LBL-32611
UC-800

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

EARTH SCIENCES DIVISION

TOUGH Simulations of Updegraff's Set of Fluid and Heat Flow Problems

G.J. Moridis and K. Pruess

November 1992

REFERENCE COPY
Does Not
Circulate
Bldg. 50 Library.
LBL-32611
Copy 1

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. Neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California and shall not be used for advertising or product endorsement purposes.

This report has been reproduced directly
from the best available copy.

Available to DOE and DOE Contractors
from the Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, VA 22161

Lawrence Berkeley Laboratory is an equal opportunity employer.

LBL-32611

TOUGH Simulations of Updegraff's Set of Fluid and Heat Flow Problems

by

George J. Moridis and Karsten Pruess

Earth Sciences Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

November 1992

This work was supported by the Director, Office of Civilian Radioactive Waste Management, through the Waste Isolation Pilot Project (Sandia National Laboratories) and through the Yucca Mountain Site Characterization Project, under U.S. Department of Energy Contract No. DE-AC03-76SF00098.

Printed on recycled paper

ABSTRACT

The TOUGH code [*Pruess,* 1987] for two-phase flow of water, air, and heat in permeable media has been exercised on a suite of test problems originally selected and simulated by *C. D. Updegraff* [1989]. These include five *"verification"* problems for which analytical or numerical solutions are available, and three *"validation"* problems that model laboratory fluid and heat flow experiments. All problems could be run without any code modifications (*). Good and efficient numerical performance, as well as accurate results were obtained throughout. Additional code verification and validation problems from the literature are briefly summarized, and suggestions are given for proper applications of TOUGH and related codes.

(*) To model the infiltration experiment of *Vauclin et al.* [1979], the relative permeability function measured in the experiment had to be added to TOUGH.

TABLE OF CONTENTS

LIST OF FIGURES vi
LIST OF TABLES ix
1. INTRODUCTION 1
1.1 Background 1
1.2. The critique of TOUGH 1
1.3 Purpose 2
1.4 Organization and Approach 2
2. 1-D HORIZONTAL INFILTRATION (VERIFICATION PROBLEM 1) 4
2.1 Description 4
2.2 Updegraff's approach & results 4
2.3 Modification of approach and data inputs 4
2.4 Discussion of the TOUGH output from the modified input files 8
3. 1-D COUPLED HEAT AND MASS TRANSPORT (VERIFICATION PROBLEM 2) 9
3.1 Description 9
3.2 Updegraff's approach & results 9
3.3 Modification of approach and data inputs 13
3.4 Discussion of the TOUGH output from the modified input files 13
4. RADIAL HEAT TRANSPORT (VERIFICATION PROBLEM 3) 16
4.1 Description 16
4.2 Updegraff's approach & results 16
4.3 Modification of approach and data inputs 23
4.4 Discussion of the TOUGH output from the modified input files 23
5. FLOW TO A GEOTHERMAL WELL AND HEAT PIPE (VERIFICATION PROBLEMS 4&5) 31
5.1 Description 31
5.2 Updegraff's approach & results 31
6. TWO-DIMENSIONAL INFILTRATION EXPERIMENT (VALIDATION PROBLEM 1) 37
6.1 Description 37
6.2 Updegraff's approach & results 37
6.3 Modification of approach and data inputs 41
6.4 Discussion of the TOUGH output from the modified input files 42

7. CONVECTION CELL EXPERIMENT (VALIDATION PROBLEM 2) 53
7.1 Description 53
7.2 Updegraff's approach & results 53
7.3 Modification of approach and data inputs 59
7.4 Discussion of the TOUGH output from the modified input files 60
8. TWO-PHASE FLOW EXPERIMENT (VALIDATION PROBLEM 3) 66
8.1 Description 66
8.2 Updegraff's approach & results 66
8.3 Modification of approach and data inputs 69
8.4 Discussion of the TOUGH output from the modified input files 71
9. FURTHER CODE VERIFICATIONS AND VALIDATIONS 73
9.1 The MULKOM/TOUGH family of codes 73
9.2 Summary of verifications and validations 73
10. CONCLUSIONS AND DISCUSSION 75
ACKNOWLEDGEMENTS 76
REFERENCES 77
APPENDIX
Local Truncation Error in the Integral Finite Difference Method 81
REPORT DISTRIBUTION 84

LIST OF FIGURES

Figure 1. A schematic of the one-dimensional horizontal infiltration problem (from *Updegraff* [1989]). 5

Figure 2. TOUGH grid for the one-dimensional horizontal infiltration problem (from *Updegraff* [1989]). 6

Figure 3. Comparison of the analytical and the TOUGH solutions to the Verification Problem 1. 7

Figure 4. The one-dimensional heat transport problem in Verification Problem 2 (from *Updegraff* [1989]). 10

Figure 5. The TOUGH grid used by *Updegraff* [1989] in the simulation of the Verification Problem 2. 11

Figure 6. Comparison of the TOUGH and the analytical solutions using *Updegraff*'s [1989] data in Verification Problem 2. The corrected analytical solution is also shown. 12

Figure 7. Comparison of the analytical solution to the TOUGH solutions in Verification Problem 2. 14

Figure 8. The radial heat transport problem in Verification Problem 2 (from *Updegraff* [1989]). 17

Figure 9. The TOUGH grid used by *Updegraff* [1989] in the simulation of the Verification Problem 3. 18

Figure 10. The TOUGH solution reported by *Updegraff* [1989] in the simulation of the Verification Problem 3. 20

Figure 11. The NORIA solution reported by *Updegraff* [1989] in the simulation of the Verification Problem 3. 21

Figure 12. The PETROS solution reported by *Updegraff* [1989] in the simulation of the Verification Problem 3. 22

Figure 13. Comparison of the TOUGH and the analytical solutions using *Updegraff*'s [1989] data in Verification Problem 3. The corrected analytical solution is also shown. 25

Figure 14. Comparison of the analytical and the TOUGH solutions at $t = 10^6$ *sec.* 27

Figure 15. Comparison of the analytical and the TOUGH solutions at $t = 10^9$ *sec.* 28

Figure 16. The analytical and numerical similarity solutions to the Verification Problem 3. 29

Figure 17. The analytical and numerical similarity solutions to the Verification Problem 3 (detail). 30
Figure 18. A schematic of the radial boiling front problem (from *Updegraff* [1989]). 32
Figure 19. A schematic of the heat pipe problem (from *Updegraff* [1989]). 33
Figure 20. Comparison of the TOUGH and the Garg [1980] solutions for the Verification Problem 4 (from *Updegraff* [1989]). 34
Figure 21. Comparison of the TOUGH and the *Udell and Fitch* [1985] steady-state solutions for the Verification Problem 5 (from *Updegraff* [1989]). 35
Figure 22. The two-dimensional infiltration system in Validation Problem 1 (from *Updegraff* [1989]). 38
Figure 23. TOUGH grid used by Updegraff for the simulation of Validation Problem 1 (from *Updegraff* [1989]). 39
Figure 24(a). TOUGH predictions and experimental measurements at $x = 0.19\ m$ in Validation Problem 1. 43
Figure 24(b). TOUGH predictions and experimental measurements at $x = 0.49\ m$ in Validation Problem 1. 44
Figure 24(c). TOUGH predictions and experimental measurements at $x = 0.79\ m$ in Validation Problem 1. 45
Figure 24(d). TOUGH predictions and experimental measurements at $x = 1.09\ m$ in Validation Problem 1. 46
Figure 24(e). TOUGH predictions and experimental measurements at $x = 1.39\ m$ in Validation Problem 1. 47
Figure 24(f). TOUGH predictions and experimental measurements at $x = 1.69\ m$ in Validation Problem 1. 48
Figure 24(g). TOUGH predictions and experimental measurements at $x = 1.99\ m$ in Validation Problem 1. 49
Figure 25. Comparison of TOUGH predictions and experimental data of water pressure in Validation Problem 1. 51
Figure 26. Schematic of the convection cell apparatus (from *Reda* [1984]). 54
Figure 27. The convection cell experiment in Validation Problem 2 (from *Updegraff* [1989]). 55
Figure 28. The TOUGH grid used by Updegraff in the simulation of Validation Problem 2 (from *Updegraff* [1989]). 56

Figure 29. Comparison of Updegraff's TOUGH results with experimental data in Validation Problem 2 (from *Updegraff* [1989]) 57
Figure 30(a). Comparison of TOUGH predictions with experimental data at the heater bottom ($z/\Delta r = 2$) and top ($z/\Delta r = 3$). The bars attached to the TOUGH curves indicate the predicted temperature in the first radial element (i.e. on the surface of the heating element). 62
Figure 30(b). Comparison of TOUGH predictions with experimental data at $z/\Delta r = 3.5$ and $z/\Delta r = 3.75$. 63
Figure 31. Temperature sensitivity to z at the heater bottom ($z/\Delta r = 2$) and top ($z/\Delta r = 3$). 65
Figure 32. A schematic of the two-phase flow problem (Validation Problem 3, from *Updegraff* [1989]). 67
Figure 33. TOUGH grid used by Updegraff for the simulation of Validation Problem 3 (from *Updegraff* [1989]) 68
Figure 34. Comparison of TOUGH predictions and experimental data in Validation Problem 3 72
Figure 35. A flow domain V with sub-domain Vn. 83
Figure 36. One-dimensional block-centered grid. 83

LIST OF TABLES

TABLE 1. Grid discretization for the TOUGH simulation of Verification Problem 3. 24
TABLE 2. Specifications of the refined 2-D *x-z* grid in Validation Problem 1. 42
TABLE 3. Specifications of the refined 2-d *r-z* grid in Validation Problem 2. 59

1. INTRODUCTION

1.1 Background

Under the sponsorship of the U.S. Nuclear Regulatory Commission, Sandia National Laboratories (SNL) is developing a performance assessment methodology for the analysis of long-term disposal of High-level Radioactive Waste (HRW) in unsaturated welded tuff (the only potential host rock presently under consideration by the U.S. Department of Energy). As part of this effort, a comparison study of three simulation codes modeling strongly coupled mass and heat flow in unsaturated porous media was conducted [*Updegraff and Bonano,* 1988; *Updegraff,* 1989].

The three codes evaluated were: (a) TOUGH, developed by *Pruess* [1987] at Lawrence Berkeley Laboratory (LBL); (b) NORIA, developed by *Bixler* [1985] at SNL; and (c) PETROS, developed by *Hadley* [1985] at SNL. These codes were tested against one- and two-dimensional flow problems for which analytical solutions, numerical solutions or experimental results are available. The problems were selected to test the capabilities of the codes for a wide variety of flow problems representing different levels of complexity and numerical difficulty, ranging from simple, uncoupled processes (such as one-dimensional infiltration) to strongly coupled processes (such as two-dimensional heat-driven flow and vaporization).

The SNL report [*Updegraff,* 1989] stated that all three codes were cumbersome to use because of limitations in the selection of time-step size, the treatment of boundary conditions, and the handling of evaporation and condensation. The report remarked that *"...each code exhibits one weakness or another, whether it be boundary conditions (TOUGH, PETROS), core storage (TOUGH), or computational time (NORIA). In addition, none of the codes can directly handle fractures, a feature of welded tuff formations."* Based on these conclusions, *Updegraff* [1989] recommended that a new code be developed combining the strengths of each of the tested codes without suffering from their individual weaknesses.

1.2. The critique of TOUGH

In his final review of the performance of TOUGH, *Updegraff* [1989] concluded that:

(a) TOUGH was capable of solving most of the problems, produced some type of solution in all cases, and was ranked as the best of the three codes tested.

(b) The problems in which TOUGH produced an erroneous solution were characterized by an inability to converge on the dependent variables, resulting in extremely small time-steps and (consequently) long execution times and inefficient runs. In such cases the simulation period was cut short.

(c) It exhibited significant numerical dispersion in heat transport problems.

(d) It had large core storage requirements.

(e) The execution time requirements covered a wide range.

(f) The available options for the treatment of boundary conditions in TOUGH were inadequate, and may limit the range of applications of the code. This was considered as "TOUGH's greatest weakness".

(g) The type of data inputs required by TOUGH make its use cumbersome, especially in multi-dimensional simulations. On the other hand, this formulation is an asset since it allows complete flexibility and a seamless application in one-, two-, or three-dimensional problems.

(h) TOUGH solves three strongly non-linear Partial Differential Equations (PDE's) where the dependent variables are the gas or liquid phase pressure, air mass fraction, and temperature. However, its does not account for Knudsen diffusion or thermodiffusion which may be important in welded tuffs.

(i) Faster and less memory-intensive matrix solvers (such as conjugate gradients) are needed.

1.3 Purpose

The purpose of this study is to address the issues raised by *Updegraff* [1989] in the SNL Report. We demonstrate that:

(a) The difficulties encountered and described by *Updegraff* [1989] can be overcome by careful consideration of the physical processes modeled. Close attention must be paid to issues of space and time discretization, interface weighting procedures, and implementation of boundary conditions.

(b) TOUGH is capable of handling all the test problems and obtaining correct answers by suitable preparation of input data, without any code modification.

(c) In all test problems TOUGH produces very efficient runs (in terms of number of time steps) which cover the entire desired simulation periods.

Moreover, by re-examining Updegraff's test problems we hope to demonstrate a set of sound simulation principles and practices to be used in the application of TOUGH. We also give a brief summary of verification and validation problems which have been presented in the literature for the MULKOM/TOUGH family of numerical simulation programs.

1.4 Organization and Approach

All the test problems examined in the SNL study are re-investigated. These problems include five verification problems (for which either analytical or numerical solutions exist) and three validation problems (for which experimental results are available). Verification is shown by the proximity of the TOUGH-produced solutions to the known analytical and/or numerical solution. Validation is indicated by the ability of the TOUGH solutions to reproduce experimentally observed data. All calculations reported here were performed on an IBM RS/6000 workstation using double-precision (64-bit) arithmetic.

The review and discussion of each of the eight test problems occupies the next seven sections, in each of which the following approach is used:

(a) A short description of the problem is presented.

(b) The inputs and approach used by *Updegraff* [1989] are discussed, making use of a complete set of Updegraff's TOUGH input files that were supplied for this purpose by S. Webb(*) of Sandia National Laboratories. Using the *Updegraff* [1989] input data, a TOUGH run is made to attempt to reproduce his results and use it as a reference.

(c) The necessary changes (if any) to the data inputs and approach are listed and explained.

(d) TOUGH is run using the new/modified input data set. The new simulation results are discussed, and, where appropriate, relevant comments of *Updegraff*'s [1989] are addressed.

A computer diskette (PC type of format) with all the input files used in our simulations is included in this report. To make the input files more easily readable we have added column counters to the keywords. We also use the single-record data block "START" as a convenient means for providing informal comments. An explanation of the files and their content is found in the text file "ReadMe" also included in the same disk. These input files can serve as references and as building blocks for other TOUGH applications. The diskette also includes a listing of subroutine RELP of TOUGH with the *Vauclin* [1979] relative permeability function added.

(*) Stephen Webb (private communication to the authors) indicated that several of the input files originally given to him by D. Updegraff did not reproduce the results in *Updegraff* [1989]. S. Webb then obtained the original TOUGH outputs from D. Updegraff, and made an effort to modify the input files to reproduce those outputs. It is these modified files that formed the starting point for the present study.

2. 1-D HORIZONTAL INFILTRATION (VERIFICATION PROBLEM 1)

2.1 Description

The first test problem was a horizontal infiltration problem originally solved by *Philip* [1955]. The problem was described by *Ross et al.* [1982], and was featured as Sample Problem No. 2 in the TOUGH User's Guide [*Pruess,* 1987]. A semi-infinite horizontal tube filled with a homogeneous soil is partially saturated with water. The soil porosity is $\phi = 0.45$, and the initial moisture content is $\theta = 0.2$, corresponding to a liquid saturation of $S = \theta/\phi = 0.44$. The liquid saturation at the $x=0$ boundary is held constant at $S = 1$ for $t > 0$. Due to a capillary pressure differential, water infiltrates into the horizontal system. Air is considered a passive phase, and its effects are neglected. A schematic of the problem along with pertinent information on the properties of the porous medium appears in Figure 1.

TOUGH predictions are obtained for $t = 864$ *sec*, $t = 5184$ *sec*, and $t = 9504$ *sec*, at which *Ross et al.* [1982] specify exact solutions. The simulated length was limited to $L = 0.2$ *m* because the solution of *Philip* [1955] indicated that it is sufficient to produce a semi-infinite behavior.

2.2 Updegraff's approach & results

Figure 2 shows the space discretization used by *Updegraff* [1989]. The second row of gridblocks (R1 to R40) was used to allow for gas escape, thus avoiding pressure buildup and deviation from the conditions of a passive air phase assumed in the development of the analytical solution. A very large volume ($5.0x10^{50}$ m^3) was assigned to the element LB1, thus maintaining stable its initial liquid saturation $S = 1$.

The input file supplied by S. Webb is essentially identical to the input file for sample problem 2 from the TOUGH report [*Pruess*, 1987]. Results of the run (using the original input data set) for $t = 864$ *sec*, 5184 *sec*, and 9504 *sec* are shown in Figure 3. This run duplicated Updegraff's solution and confirmed his observations that (a) a very good agreement with the exact solution is observed for a saturation $S > 0.7$, (b) below this limit the simulation results exceed the exact solution by less than 5%, and (c) in general a good agreement between the numerical and analytical solutions exists.

