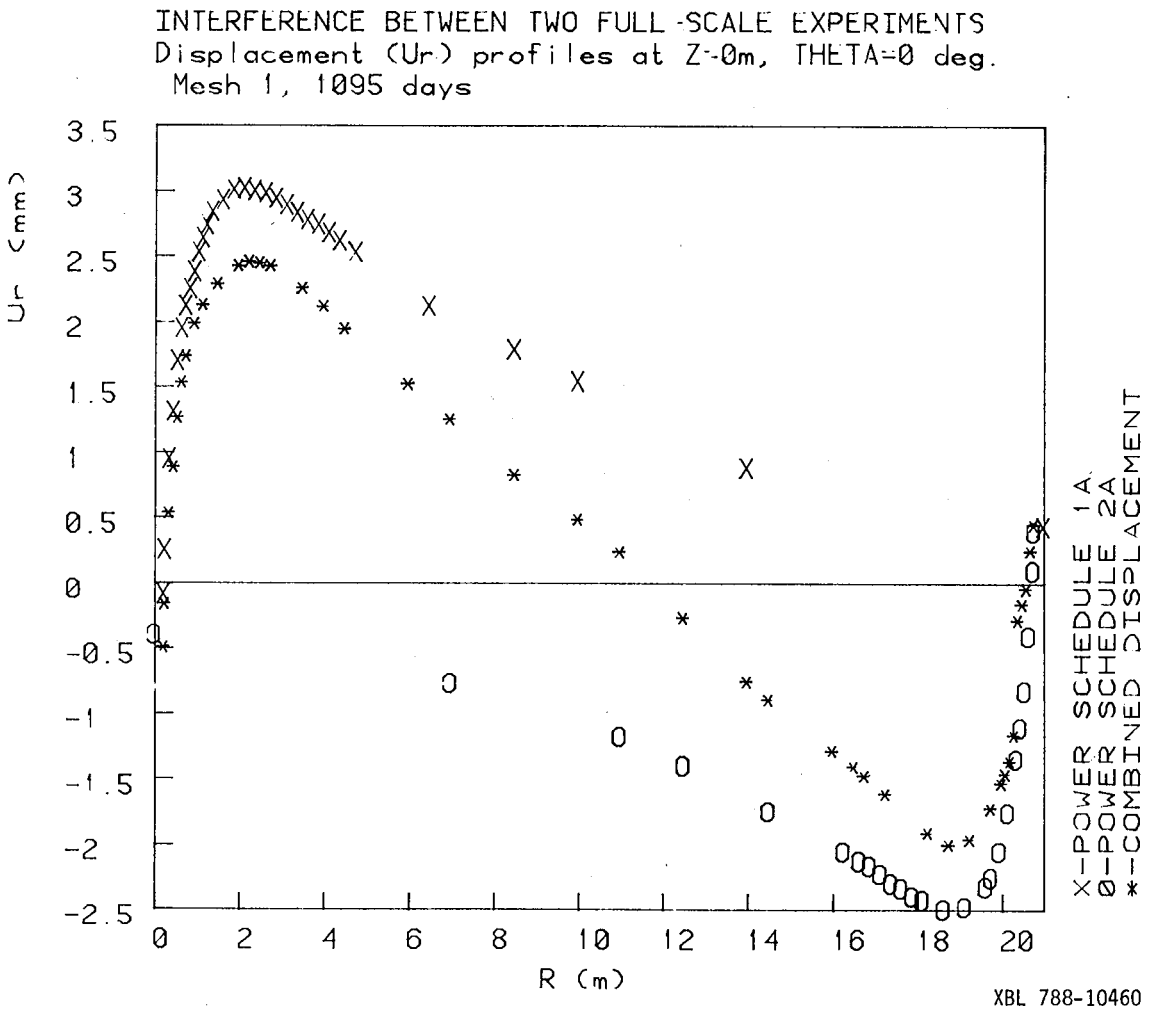
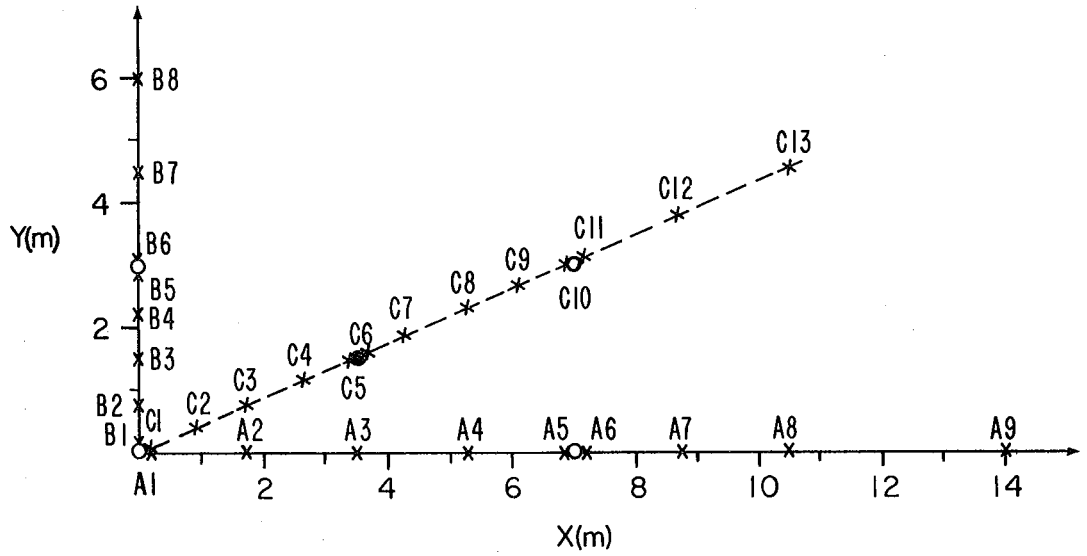

INTERFERENCE BETWEEN TWO FULL-SCALE EXPERIMENTS
Displacement (Ur) profiles at Z=0m, THETA=0 deg.
Mesh 1, 1095 days
Ur (mm)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0
2
4
6
8
10
12
14
16
18
20
R (m)
X-POWER SCHEDULE 1A
0-POWER SCHEDULE 2A
*-COMBINED DISPLACEMENT
XBL 788-10460

Figure D30b

QUARTER PLANE SHOWING LOCATIONS AT WHICH TEMPERATURE PROFILES WERE MADE

Hanford time-scaled experiment



○ PRIMARY HEATERS, ENERGIZED AT THE START OF EXPERIMENT.

● SECONDARY HEATERS, ENERGIZED TWO YEARS AFTER THE START OF EXPERIMENT.

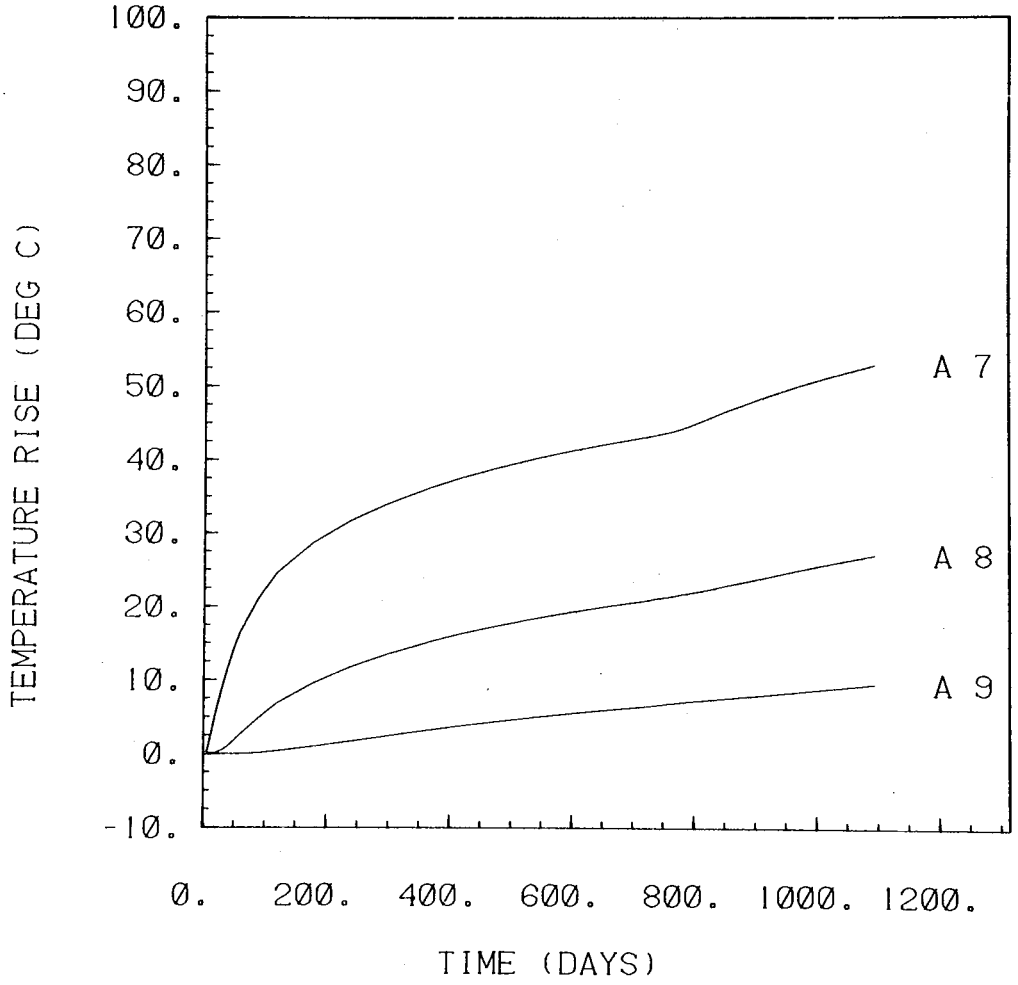
(Heaters not drawn to scale).

