See Pocket 7 for
enc

CorSTAR

A TEKNEKRON INDUSTRIES AFFILIATE

WM DOCKET CONTROL CENTER

October 15, 1984

NRC FIN B6985

'84 OCT 15 P2:37

WM Record File WM-R25 (B6985) CorStar

WM Project 10, 11, 16
Docket No.
PDR ✓
LPDR ✓ (B, N, S)

Distribution:
X PBrooks
X Nitte
X Joan - ticket
(Return to WM, 623-SS)

Ms. Pauline Brooks, Project Officer
Division of Waste Management
MS 623 SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Contract No. NRC-02-81-026
Benchmarking of Computer Codes and Licensing Assistance
Monthly Letter Progress Report for September 1984

Dear Pauline:

This letter contains a management level summary of progress during the month of September. Attached to the report is a copy of the technical status summary with further discussion of work performed during this period. We are submitting a cost summary report under separate cover.

Task 1 - Literature Search - Waste Package Codes

Interim final copies of the waste package code data set report were submitted to the NRC by letter dated September 17, 1984. We are in the process of obtaining permission to use tables and figures in that report. Once permission is obtained we will forward a final camera ready copy to you for publication.

Task 3 - Benchmark Problem Report - Waste Package Codes

By letter dated September 21, 1984, CorSTAR submitted the draft benchmark problem report for the waste package codes to the NRC. The report is being submitted simultaneously for external QA review. We would like to receive the NRC's comments on this report within the next four weeks.

Tasks 4&5 - Siting Codes

During September, the revised Benchmark Problem Report was edited. No other significant activities were conducted during the month.

Tasks 4&5 - Radiological Assessment Codes

During September effort was initiated in writing the manuscript for the benchmark analysis report. Final ORIGEN runs were prepared and submitted to ORNL. As of the date of this progress report, essentially all of the ORIGEN runs have been completed.

1576

Tasks 4&5 - Repository Design Codes

No new codes were obtained during the month. A special meeting was held at the NRC on September 27 to review progress and to outline our recommendations for dealing with the inavailability of SPECTROM codes. Notes from this meeting are included with the technical status summary report. Also during the month, the code VISCOT was installed at Brookhaven. Enclosed with the technical status summary report is a revised outline for the benchmark analysis report incorporating CorSTAR's and NRC's comments on a draft outline prepared by Acres.

General

The following items that were identified in the July monthly progress report have the potential to impact project schedule or budget. Their status is updated below:

- We have met with NRC to review an approach for responding to comments on the Tasks 4&5 report for the siting codes.
- The NRC will obtain the codes ADINA and ADINAT directly from Adina Engineering for use on this project. We are still awaiting receipt of the codes by the NRC.
- We will prepare revised recommendations for problem substitution for the SPECTROM codes for approval by the NRC.
- We understand that the NRC will obtain a charge number for the use of the code STEALTH at the INEL computer facility.

Our estimate of costs through the end of September (through September 15 for CorSTAR) is:

Actual costs this month:	48K
Actual costs this fiscal year:	775.5K
Actual costs to date:	2774K
Planned costs this month:	58K
Planned costs this fiscal year:	883K

These estimated costs include labor, labor additive, overhead, subcontractor costs, other direct costs, G&A and fee. These cost estimates have not been confirmed by our accounting department.

Sincerely,

Douglas K. Vogt

Douglas K. Vogt
Project Manager

cc: D. Fehringer

See folder for Ltr. to P. Brooks from Vogt. 10-15-84

TECHNICAL STATUS SUMMARY

CorSTAR

TECHNICAL STATUS

Tasks 4&5 - Radiological Assessment Codes

During the past month work continued on the preparation of the Draft Final Report for the Benchmarking of Radiological Assessment Codes. Attached is the report outline and Introduction.

Benchmarking of Radiological Assessment Computer Codes

Revised Report Outline

I. INTRODUCTION

   A. Background
   B. Purpose of Report
   C. Report Organization

II. SUMMARY OF MAJOR FINDINGS

   A. Radionuclide Inventory and Heat Generation Codes
   B. Environmental Pathways and Dose-to-Man Codes

III. BENCHMARKING OF RADIONUCLIDE INVENTORY AND HEAT GENERATION CODES

   A. ORIGEN

      1. Code Description
      2. Description of Inventory and Heat Benchmark Problems
      3. Benchmarking Results and Conclusions

   B. ANSIDECH/BURNUP

      1. Code Description
      2. Description of Heat Problems
      3. Benchmarking Results and Conclusions

   C. Code Comparison and Evaluation

IV. BENCHMARKING OF ENVIRONMENTAL PATHWAYS AND DOSE-TO-MAN CODES

   A. PATH1/DOSHEM

      1. Code Description
      2. Description of Benchmark Problems
      3. Benchmarking Results and Conclusions

   B. CELLTRANS

      1. Code Description
      2. Description of Benchmark Problems
      3. Benchmarking Results and Conclusions

   C. BIODOSE

      1. Code Description
      2. Description of Benchmark Problems
      3. Benchmarking Results and Conclusions

CorSTAR

I. INTRODUCTION

A. Background

The licensing of a reposiotry for high level radioactive waste will necessarily involve the application of computer codes to analyze the numerous interrelated factors affecting the performance of the repository. The Nuclear Regulatory Commission (NRC), which has the responsibility for reviewing repository license applications, is sponsoring an evaluation of computer codes in the following five areas of repository performance assessment: (1) repository siting, (2) radiological assessment, (3) repository design, (4) waste package design, and (5) overall systems analysis.

Repository siting codes deal with the analysis of saturated flow, unsaturated flow, surface water flow, solute transport, heat transport and geochemistry. Radiological assessment codes include computer programs for analyzing radionuclide source terms, the transport of radionuclides between various compartments of the surface environment, and the resulting dose-to-man due to ingestion, inhalation and external exposure. The repository design codes will be used to analyze geomechanical processes, structural design and heat transport. Waste package codes simulate those interactions taking place within the waste package and with the surrounding repository host rock. Overall systems codes will be used to address multiple areas of repository performance assessment. The radiological assessment codes PATH1 and BIODOSE, which are evaluated in this report, are actually components of larger systems codes.

The first step in this evaluation of computer codes was a comprehensive survey of available codes in each area. Those codes most applicable to high level waste repository analysis were summarized on the basis of available code documentation. Each code summary dealt with both the operating characteristics of the code (computing time, storage, input and output) and the underlying theory upon which the code is based (equations, numerical approximations and simplifications). In addition, the summary reported the extent to which the code had been subjected to verification, validation and sensitivity analysis.

Following the preparation of a summary report for a particular code area, a second report was assembled which defined both the independent and dependent variables appearing in the codes and presented data indicating the range of values these variables could take on for repository assessment applications. The first purpose for this data set report was to provide users of the codes with a quick reference to aid in the interpretation of code input data requirements. The report was also designed to serve as a guide in the preparation of benchmark problems for the actual evaluation of computer codes.

The third report of the series gives a detailed description of these benchmark problems. The set of benchmark problems for each code area was developed with several objectives in mind. In some cases the problems were based upon field or laboratory measurements so that running the problem could serve as a validation of the code. A number of the problems have analytic solutions, which can be used to verify the accuracy of numerical methods employed in the codes. Another class of problems is designed to test whether a code can even be used to analyze a hypothetical repository situation. By running these hypothetical problems, the following types of code errors and limitations can be uncovered:

- Code options advertised in the user's manual but not actually available in the program
- Parameter values set within the code which cannot be overridden by the user
- Division by zero, logarithm of a negative number, etc.
- Array size constraints and excessive program run times
- Cumbersome input data requirements
- Options added to a code without having been checked out or even used by the developers of the code
- Vestigial sections of the code which either can no longer be accessed or which cannot affect the outcome of the calculation

In addition to making it possible to evaluate a code, these problems can serve as benchmarks by which the impact of future modifications to the codes can be judged. Also, when a code is undergoing modification, a coding error can introduce problems within portions of the code which have been previously checked out. If the complete set of benchmark problems is rerun after each code modification, this type of problem can be discovered early on in the modification process.

B. Purpose of the Report

After these benchmark problems have been documented, they are run using a subset of the codes which were presented in the code summary report described earlier. The purpose of the current report is the presentation of the results of this benchmarking study for the radiological assessment codes. While much of this report is devoted to a comparison of outputs from different codes, an effort has also been made to evaluate the codes based upon their ease of use. This is an important consideration for the environmental pathways and dose-to-man codes which require long times for the preparation of input data files. The steps and compromises involved in this input data preparation are thoroughly documented.

Although they have been grouped under the general heading of "radiological assessment," the codes covered in this report fall into two distinct categories. The first group of codes calculates the time-dependent radionuclide inventory (ORIGEN) or heat production (ORIGEN, ANSIDECH/BURNUP) within reactor fuel elements based upon the operating history of reactor during the residence time of the fuel element. The second group of codes (PATH1/DOSHEM, CELLTRAN, BIODOSE, PABLM and LADTAP) simulate the transport of radionuclides through the surface environment, their movement through the food chain and the eventual dose-to-man due to ingestion, inhalation and external exposure. The only connection between the two code groups is that the time dependent radionuclide inventory is a required input to a solute transport model which in turn provides the surface water radionuclide input for environmental transport modeling. The benchmark problems for the two code groups are quite different. The problems for ORIGEN and ANSIDECH/BURNUP are based upon engineering data, while the problems for the environmental pathways and dose-to-man codes are hypothetical. The primary reason for combining these code groups is an administrative one.

C. Report Organization

The organization of the report reflects the fact that two different types of codes are being benchmarked. In the discussion of benchmarking results and code to code comparisons, these two code types are treated separately. In Section II of this report the major findings of the study are summarized. The benchmarking of the radionuclide inventory and heat generation codes is described in Section III, with Part A devoted to the code ORIGEN and Part B to ANSIDECH/BURNUP. For each code the discussion is divided into three subparts. The first gives a brief code description which highlights the most important features and capabilities of the code. For a more detailed description of a code the reader should consult the code user's manual or the code summary report described earlier. The code ANSIDECH/BURNUP will, however, be described in detail since it was not summarized in the earlier report. The second subpart provides a detailed description of the benchmark problems to be solved by the code. This benchmark problem description will not be repeated for each code. Instead, only those aspects of the problem which cause difficulties for the code or which require a problem restatement will be examined. In Subpart 3 the benchmarking results for each code will be presented. Part C of Section III will be devoted to an evaluation of the ORIGEN and ANSIDECH/BURNUP codes and the presentation of selected comparisons of code outputs. Section IV contains the benchmarking discussion for the environmental pathways and dose-to-man codes PATH1/DOSHEM, CELLTRANS, BIODOSE, PABLM and LADTAP. The format for this section is identical to the one for Section III. The code description for CELLTRANS is more detailed than for the other codes since the code was not covered in the earlier summary report.

TECHNICAL STATUS REPORT ATTACHMENT TO
PROGRESS REPORT FOR SEPTEMBER

Repository Design Codes

Task 4 - Solve Benchmark Problems

Discussions were held on September 27, 1984 at NRC offices relative to the procurement of ADINA/T and SPECTROM codes. The notes of this meeting dealt with outstanding code procurement issues and have been forwarded separately.

Code Procurement

The installation of VISCOT (QA version identifier 420--11C-02) was completed during the month. Direct installation was not possible due to limitations in the small core memory size. To overcome this, the size of the real storage array was reduced; however, this limited the problem size to fewer nodes than required for the hypothetical and validation problems. To overcome this limitation, an update deck to run an example problem which transfers the real storage array to large core memory, has been prepared and successfully used.