2.3 Modification of approach and data inputs

We created two modified data sets. The first modification involved the removal of the second row of gridblocks (R1 to R40), thus reducing the size of the problem by 50%. This action was prompted by the expectation that the desired constant air pressure could be approximated without special "guard" blocks. Everything else remained as in the original Updegraff file, in which an option MOP(11) = 0 was used (signifying an upstream weighting of mobilities, permeabilities, and thermal properties).

The second modified data set differed from the first in the value of MOP(11), which was 1 in this case. This indicates a midpoint weighting, and has some interesting implications. From the strict point of view of error analysis, midpoint weighting is $O(\Delta x^2)$ and $O(\Delta t)$ accurate, and thus seemingly superior to the upstream weighting scheme which is only $O(\Delta x)$ and $O(\Delta t)$ accurate. However, this apparent superiority is not unconditional, and if the midpoint weighting scheme is not used judiciously, it may produce solutions

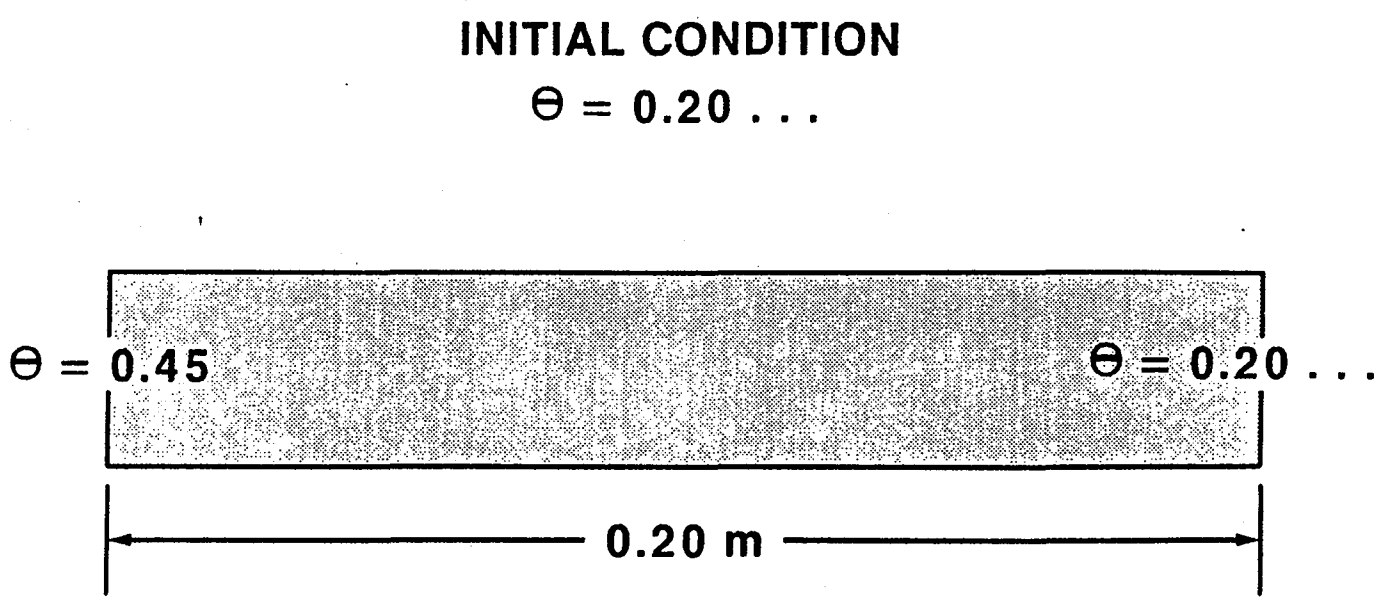

Figure 1. A schematic of the one-dimensional horizontal infiltration problem (from *Updegraff* [1989]).

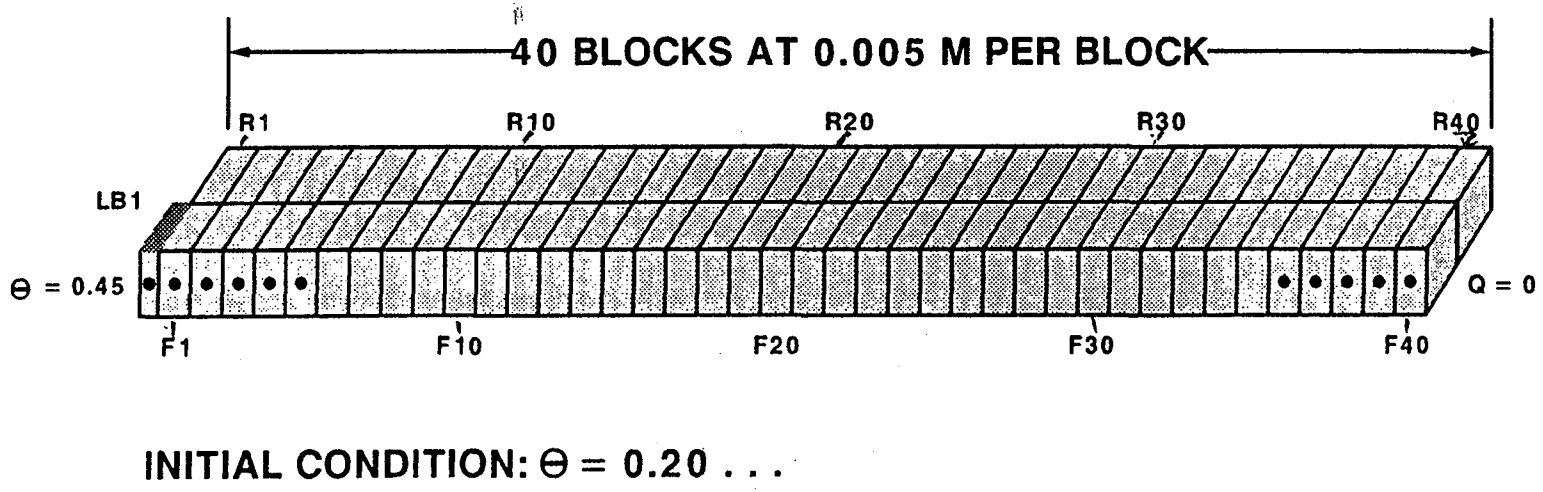

Figure 2. TOUGH grid for the one-dimensional horizontal infiltration problem (from *Updegraff* [1989]).

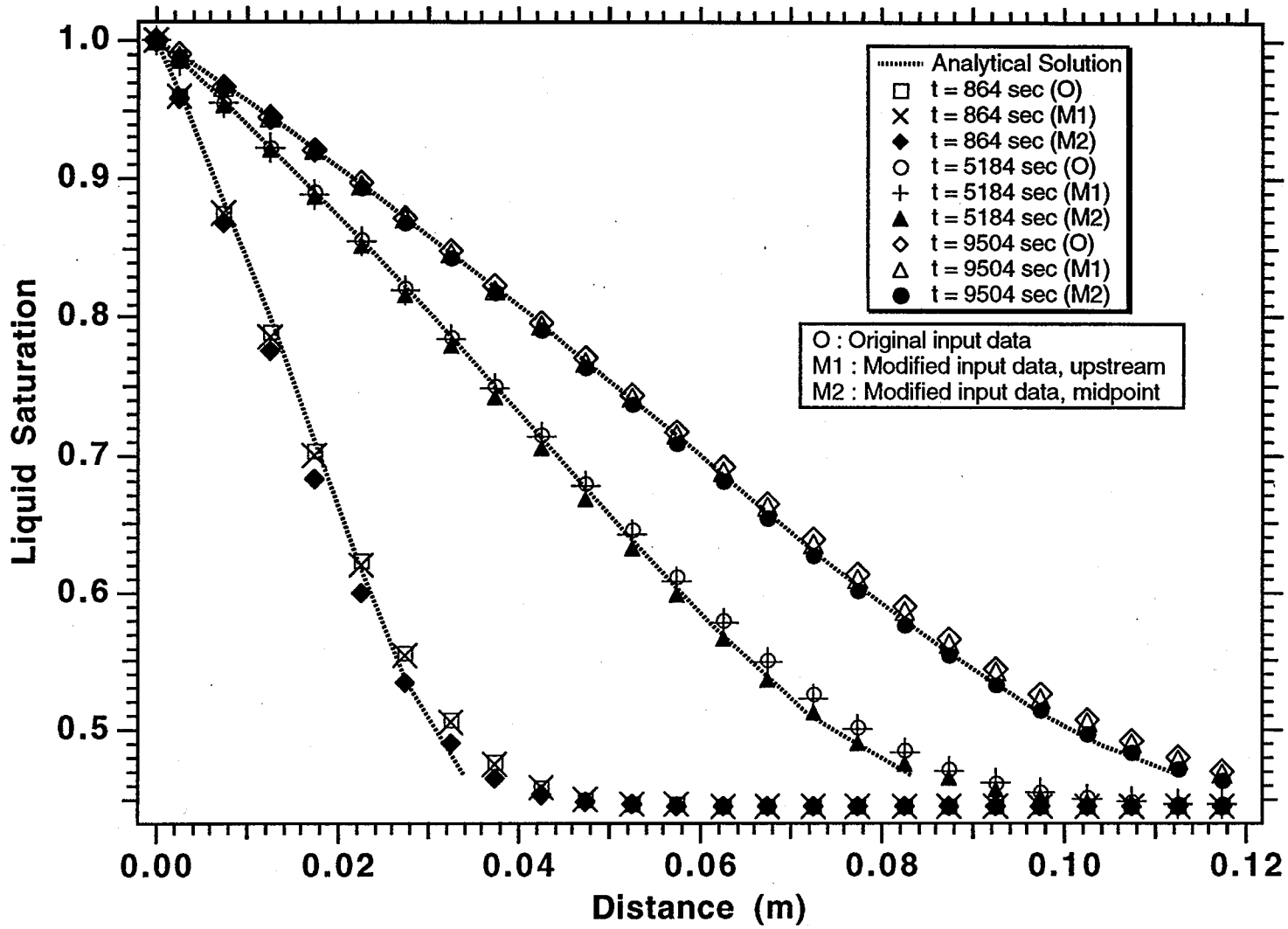

Figure 3. Comparison of the analytical and the TOUGH solutions to the Verification Problem 1.

which may be mathematically correct but physically unrealistic. These potential problems stem from the fact that the unconstrained implementation of such a scheme may violate the second law of thermodynamics by allowing mass and energy to flow from a lower to a higher level. When certain conditions of monotonicity [*vanLeer,* 1977] are met, the midpoint scheme can be used and results in a more accurate solution. The verification problem under investigation meets strict monotonicity criteria (with a maximum $S = 1$ at $x = 0$ and monotonously decreasing saturations with increasing x), and as such is ideally suited to the implementation of a midpoint weighting scheme. Caution should always be exercised when such a scheme is used in two dimensional systems (especially in cases with strong curvature of the flow lines). While the midpoint weighting scheme is more accurate, the upstream weighting scheme is far more robust, enables the simulation of complex mass and energy flow patterns without violating the second law of thermodynamics, and should be always preferred unless the monotonicity of the problem under consideration is indisputable.

2.4 Discussion of the TOUGH output from the modified input files

The results of the TOUGH simulation obtained with the two modified data files are also shown in Figure 3. Each of the three runs required 28 time steps to reach the maximum simulation time of $t_{max} = 9504\ sec$. It can be seen that:

(a) The elimination of the second row of gridblocks (and the corresponding reduction of the size of the problem by half) does not adversely affect the solutions.

(b) The use of the midpoint weighting scheme in the second modified input file further improves the accuracy of the solution, providing an excellent match for larger times. This eliminates the discrepancy of less than 5% mentioned by Updegraff. At $t = 864\ sec$ this solution lags slightly behind the other solutions, but is always more accurate near the tail end of the saturation curve.

(c) All three numerical solutions indicate an efficient simulation (in terms of time steps required to reach t_{max}) and provide an excellent agreement with the exact solution.

3. 1-D COUPLED HEAT AND MASS TRANSPORT (VERIFICATION PROBLEM 2)

3.1 Description

The analytical solution to the second verification problem of one-dimensional heat and mass transport was developed by *Avdonin* [1964]. A description of the problem and a solution were presented by *Ross et al.* [1982]. Cold water is injected into a semi-infinite, high-temperature aquifer at a specified constant mass flow rate. The overburden and underburden are impermeable to mass and heat flow, acting as no-flow and adiabatic boundaries and reducing the equation governing heat transport to that of convection-diffusion. A schematic of the problem along with other pertinent information appears in Figure 4.

The TOUGH predictions are compared to the analytical solution at $t = t_{max} = 130{,}000\ sec$ after the initiation of the cold water injection. The simulated length used by Updegraff was $L = 50\ m$ because previous modeling studies [*Ward et al.,* 1984] had demonstrated that this length suffices to approximate the semi-infinite behavior of the aquifer.

3.2 Updegraff's approach & results

Figure 5 shows the space discretization used by *Updegraff* [1989]. It consisted of 500 equally spaced gridblocks, and two boundary gridblocks. The space and time discretization were based on criteria established by *Reeves et al.* [1986]. A very large volume ($10^{50}\ m^3$) was assigned to the boundary gridblocks LB1 and RB1, thus ensuring constant boundary pressures and temperatures during the simulation. An initial pressure distribution varying linearly between $5.05x10^6\ Pa$ (at the left-hand boundary) and $5.0x10^6\ Pa$ (at the right-hand boundary) was imposed on the gridblocks of the simulated domain. Instead of direct injection into the gridblock at $x = 0$, the prescribed pressure differential on the boundaries created an influx which resulted in an equivalent system. For this flux to equal the desired injection rate of $10\ kg/sec$ at the conditions of average pressure and temperature, *Updegraff* [1989] specified a permeability of $1.74x10^{-9}\ m^2$.

Using the water property values listed in *Updegraff* [1989], application of Darcy's law between the boundaries results in a permeability of $1.7357x10^{-11}\ m^2$, i.e. two orders of magnitude lower than the reported value. This was the value used in the original data set (supplied by S. Webb), so we presumed that this discrepancy was due to a typographical error in the report. Figure 6 shows the analytical solution and the TOUGH results at $t = 1.3x10^5\ sec$ obtained using the original data set. *Updegraff* [1989] concluded that although there seems to be an agreement between the analytical and the TOUGH solutions, some numerical dispersion exists.

Examination of the report and of the input file revealed a serious problem. The water properties used in TOUGH at a pressure of $5.025x10^6\ Pa$ (the average pressure) and a temperature of $T = 165\ ^oC$ (the average temperature) are different from the ones used by Updegraff. More specifically, the water density and specific heat are $\rho_w = 905.24\ kg/m^3$ and $c_w = 4336.88\ J/kg\text{-}^oC$ respectively [*International Formulation Committee,* 1967], as opposed to the values of $\rho_w = 919\ kg/m^3$ and $c_w = 4185\ J/kg\text{-}^oC$ used by Updegraff. Although these differences are not large, they are not insignificant and have a sizable impact on the solution. The error in these inputs has three serious implications.

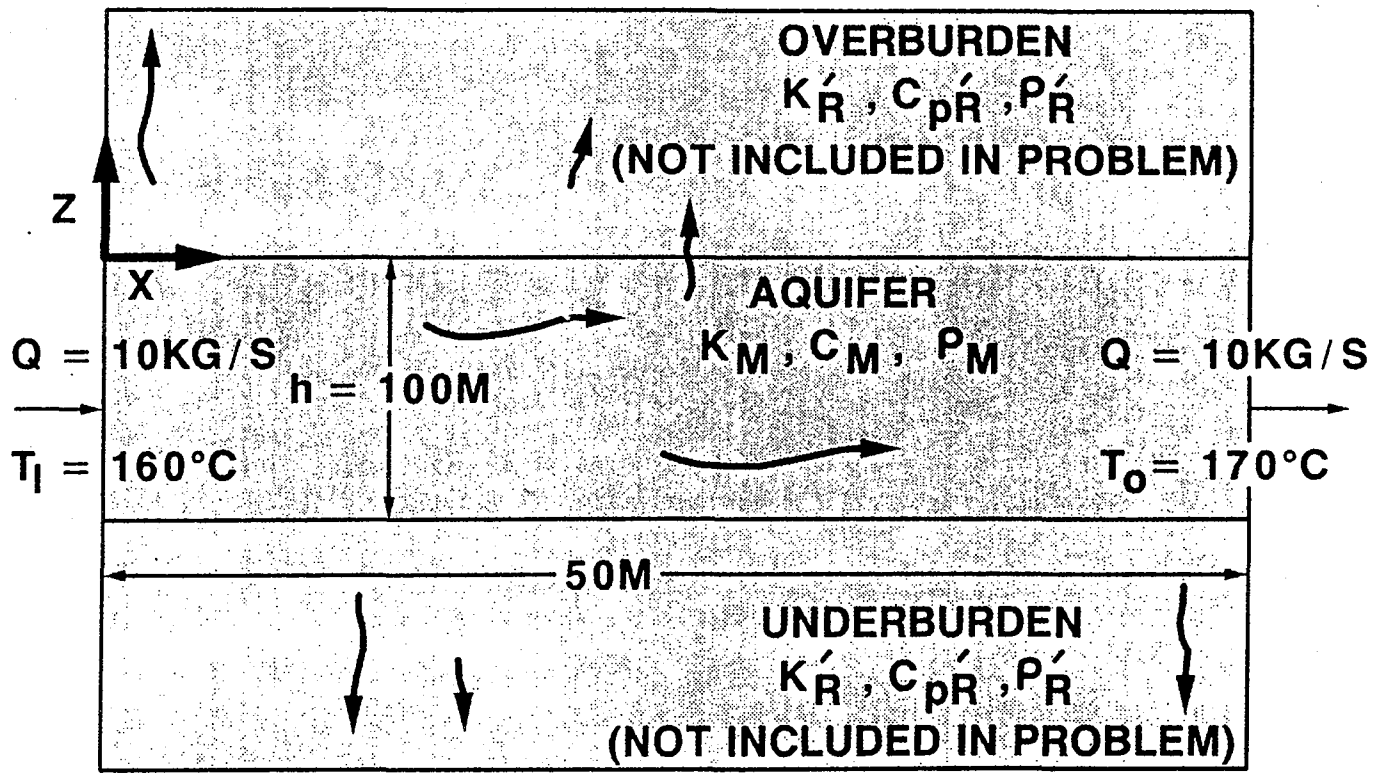

Figure 4. The one-dimensional heat transport problem in Verification Problem 2 (from *Updegraff* [1989]).