XBL 788-2014

Figure D31a

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
A 9	14.0000	0.0000	0.0000
A 8	10.5000	0.0000	0.0000
A 7	8.7500	0.0000	0.0000

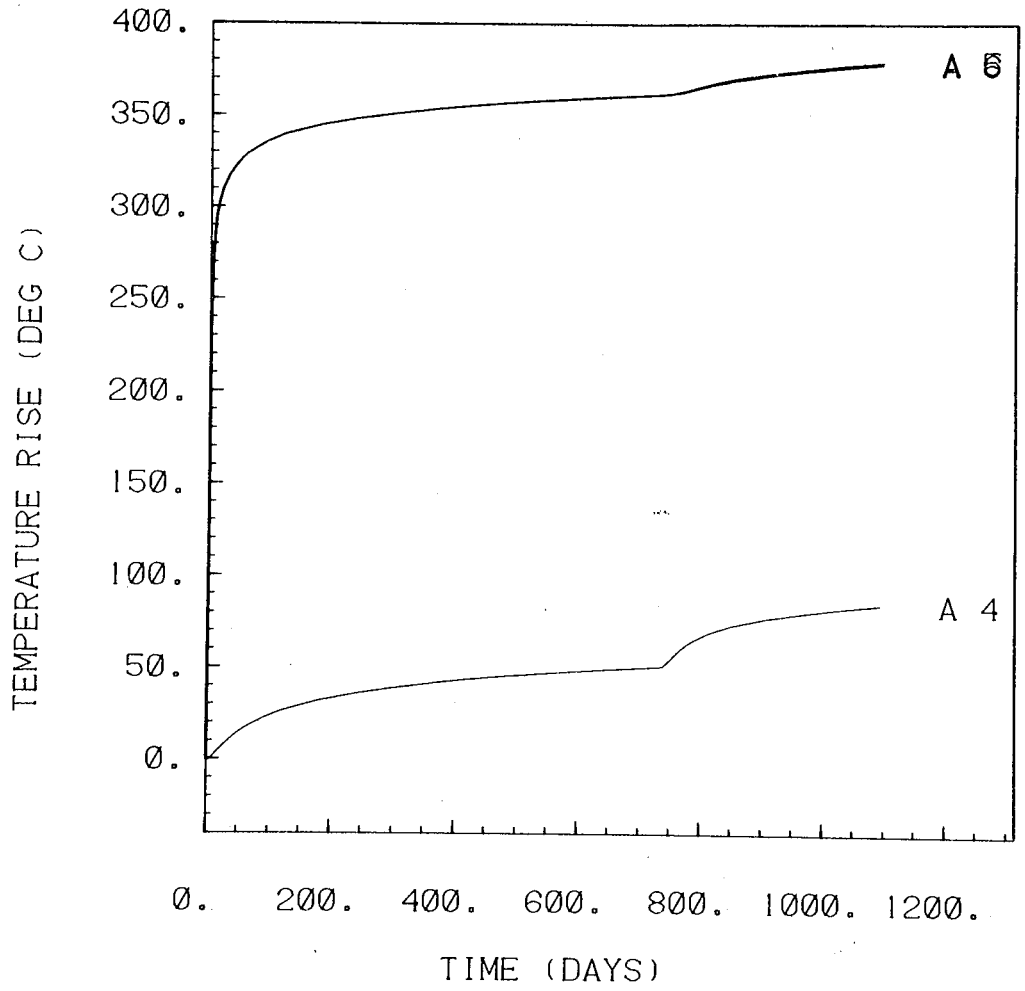


XBL 788-10464

Figure D31b

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
A 6	7.0640	0.0000	0.0000
A 5	6.9370	0.0000	0.0000
A 4	5.2500	0.0000	0.0000

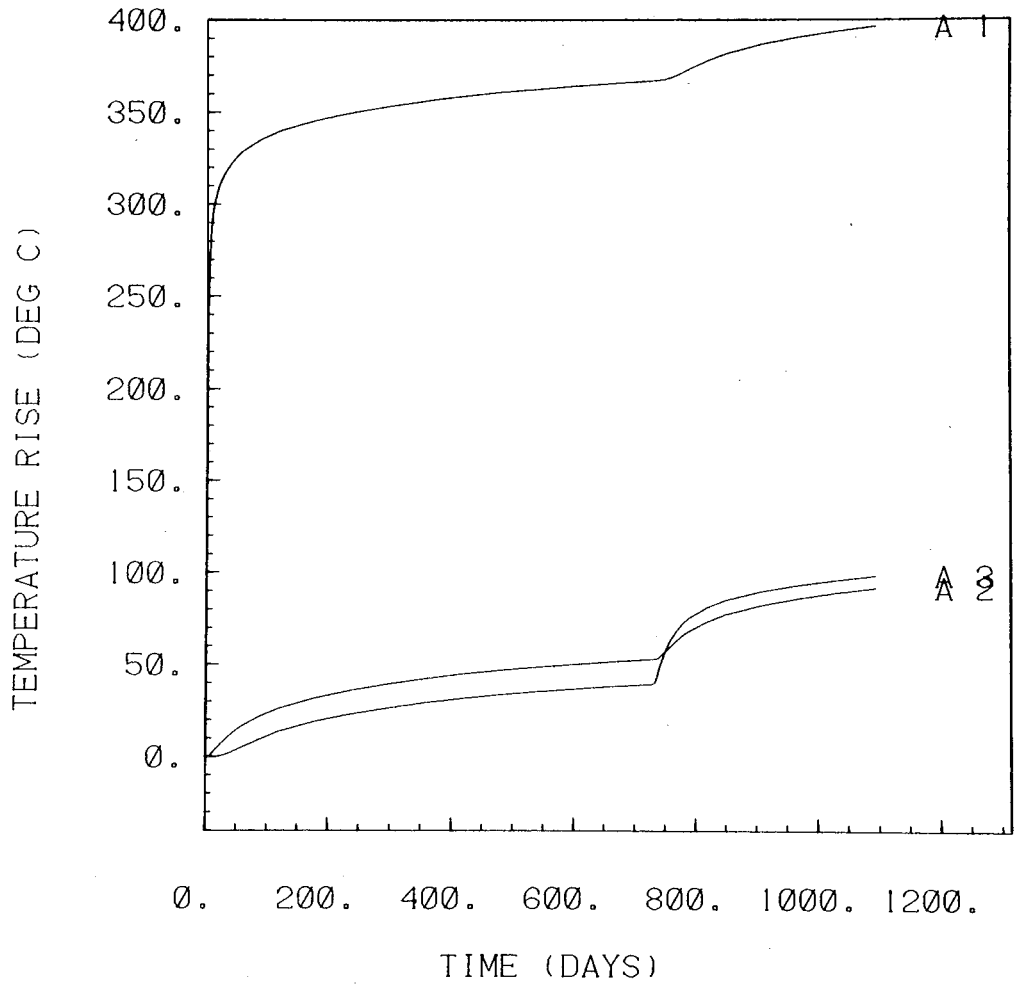


XBL 788-10463

Figure D31c

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
A 3	3.5000	0.0000	0.0000
A 2	1.7500	0.0000	0.0000
A 1	0.0640	0.0000	0.0000