Run Benchmark Problems

Problems 6.1 and 6.3 were run this month using DOT. Representative results of problem 6.3 are attached.

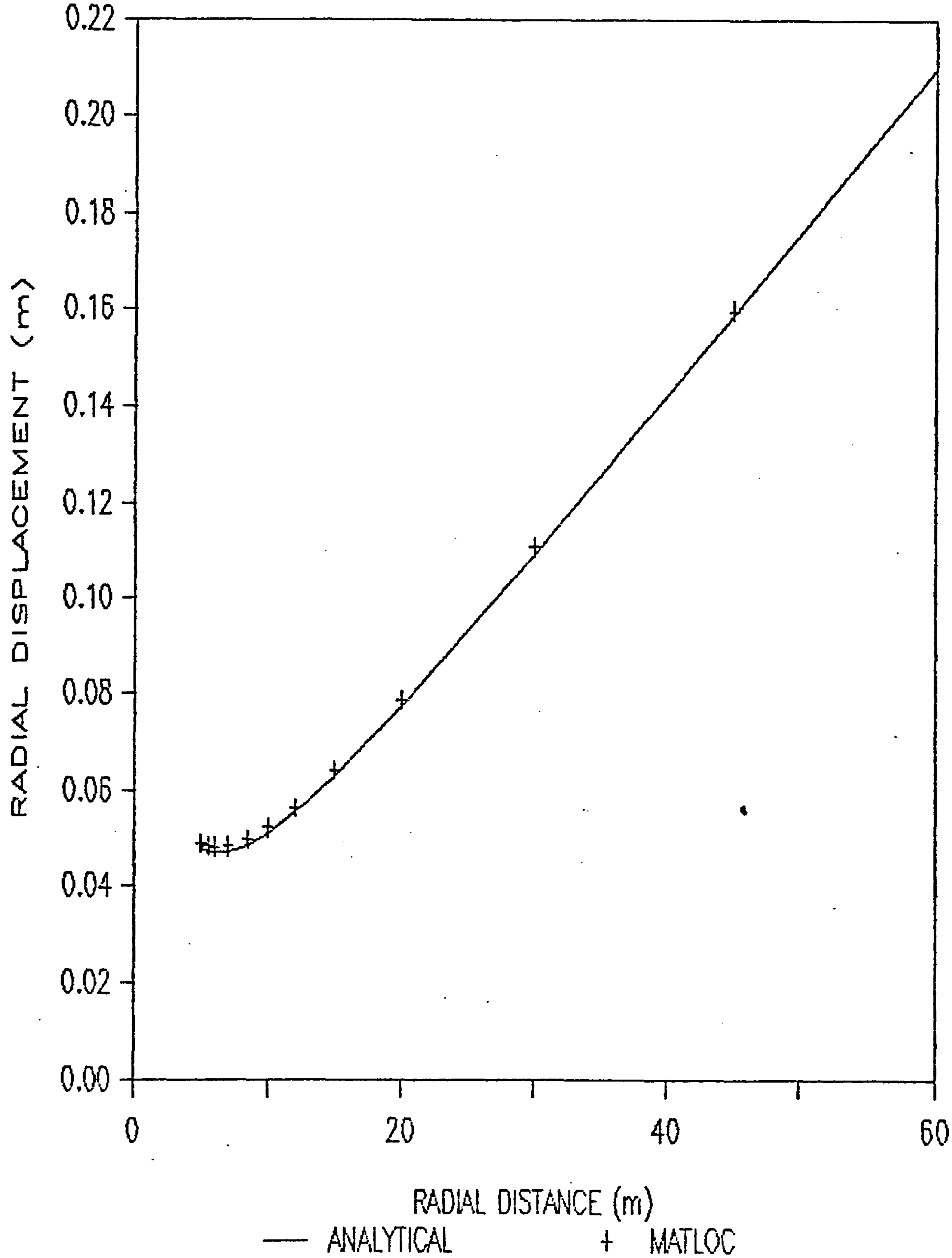
Problem 6.3 was run using COYOTECDC. Representative results are attached.

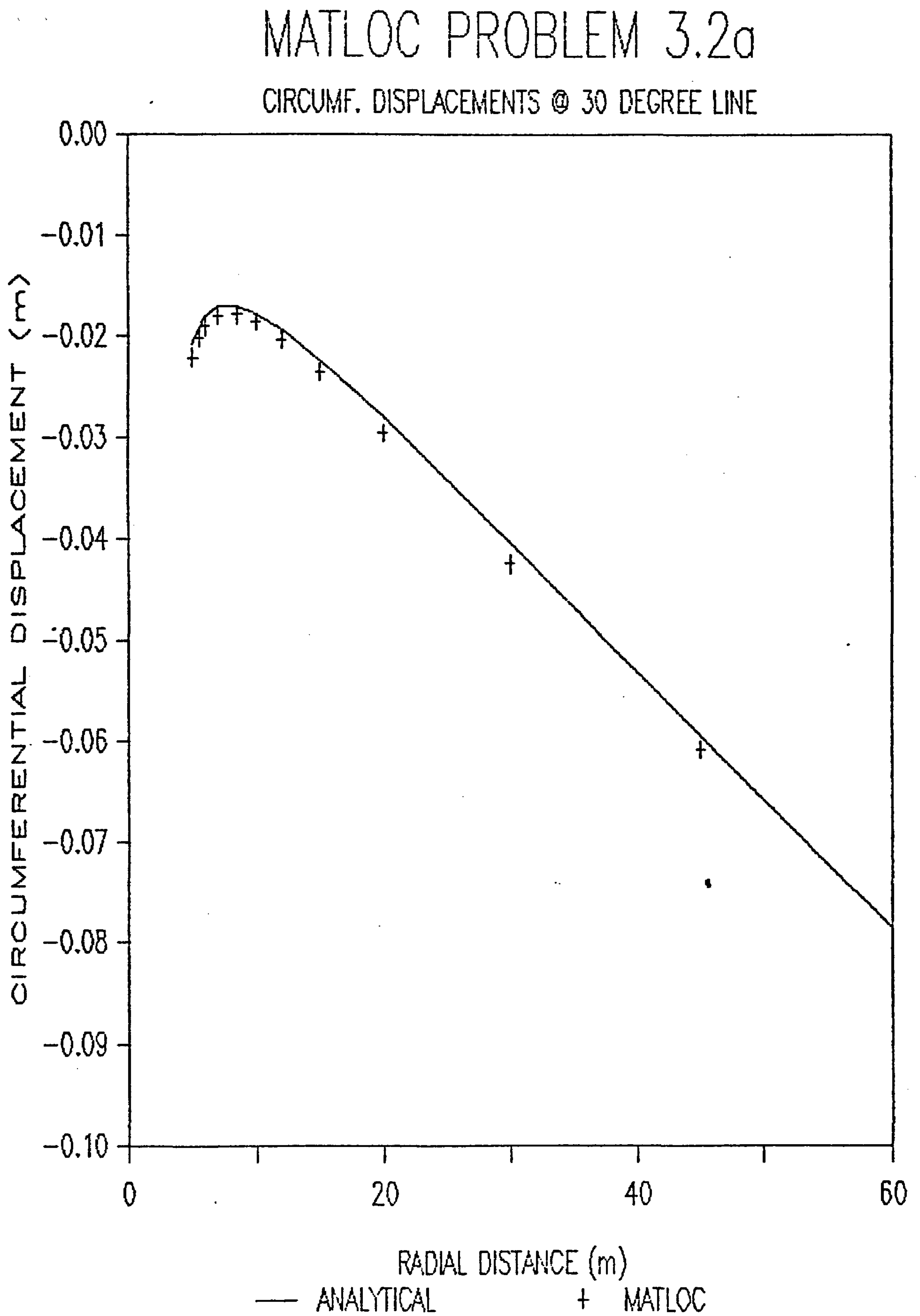
Problems 3.2a, 5.2 and 6.3 were run using MATLOC. The results of problem 3.2a (attached) show excellent agreement with the analytical solution.

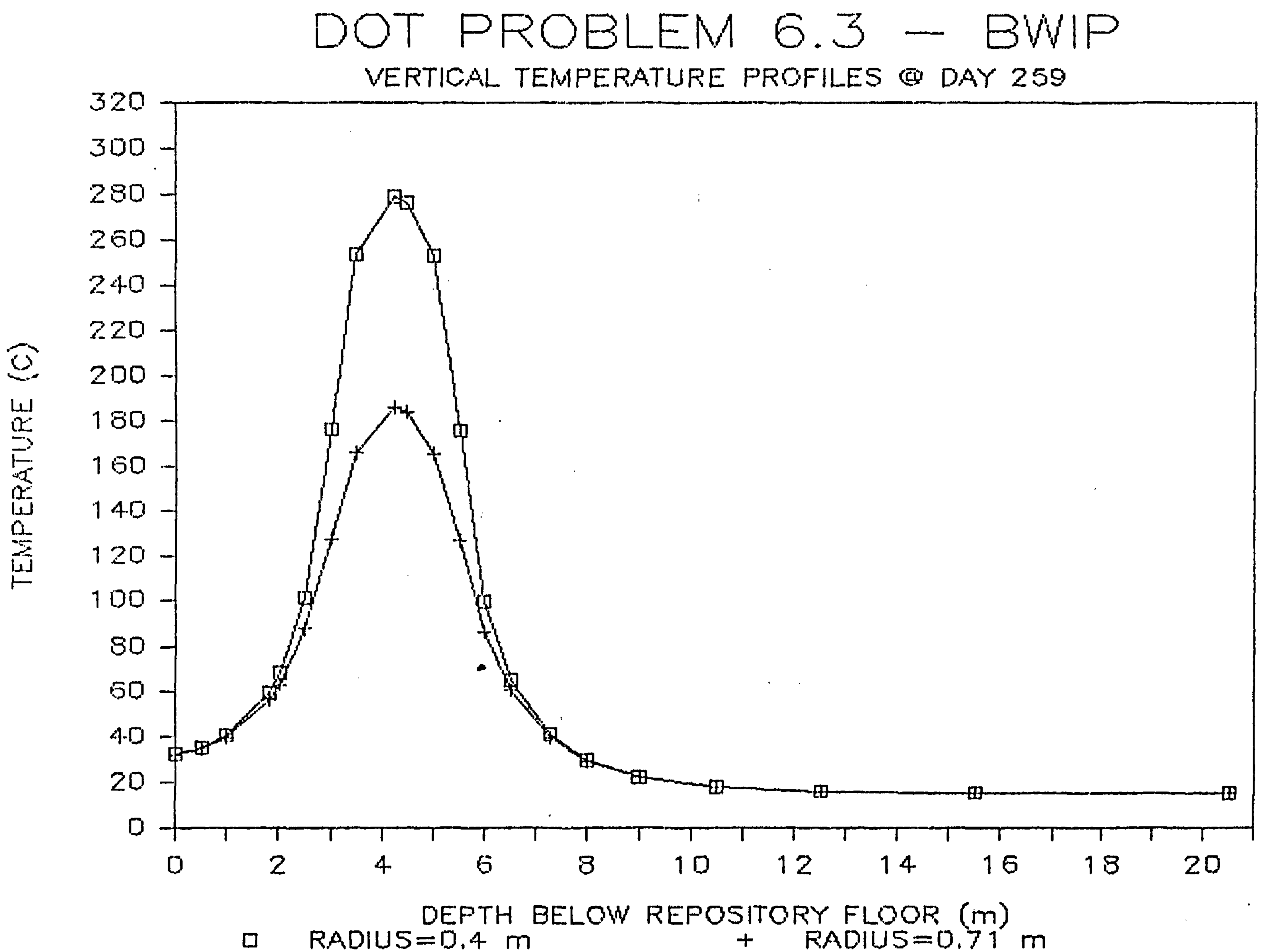
Table 3 from the original scope of work is included showing the current number of problems completed.