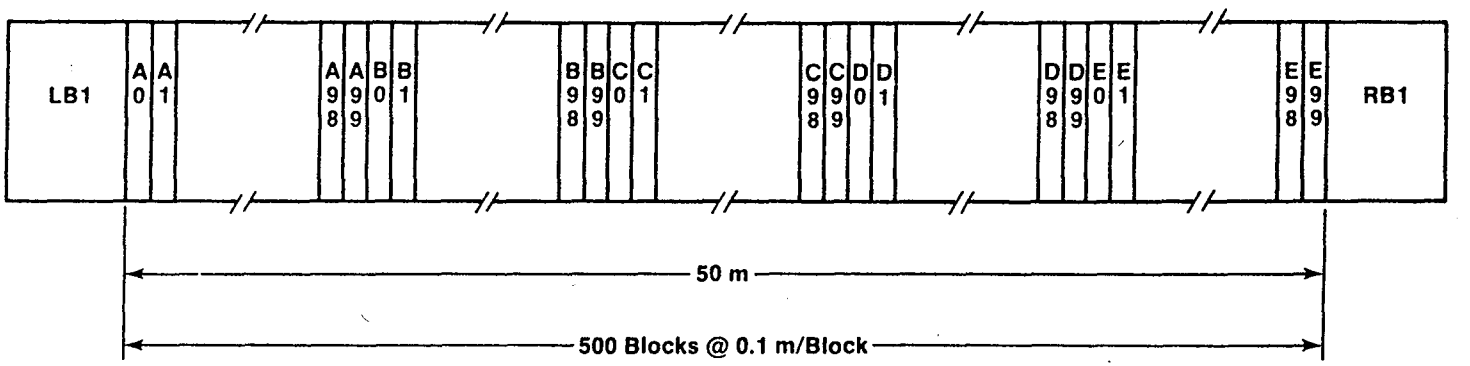

Figure 5. The TOUGH grid used by *Updegraff* [1989] in the simulation of the Verification Problem 2.

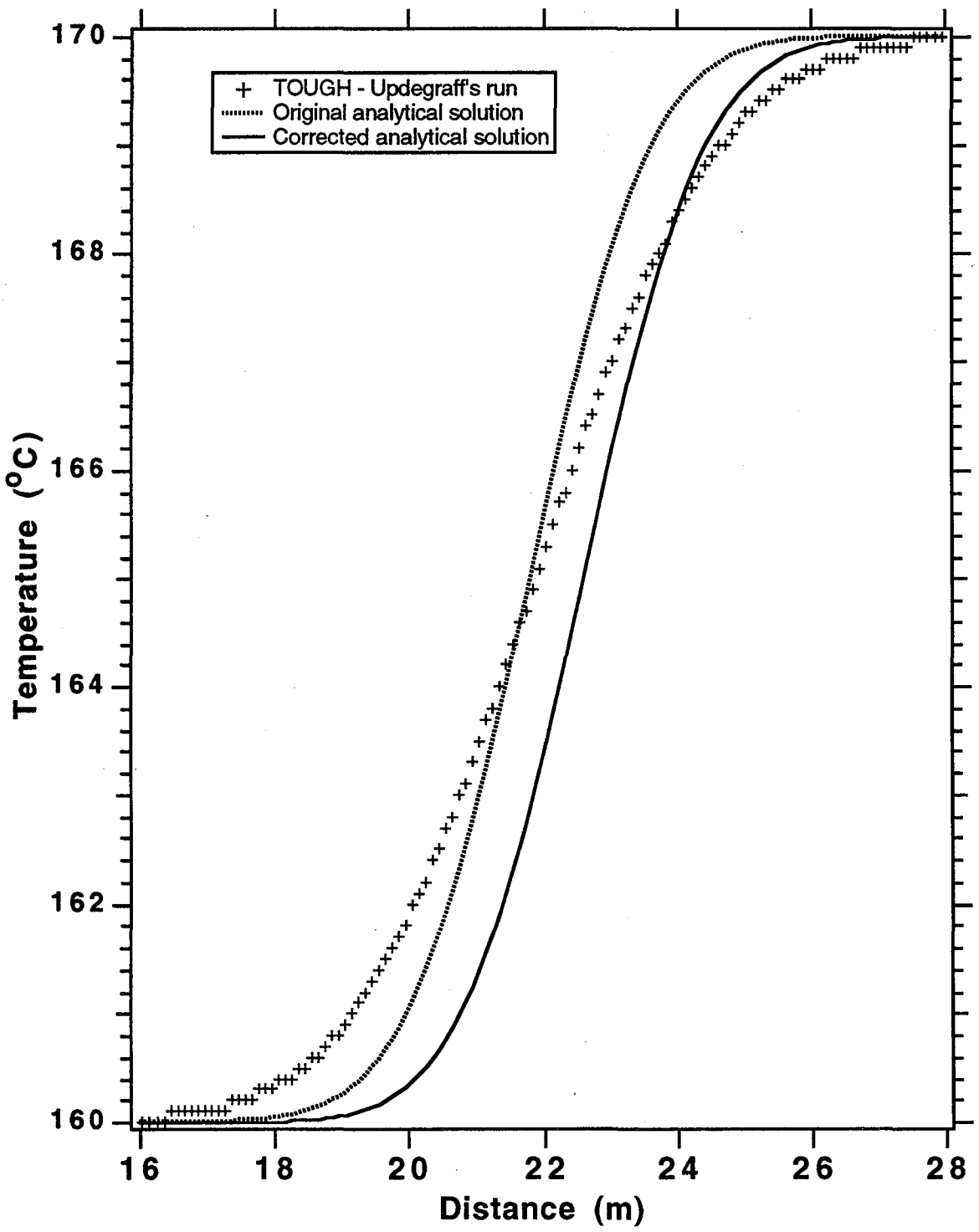

Figure 6. Comparison of the TOUGH and the analytical solutions using *Updegraff*'s [1989] data in Verification Problem 2. The corrected analytical solution is also shown.

The first implication is an erroneous analytical solution. Figure 6 shows the corrected analytical solution, in which the front has advanced about *1 m* further than predicted from the incorrect water properties. The second implication is the corresponding error in the calculation of permeability, which is calculated as $1.8138x10^{-11}\ m^2$ using the corrected water properties. The last (and potentially most important) implication is that the comparison between the original analytical solution and Updegraff's TOUGH solution may be meaningless because TOUGH uses water properties calculated internally from steam table equations [*International Formulation Committee,* 1967]. Use of incorrect property data creates a direct conflict with these "hardwired" temperature- and pressure-dependent properties, resulting in comparisons of essentially dissimilar problems.

3.3 Modification of approach and data inputs

We created three modified data sets. A grid of $L = 40\ m$ length was used in all cases, so that the problem could be run without increasing the array dimensions in TOUGH. The first modified data set involved the correction of the property values in the original data file. The value of permeability was changed to $1.8138x10^{-11}\ m^2$. The soil density and soil specific heat in the original data set ($2{,}900\ kg/m^3$ and $739.8\ J/kg\text{-}^oC$) were close to the values recalculated from given properties for full water saturation ($2{,}898.68\ kg/m^3$ and $739.35\ J/kg\text{-}^oC$). A MOP(11) = 0 was used in this data set, signifying an upstream weighting of mobilities, permeabilities, and thermal properties.

The second modified data set differed from the first in the value of MOP(11), which was 1 in this case, i.e. a midpoint weighting scheme was used. Due to the prevailing conditions of strict monotonicity (discussed in detail in section 2.3), such a weighting scheme is permissible and produces a more accurate solution. The second and third modified data set differed in the boundary conditions and the treatment of sources/sinks. Water was injected at a rate of *10 kg/sec* directly into the first gridblock, instead of imposing a rate by means of boundary pressures. An initial temperature of $160\ ^oC$ and a specific heat of $10^{40}\ J/kg\text{-}^oC$ were assigned to the first gridblock, thus effecting a constant injection of $160\ ^oC$ water. The use of direct injection eliminated the need for a large INCON data block, reducing the size of the input data file by 90%.

Strictly speaking, constant rate injection into a flow system initially at uniform pressure will result in a transient change of flow rates away from the injection point, rather than giving steady-state mass flow throughout. However, because of the large permeability ($k = 1.8138x10^{-11}\ m^2$) and the small compressibility ($c_w = 6.7x10^{-10}\ Pa^{-1}$) of liquid water, the pressure diffusivity at these conditions (a pressure of $5.05x10^6\ Pa$ and a temperature of $T = 165\ ^oC$) is very large,

$$D = k/(\phi\, \mu\, c_w) = 790\ m^2/sec$$

so that the region with practically steady flow $x \approx (Dt)^{0.5}$ expands rapidly and runs well ahead of the thermal front.

3.4 Discussion of the TOUGH output from the modified input files

The corrected analytical and the TOUGH solutions (obtained with the modified input files) appear in Figure 7. As in *Updegraff* [1989], due to the time-step constraint of

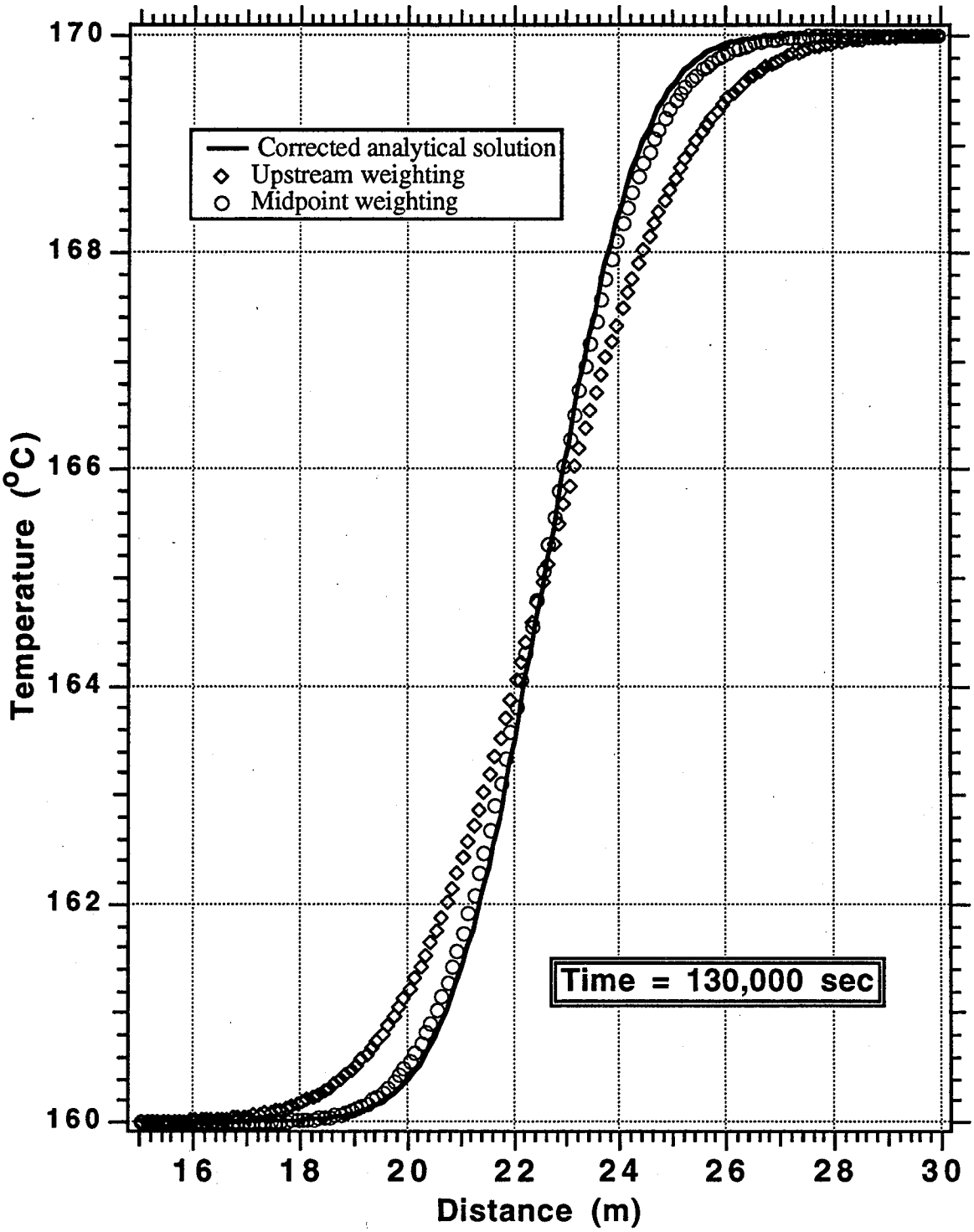

Figure 7. Comparison of the analytical solution to the TOUGH solutions in Verification Problem 2.

$\Delta t \leq 100\ sec$, the runs required 1300 time steps to reach the maximum simulation time of $t_{max} = 130{,}000\ sec$. It can be seen that:

(a) With upstream weighting, TOUGH properly predicts the midpoint of the front, but there is a certain amount of numerical dispersion which results in a broadening of the front. This broadening is due to the numerical dispersion caused by the higher truncation error of the upstream scheme (discussed in section 2.3). On the other hand, upstream weighting does not violate the second law of thermodynamics, is far more stable in more difficult situations and with longer time steps, and unless strict monotonicity criteria are satisfied, should be the preferable weighting scheme. The larger truncation error is the necessary price to pay for a far more robust numerical scheme.

As *Updegraff* [1989] indicated, a more accurate solution can be obtained using finer time and/or space discretization. However, the additional storage and execution time requirements have to be weighed against the incremental improvement in accuracy.

(b) The solution obtained using the midpoint weighting scheme (in the second modified input file) is more accurate and in excellent agreement with the analytical solution. This was expected because of the smaller truncation error of this scheme.

(c) Direct injection into the aquifer is preferable to assigning constant boundary pressures because it reduces the size of the input file by 90%.

4. RADIAL HEAT TRANSPORT (VERIFICATION PROBLEM 3)

4.1 Description

The radial heat transport in the third verification test problem was originally solved analytically by *Avdonin* [1964], and was later described by *Ross et al.* [1982]. Cold water is injected into a semi-infinite, high-temperature aquifer. This problem is very similar to the one-dimensional heat transport described in Section 3, from which it differs in the coordinate system (radial coordinates, as opposed to cartesian coordinates). The overburden and underburden are impermeable to mass and heat flow, acting as no-flow and adiabatic boundaries and reducing the equation governing heat transport to that of convection-diffusion. Figure 8 shows a diagram of the problem and other pertinent information.

The properties and conditions are as in Verification Problem 2. The radius of the aquifer is *1000 m* (sufficient to approximate the semi-infinite behavior), at which a constant temperature (equal to the initial temperature of $170\ ^oC$) is imposed. The TOUGH predictions of the temperature distribution are sought at $t = t_{max} = 10^9\ sec$ (i.e. 32 years) after the initiation of the cold water injection for comparison to the analytical solution.

4.2 Updegraff's approach & results

Updegraff [1989] discretized the space domain in 252 unequally-sized gridblocks, which included two boundary gridblocks. A schematic of this grid appears in Figure 9. The space discretization was based on an algorithm developed by *Reeves et al.* [1986] for the SWIFTII code. A very large volume ($10^{50}\ m^3$) was assigned to the boundary gridblocks IB1 and OB1, thus ensuring constant boundary pressures and temperatures during the duration of the simulation. The IB1 and OB1 boundaries were assigned pressures of $5.05x10^6\ Pa$ and $5.0x10^6\ Pa$, and temperatures of $160\ ^oC$ and $170\ ^oC$ respectively. The initial pressure distribution was determined using a logarithmic pressure function [*Updegraff*, 1989]. Instead of a direct injection, the prescribed pressure differential on the boundaries created an influx which resulted in an equivalent system. For this flux to equal the injection rate of *10 kg/sec* at the conditions of average pressure and temperature, *Updegraff* [1989] calculated a permeability of $6.36x10^{-11}\ m^2$.

Constraining the computation to ≤ 3000 time steps, *Updegraff* [1989] could only simulate the first $1.5x10^6\ sec$ of this problem. He did not elaborate whether the inability to proceed past this point was due to obviously erroneous answers or extremely small time steps (which could make further simulation impractical). Based on this performance, he concluded that TOUGH was unlikely to simulate the required period of $t_{max} = 10^9\ sec$ within a reasonable time frame, and compared the numerical and the analytical solutions at $t = 10^6\ sec$. His comparison indicated that the TOUGH solution showed limited numerical dispersion, and lagged behind the analytical solution by about 5% of the distance traveled by the front (as predicted by the analytical solution). He speculated that this discrepancy was caused by the temperature dependence of the water viscosity and density in TOUGH, which is not accounted for in the analytical solution.