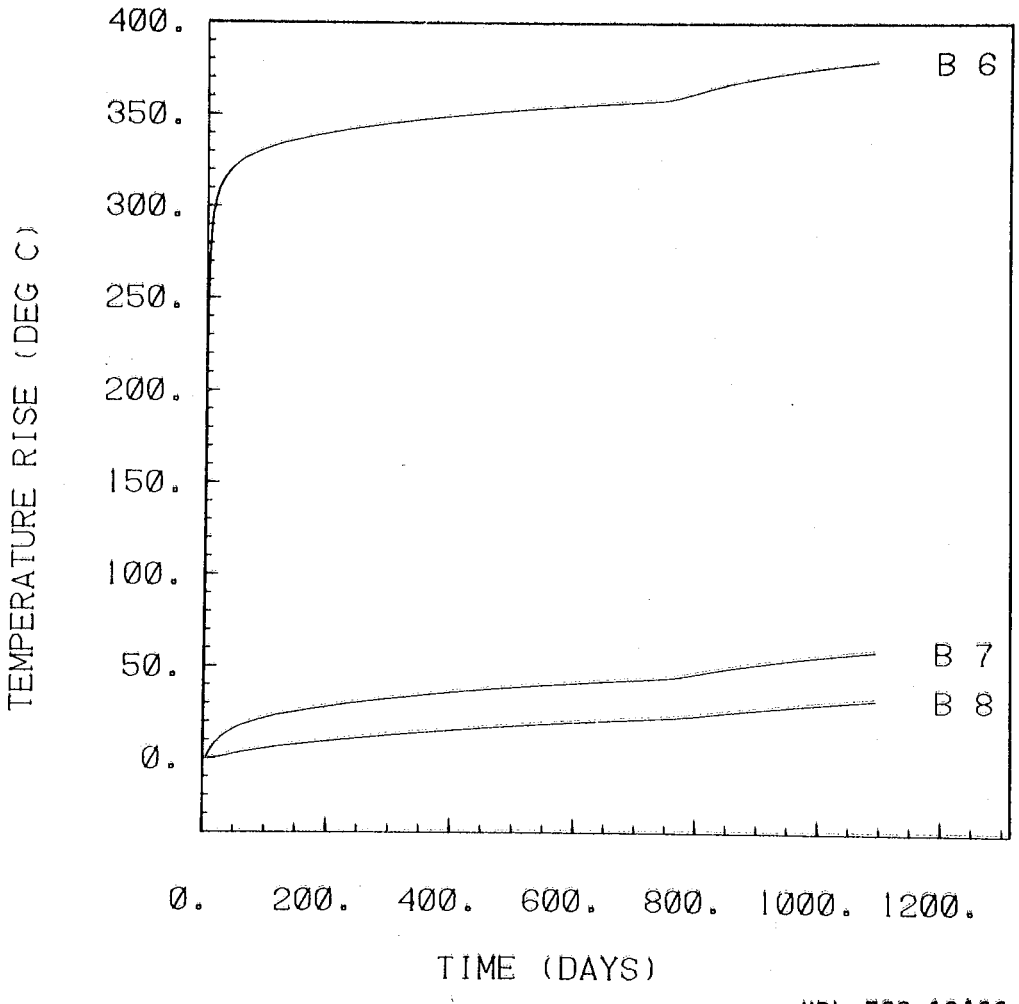


XBL 788-10471

Figure D31d

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
B 8	0.0000	6.0000	0.0000
B 7	0.0000	4.5000	0.0000
B 6	0.0000	3.0640	0.0000

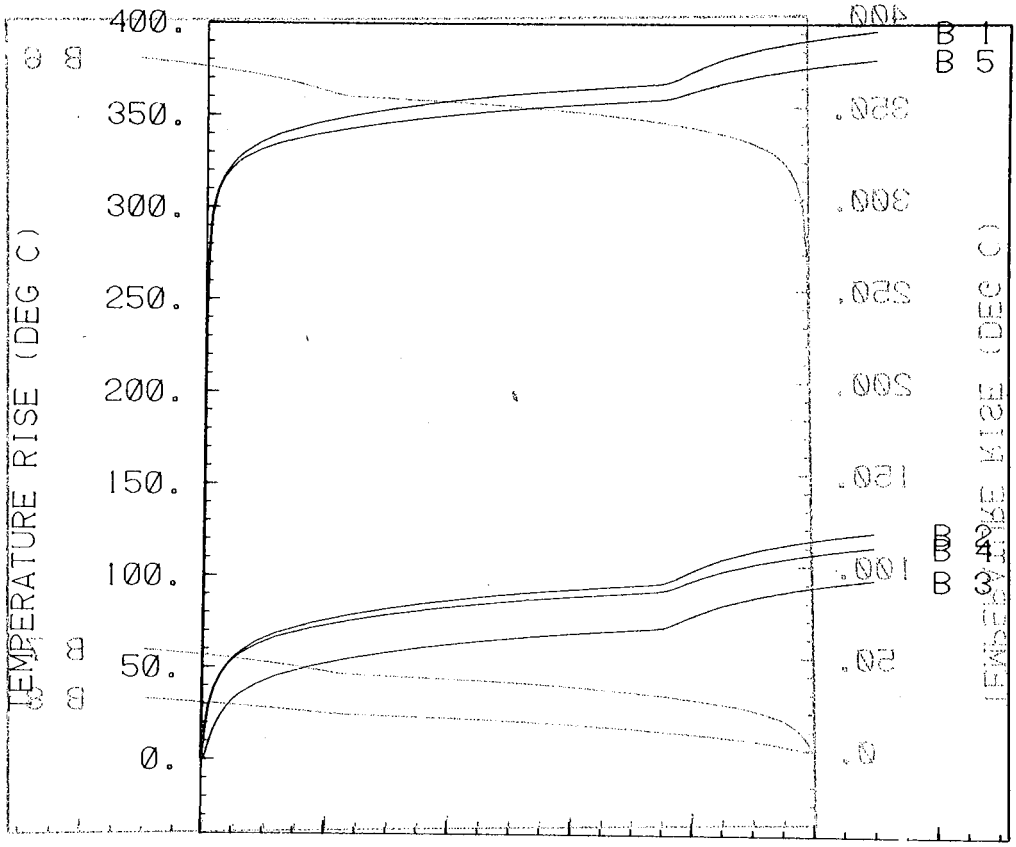


XBL 788-10466

Figure D31e

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
B 5	0.0000	2.9870	0.0000
B 4	0.0000	2.2500	0.0000
B 3	0.0000	1.5000	0.0000
B 2	0.0000	0.7500	0.0000
B 1	0.0000	0.0640	0.0000

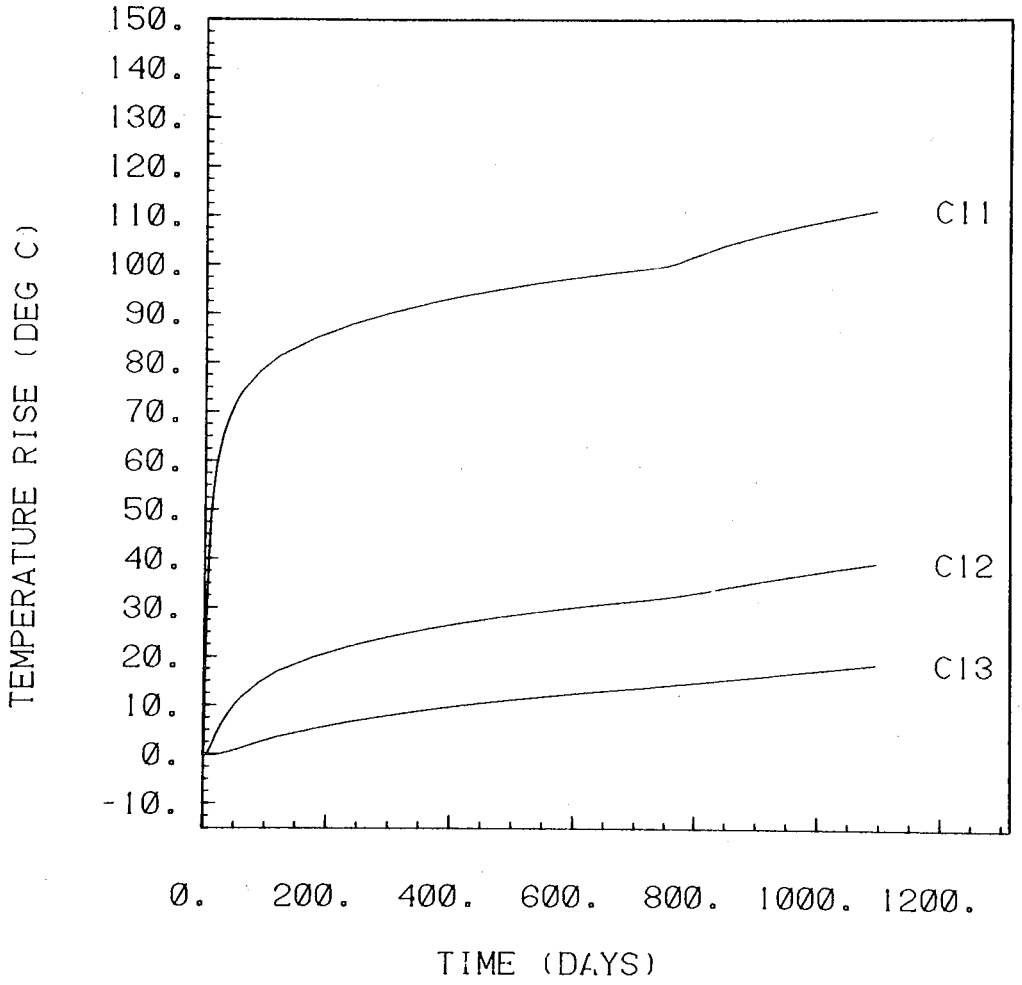


XBL 788-10473

Figure D31f

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
C13	10.5000	4.5000	0.0000
C12	8.7500	3.7500	0.0000
C11	7.0450	3.5450	0.0000