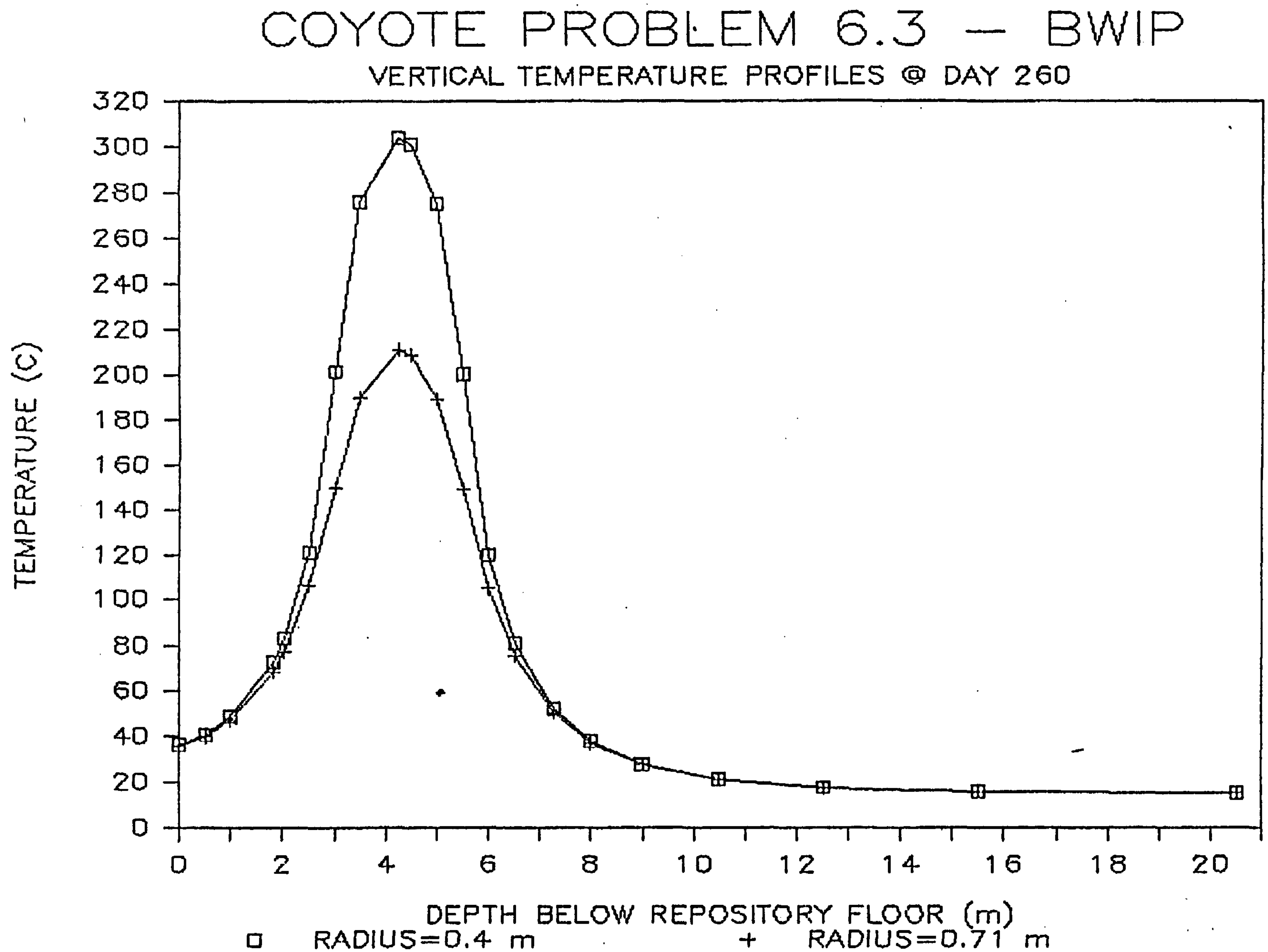
MATLOC PROBLEM 3.2a

RADIAL DISPLACEMENTS @ 30 DEGREE LINE




MATLOC PROBLEM 3.2a
CIRCUMF. DISPLACEMENTS @ 30 DEGREE LINE
CIRCUMFERENTIAL DISPLACEMENT (m)
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.10
0
20
40
60
RADIAL DISTANCE (m)
— ANALYTICAL
+ MATLOC


DOT PROBLEM 6.3 — BWIP
VERTICAL TEMPERATURE PROFILES @ DAY 259
TEMPERATURE (C)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
0
2
4
6
8
10
12
14
16
18
20
DEPTH BELOW REPOSITORY FLOOR (m)
RADIUS=0.4 m
RADIUS=0.71 m


COYOTE PROBLEM 6.3 — BWIP
VERTICAL TEMPERATURE PROFILES @ DAY 260
TEMPERATURE (C)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18
20
DEPTH BELOW REPOSITORY FLOOR (m)
□ RADIUS=0.4 m
+ RADIUS=0.71 m

BENCHMARKING OF THERMAL AND GEOMECHANICAL REPOSITORY DESIGN MODELS

Revised October 4, 1984
P6678

DRAFT OUTLINE

1 - INTRODUCTION
- 1.1 - Purpose of this Report
- 1.2 - Scope of this Report
- 1.3 - Previous Work
- 1.4 - Codes and Processes Considered

2 - SUMMARY OF FINDINGS
- 2.1 - Accuracy of Codes (discussion of analytical Problem results)
- 2.2 - Results of Hypothetical Problems
- 2.3 - Results of Validation Problems
- 2.4 - Applicability and Limitation of Codes

3 - PROBLEM DEFINITION AND SOLUTION
- 3.1 - Thermal Analysis Problems
- 3.2 - Geomechanical Analysis Problems
- 3.3 - Hypothetical Repository Design Problems
- 3.4 - Field Validation Problems

4 - BENCHMARKING OF ADINA
- 4.1 - Code Capabilities
- 4.2 - Problem 4.2b Circular Tunnel in an Elastic-Plastic Medium
  - 4.2.1 - Input Data/Discretization
  - 4.2.2 - Results
- 4.3 - Problem 4.3c Thick-Walled Cylinder of Viscoelastic Material Subjected to Internal Pressure
  - 4.3.1 - Input Data/Discretization
  - 4.3.2 - Results
- 4.4 - Etc.
- 4.5 - "
- 4.6 - "
- 4.7 - "
- 4.8 - Problems Encountered in Code Use
- 4.9 - Conclusions

5 - BENCHMARKING OF ADINAT

6 - BENCHMARKING OF DOT

7 - BENCHMARKING MATLOC

8 - BENCHMARKING OF VISCOT

9 - BENCHMARKING OF SALT

10 - BENCHMARKING OF COYOTE

11 - BENCHMARKING OF HEATING)
) CorSTAR
12 - BENCHMARKING OF STEALTH)

ONWI
Office of Nuclear Waste Isolation

BATTELLE Project Management Division
505 King Avenue
Columbus, Ohio 43201-2693

P6678

RECEIVED

OCT - 1984

ACRES AMERICAN INCORPORATED

F.192
RHC
file

September 24, 1984

Dr. D. W. Lamb
Acres American Incorporated
Suite 1000 Liberty Building
424 Main Street
Buffalo, New York 14202-3592

Dear Dr. Lamb:

NON-TRANSMITTAL OF SPECTROM CODE PACKAGES AND DOCUMENTATION

Thank you for the acknowledgement of receipt of the DOT, VISCOT, MATLOC and SALT4 code package transfers enclosed in your letter of September 11, 1984.

The SPECTROM 11, 21 and 41 code documents are not completed at this time, therefore, your request for code transfer has been disapproved. A user's manual for SPECTROM 41 has been documented (ONWI-326) and is enclosed. However, the documentation is being revised in accordance with NUREG-0856. The draft documentation shall undergo review upon receipt in early November. Once the documentation has been approved, the codes shall be available for transfer. At that time, you will be notified of code availability.

We regret any inconveniences that this may cause you.

Sincerely,

Leslie A. Scott

Leslie A. Scott
Code Custodian
Systems Analysis Department

LAS:rb

Enclosure

cc: LA Casey, SRPO
JO Neff, SRPO (3)

Battelle
Project Management Division

CODE TRANSFER FORM
(See Instructions on Reverse Side)

1. CONTROL NO.
1A. TO
2. DATE

I. 3. CODE REQUESTOR D.W. LAMB
4. ADDRESS OF REQUESTOR ACRES AMERICAN INCORPORATED
5. DATE OF REQUEST SEPT. 11, 1984

6. CODE RECEIVER same
7. ADDRESS OF RECEIVER same

8. CODE REQUESTED & I.D. NO. SPECTROM-11, SPECTROM-21, SPECTROM-41
9. INTENDED APPLICATION benchmarking

II. RESPONSIBLE MANAGER APPROVAL FOR TRANSFER

10. ☐ APPROVE TRANSFER ☒ DISAPPROVE TRANSFER

11. EXPLANATION We do not have appropriate code documentation at this time

12. SIGNED (RESPONSIBLE MANAGER) [signature] TITLE DATE 9/24/84

III. TRANSFER PACKAGE CONTENTS

13. CODE TITLE & I.D. NO. ______ 14. VERSION ______ 15. DATE ______

16. ☐ DOCUMENTATION TITLE ______

17. ☐ MODEL TAPE INDEX

18. ☐ MODEL LISTING

19. MAGNETIC TAPE FORMAT

☐ 9-TRACK
☐ UNLABELED ☐ OTHER ______
☐ 1600 BPI ☐ OTHER ______
☐ EBCDIC ☐ OTHER ______

FILES ______ BLOCK SIZE ______ RECORD LENGTH ______
FILES ______ BLOCK SIZE ______ RECORD LENGTH ______

OR 20. ☐ REQUEST REJECTED

21. COMMENTS code transfer has been disapproved (refer to part II of form)

IV. REVIEW BY TECHNICAL INDIVIDUAL

22. SIGNED (TECHNICAL INDIVIDUAL) E. Gregory McNulty DATE 9/25/84

V. CODE CURATOR CONCURRENCE

23. ☒ CONCUR ☐ DO NOT CONCUR

24. EXPLANATION ______

[signature] CC 9/28/84

25. SIGNED (CODE CURATOR) TITLE DATE

VI. PACKAGE SENT

26. CONTENTS tape transfer form, ONWI-326

27. SIGNED (CODE CUSTODIAN) [signature] 28. DATE SENT 9/28/84

BPMD-248 (3/84)

PROJECT STATUS

TABLE 3

MATRIX OF CODE/PROBLEM COMBINATIONS
(Revised 3/12/84)

Legend:

- x Benchmark Problems by Acres.
- 0 Benchmark Problems by Teknekron.
- (1) Requires 2 runs, one for MATLOC and one for VISCOT.
- (2) Two-Dimensional Analysis.