Examination of the report and input file revealed a series of problems of varying significance. More specifically:

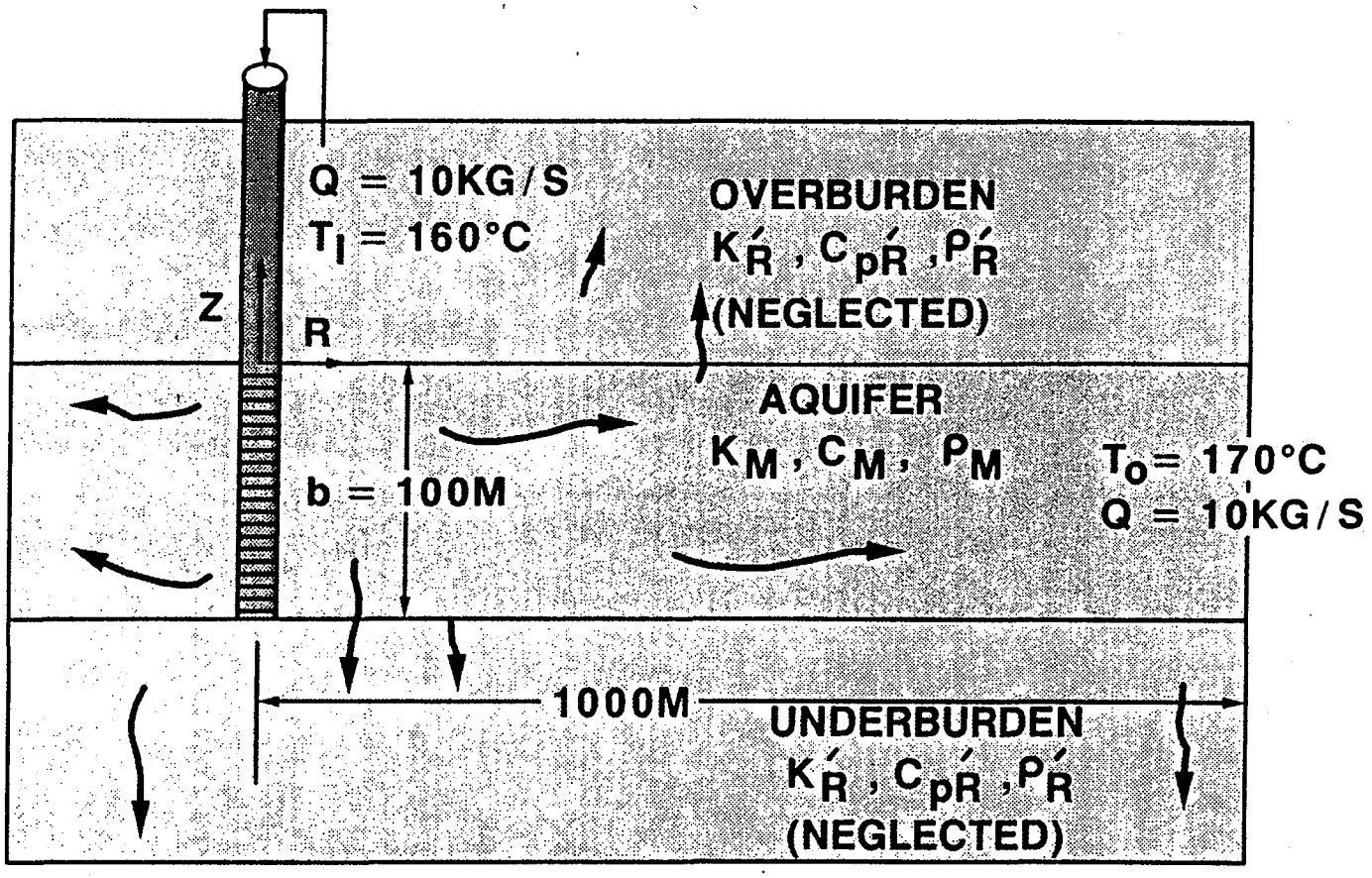

Figure 8. The radial heat transport problem in Verification Problem 2 (from *Updegraff* [1989]).

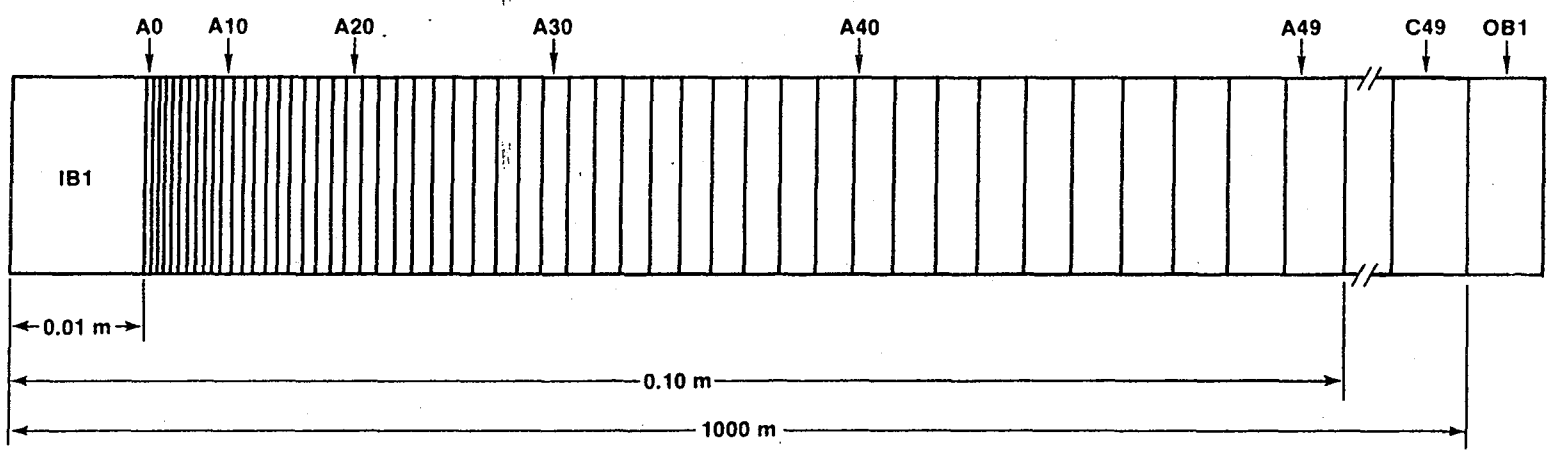

Figure 9. The TOUGH grid used by *Updegraff* [1989] in the simulation of the Verification Problem 3.

(a) A wrong permeability was listed in the report (as in the previous problem, section 3.2) Using the water property values listed in *Updegraff* [1989], application of Darcy's law between the boundaries results in a permeability of 6.499×10^{-13} m^2, i.e. two orders of magnitude lower than the reported value. The fact that the original input file (supplied by S. Webb) used a value of 6.36×10^{-13} m^2 led us to believe that this discrepancy was due to a typographical error in the report.

(b) The Updegraff report compared the performance of TOUGH, NORIA, and PETROS at $t = 10^6$ *sec* against the analytical solution (Figures 10, 11, and 12). Comparison of these graphs indicate that the analytical solution shown in the TOUGH graph (Figure 10) bears no resemblance to the analytical solution in the NORIA and PETROS graphs (Figures 11 and 12) at the same time. The obvious conclusion is that the solutions in Figure 10 do not correspond to the stated time of $t = 10^6$ *sec* but to some other unknown time, raising questions about the applicability or validity of Updegraff's observations and comments.

(c) The same discrepancy as observed in the Verification Problem 2 (subsection 3.2) between the water properties used by Updegraff and their correct values (as provided by the *International Formulation Committee* [1967] incorporated in TOUGH) exists in the Verification Problem 3. The water density and specific heat at the average pressure of 5.025×10^6 *Pa* and the average temperature of $T = 165\ ^oC$ are $\rho_w = 905.24\ kg/m^3$ and $c_w = 4336.88\ J/kg\text{-}^oC$ respectively, as compared to values of $\rho_w = 919\ kg/m^3$ and $c_w = 4185\ J/kg\text{-}^oC$ used by Updegraff. The corrected permeability is then calculated as $6.6646 \times 10^{-13}\ m^2$.

These differences have a significant impact on the solution and the results drawn thereof for the same reasons as discussed in detail in the subsection 3.2 of the Verification Problem 2. More specifically, these inaccurate data (i) produce an incorrect analytical solution and thus an unreliable reference basis, (ii) result in an incorrect calculation of the permeability and in accordingly inaccurate determination of the front position in the numerical predictions, and (iii) are likely to cause a conflict with the correct water property data "hardwired" in TOUGH and thus undermine the validity of any conclusions (since they are inevitably based on essentially dissimilar problem specifications).

(d) A serious problem was detected in the space discretization of the radial direction r. The first $0.09\ m$ immediately next to the well bore (i.e. the region between $r = 0.01\ m$ and $r = 0.10\ m$) was discretized into 50 gridblocks, all of which had Δr's in the 10^{-4} to 10^{-2} m range.

Such a fine discretization can produce severe loss of accuracy when calculating interblock flows from small differences in the pressure of adjacent gridblocks, and it increases the size of the system of linear equations to be solved. This approach makes the numerical aspects of the problem unnecessarily difficult, without resolving additional physics.

In an effort to duplicate Updegraff's results we made a single run using the original data input file supplied by S. Webb. Figure 13 shows the simulation results from this TOUGH run, the analytical solution based on the water properties used by *Updegraff* [1989], as well as the corrected analytical solution.

Because the TOUGH solution reported by *Updegraff* [1989] could not be used as a basis of reference for the aforementioned reasons, there is no certainty that this run reproduced his observations if the maximum time he was capable of simulating was indeed

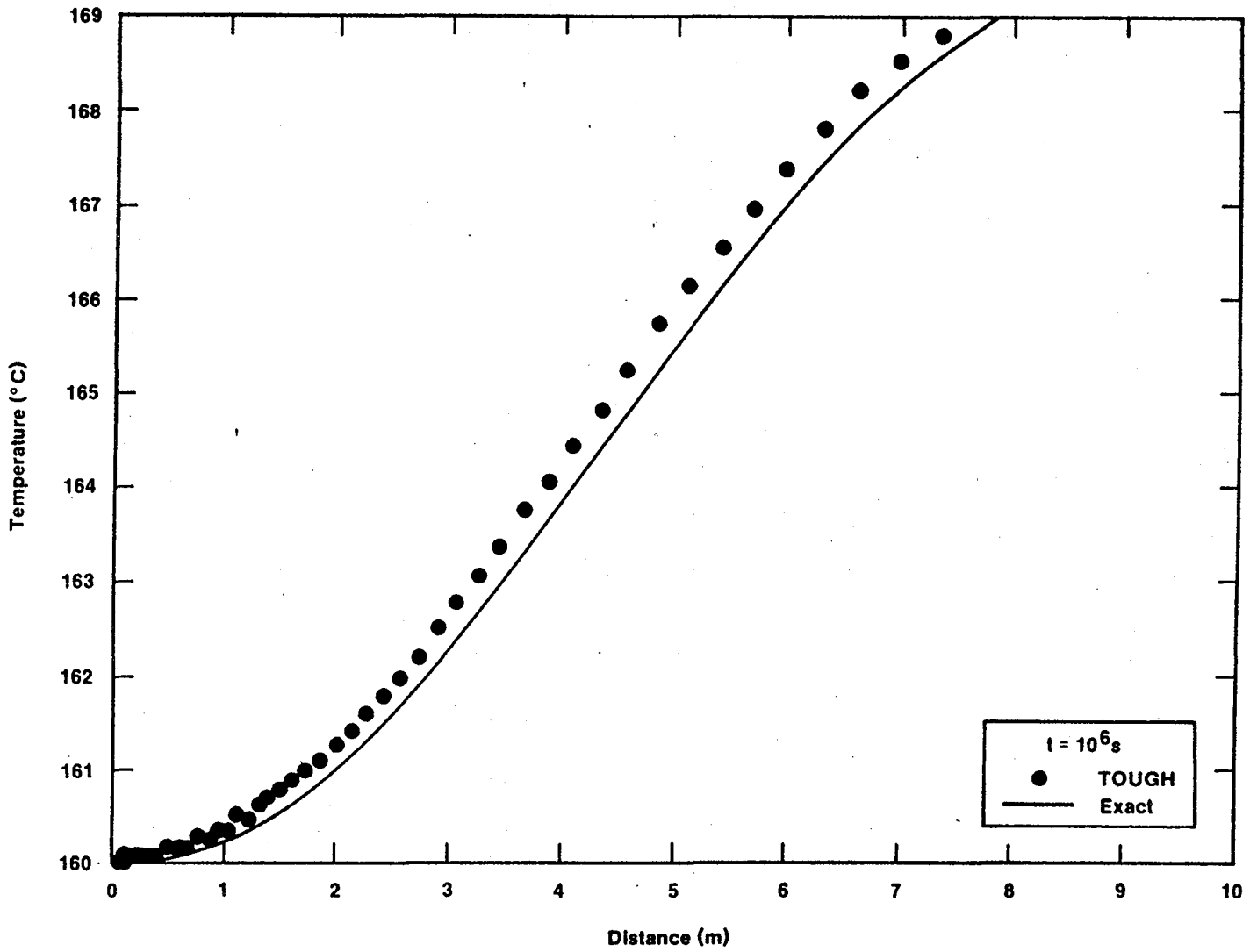

Figure 10. The TOUGH solution reported by *Updegraff* [1989] in the simulation of the Verification Problem 3.

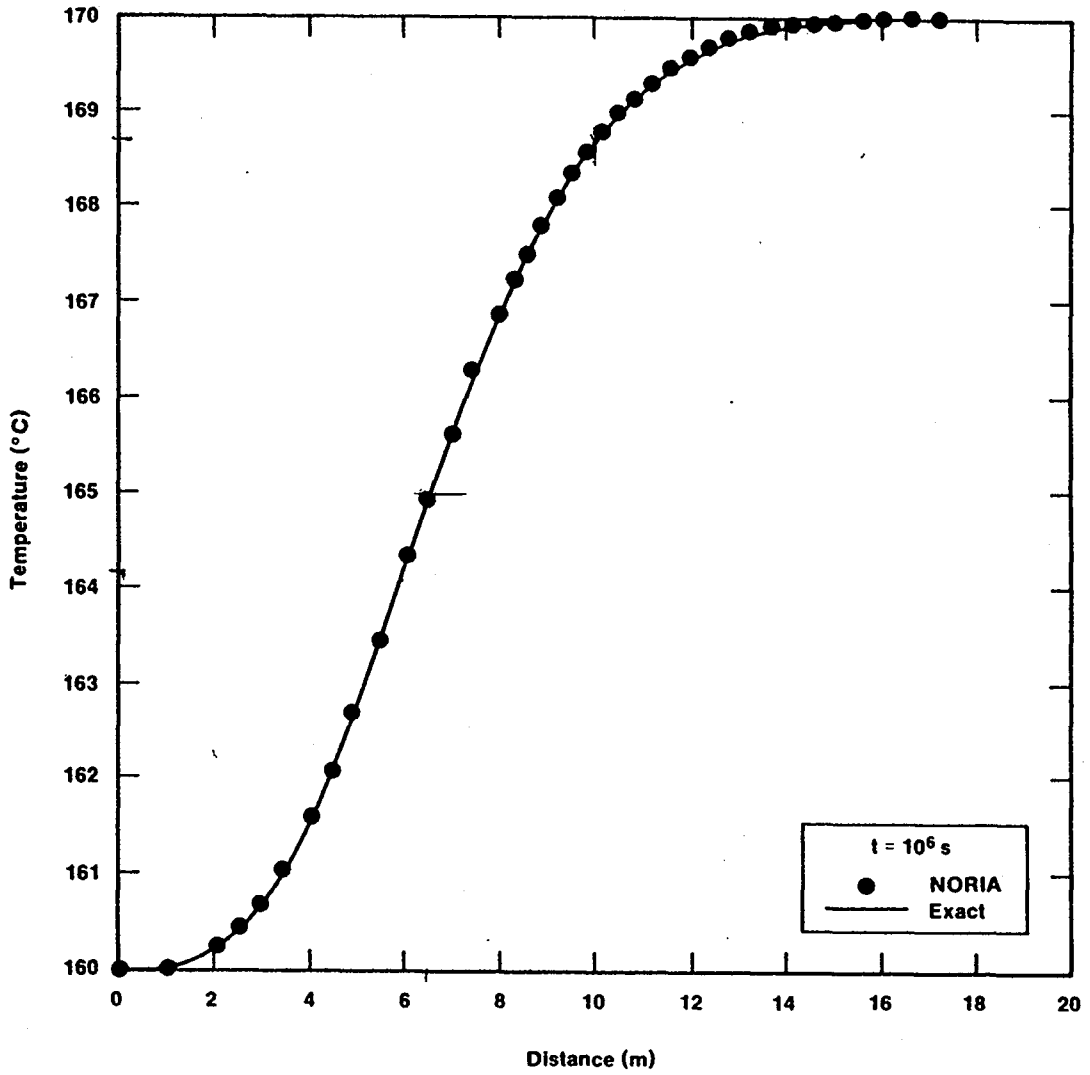

Figure 11. The NORIA solution reported by *Updegraff* [1989] in the simulation of the Verification Problem 3.