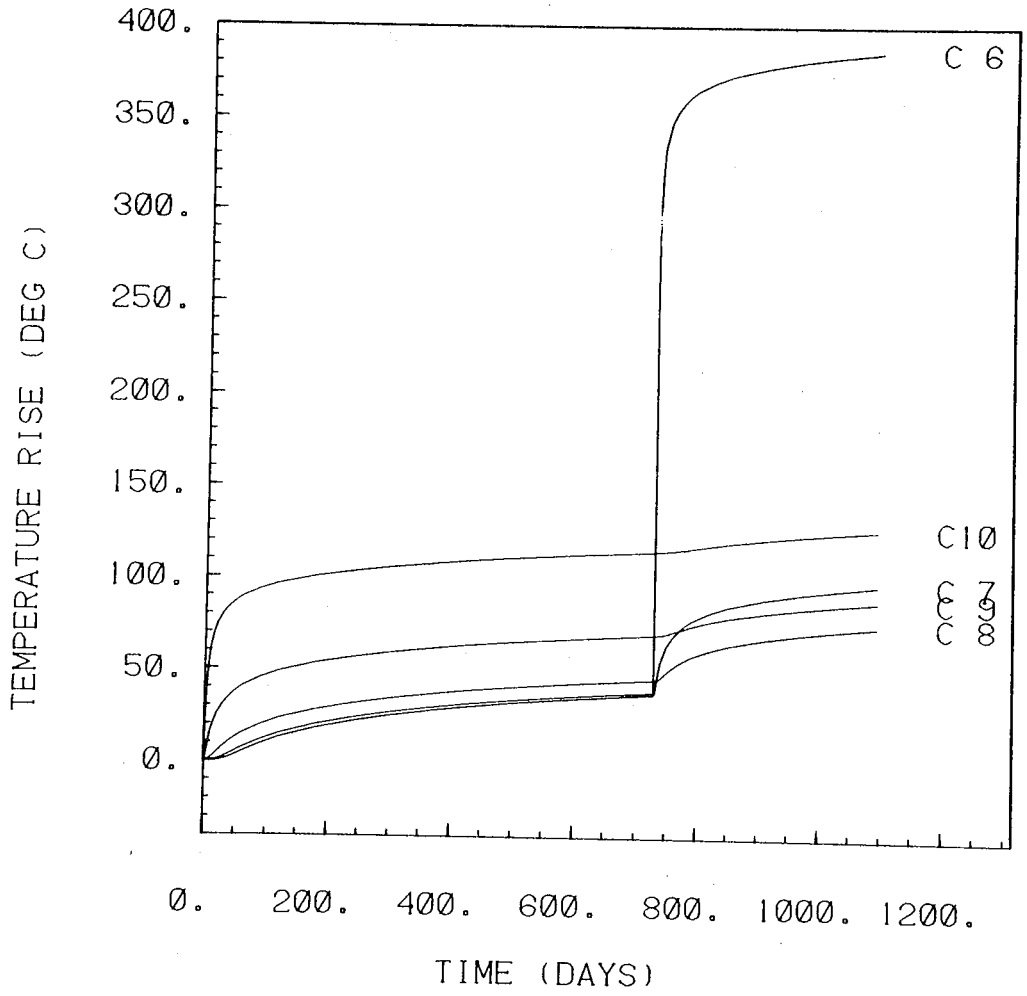


XBL 788-10465

Figure D31g

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
C10	6.9550	3.4550	0.0000
C 9	6.1250	2.6250	0.0000
C 8	5.2500	2.2500	0.0000
C 7	4.3750	1.8750	0.0000
C 6	3.5450	1.5450	0.0000

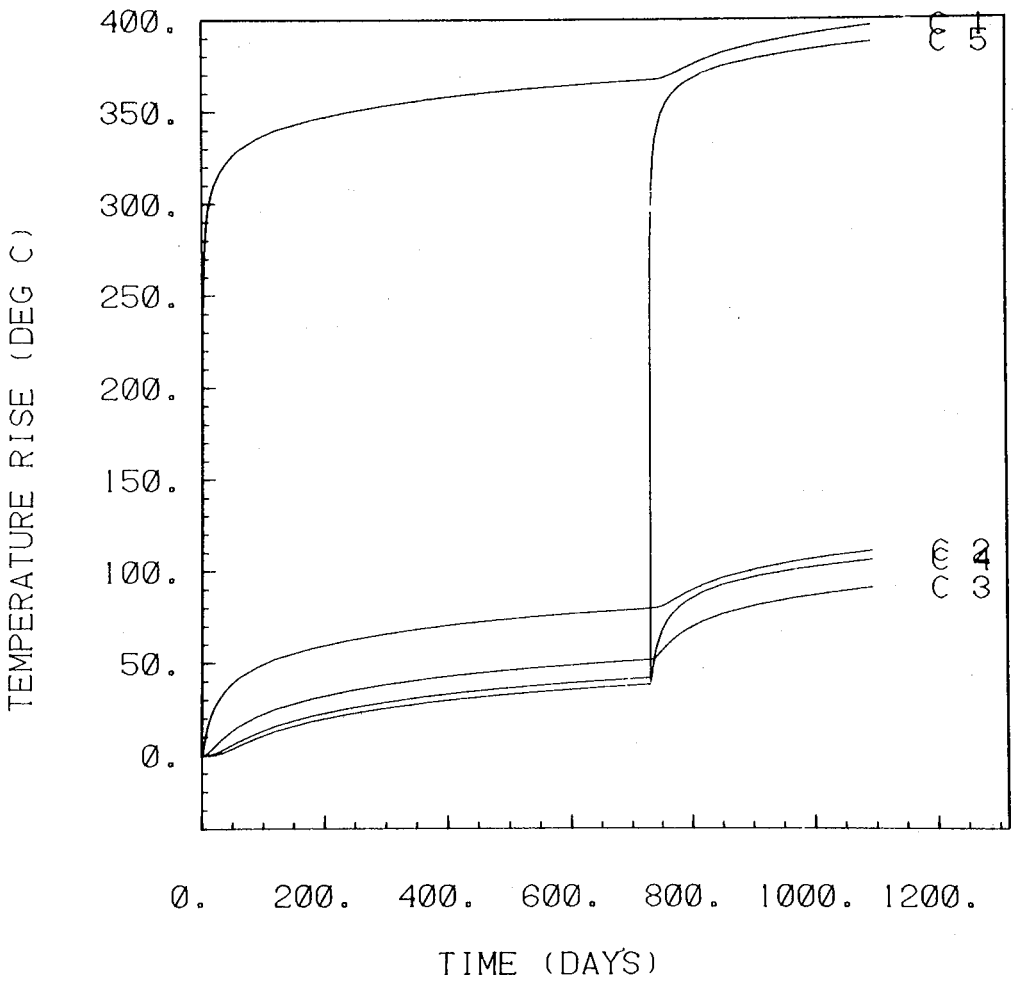


XBL 788-10474

Figure D31h

HANFORD TIME-SCALE EXPERIMENT
POWER SCHEDULE 3

LABEL	X	Y	Z
C 5	3.4550	1.4550	0.0000
C 4	2.6250	1.1250	0.0000
C 3	1.7500	0.7500	0.0000
C 2	0.8750	0.3750	0.0000
C 1	0.0450	0.0450	0.0000