CODES

	ADINA - 3D	ADINAT - 3D	DOT	HEATING	MATLOC	SPECTROM 11	SPECTROM 41	VISCOT	COYOTE	SALT 4	STEALTH
2.0 THERMAL ANALYSIS CASE PROBLEMS											
2.6 Transient Temperature Analysis of an Infinite Rectangular Bar With Anisotropic Conductivity (Schneider, 1955, pp. 261)		x	☐	0			x		☐		0
2.8 Transient Temperature Response to the Quench of an Infinite Slab With a Temperature-Dependent Convection Coefficient (Kreith, 1958, pp. 161)		x		0					☐		0
2.10 Steady Radiation Analysis of a Infinite Rectangular Opening (Rohsenow and Hartnett, 1973, pp. 15-32)		x		0					x		0
3.0 GEOMECHANICAL ANALYTICAL PROBLEMS											
3.2 Circular Tunnel (Long Cylindrical Hole in An Infinite Medium)											
a) Unlined in elastic medium - biaxial stress field					x						
b) Unlined in plastic medium (Tresca) von Mises	x					x		x			0
3.3 Thick-Walled Cylinder Subjected to Internal and/or External Pressure											
c) Plane strain - creep	x							x			
3.5 Plane Strain Compression of an Elastic-Plastic Material von Mises; Drucker, Prager	x					x					0
4.0 THERMOMECHANICAL ANALYTICAL PROBLEMS											
5.0 HYPOTHETICAL REPOSITORY DESIGN PROBLEMS											
5.1 Hypothetical Very Near Field Problem	x	x		0							
5.2 Hypothetical Near Field Problem			(0) ☐		☐	x	x	x	☐	x	0
5.3 Hypothetical Far Field Problem	(2)	(2)				x	x			x	0
6.0 FIELD VALIDATION PROBLEMS											
6.1 Project Salt Vault-Thermomechanical Response Simulation Problem	(2)	(2)	☐					x		x	0
6.3 In Situ Heater Test-Basalt Waste Isolation Project	(2)	(2)	☐		☐	x	x		☐		0

☐ Problems Completed

September 28, 1984
P6678.230

Notes of Meeting
Held September 27, 1984 at
NRC Offices, Silver Springs, MD

Present:

Pauline Brooks - NRC
Dan Fehringer - NRC
John Greeves - NRC
Raj Nataraja - NRC
John Buckley - NRC
M. Logsdon - NRC

Doug Vogt - CorSTAR

Robert Curtis - Acres

PURPOSE

The purpose of this meeting was to review the progress on the benchmarking of repository design codes and to discuss the unresolved issues related to the benchmarking of the SPECTROM and ADINA codes.

STATUS OF BENCHMARKING ACTIVITIES

Figure 1 shows the current status of the project. All of the codes except ADINA/T and SPECTROM have been received. DOT, MATLOC, VISCOT, COYOTE, and STEALTH have been compiled.

For the initial compilation of VISCOT, the size of the main storage array had to be reduced to fit the small core memory limitation at Brookhaven. Currently, an effort is underway to make changes to the program which will allow larger problems to be solved by storing certain arrays in the large core memory. The use of dynamic dimensioning by VISCOT makes this more difficult than for the previously compiled codes.

A total of four analytical and five hypothetical problems have been completed. Work is currently underway benchmarking MATLOC and VISCOT. The ADINA/T codes will be required within approximately two weeks to prevent delay in the schedule.

Although problem 2.10 was attempted using COYOTE, the problem, which is applicable to repository analysis, cannot be handled by COYOTE. Radiation used in COYOTE is from a surface of the model to a Body at constant temperature outside of the model. Thus, Radiation heat exchange between two parts of the model cannot be directly computed. This will be reported in the final report.

ADINA AND SPECTROM CODES

Acres and CorSTAR proposed that in the light of difficulty in obtaining the SPECTROM codes and the cost of obtaining ADINA, the SPECTROM codes be dropped and VISCOT be benchmarked to elastic-plastic applications. The revised scope would then be as indicated on Figure 15. John Greeves suggested we attempt to obtain ADINA free.

Subsequent to the meeting, a call was placed to Dr. Bathe, the author of ADINA. It was agreed by Dr. Bathe that the NRC could obtain ADINA for benchmarking free of rental charges conditional upon certain terms to be spelled out in a lease agreement. Dr. Bathe will send the lease agreement to John Greeves.

Robert H. Curtis

Submitted by: R. H. Curtis

RHC/ms
Attachments

September 28, 1984

PROJECT STATUS

TABLE 3

MATRIX OF CODE/PROBLEM COMBINATIONS
(Revised 3/12/84)

REC'D

Legend:

x Benchmark Problems by Acres.
0 Benchmark Problems by Teknekron.
(1) Requires 2 runs, one for MATLOC and one for VISCOT.
(2) Two-Dimensional Analysis.

COMPILED

CODES

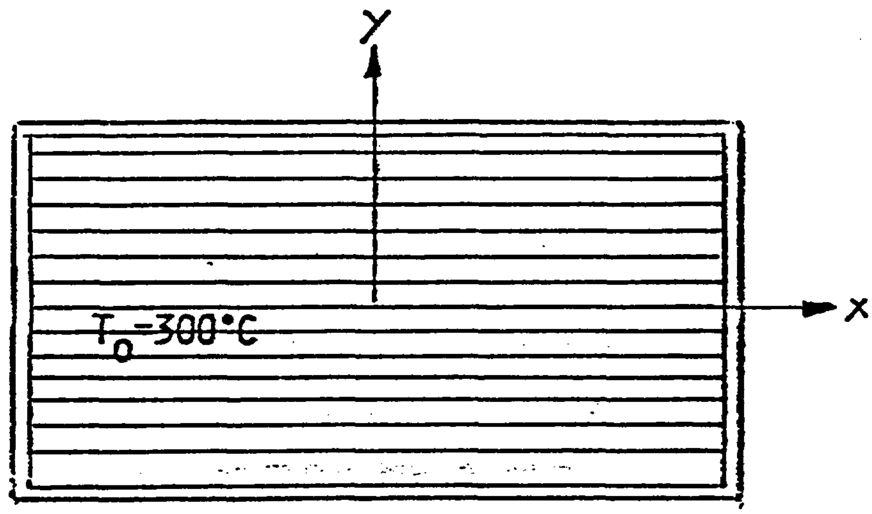
Problem	ADINA - 3D	ADINAT - 3D	DOT	HEATING	MATLOC	SPECTROM 11	SPECTROM 41	VISCOT	COYOTE	SALT 4	STEALTH
2.0 THERMAL ANALYSIS CASE PROBLEMS											
2.6 Transient Temperature Analysis of an Infinite Rectangular Bar With Anisotropic Conductivity (Schneider, 1955, pp. 261)		x	■	0			x		■		0
2.8 Transient Temperature Response to the Quench of an Infinite Slab With a Temperature-Dependent Convection Coefficient (Kreith, 1958, pp. 161)		x		0					■		0
2.10 Steady Radiation Analysis of a Infinite Rectangular Opening (Rohsenow and Hartnett, 1973, pp. 15-32)		x		0					x		0
3.0 GEOMECHANICAL ANALYTICAL PROBLEMS											
3.2 Circular Tunnel (Long Cylindrical Hole in An Infinite Medium) a) Unlined in elastic medium - biaxial stress field b) Unlined in plastic medium (Tresca) von Mises	x				■	x		x			0
3.3 Thick-Walled Cylinder Subjected to Internal and/or External Pressure											
c) Plane strain - creep	x							x			
3.5 Plane Strain Compression of an Elastic-Plastic Material von Mises; Drucker, Prager	x					x					0
4.0 THERMOMECHANICAL ANALYTICAL PROBLEMS											
5.0 HYPOTHETICAL REPOSITORY DESIGN PROBLEMS											
5.1 Hypothetical Very Near Field Problem	x	x		0							
5.2 Hypothetical Near Field Problem			■		■	x	x	x	■	x	0
5.3 Hypothetical Far Field Problem	(2)	(2)				x	x			x	0
6.0 FIELD VALIDATION PROBLEMS											
6.1 Project Salt Vault-Thermomechanical Response Simulation Problem	(2)	(2)	x					x		x	0
6.3 In Situ Heater Test-Basalt Waste Isolation Project	(2)	(2)	■		x	x	x		■		0

■ Problems Completed

Figure 1

September 28, 1984

PROBLEM 2.6 TRANSIENT TEMPERATURE ANALYSIS OF AN INFINITE BAR WITH ANISOTROPIC CONDUCTIVITY



$K_x = 2.0$ W/(m- °C)

$K_y = 1.0$ W/(m- °C)

$h = 2.0$ W/(m^2- °C)

$T_{QUENCH} = 30$°C

<u>CODES</u>:

ADINAT/3D ELEMENT

DOT

SPECTROM 41

COYOTE/ISOPARAMETRIC QUAD. ELEMENT

<u>PROBLEM TESTS</u>:

1. NUMERICAL SOLUTION ACCURACY
2. ANISOTROPIC CONDUCTIVITY ELEMENT FORMULATION
3. CONVECTIVE BOUNDARY CONDITION

<u>SOLUTION</u>:

ANALYTICAL/GRAPHICAL

Figure 2

September 28, 1984

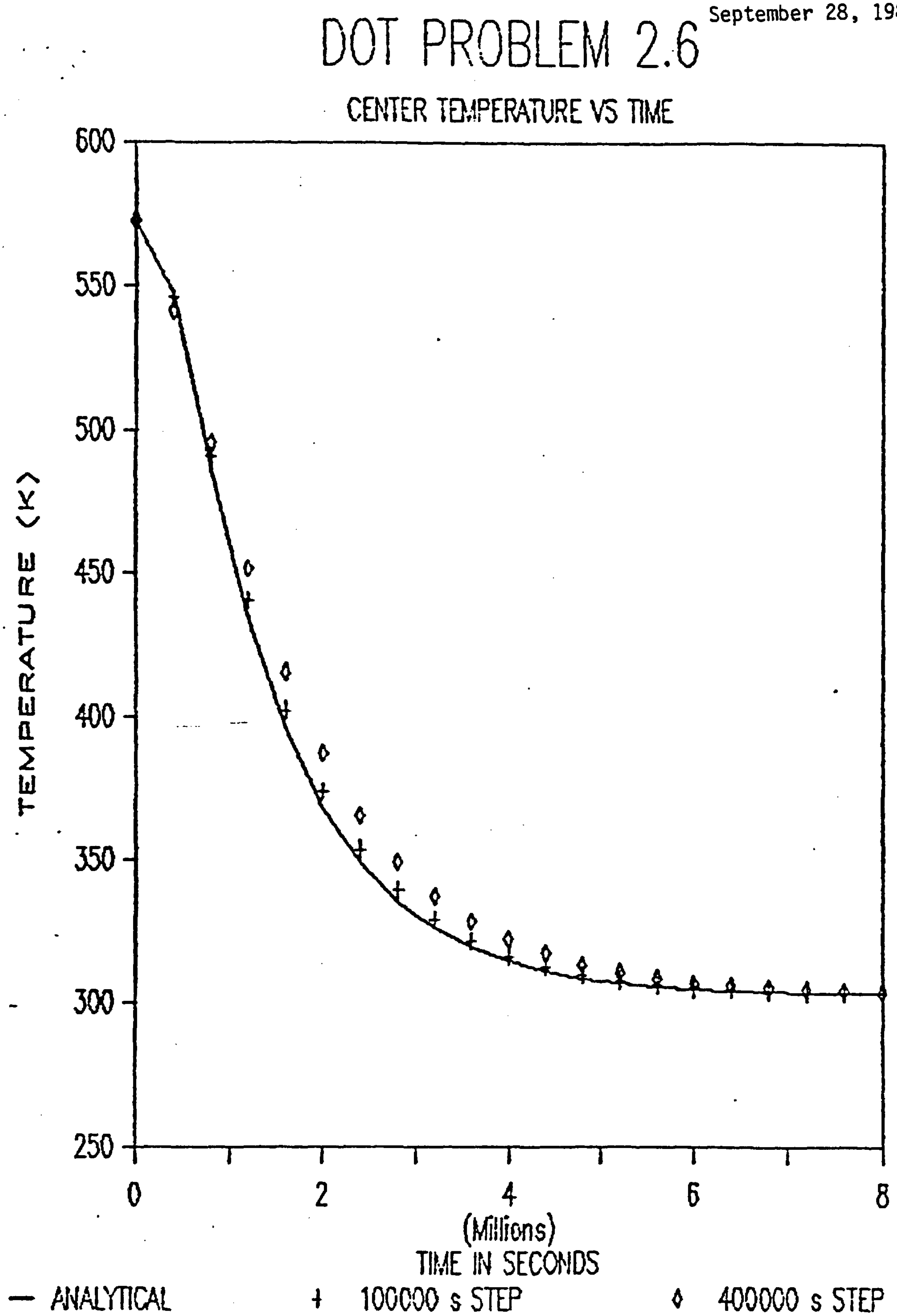


Figure 3

September 28, 1984

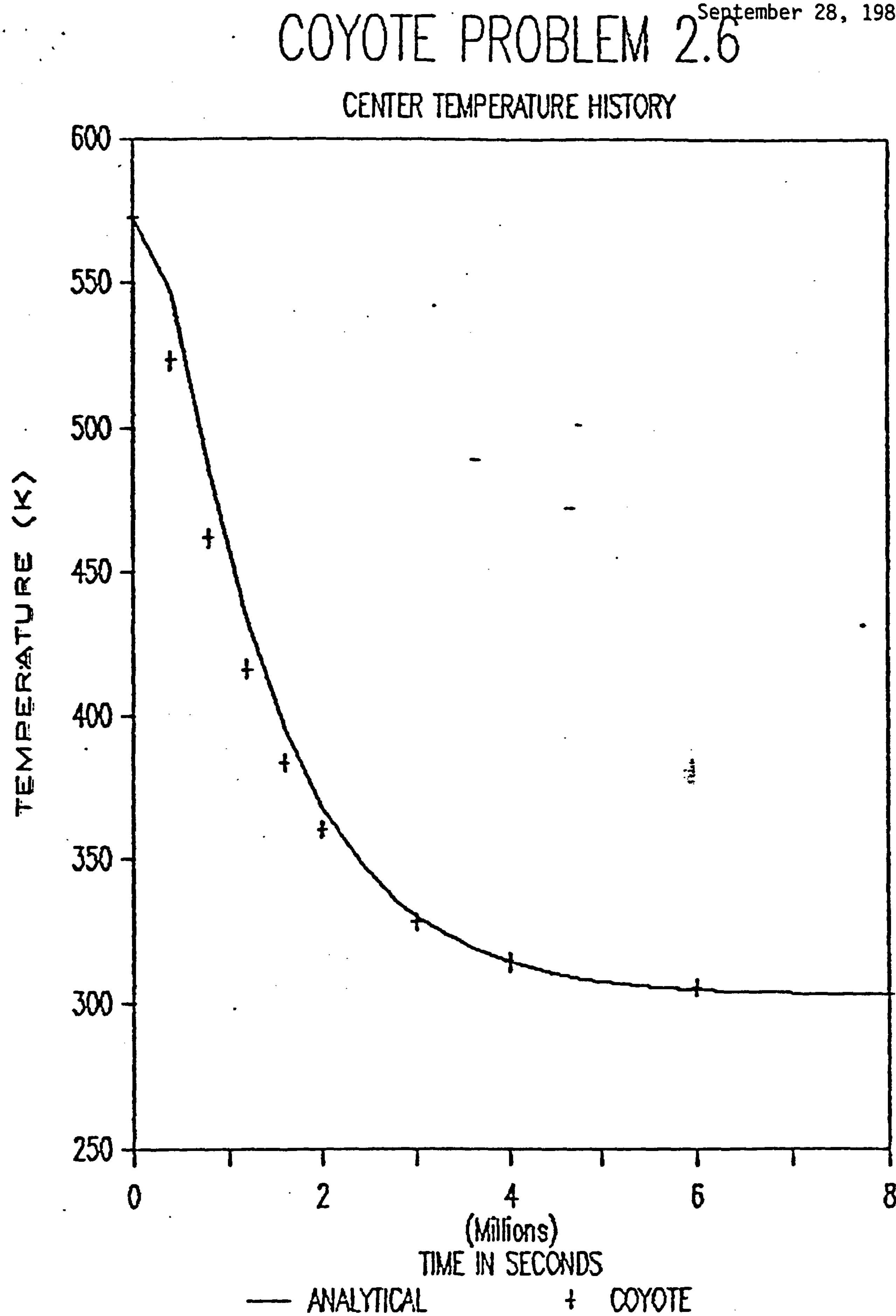
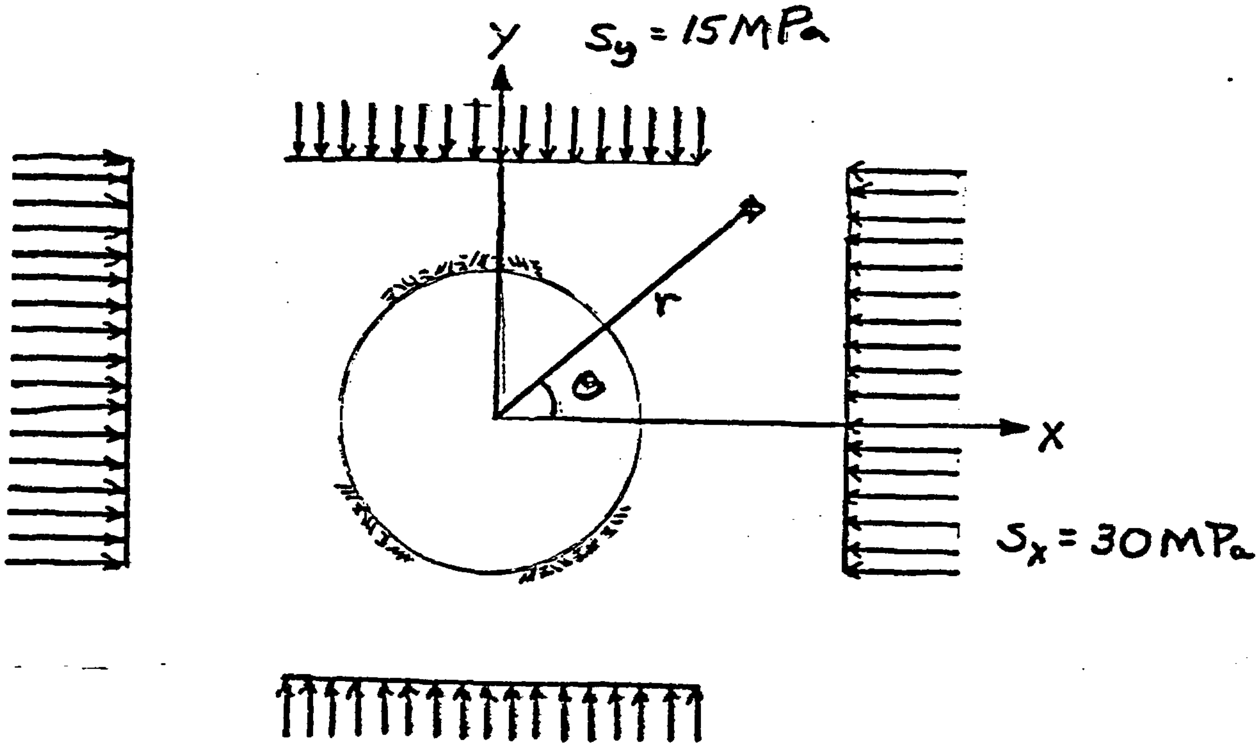


Figure 4

PROBLEM 3.2A UNLINED TUNNEL IN AN ELASTIC MEDIUM WITH BIAXIAL STRESS FIELD



CODES:

MATLOC/8 NODE ISOPARAMETRIC - PLANE STRAIN

PROBLEM TESTS:

1. NUMERICAL SOLUTION ACCURACY
2. ELEMENT FORMULATION
3. ABILITY TO SIMULATE INFINITE BOUNDARY CONDITIONS

SOLUTION:

CLOSED FORM ANALYTICAL

Figure 5

MATLOC PROBLEM 3.2a

RADIAL DISPLACEMENTS @ 30 DEGREE LINE

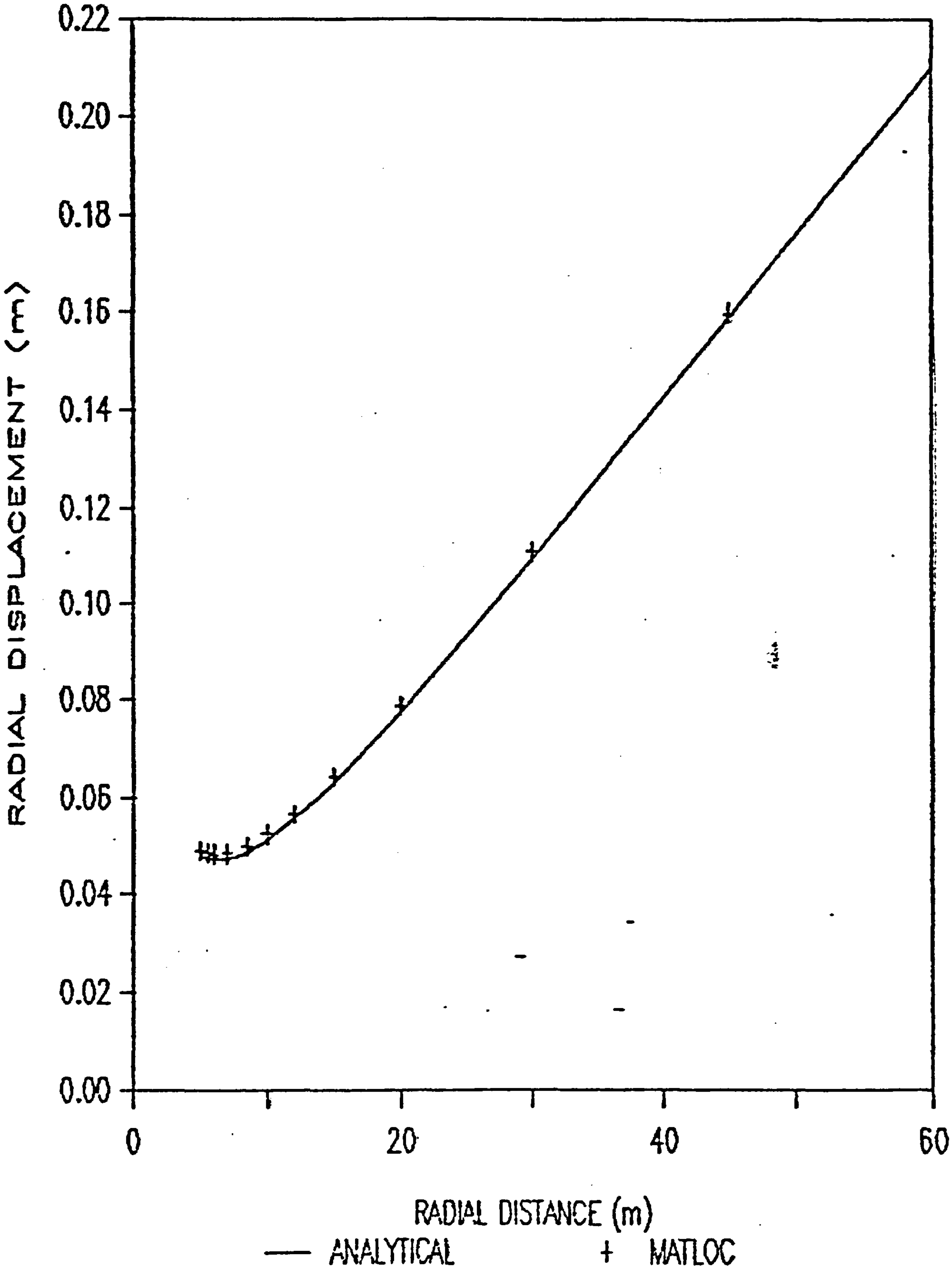
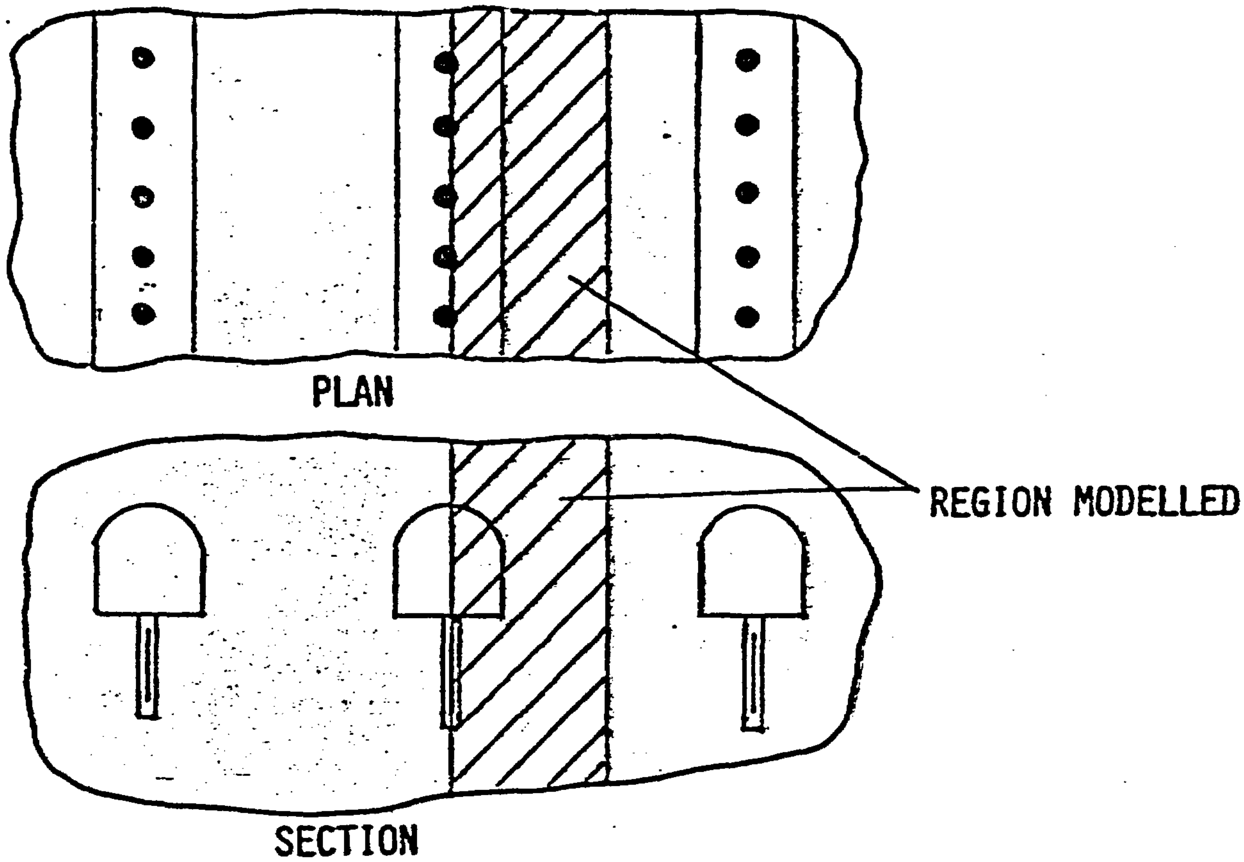


Figure 6

PROBLEM 5.2 HYPOTHETICAL TWO-DIMENSIONAL NEAR FIELD ANALYSIS



CODES:

COYOTE
DOT
SPECTROM 41
MATLOC
VISCOT
SALT 4
SPECTROM 11

PROBLEM REQUIRES:

1. TRANSIENT THERMAL ANALYSIS
2. DECAYING HEAT COURSE
3. NONLINEAR CONVECTIVE HEAT TRANSFER
4. RADIATIVE BOUNDARY CONDITIONS
5. TRANSIENT STRESS ANALYSIS
6. THERMAL STRESS COMPUTATION
7. DRUCKER-PRAGER FAILURE CRITERIA (OR) CREEP MODEL