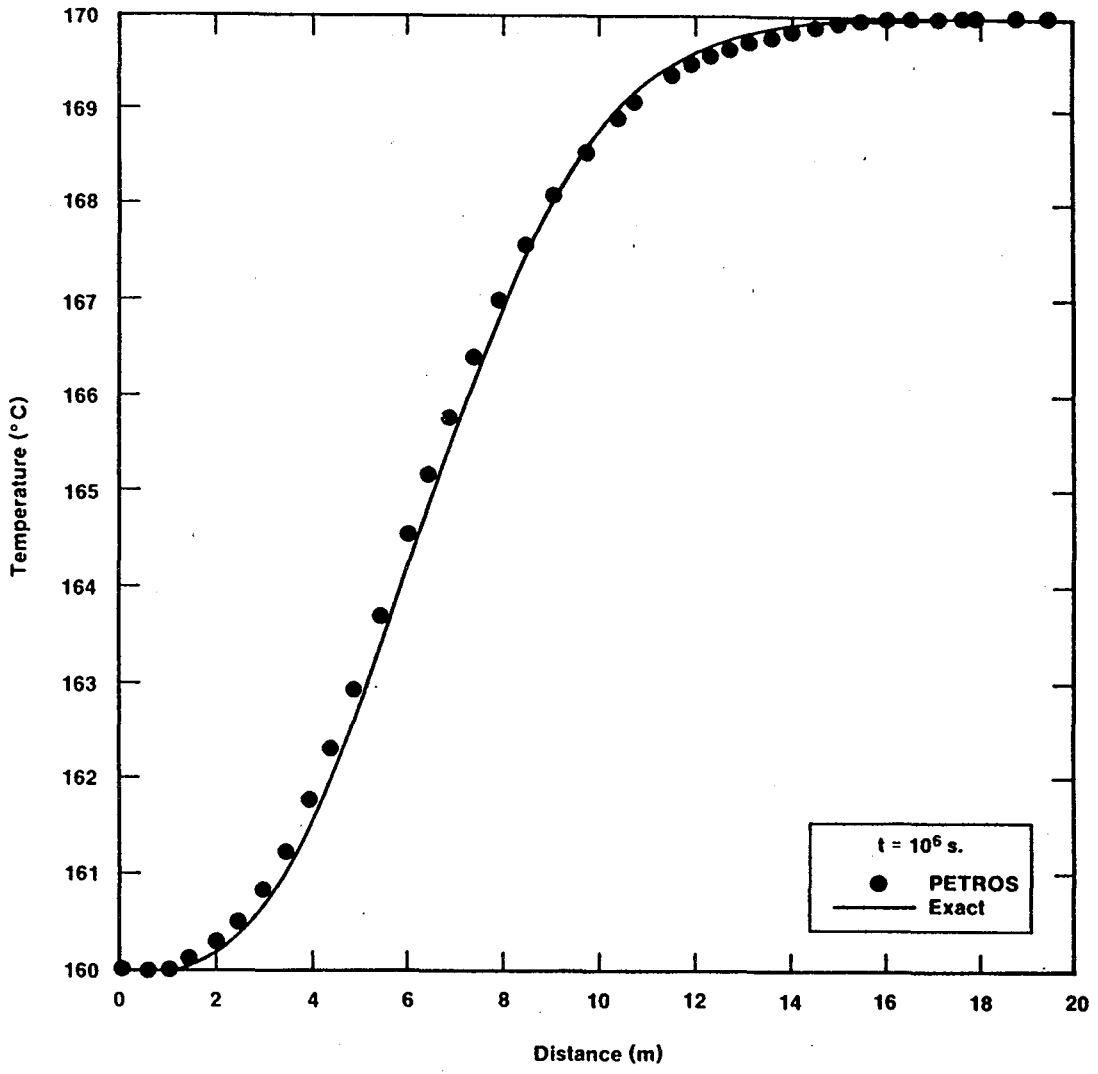

Figure 12. The PETROS solution reported by *Updegraff* [1989] in the simulation of the Verification Problem 3.

$1.5x10^6$ *sec*. Our run proceeded smoothly until a $t = 1.5886x10^8$ *sec*, exceeding Updegraff's reported time by a factor of 100. The cause of the inability to reach the desired observation time of $t_{max} = 10^9$ *sec* was traced to the shortcomings of the exceedingly fine space discretization (described in detail above). After $t = 1.5886x10^8$ *sec* convergence is obtained at unchanged primary variables (ITER = 1), resulting in an advancement of time without a corresponding advancement of the front and a numerical solution lagging behind the correct solution.

4.3 Modification of approach and data inputs

We evaluated the ability of TOUGH to yield an accurate solution at two times: $t = 10^6$ *sec* (used for comparisons by Updegraff) and $t = t_{max} = 10^9$ *sec* (specified by the problem). Four very similar data sets were created for the purpose, all of which shared the same space discretization. The number of gridblocks was reduced from 252 in *Updegraff* [1989] to 127, which considerably decreased the execution time. Table 1 lists the specifications of the refined grid, which for simplicity and convenience was generated with the MESHMAKER facility built into the TOUGH2 code [*Pruess*, 1991]. A very large volume (10^{38} m^3) was assigned to the single boundary gridblock in the radial direction (127th), thus ensuring constant boundary pressures and temperatures during the duration of the simulation.

As discussed in the previous problem, water at a temperature of $160\ ^oC$ and a rate of *10 kg/sec* is injected directly into the first gridblock located next to the wellbore. We believe that this is a markedly better approach than creating influx in response to boundary pressure differentials because it is more physically correct, less cumbersome to implement, and significantly simplifies and reduces the size of the input file. With flow rate directly specified through a mass source, the problem becomes insensitive to the precise value of permeability; we used a value of $k = 6.6646x10^{-13}\ m^2$. The soil density and soil specific heat were the same as in the Verification Problem 2 (*2,898.68* kg/m^3 and *739.35* $J/kg^o\text{-}C$).

The first two input files were used to simulate the desired period of 10^9 *sec*. They only differed in the value of MOP(11) (= 0 in the first and 1 in the second), and returned numerical solutions using both an upstream (preferable) and the midpoint (allowed due to strict monotonicity) weighting schemes. The maximum allowed time step size in both files was $\Delta t = 10^6$ *sec*, i.e. 1/1000th of the maximum.

The third and fourth input files were necessitated by the realization that the simulation time of 10^6 sec (at which comparisons of the numerical and analytical solutions are to be made) is reached after only 27 time steps (as opposed to the 3000 reported by Updegraff) in the first two runs. Such a time discretization is perfectly acceptable for the solution at 10^9 *sec*, but is coarse and provides an insufficiently detailed solution at 10^6 *sec*. Therefore, the third and fourth input files were created, differing from the first and second in the maximum simulation time (10^6 *sec*) and the maximum allowable Δt (10^3 *sec*, i.e. 1/1000th of the maximum).

4.4 Discussion of the TOUGH output from the modified input files

Our four input files produced very efficient runs which did not suffer from any of the shortcomings reported by *Updegraff* [1989]. The numerical simulations based on the first and second input files both reached 10^6 *sec* in 27 time steps and $t_{max} = 10^9$ *sec* in 1031 time steps. The finer time discretization in the third and fourth input files required

TABLE 1. Grid discretization for the TOUGH simulation of Verification Problem 3.

Block	Δr (m)	Block	Δr (m)	Block	Δr (m)	Block	Δr (m)	Block	Δr (m)	Block	Δr (m)
1	1.00E-04 †	22	4.4060E-02	43	1.9416E-01	64	8.5540E-01	85	3.7700E+00	106	1.6610E+01
2	1.0732E-02	23	4.7280E-02	44	2.0840E-01	65	9.1800E-01	86	4.0460E+00	107	1.7824E+01
3	1.1518E-02	24	5.0740E-02	45	2.2360E-01	66	9.8520E-01	87	4.3420E+00	108	1.9128E+01
4	1.2360E-02	25	5.4460E-02	46	2.4000E-01	67	1.0574E+00	88	4.6580E+00	109	2.0520E+01
5	1.3264E-02	26	5.8440E-02	47	2.5760E-01	68	1.1348E+00	89	5.0000E+00	110	2.2040E+01
6	1.4234E-02	27	6.2720E-02	48	2.7640E-01	69	1.2178E+00	90	5.3660E+00	111	2.3640E+01
7	1.5276E-02	28	6.7320E-02	49	2.9660E-01	70	1.3068E+00	91	5.7580E+00	112	2.5380E+01
8	1.6394E-02	29	7.2240E-02	50	3.1820E-01	71	1.4024E+00	92	6.1800E+00	113	2.7220E+01
9	1.7594E-02	30	7.7520E-02	51	3.4160E-01	72	1.5052E+00	93	6.6320E+00	114	2.9220E+01
10	1.8882E-02	31	8.3200E-02	52	3.6660E-01	73	1.6152E+00	94	7.1180E+00	115	3.1360E+01
11	2.0260E-02	32	8.9280E-02	53	3.9340E-01	74	1.7334E+00	95	7.6380E+00	116	3.3660E+01
12	2.1740E-02	33	9.5820E-02	54	4.2220E-01	75	1.8602E+00	96	8.1960E+00	117	3.6120E+01
13	2.3340E-02	34	1.0282E-01	55	4.5300E-01	76	1.9964E+00	97	8.7960E+00	118	3.8760E+01
14	2.5040E-02	35	1.1036E-01	56	4.8620E-01	77	2.1420E+00	98	9.4400E+00	119	4.1600E+01
15	2.6880E-02	36	1.1842E-01	57	5.2180E-01	78	2.3000E+00	99	1.0132E+01	120	4.4640E+01
16	2.8840E-02	37	1.2710E-01	58	5.6000E-01	79	2.4680E+00	100	1.0872E+01	121	4.7900E+01
17	3.0960E-02	38	1.3640E-01	59	6.0100E-01	80	2.6480E+00	101	1.1668E+01	122	5.1420E+01
18	3.3220E-02	39	1.4638E-01	60	6.4500E-01	81	2.8420E+00	102	1.2522E+01	123	5.5180E+01
19	3.5640E-02	40	1.5708E-01	61	6.9220E-01	82	3.0500E+00	103	1.3438E+01	124	5.9220E+01
20	3.8260E-02	41	1.6858E-01	62	7.4280E-01	83	3.2720E+00	104	1.4422E+01	125	6.3540E+01
21	4.1060E-02	42	1.8092E-01	63	7.9720E-01	84	3.5120E+00	105	1.5476E+01	126	6.8200E+01
										127	1.0000E+00*

(*): Assigned a large volume (10^{38} m^3).
(†): Assigned a large heat capacity (10^{50} $J/kg\ ^oC$) to enforce injection at constant temperature.

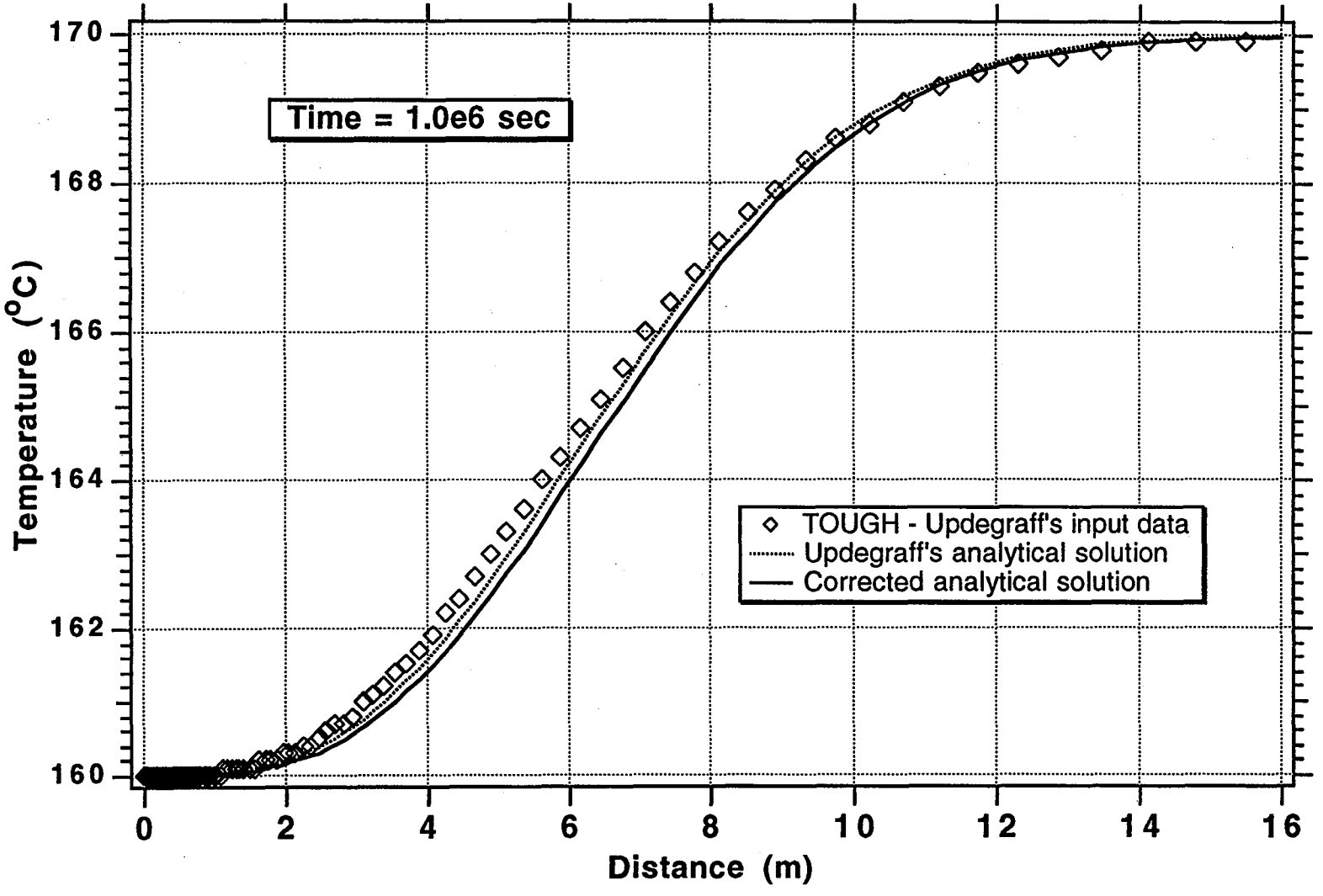

Figure 13. Comparison of the TOUGH and the analytical solutions using *Updegraff*'s [1989] data in Verification Problem 3. The corrected analytical solution is also shown.

1009 time steps to reach the desired observation time of 10^6 *sec.*

Figure 14 shows the corrected analytical solution and four TOUGH solutions (corresponding to the two time discretizations and the two weighting schemes) at $t = 10^6$ *sec*. Figure 15 shows the corrected analytical solution and two TOUGH solutions (corresponding to the two weighting schemes) at $t = 10^9$ *sec.*

Before discussing these results further, we wish to point out that the problem at hand has a *"similarity solution"* in terms of the variable r^2/t [*O'Sullivan,* 1981; *Doughty and Pruess,* 1990; 1992]. The temperature changes in space and time are coupled in such a way that they depend solely on r^2/t, rather than on r and t separately. In Figure 16 we plot the analytical solution, the two TOUGH solutions at $t = 10^6$ *sec* (with the fine time discretization), and the two TOUGH solutions at $t = 10^9$ *sec* versus the similarity variable r^2/t. Figure 17 demonstrates the same similarity solution, but offers much finer detail by focusing on the portion of the r^2/t axis where most of the changes occur. It also includes the TOUGH solutions with the coarse time discretization at $t = 10^6$ *sec.* An examination of the simulation results and Figures 14 through 17 reveals that:

(a) TOUGH is capable of an efficient simulation of the radial heat transport problem. All the simulations reached the desired maximum simulation times without any oscillations. The maximum timestep was not limited by code-imposed internal criteria but by restricting the maximum allowable size to a 1/1000th of the maximum (10^6 sec in the first two and 10^3 *sec* in the remaining two runs). The number of time steps to reach 10^6 and 10^9 *sec* was 27 and 1031.

(b) The TOUGH results are consistent with the r^2/t invariance that is known to exist in this problem. At $t_{max} = 10^9$ *sec* the two TOUGH solutions (corresponding to the two weighting schemes) virtually coincide with the analytical solution. The midpoint-weighted solution is slightly more accurate, but the difference from the upstream-weighted solution is almost imperceptible.

(c) Similar observations are made for the solutions at $t = 10^6$ *sec.* When the time discretization is fine, a very good agreement between the analytical solution and the two TOUGH solutions is observed. This degree of match is satisfactory for most practical applications. The small degree of numerical diffusion is due mostly to errors associated with the coarse time discretization. The solution based on midpoint weighting is consistently more accurate than the upstream-based solution, but the difference is not significant.