XBL 788-10472

Figure D31i

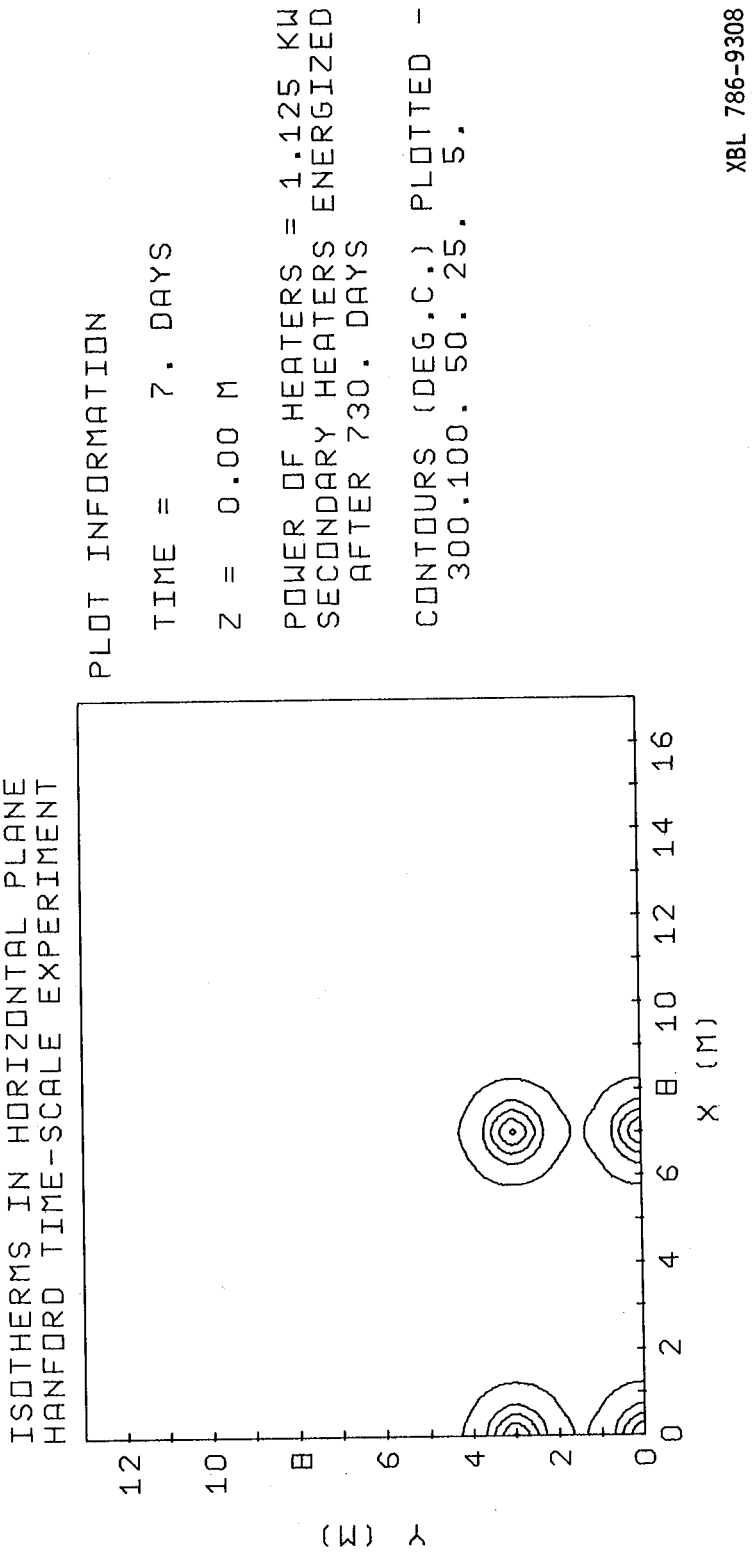

ISOTHERMS IN HORIZONTAL PLANE
HANFORD TIME-SCALE EXPERIMENT
PLOT INFORMATION
TIME = 7. DAYS
Z = 0.00 M
POWER OF HEATERS = 1.125 KW
SECONDARY HEATERS ENERGIZED
AFTER 730. DAYS
CONTOURS (DEG.C.) PLOTTED -
300.100. 50. 25. 5.
Y (M)
X (M)
0
2
4
6
8
10
12
14
16
XBL 786-9308

Figure D32a

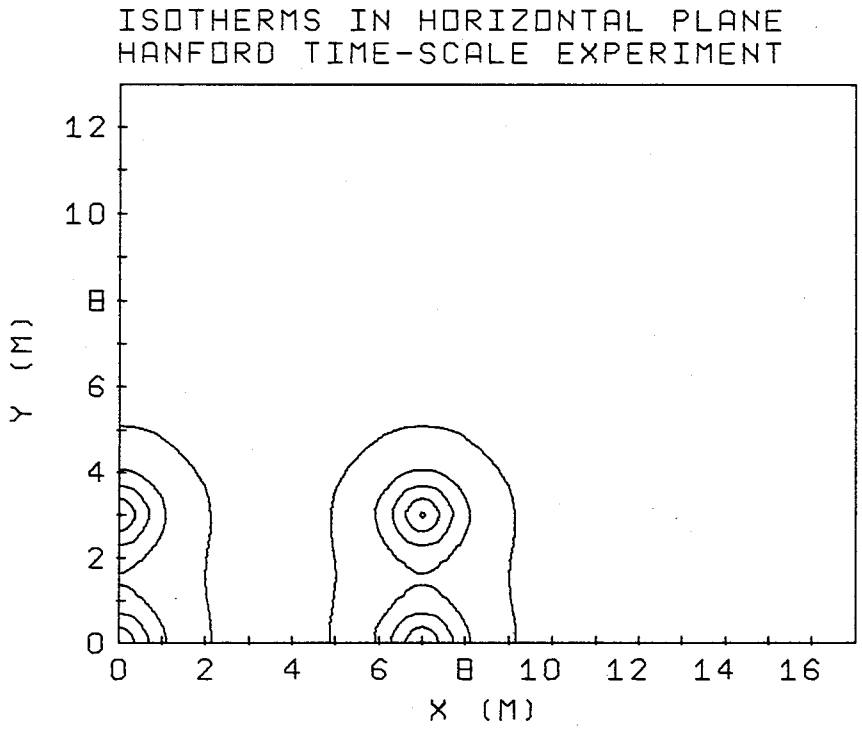
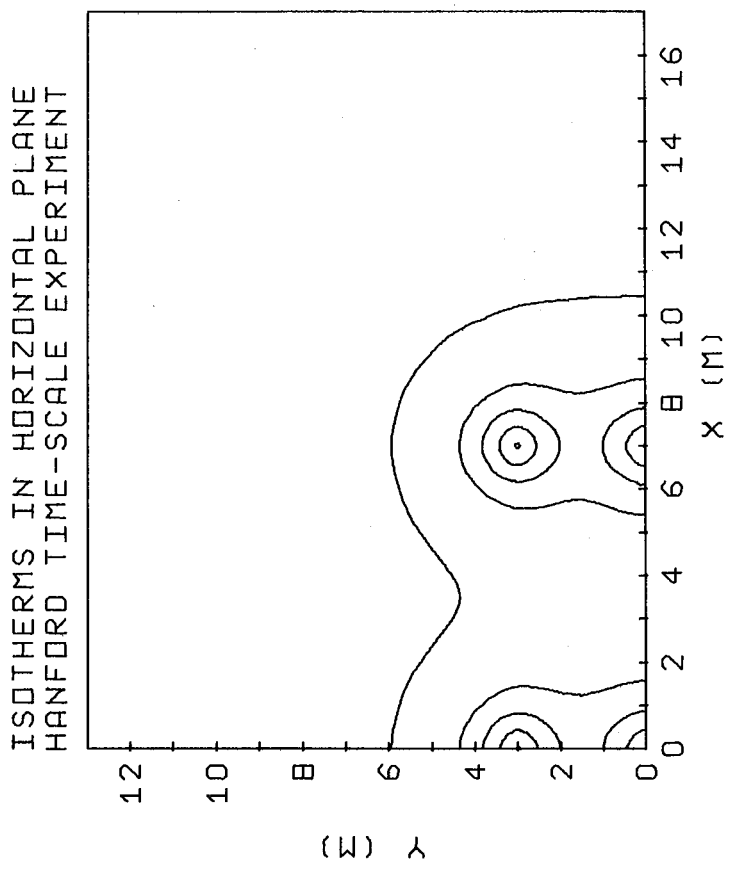

ISOTHERMS IN HORIZONTAL PLANE
HANFORD TIME-SCALE EXPERIMENT
PLOT INFORMATION
TIME = 30. DAYS
Z = 0.00 M
POWER OF HEATERS = 1.125 KW
SECONDARY HEATERS ENERGIZED
AFTER 730. DAYS
CONTOURS (DEG.C.) PLOTTED -
325.100. 50. 25. 5.
Y (M)
X (M)
0
2
4
6
8
10
12
14
16
XBL 786-9309