Figure 7

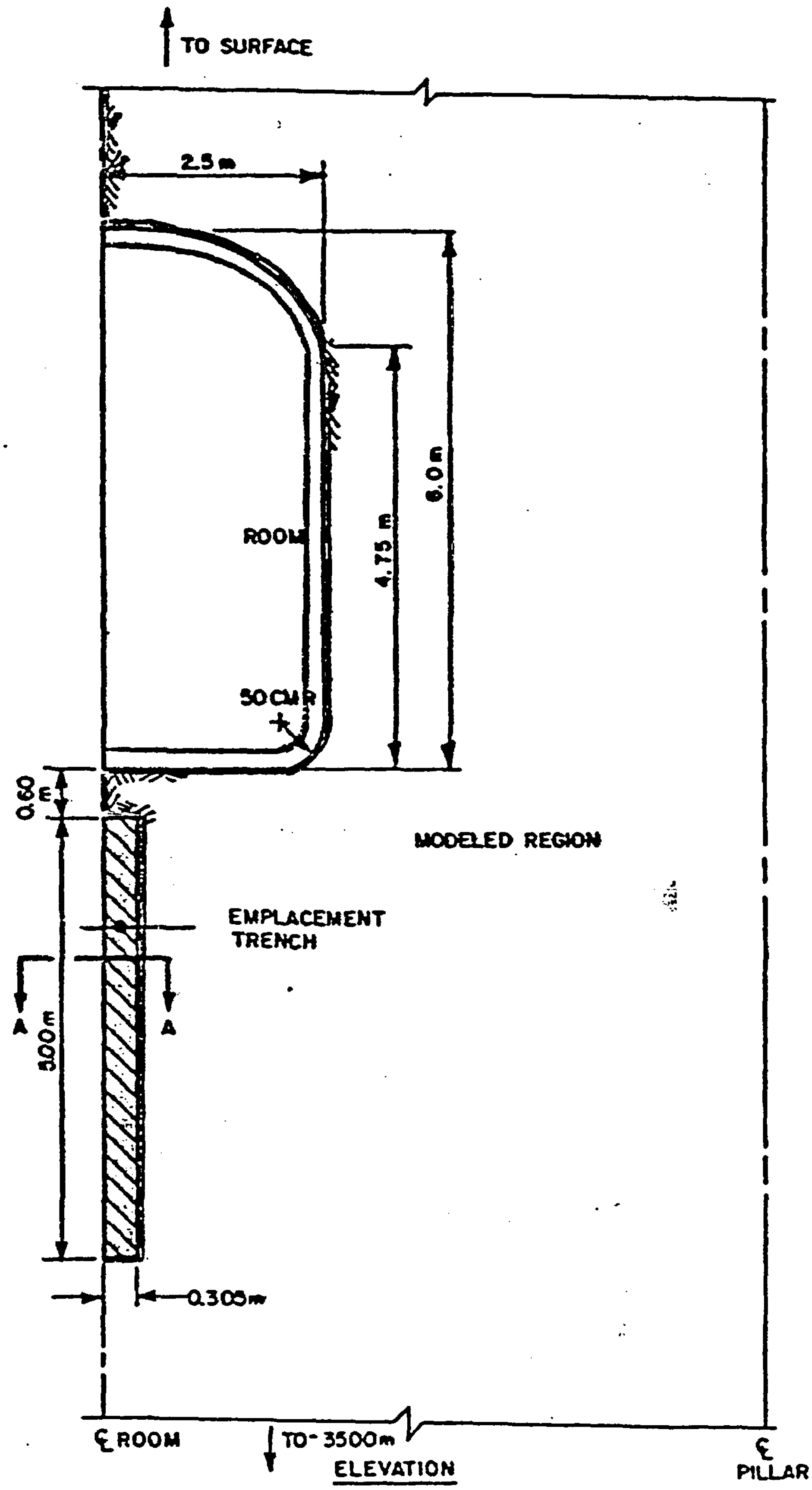


Figure 5.2-1 Near Field (Room) Model

Figure 8

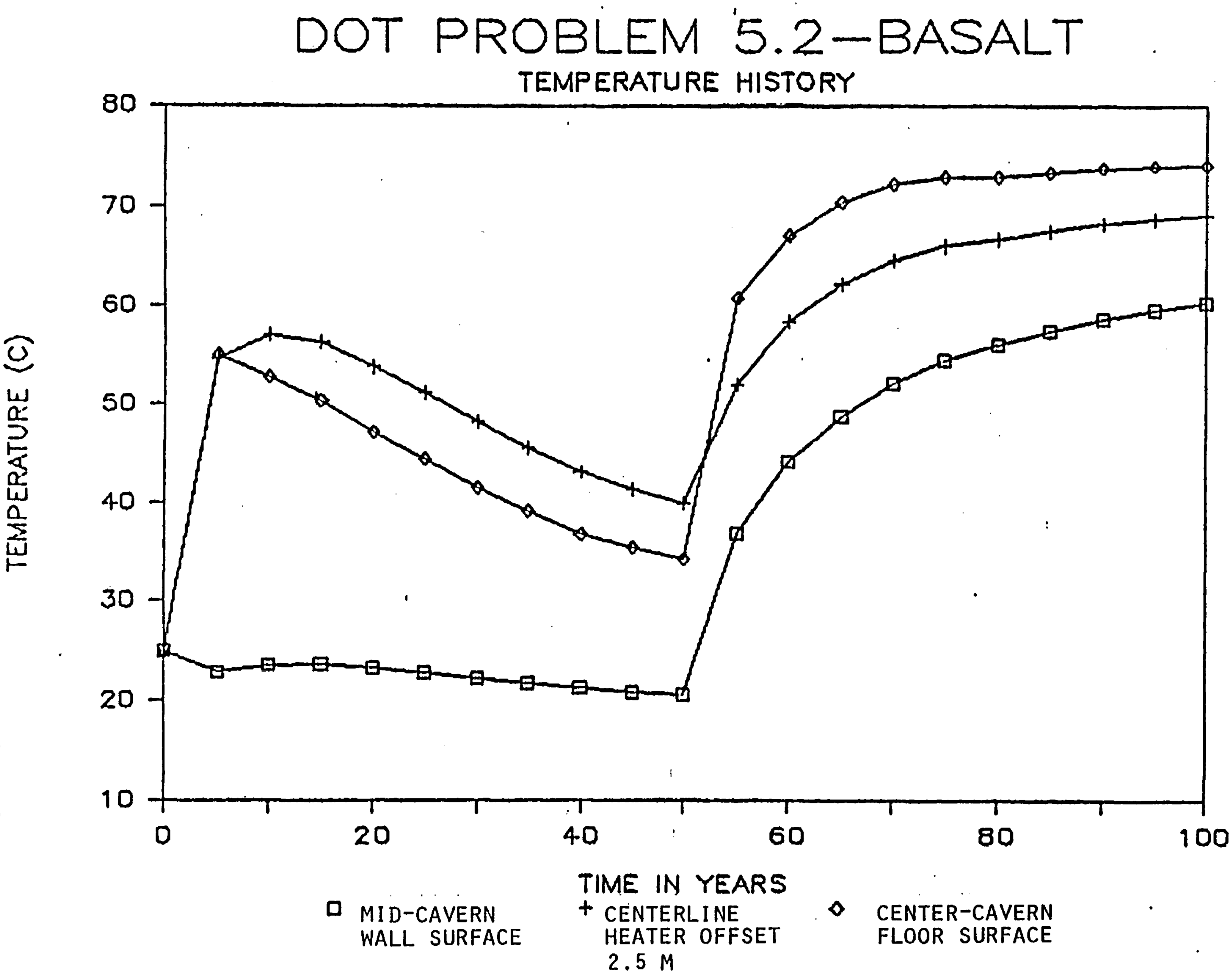


Figure 9

September 28, 1984

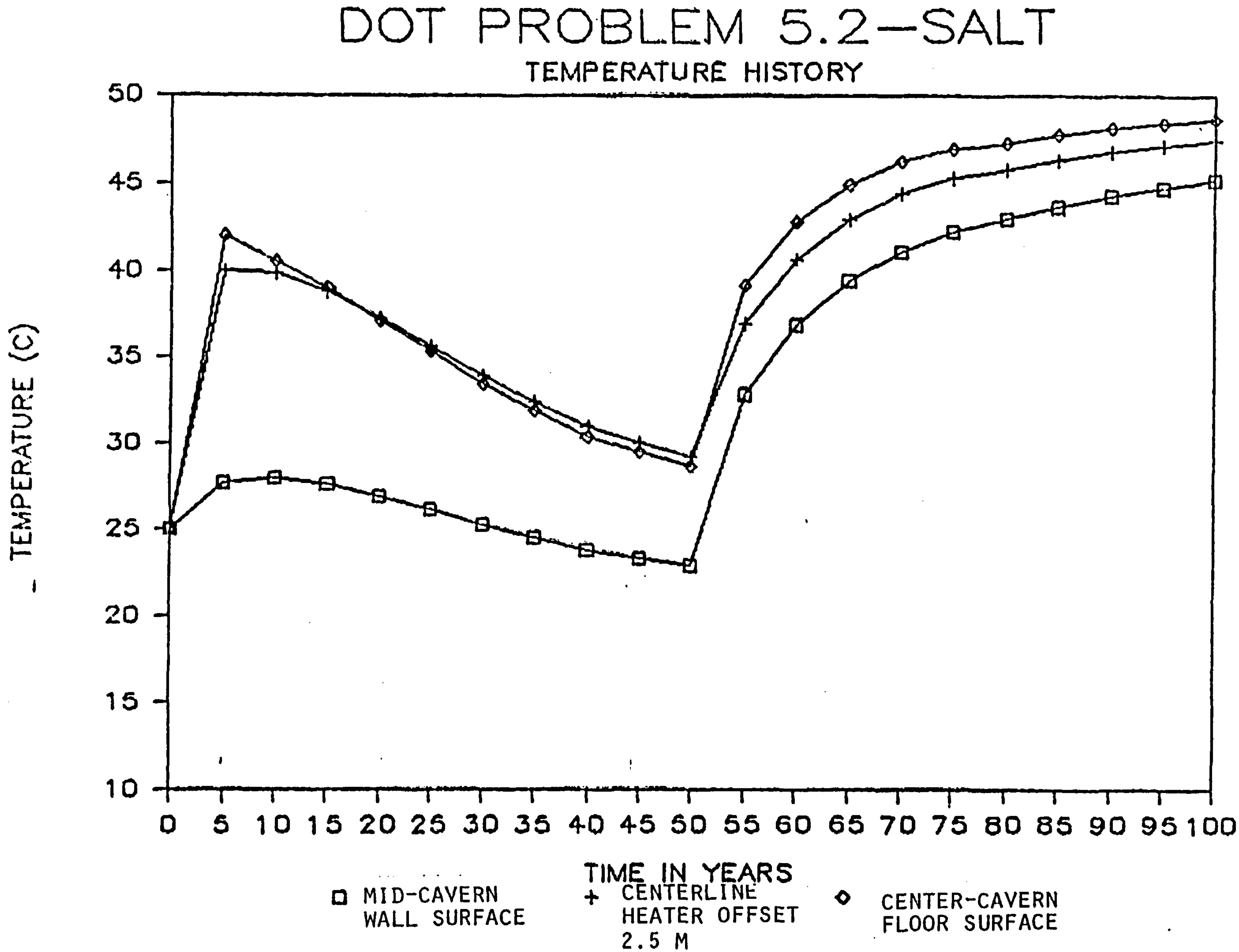


Figure 10

September 28, 1984

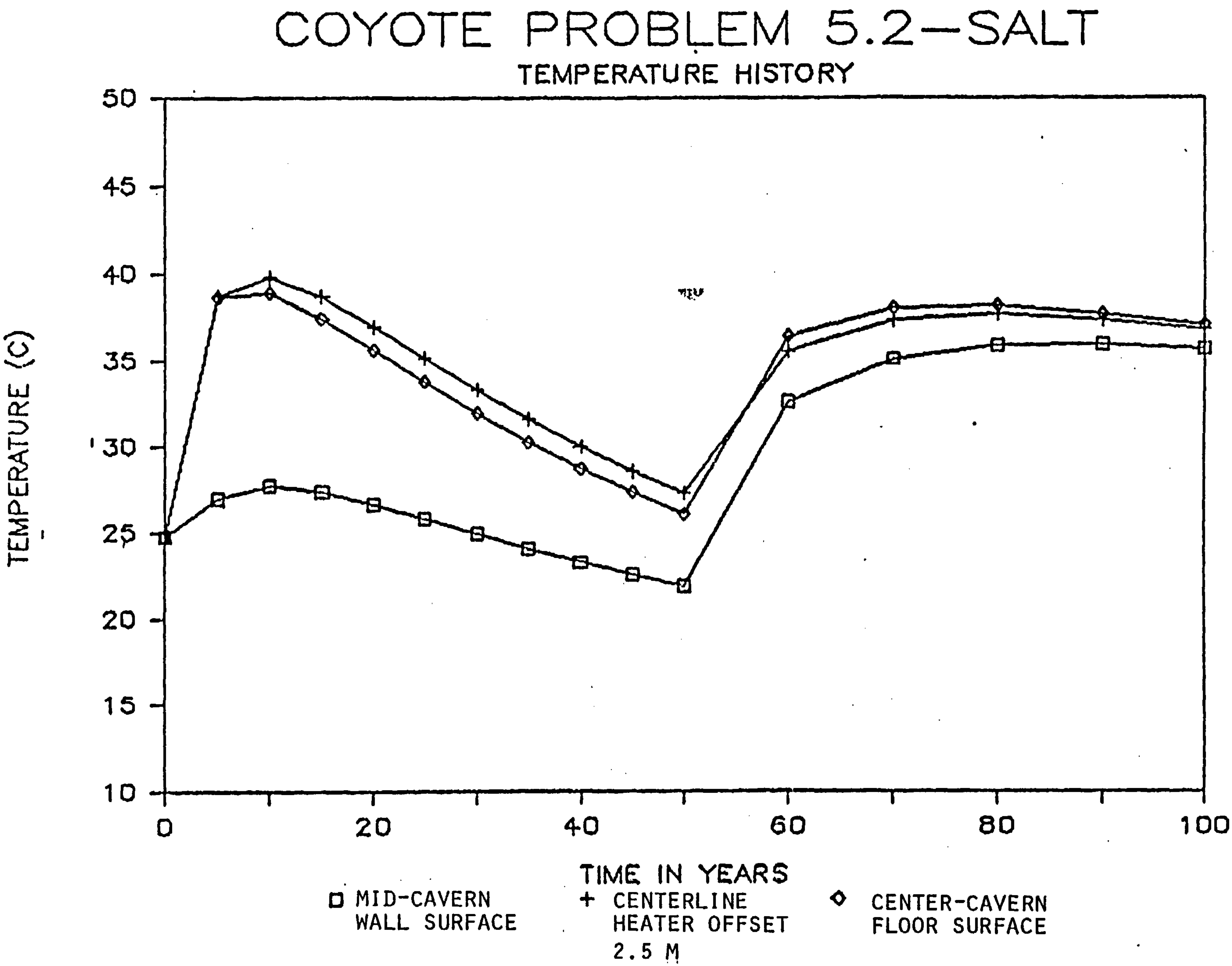
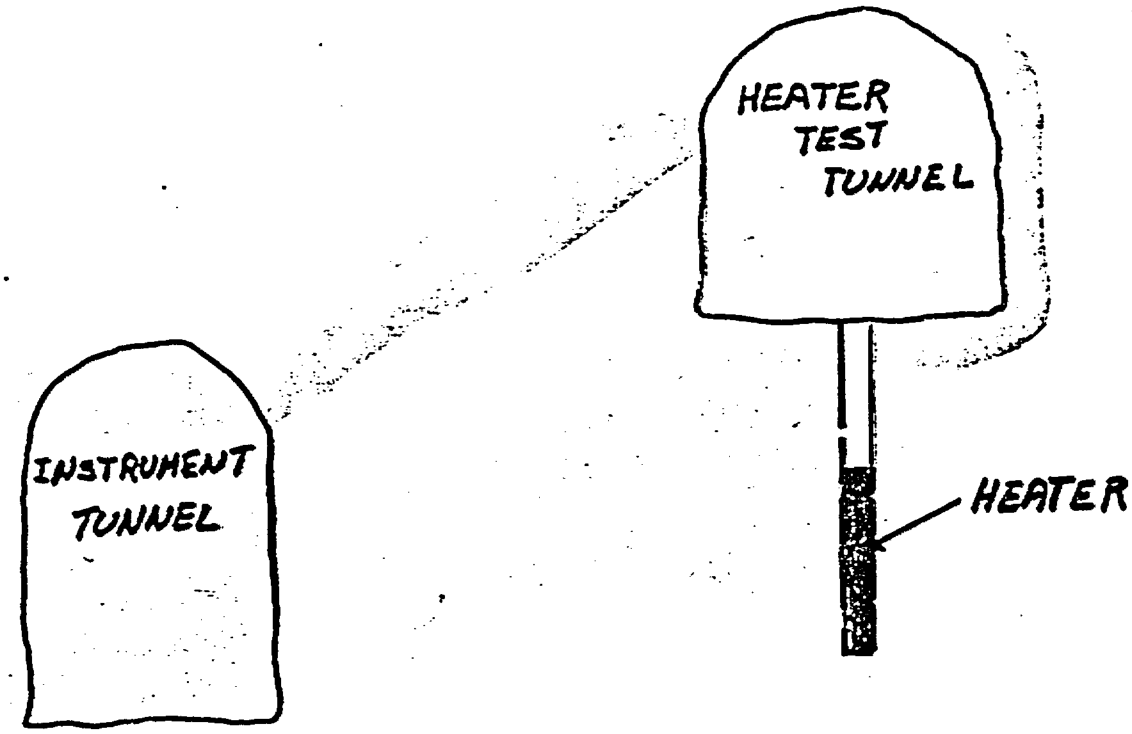