These results directly negate *Updegraff*'s [1989] statements that *"TOUGH could only simulate the first 1.5x10^6 sec ..."* and that *"PETROS...was the only code to solve the radial heat transport problem".*

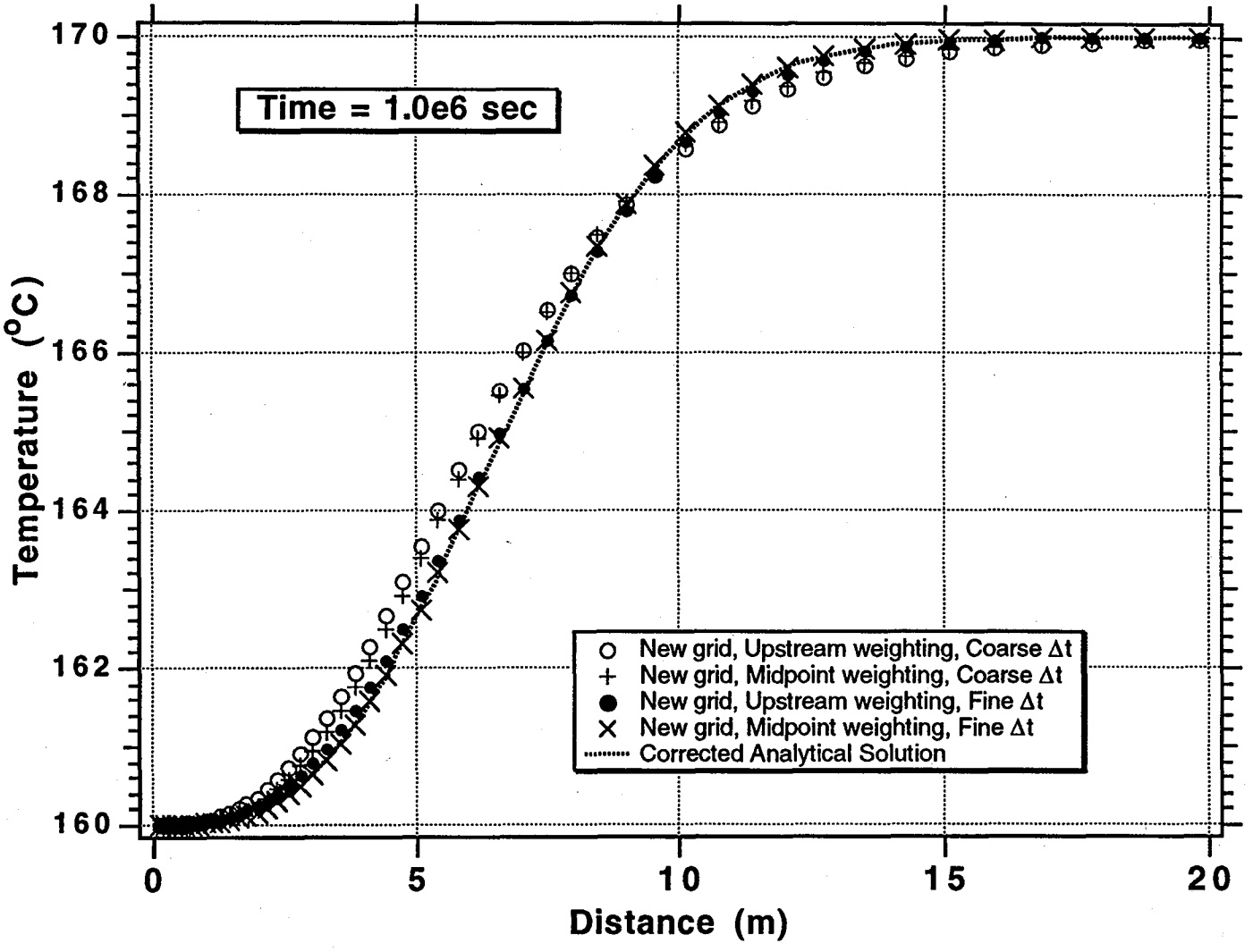

Figure 14. Comparison of the analytical and the TOUGH solutions at $t = 10^6$ *sec*.

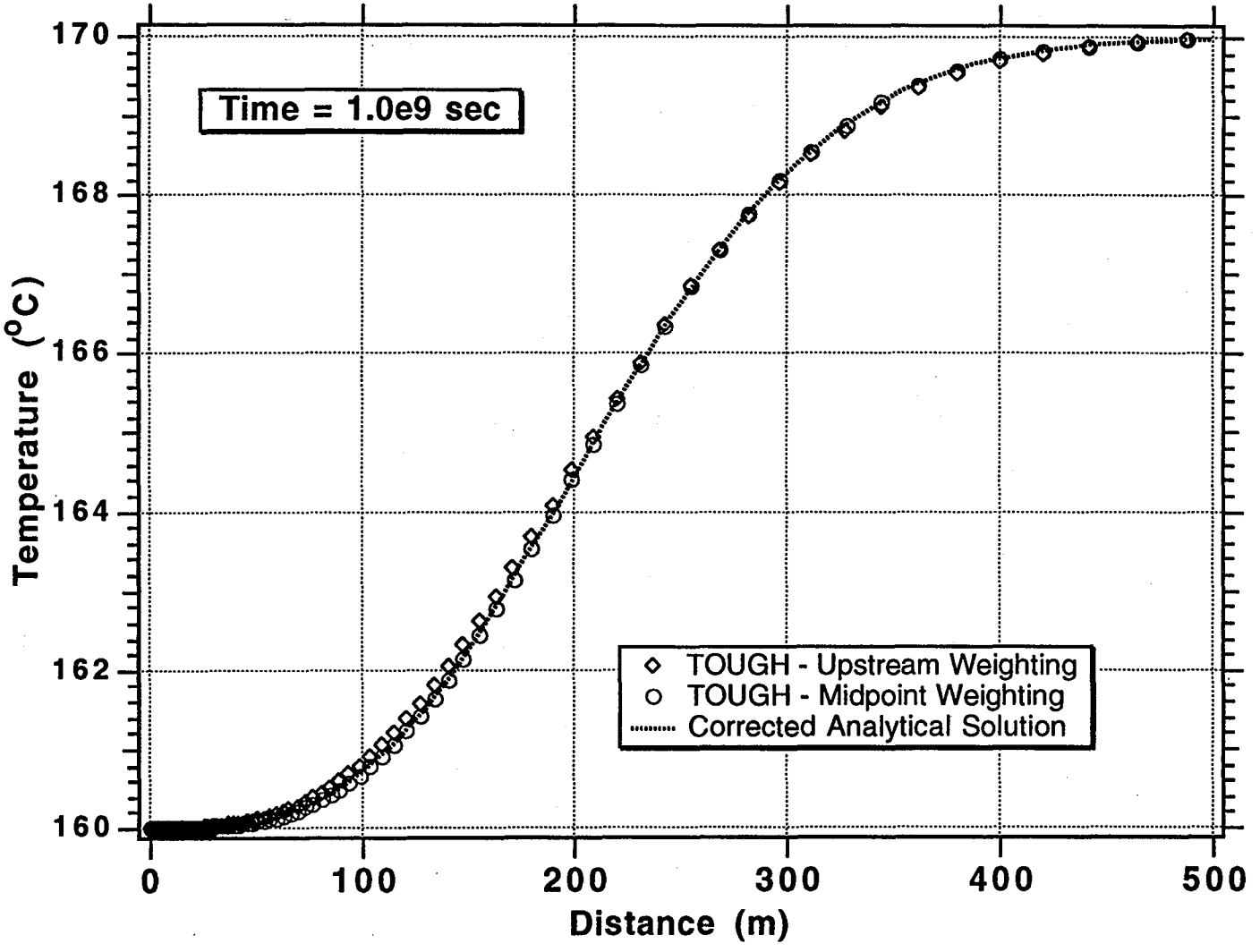

Figure 15. Comparison of the analytical and the TOUGH solutions at $t = 10^9$ *sec.*

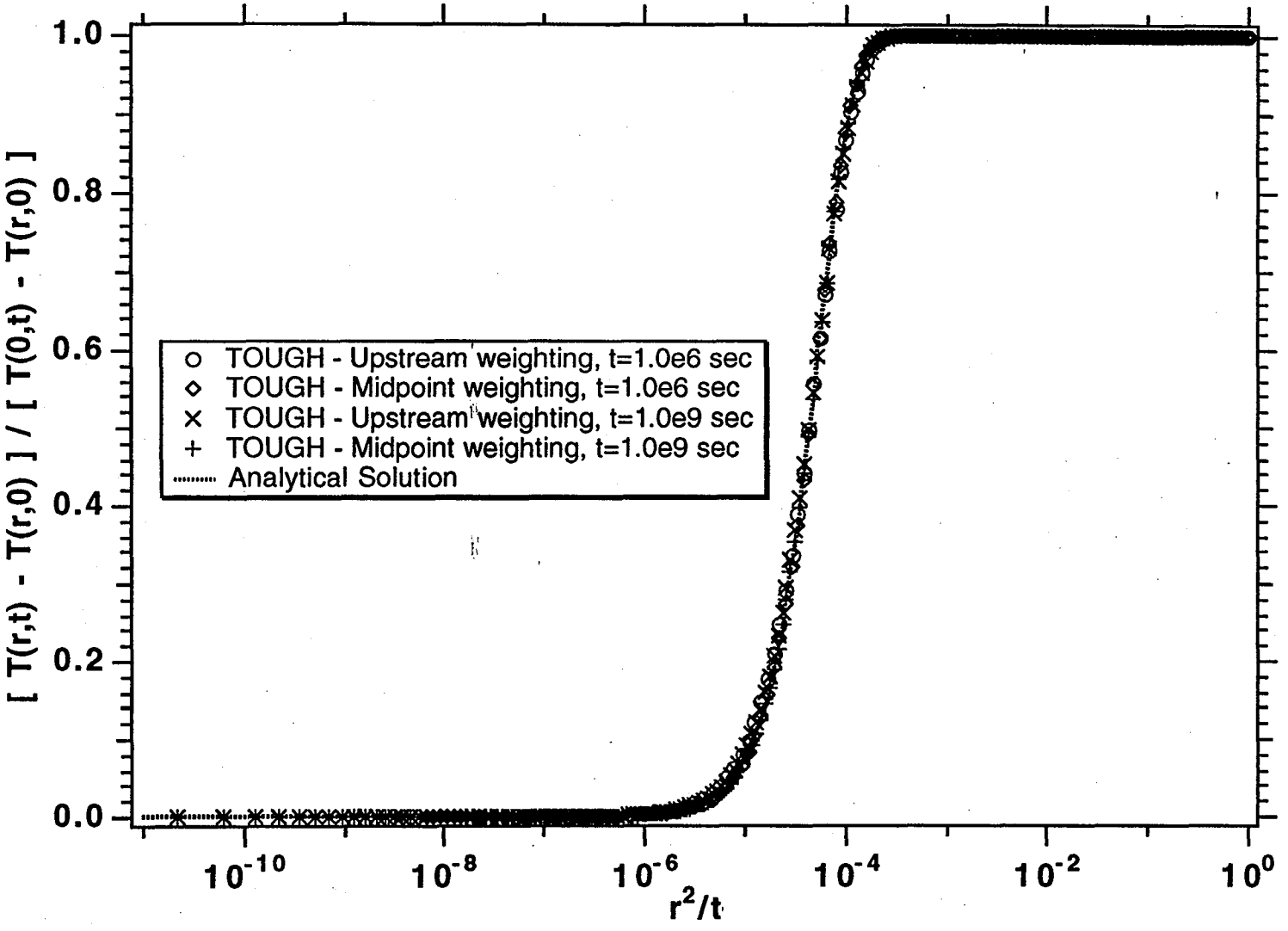

Figure 16. The analytical and numerical similarity solutions to the Verification Problem 3.

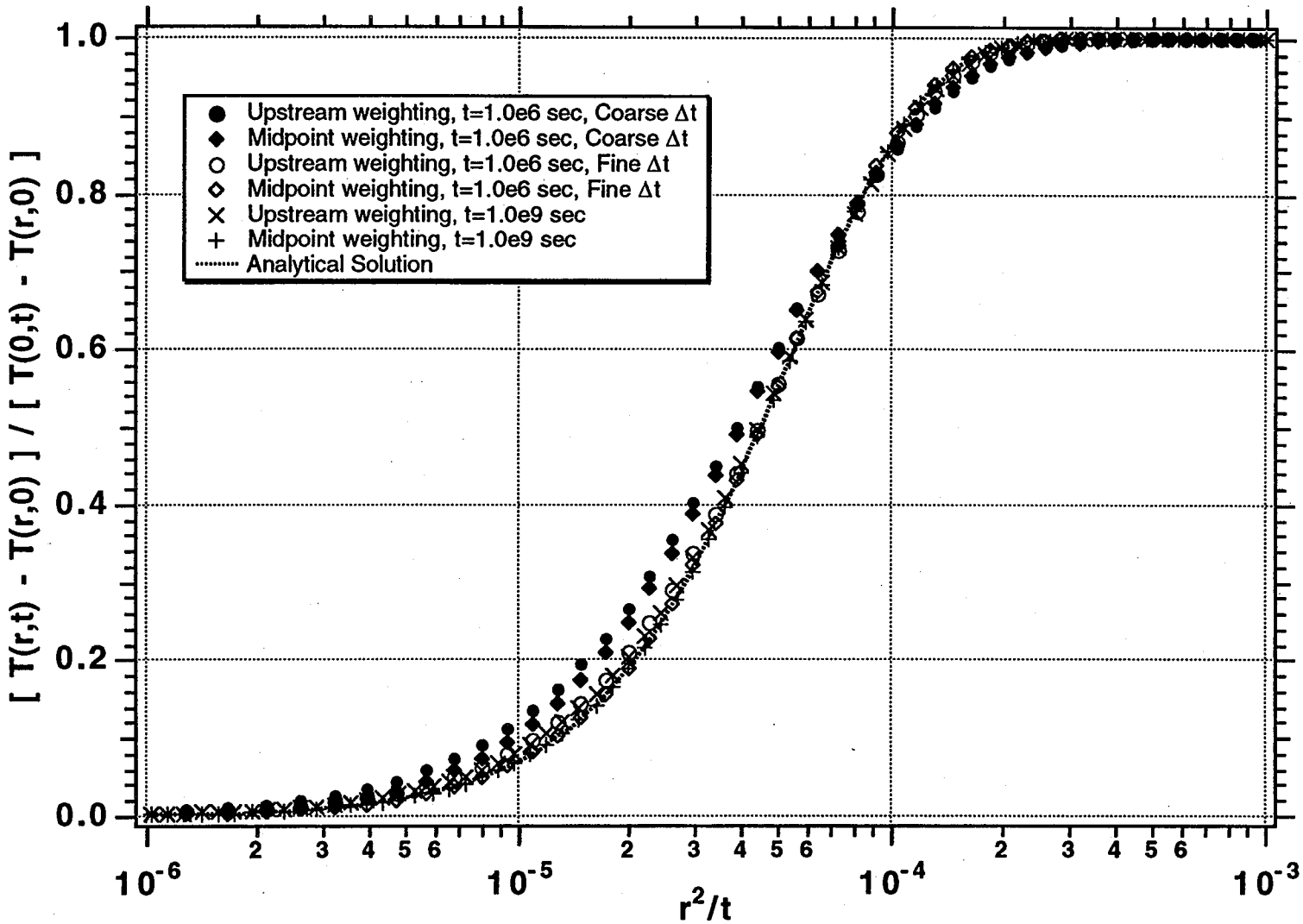

Figure 17. The analytical and numerical similarity solutions to the Verification Problem 3 (detail).

5. FLOW TO A GEOTHERMAL WELL AND HEAT PIPE (VERIFICATION PROBLEMS 4 & 5)

5.1 Description

Verification Problem 4 is the radial boiling front problem described and solved by *Garg* [1980], and also included in the TOUGH User's Guide [*Pruess,* 1987] as Sample Problem No. 4. In this problem water and/or steam is produced from a well in the center of an infinite cylindrical hot water aquifer. Figure 18 shows a schematic of the problem and lists pertinent parameter values. Water boils in response to a decrease in pressure brought about by the water removal at the well, and the resulting flash front advances away from the well and into the aquifer over time. The problem to be solved is that of one-component, two-phase flow and heat transport. The semi-analytical solution of *Garg* [1980] predicts the wellbore pressure over a period of time.

Verification Problem 5 is a heat pipe problem described and simulated by *Udell and Fitch* [1985], and included in the TOUGH User's Guide [*Pruess,* 1987] as Sample Problem No. 6. A one-dimensional horizontal layer of porous medium filled with water and a two component gas (air and water vapor) is subjected to a heat flux at the right end. A schematic of the problem and relevant information is shown in Figure 19. Due to the heat flux, (a) the right end dries, (b) moisture is collected at the left end, (c) near the saturated left end the temperature increases strongly while (d) it approaches a constant value at the right end, and (e) the mass fraction of air in the gaseous phase decreases rapidly to zero as it approaches the left end of the porous medium. It should be noted that the fluid properties used in the *Udell and Fitch* [1985] solution were considered constants, i.e. independent of pressure and temperature.

These two problems are used to investigate the performance of numerical codes in the simulation of fully coupled two-phase flow, heat transport, and phase changes (evaporation). In Verification Problem 4, the TOUGH predictions of the wellbore pressure over a period of 9.0×10^5 sec are compared to the semi-analytical solution of *Garg* [1980]. In Verification Problem 5, the semi-analytical and the TOUGH predictions of temperature, saturation, and air mole fraction are compared at steady state.

5.2 Updegraff's approach & results

The input files used by *Updegraff* [1989] were identical in all aspects to the ones in the TOUGH User's Guide [*Pruess* , 1987]. The results of the Updegraff simulations (which we repeated to confirm the identity) are therefore identical to the ones reported in the TOUGH User's Guide. TOUGH was the only code among the three tested (TOUGH, NORIA, and PETROS) to successfully simulate both these problems.