Figure D32b



XBL 786-9307

Figure D32c

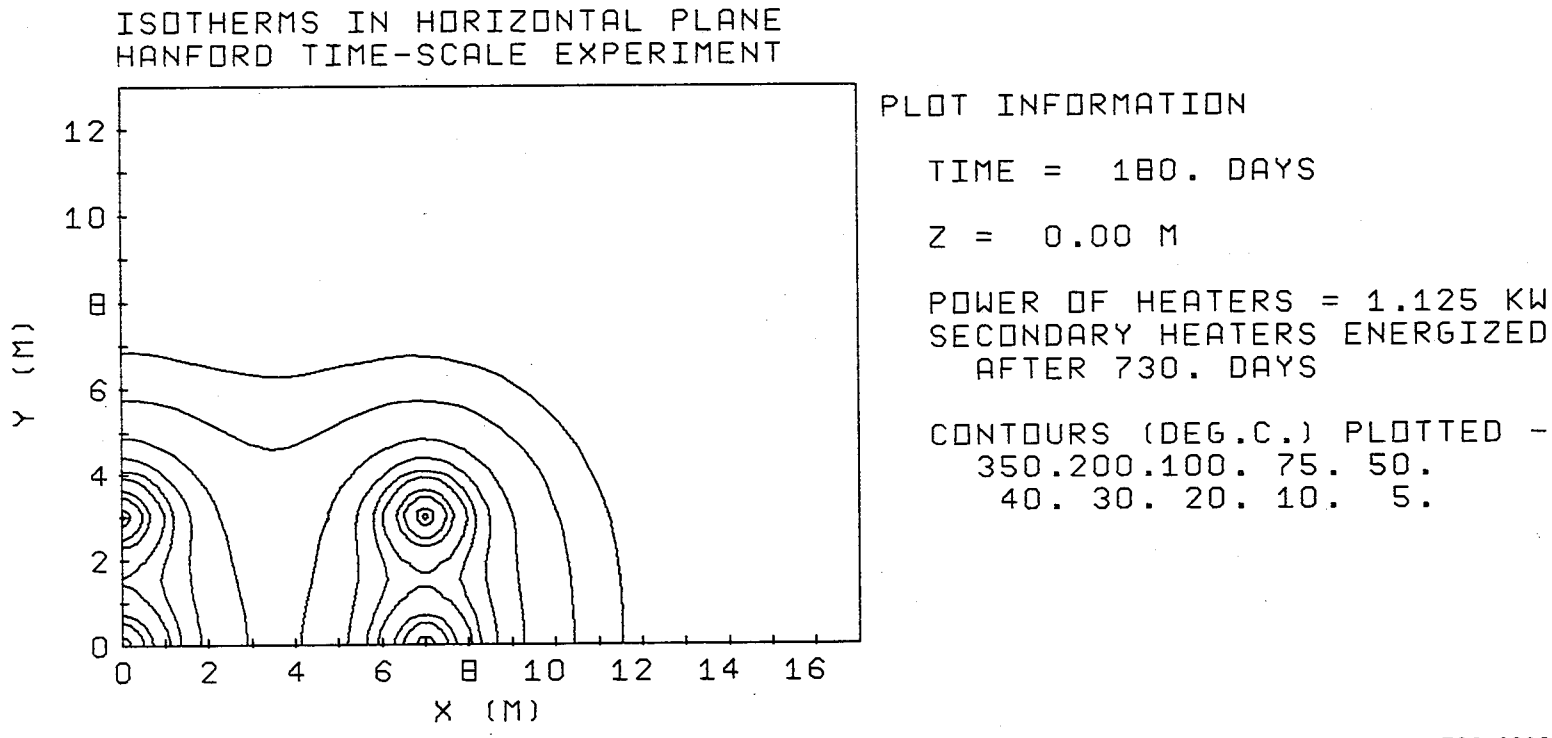
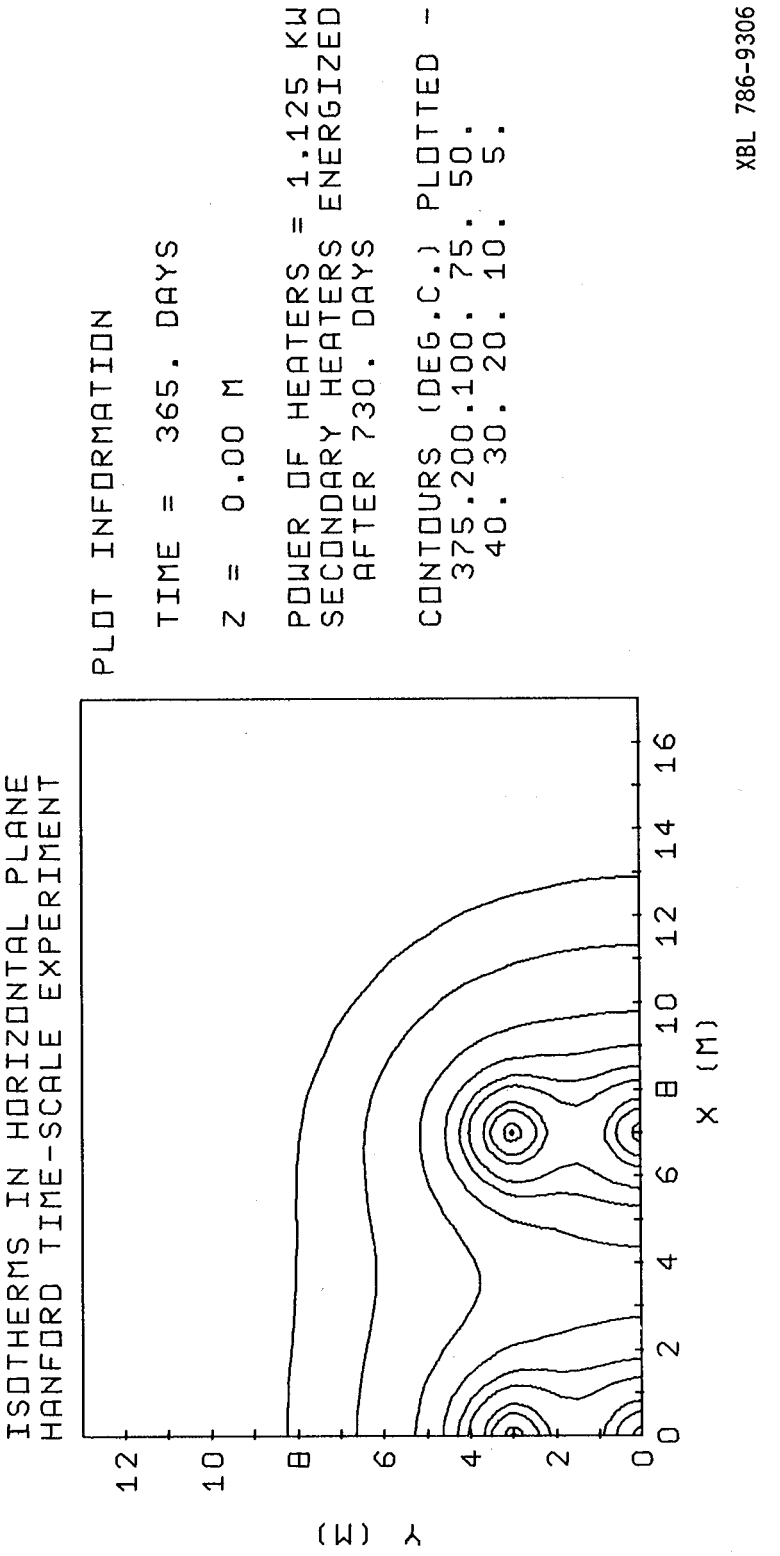
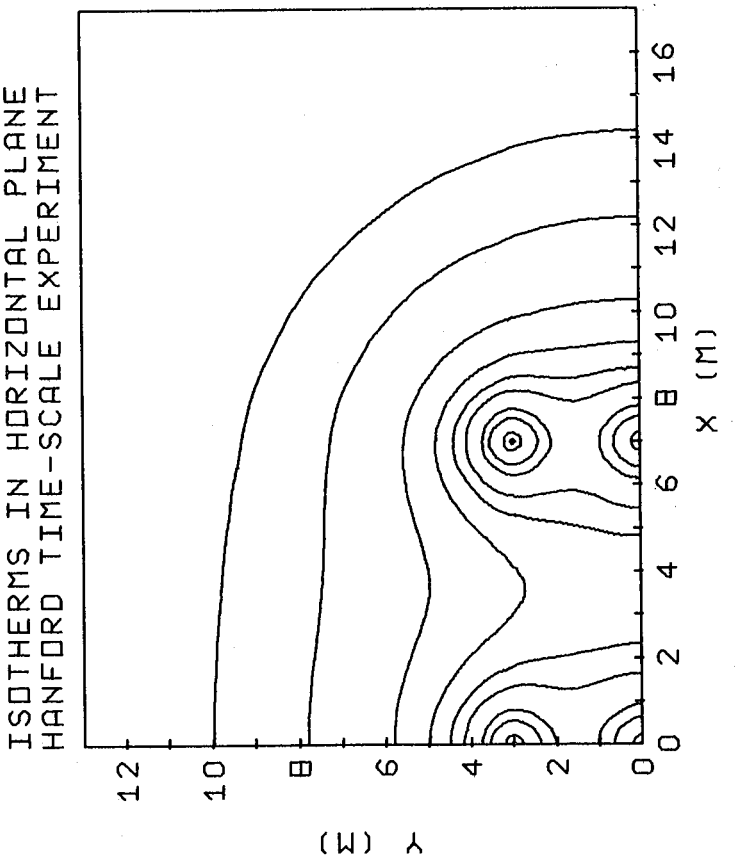