Figure 11

September 28, 1984

PROBLEM 6.3 BASALT WASTE ISOLATION PROJECT VALIDATION PROBLEM



CODES:

ADINAT/2 DIMENSIONAL ELEMENT
DOT
SPECTROM 41
COYOTE

ADINA/2 DIMENSIONAL ELEMENT
MATLOC
SPECTROM 11

PROBLEM TESTS:

1. TRANSIENT THERMAL ANALYSIS
2. NONLINEAR SPECIFIC HEAT AND THERMAL CONDUCTIVITY
3. LINEAR CONVECTION
4. STRESS ANALYSIS
5. NONLINEAR COEFFICIENT OF THERMAL CONDUCTIVITY

Figure 12

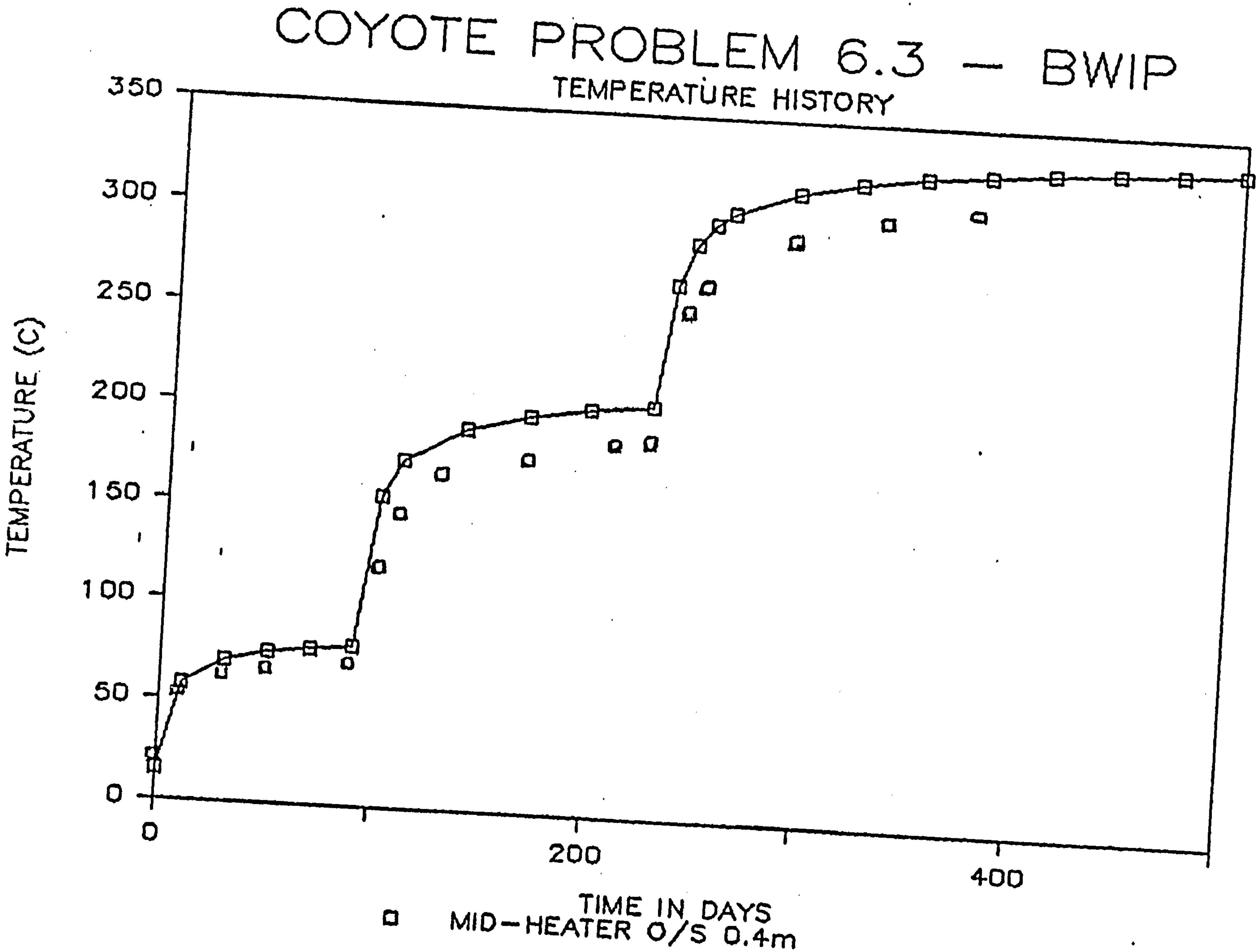


Figure 13

September 28, 1984

COYOTE PROBLEM 6.3 — BWIP

VERTICAL TEMPERATURE PROFILES @ DAY 260

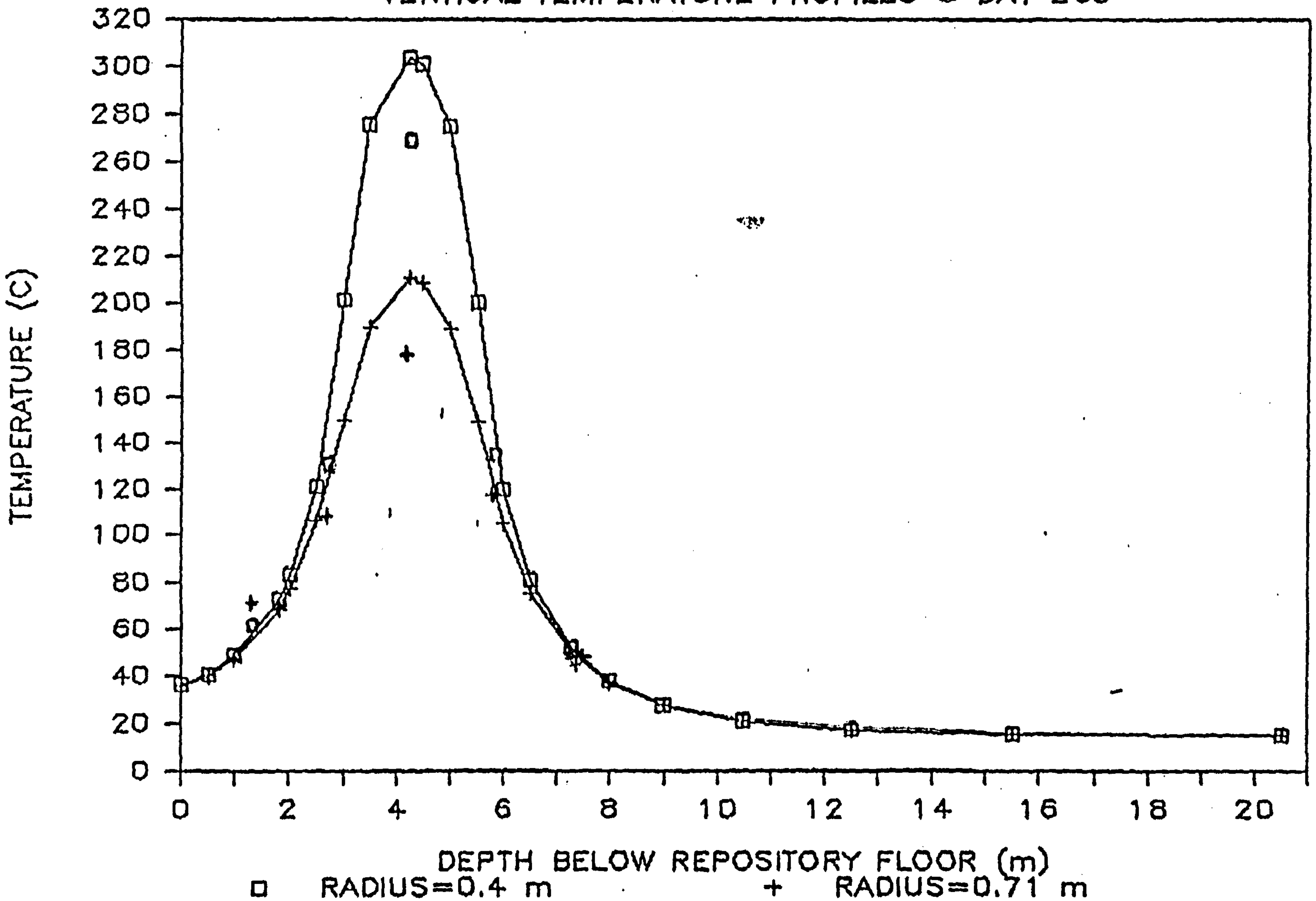


Figure 14

September 28, 1984

PROPOSED SCOPE CHANGE

TABLE 3

MATRIX OF CODE/PROBLEM COMBINATIONS
(Revised 3/12/84)

Legend:

x Benchmark Problems by Acres.
0 Benchmark Problems by Teknekron.
(1) Requires 2 runs, one for MATLOC and one for VISCOT.
(2) Two-Dimensional Analysis.

	CODES										
	ADINA - 3D	ADINAT - 3D	DOT	HEATING	MATLOC	SPECTROM-11	SPECTROM-41	VISCOT	COYOTE	SALT 4	STEALTH
2.0 THERMAL ANALYSIS CASE PROBLEMS											
2.6 Transient Temperature Analysis of an Infinite Rectangular Bar With Anisotropic Conductivity (Schneider, 1955, pp. 261)		x	x	0					x		0
2.8 Transient Temperature Response to the Quench of an Infinite Slab With a Temperature-Dependent Convection Coefficient (Kreith, 1958, pp. 161)		x		0					x		0
2.10 Steady Radiation Analysis of a Infinite Rectangular Opening (Rohsenow and Hartnett, 1973, pp. 15-32)		x		0					x		0
3.0 GEOMECHANICAL ANALYTICAL PROBLEMS											
3.2 Circular Tunnel (Long Cylindrical Hole in An Infinite Medium)											
a) Unlined in elastic medium - biaxial stress field					x						
b) Unlined in plastic medium (Tresca) von Mises	x							x			0
3.3 Thick-Walled Cylinder Subjected to Internal and/or External Pressure											
c) Plane strain - creep	x							x			
3.5 Plane Strain Compression of an Elastic-Plastic Material von Mises; Drucker, Prager	x							X			0
4.0 THERMOMECHANICAL ANALYTICAL PROBLEMS											
5.0 HYPOTHETICAL REPOSITORY DESIGN PROBLEMS											
5.1 Hypothetical Very Near Field Problem	x	x		0							
5.2 Hypothetical Near Field Problem			⊗(1)		x			X x	x	x	0
5.3 Hypothetical Far Field Problem	(2)	(2)								x	0
6.0 FIELD VALIDATION PROBLEMS											
6.1 Project Salt Vault-Thermomechanical Response Simulation Problem	(2)	(2)	x					x		x	0
6.3 In Situ Heater Test-Basalt Waste Isolation Project	(2)	(2)	⊗ x		x			X	x		0

X = New Problem

⊗ = Same Problem run again w/ Output in different format.

Figure 15