An excellent agreement is observed between the TOUGH and *Garg*'s [1980] solution in the Verification Problem 4 (Figure 20). In Verification Problem 5, the TOUGH solutions of temperature and mole fraction (Figure 21) are in excellent quantitative agreement with the *Udell and Fitch* [1985] predictions, while a similar qualitative behavior (but some quantitative differences) are observed in the prediction of saturation. These differences stem from the fact that TOUGH does not resort to the simplifications involved in the derivation of the semi-analytical solution, thus producing a solution which is more physically accurate than the one predicted by *Udell and Fitch* [1985]. *Updegraff* [1989] correctly attributed the differences in the predictions to the fact that gas and liquid properties in TOUGH were fully pressure- and temperature-dependent but were considered constant

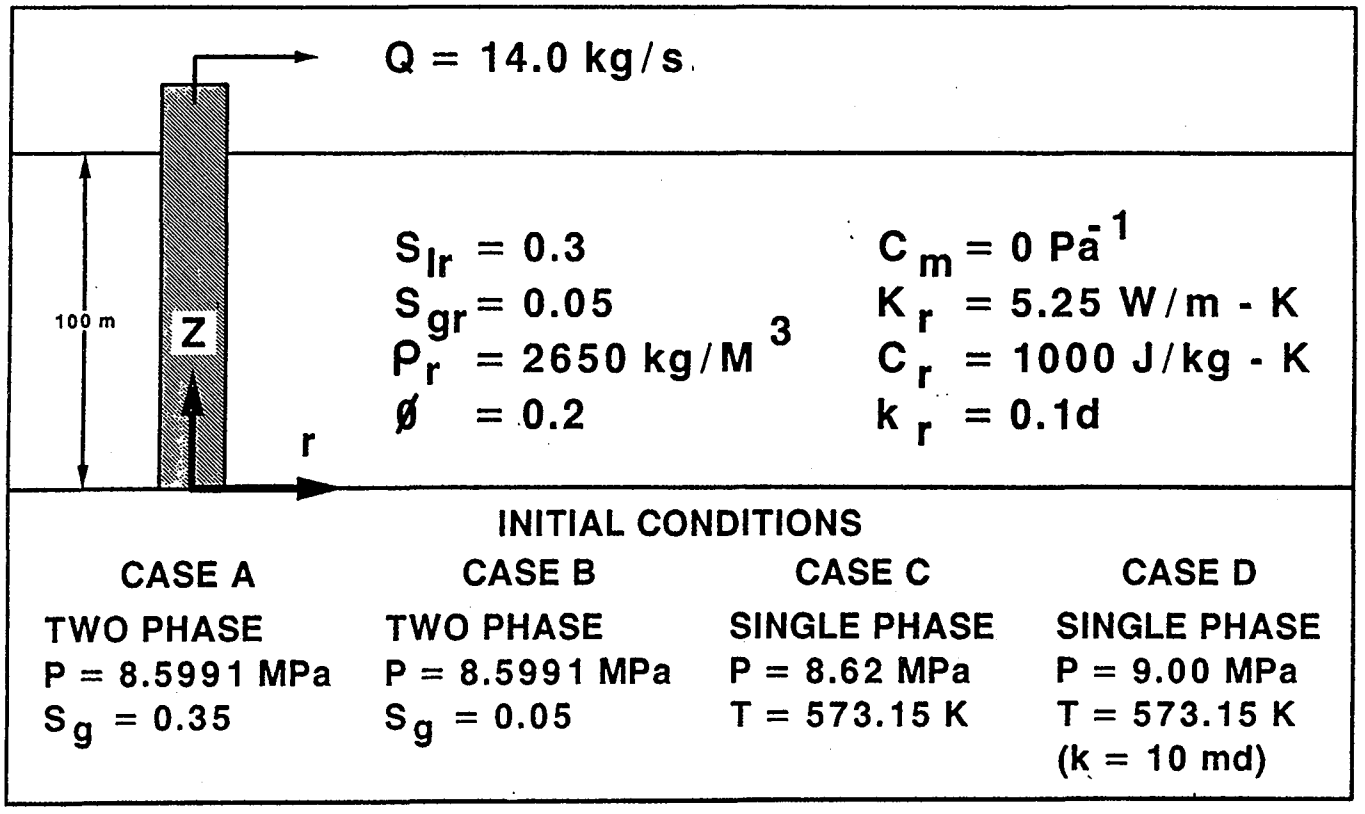

Figure 18. A schematic of the radial boiling front problem (from *Updegraff* [1989]).

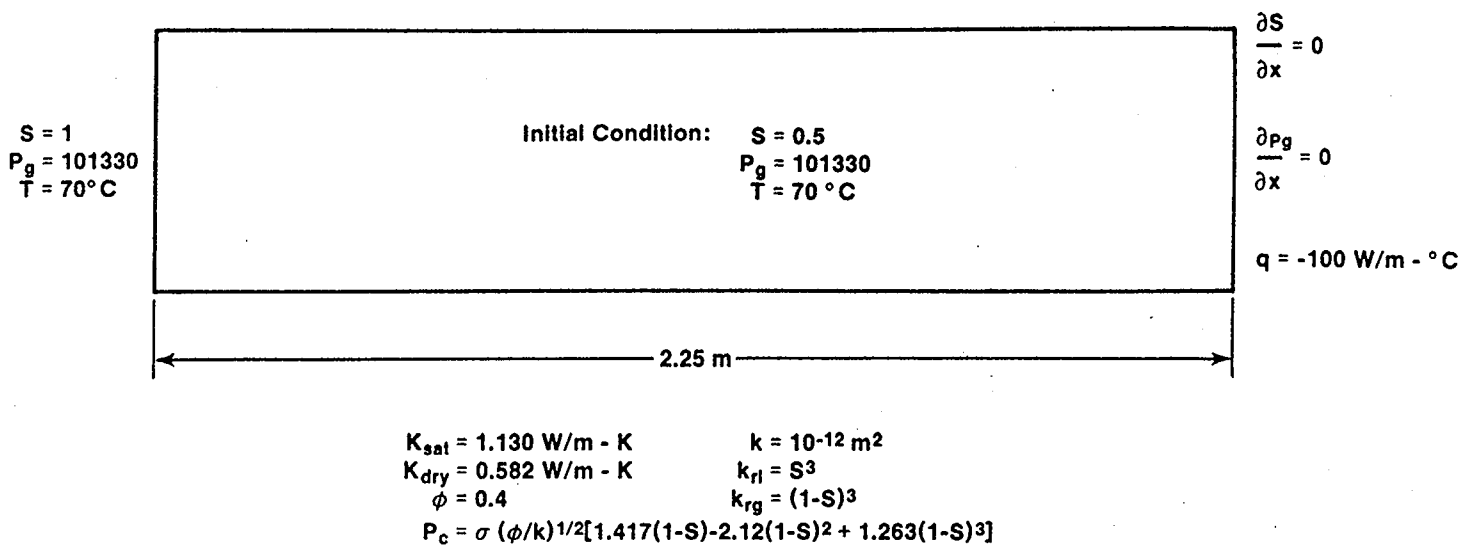

Figure 19. A schematic of the heat pipe problem (from *Updegraff* [1989]).

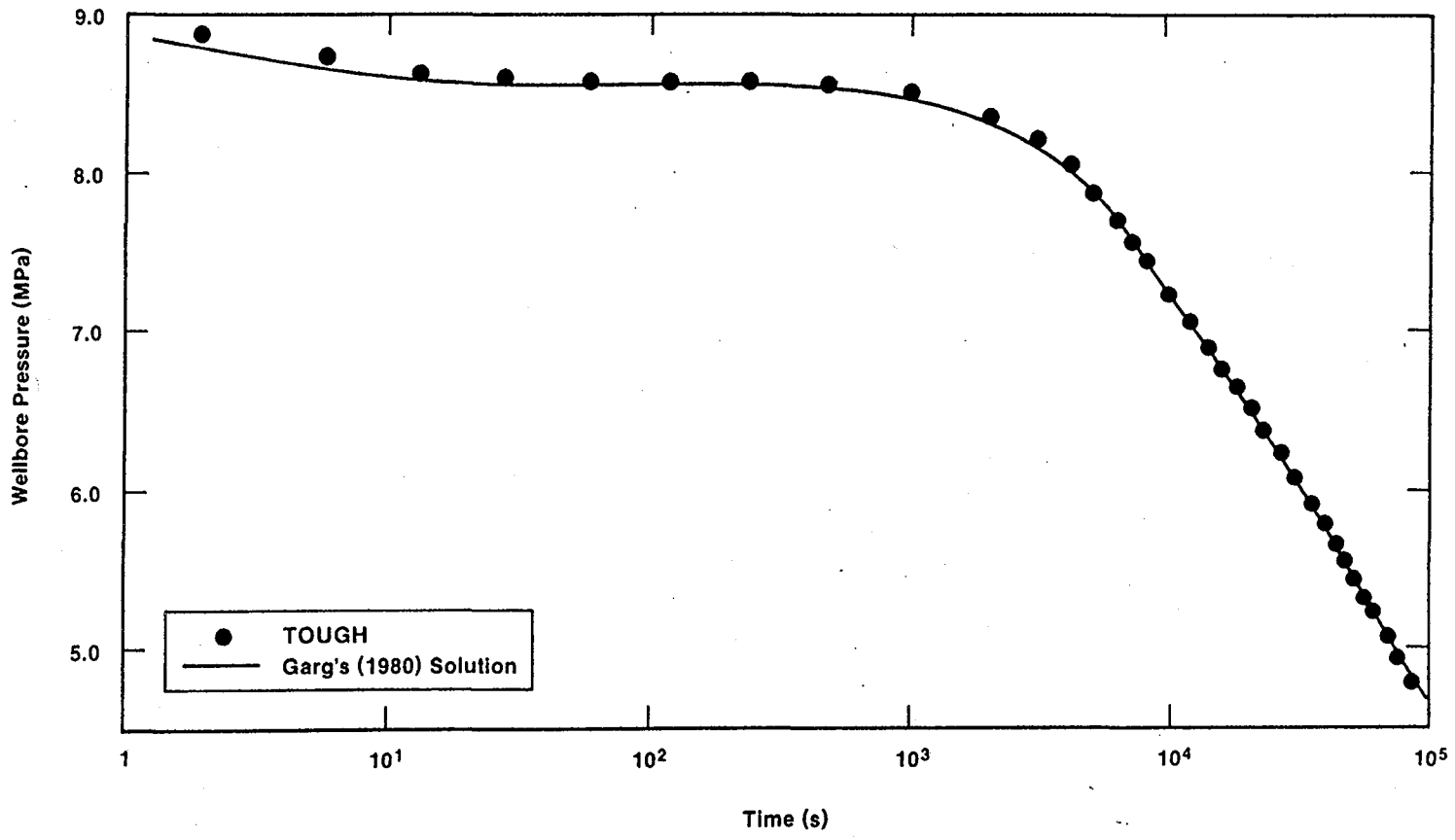

Figure 20. Comparison of the TOUGH and the *Garg* [1980] solutions for the Verification Problem 4 (from *Updegraff* [1989]).

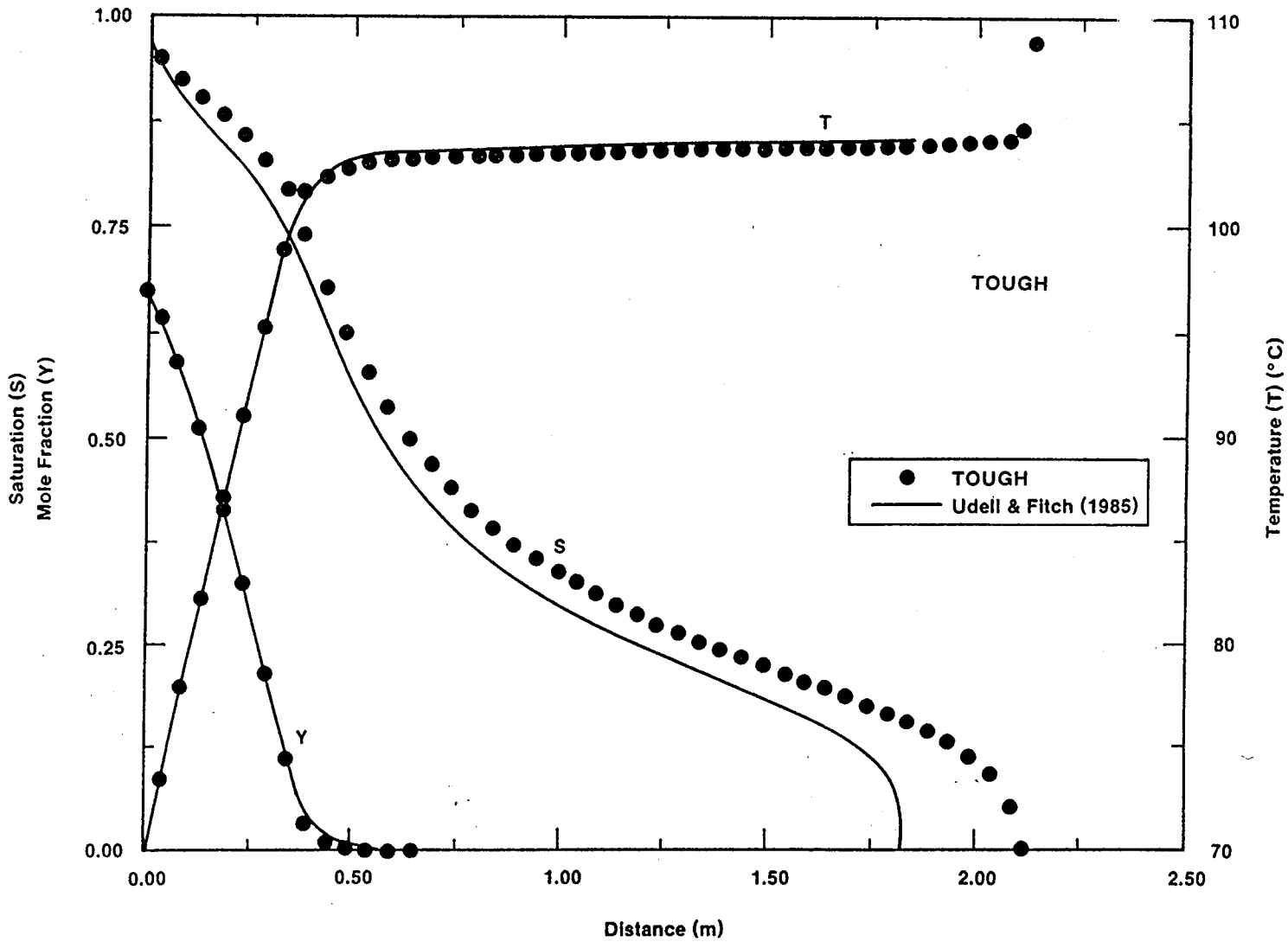

Figure 21. Comparison of the TOUGH and the *Udell and Fitch* [1985] steady-state solutions for the Verification Problem 5 (from *Updegraff* [1989]).

in the *Udell and Fitch* [1985] solution. This discrepancy in the saturation predictions was addressed by *Doughty and Pruess* [1987], who (as a further check) modified TOUGH to implement the same simplifying assumptions used in the reference solution and reported an excellent agreement of the solutions.

The above brief discussion of Verification Problems 4 and 5 was included here for completeness. No issues were identified that would have necessitated any revisions in the TOUGH solutions as originally reported [*Pruess,* 1987].

6. TWO-DIMENSIONAL INFILTRATION EXPERIMENT (VALIDATION PROBLEM 1)

6.1 Description

Experimental measurements and a numerical solution to the problem of two-dimensional infiltration were provided by *Vauclin et al.* [1979]. Water infiltrates at a rate of 4.111×10^{-5} *m/sec* over a length of *0.5 m* of the vertical slab of soil depicted in Figure 22 which, due to symmetry, represents only the right half of the problem. The water table stands at *0.65 m* from the bottom. The bottom boundary and the left boundary (line of symmetry) are considered impermeable to flow. Below $z = 0.65$ *m* the right boundary is a constant pressure boundary with a water saturation of 1 in the bottom; above $z = 0.65$ *m* it is a seepage surface, i.e. a mixed type of boundary condition which sets the water flux equal to zero when the medium is unsaturated and has a head equal to the hydraulic head when the medium is saturated. This problem is used to test the ability of TOUGH to simulate two-dimensional two-phase flow.

The TOUGH evaluation process compares the volumetric moisture content distributions with depth z at distances of $x = 0.19, 0.49, 0.79, 1.09, 1.39$, and *1.99 m* from the line of symmetry. The TOUGH predictions are compared to the experimental measurements at $t = 1800, 3600, 5400, 7200, 10800, 14400, 18000, 21000$, and *28800 sec* after the initiation of infiltration.

6.2 Updegraff's approach & results

Figure 23 shows the space discretization used by *Updegraff* [1989]. It consisted of 194 gridblocks which included 120 gridblocks with dimensions *0.25m x 0.135 m x 1 m*, 48 gridblocks with dimensions *0.25m x 0.1625 m x 1 m*, and 26 boundary gridblocks. The top layer (O) and the right column (13) of gridblocks were used as the boundary gridblocks. The gridblocks O1 and O2 were extremely thin and controlled infiltration into the slab. A very large volume (10^{50} m^3) was assigned to all the other boundary gridblocks, thus effecting (a) constant pressure and temperature, and (b) zero infiltration boundary conditions to gridblocks O3 to O13. The lack of boundary gridblocks along the bottom and the left end of the slab corresponds to zero mass and heat fluxes along these boundaries. The water content distribution in the boundary gridblocks in column 13 was determined from their distance from the water table and the capillary pressure curve which pertained to the particular soil of the experiment [*Vauclin et al.*, 1979], and defined an equilibrium (i.e. zero vertical flux) system.