ISOTHERMS IN HORIZONTAL PLANE
HANFORD TIME-SCALE EXPERIMENT
Y (M)
X (M)
0
2
4
6
8
10
12
14
16
PLOT INFORMATION
TIME = 180. DAYS
Z = 0.00 M
POWER OF HEATERS = 1.125 KW
SECONDARY HEATERS ENERGIZED
AFTER 730. DAYS
CONTOURS (DEG.C.) PLOTTED -
350.200.100. 75. 50.
40. 30. 20. 10. 5.
XBL 786-9302

Figure D32d



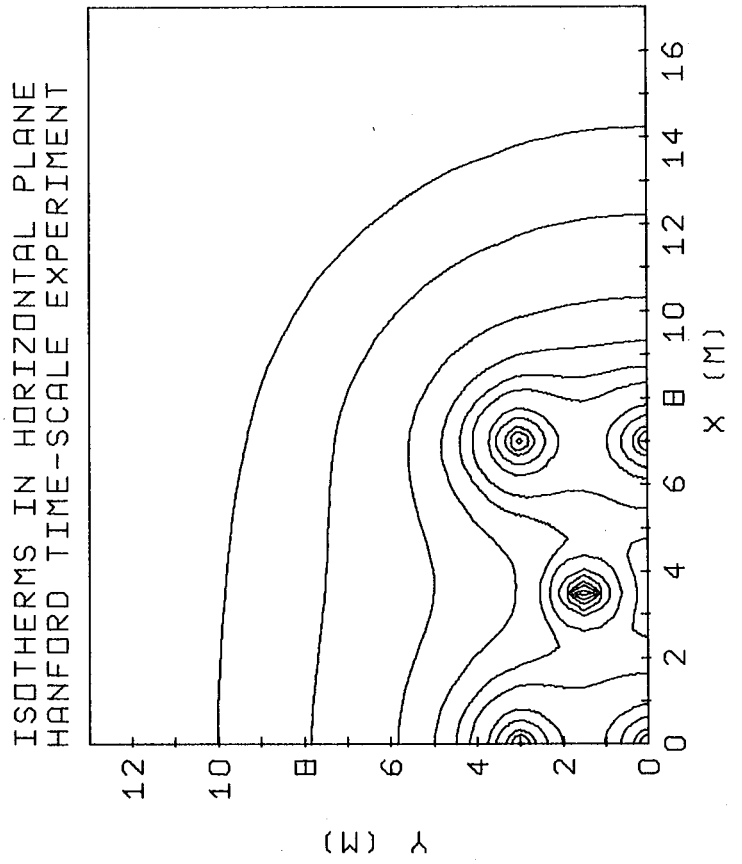
XBL 786-9306

Figure D32e



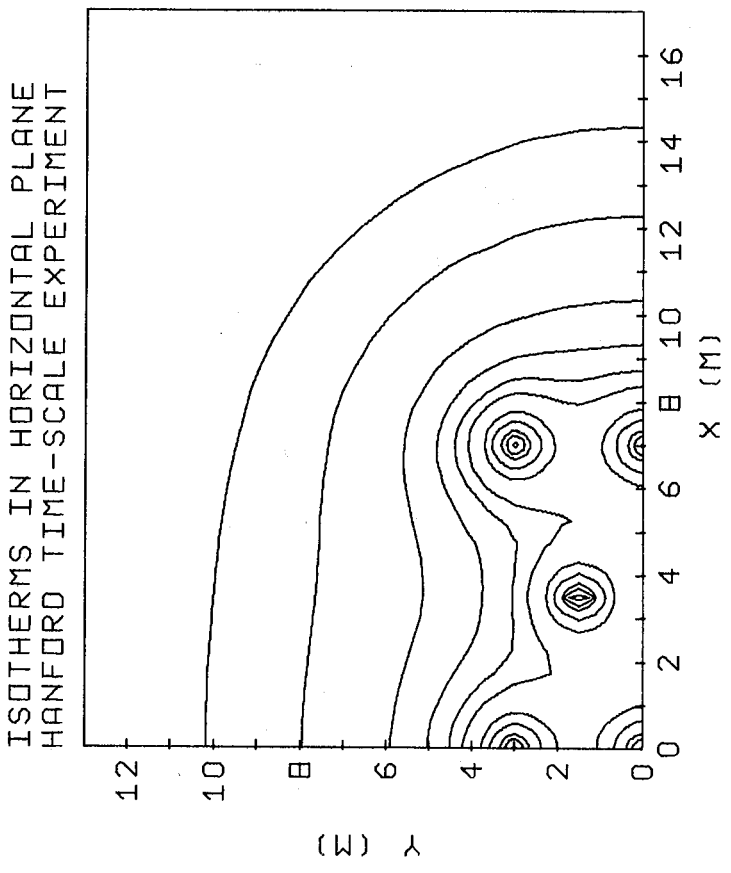
XBL 786-9304

Figure D32f



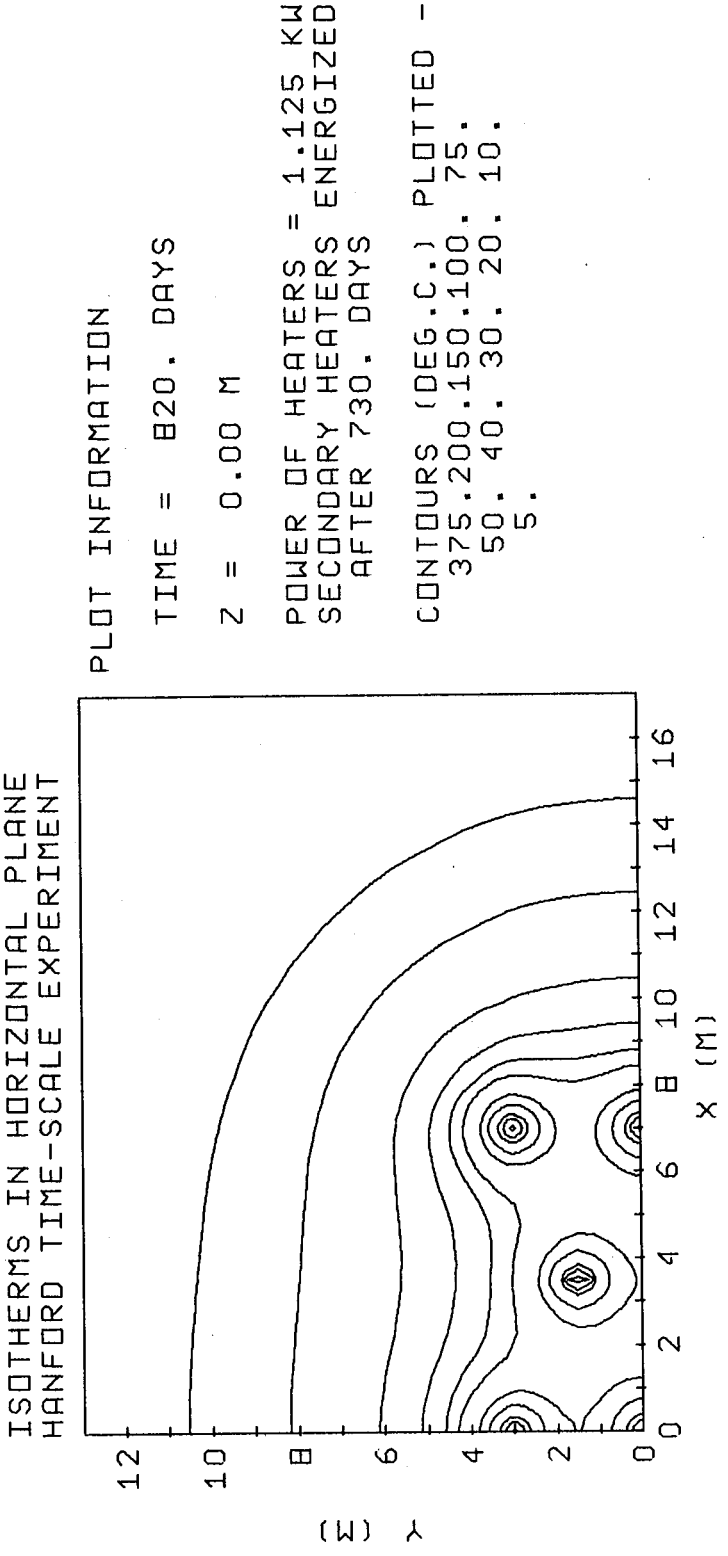
XBL 786-9305

Figure D32g



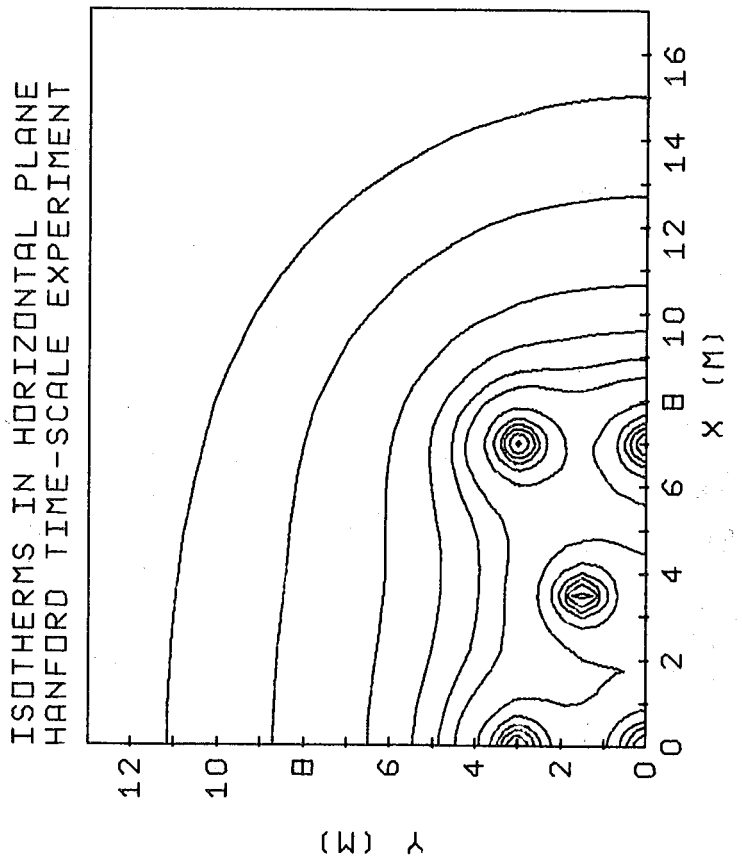
XBL 786-9303

Figure D32h



XBL 786-9301

Figure D32i



XBL 786-9310

Figure D32j

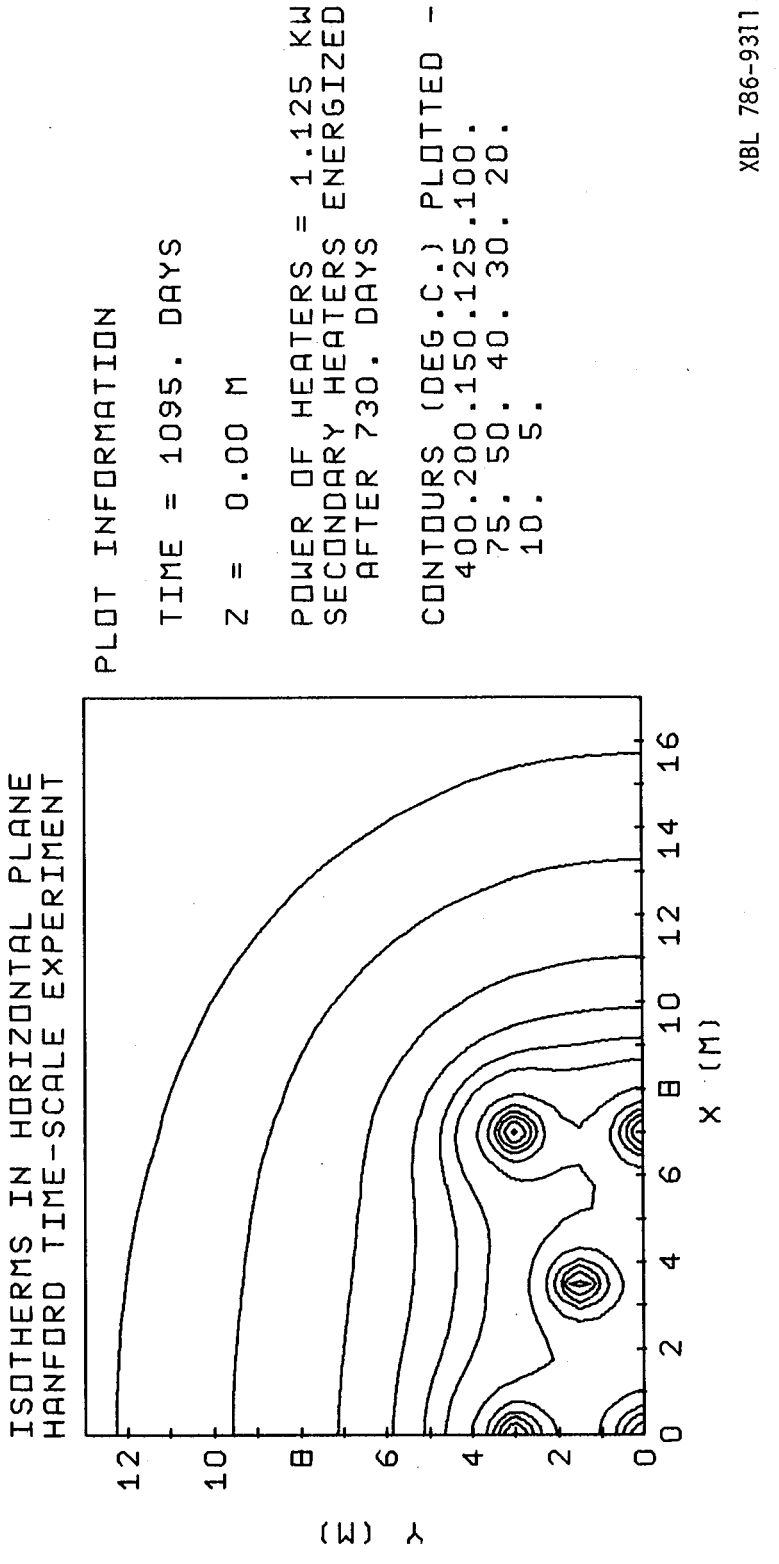
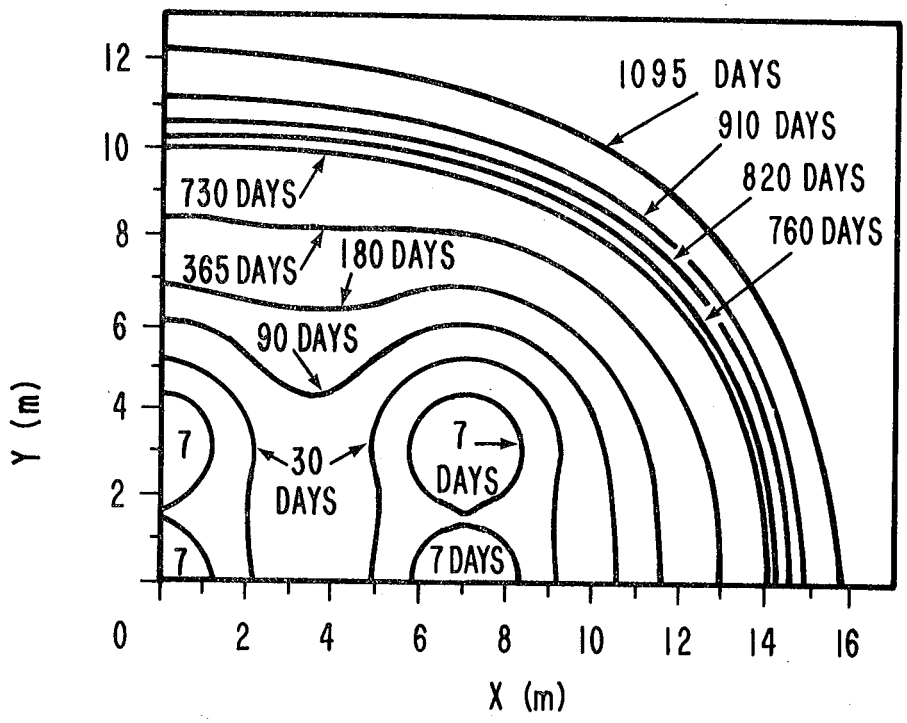

ISOTHERMS IN HORIZONTAL PLANE
HANFORD TIME-SCALE EXPERIMENT
PLOT INFORMATION
TIME = 1095. DAYS
Z = 0.00 M
POWER OF HEATERS = 1.125 KW
SECONDARY HEATERS ENERGIZED
AFTER 730. DAYS
CONTOURS (DEG.C.) PLOTTED -
400.200.150.125.100.
75. 50. 40. 30. 20.
10. 5.
Y (M)
X (M)
0
2
4
6
8
10
12
14
16
XBL 786-9311

Figure D32k

MIGRATION OF 5° ISOTHERM
HANFORD TIME-SCALE EXPERIMENT



PLOT INFORMATION
Z = 0(m)
Power of heaters = 1.125 kW
Secondary heaters energized
after 730 days. (Contours (days) shown).

XBL 788-2014A

Figure D33

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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