Infiltration into the slab was simulated by injecting water into gridblocks O1 and O2 at a mass rate of *0.01028 kg/sec* (each), which corresponds to the infiltration rate of 4.111×10^{-5} *m/sec*. Gridblocks in rows A through D were assigned an initial pressure equal to the hydrostatic and an initial liquid saturation equal to *1*. Gridblocks in rows E through N were assigned an initial pressure equal to atmospheric *(101300 Pa)* and a saturation calculated from their elevation above the water table and the relationship between the capillary pressure and saturation. This saturation and pressure distribution resulted in an initial state of equilibrium i.e. zero water flux in the vertical direction. A liquid saturation of 0 and an atmospheric pressure was assigned to gridblocks O3 through O12. In describing the handling of the boundary conditions, *Updegraff* [1989] remarked that *"...a seepage-face boundary condition should be applied to the right-side grid blocks above the water table, but TOUGH does not have this capability."*.

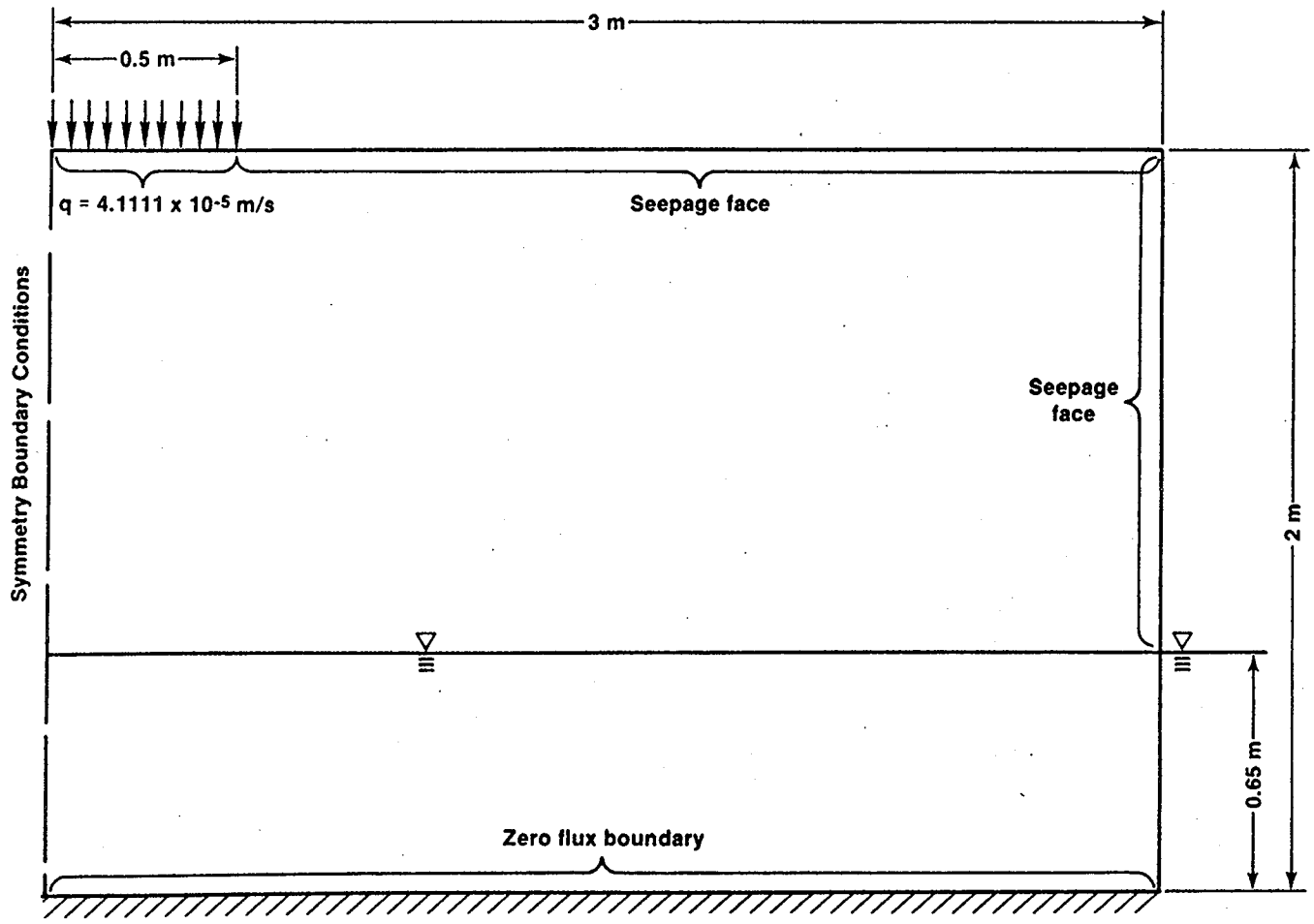

Figure 22. The two-dimensional infiltration system in Validation Problem 1 (from *Updegraff* [1989]).

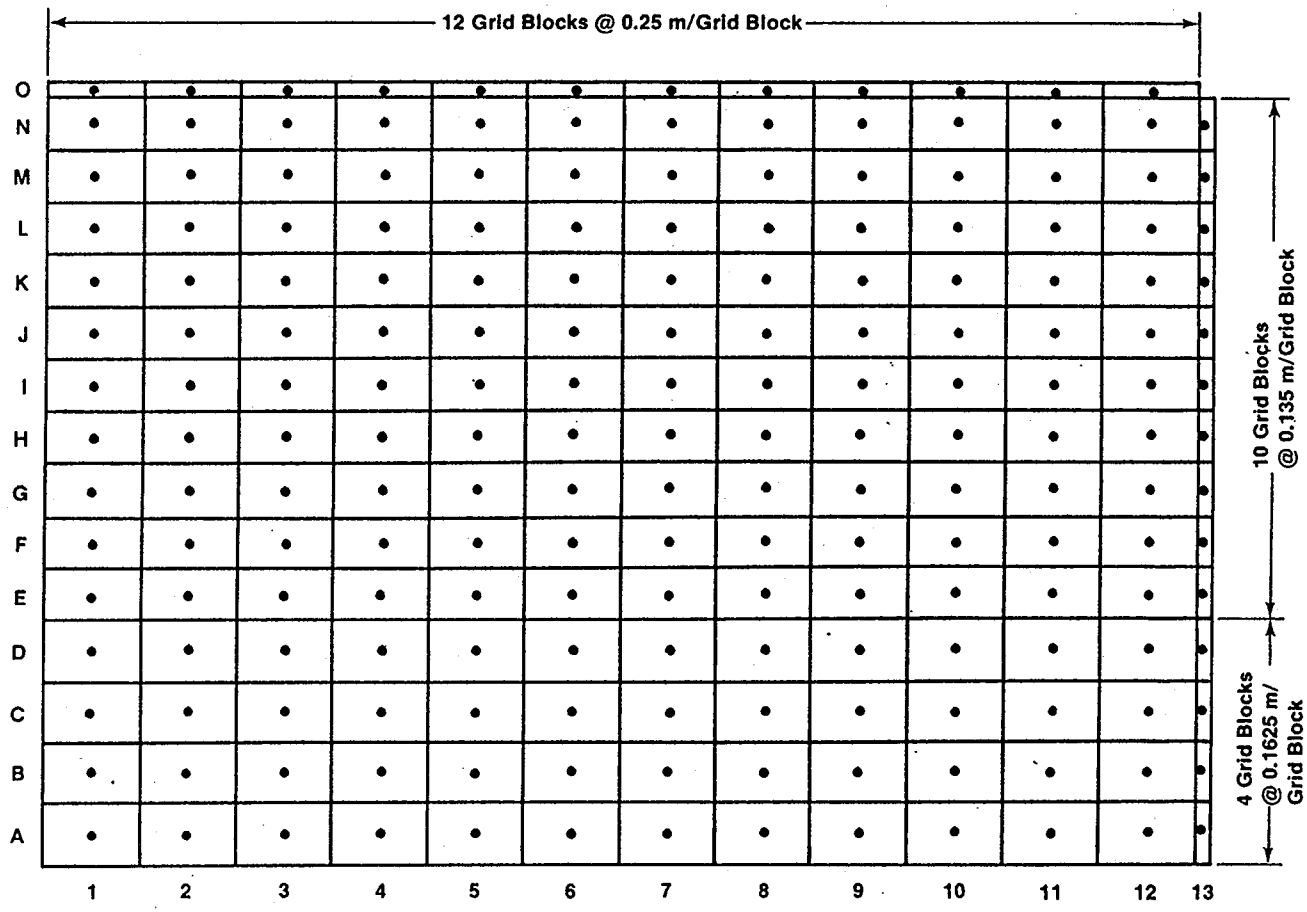

Figure 23. TOUGH grid used by Updegraff for the simulation of Validation Problem 1 (from *Updegraff* [1989]).

Of the *28800 sec* total desired simulation time, *Updegraff* [1989] was able to simulate a period of only *6722 sec.* TOUGH required only 39 time steps for the first *6300 sec.* Thereafter, the size of time steps became very small, requiring 231 time-steps to cover the next *422 sec.* Based on this deteriorating performance, he concluded that TOUGH was unlikely to simulate the required period of $t_{max} = 28800\ sec$ (8 hours) within a reasonable time frame, and terminated the simulation. The limited time range of the simulation enabled him to compare the numerical solutions and the experimental observations of the water content distribution up to a time of *5400 sec (1.5 hr).*

The comparison set included three curves at $x = 0.19\ m$ and $x = 0.49\ m$ (at *0.5, 1,* and *1.5 hrs*) and a single curve at $x = 0.79\ m$ and *1.5 hrs.* The agreement between experiment and simulation was quite good at $x = 0.19\ m$. Updegraff attributed existing discrepancies to heterogeneities, a conclusion further supported by the observation of similar behavior at the $x = 0.49\ m$ axis. He rated the agreement at $x = 0.49\ m$ as poor, and attributed it to (a) the coarse grid and (b) errors caused by interpolation near the boundaries of relatively large gridblocks in an area of steep saturation fronts. It is curious that although Updegraff identified these reasons as potential causes of the perceived poor performance of TOUGH, he made no attempt to investigate whether addressing them would alleviate or eliminate the deviations between experiment and simulation. Finally, at $x = 0.79\ m$ and $t = 1.5\ hr$ Updegraff reported a good qualitative agreement but a quantitative discrepancy between the observed and the predicted water content distributions. He indicated that in order to determine conclusively the cause of the discrepancy, simulation results at longer times were needed.

Examination of the report and input file revealed a number of problems which either prevented the completion of the simulation runs or affected their quality. More specifically:

(a) The option MOP(11) = 1 was used in Updegraff's simulation, indicating a midpoint weighting scheme for interface mobilities. As discussed earlier, for problems with smooth saturation distributions and no phase change this is more accurate than upstream weighting, but it may violate the second law of thermodynamics and lead to physically unrealistic answers if improperly applied.

The use of midpoint weighting is inappropriate for this problem because (i) in problems with propagating phase fronts a fully upstream weighting scheme must be used [*Aziz and Settari,* 1979] and (ii) the conditions of strict monotonicity which must be satisfied for the valid application of this scheme are much harder to establish or verify in two dimensions. Midpoint averaging can produce a large mobility for a phase that is present at a very low saturation, resulting in an unstable situation. We found that use of MOP(11) = 0 (the default option in TOUGH) alleviates the problem.

(b) The implementation of the permeability vs. saturation relationship of *Vauclin et al.* [1979] in TOUGH was done in a manner that produced a discontinuity of the gas relative permeability at a gas saturation of $S_g = 10^{-4}$. For an S_g approaching 10^{-4} the gas relative permeability tended to 3.65×10^{-4}, but $k_{rg} = 0$ for an $S_g = 10^{-4}$.

This violated the basic requirement of TOUGH that all parameters appearing in the governing equations must be continuous functions of the primary variables, a requirement dictated by the fully implicit formulation in TOUGH and the use of Newton-Raphson iteration for the solution of the resulting strongly non-linear equations. The discontinuity in Updegraff's implementation yielded erroneous saturation derivatives in the Jacobian matrix which prevented the convergence of the solution and led to successive reductions in the size of the timestep. The problem is eliminated by removing the code statement that produces the discontinuity.

These first two problems were the reasons for Updegraff's inability to proceed past the first *6722 sec* in the simulation. The following two problems affected the quality of the output, but did not obstruct the simulation process.

(c) An examination of the space discretization revealed that a rather coarse grid was used and that the selection of the gridblock size (uniform in the x-direction, locally uniform in the two sub-regions in the z-direction) reflected ease of input generation rather than an effort to obtain sufficiently detailed information at the prescribed locations.

Consequently, the water content distributions along z at the desired x locations had to be calculated by interpolating between gridblock centers over significant distances. This was a cumbersome procedure which could potentially introduce significant errors in the calculations (especially when interpolating across steep fronts with highly non-linear spatial variation of water content).

(d) Contrary to Updegraff's statement, TOUGH can easily model seepage faces. For his space discretization in Figure 23, this can be accomplished by (i) specifying the boundary blocks E13 through N13 as single-phase gas in pressure equilibrium with the rest of the system, and (ii) assigning these gridblocks to a domain with zero capillary pressure.

In our attempt to duplicate Updegraff's results we made two basic runs. The first run used the original data input file supplied by S. Webb, and reproduced the results and difficulties observed and reported by *Updegraff* [1989]. The input file in the second run differed in the value of MOP(11), which was set to the default zero for upstream weighting. We also removed the discontinuity that had been present in the coding of the relative permeability function of *Vauclin et al.* [1979].

The implementation of these two simple changes eliminated the difficulties observed in the first run and produced a very efficient TOUGH run, which covered the desired simulation period of *28,800 sec* in 64 time steps without any problems related to phase appearance or disappearance. The same run showed that the mass flux through the top boundary (i.e. row O) was practically insignificant, which indicated that row O could be removed from the simulated domain, thus reducing the size of the problem without affecting the quality of the simulation. We did not compare these simulation results to the experimental observations of *Vauclin et al.* [1979] because we deemed the Updegraff space discretization rather coarse for the requirements of the problem .

6.3 Modification of approach and data inputs

For our simulation we created a new data set. The number of gridblocks was increased from 194 (15x13 in x,z) in *Updegraff* [1989] to 378 (21x18 in x,z). The new discretization appears in Table 2, and does not require interpolation for the determination of the water content distributions at $x = 0.19, 0.79, 1.09, 1.39$, and $1.99\ m$ from the line of symmetry, as there are gridblocks centered at these locations. Interpolation is only required at the $x = 0.49\ m$ axis, but the discretization in the vicinity of this location is quite fine. Although it is not necessary, for simplicity we used the MESHMAKER facility of TOUGH2 [*Pruess,* 1991], to generate the grid. A very large volume ($10^{29}\ m^3$) was assigned to the right-hand boundary gridblocks (column 21), thus ensuring constant boundary pressures, saturations, and temperatures during the duration of the simulation.

TABLE 2. Specifications of the refined 2-D x-z grid in Validation Problem 1. (left to right, top to bottom)

Δx *(m)*	0.115	0.15	0.155	0.09	0.08
	0.14	0.15	0.15	0.15	0.15
	0.15	0.15	0.15	0.15	0.15
	0.16	0.18	0.20	0.20	0.20
	1.00E-04				
Δz *(m)*	0.10	0.10	0.10	0.10	0.10
	0.10	0.10	0.10	0.10	0.10
	0.10	0.10	0.10	0.05	0.05
	0.10	0.20	0.30		

An upstream weighting scheme (i.e. MOP(11) = 0) was used in this simulation. For the reasons discussed in the previous Subsection (6.2), a no-flow top boundary was used and water was injected directly into the four gridblocks A111 through A114 by specifying appropriate sources.

Initial pressures and saturations were hand-calculated and assigned using (i) the hydrostatic pressure distribution below the watertable, and (ii) the capillary pressure vs. water content relationship in *Vauclin et al.* [1979]. Note that the initial equilibrium state could have been also generated with a TOUGH run. A seepage face was assigned to the right-hand boundary gridblocks above the water table by using the procedures described in detail in item (d) in Subsection 6.2. The maximum allowed time step size was $\Delta t = 900$ *sec* (vs. *1,800 sec* used by Updegraff).

6.4 Discussion of the TOUGH output from the modified input files

Our input file produced a very efficient run which did not encounter any of the shortcomings which hampered the *Updegraff* [1989] run. Figures 24(a) through 24(g) show the TOUGH predictions and the experimental observations at the desired locations and times. An examination of the experimental data and simulation results reveals the following:

(a) There seems to exist considerable heterogeneity in the soil slab. This is evidenced by: (i) the initial water content distributions measured by *Vauclin et al.* [1979] at $x =$ *0.19, 0.49, 0.79, 1.09, 1.39, 1.69* and *1.99 m* show wide variability; (ii) initial volumetric water contents θ above the water table exceed the reported saturation value $\theta_S = 0.30$ (used in the simulations) at a significant number of locations; (iii) θ's exceed the maximum value of *0.256* (i.e. $S_l = 0.853$, attainable directly below the infiltration surface) in the $x = 0.49$ *m* curves; and (iv) the shapes of the θ profiles are quite jagged, as opposed to the smooth curves that would result under homogeneous and isotropic conditions.

In light of our current understanding of the difficulties of packing even the smallest of containers (let alone a *3m x 2m* sand box) with a uniform distribution of sand, such heterogeneity is entirely expected and must be considered in the evaluation of the performance of the TOUGH model.

(b) TOUGH is capable of an efficient simulation of the two-dimensional infiltration (two-phase) problem. The simulation reached the desired maximum simulation

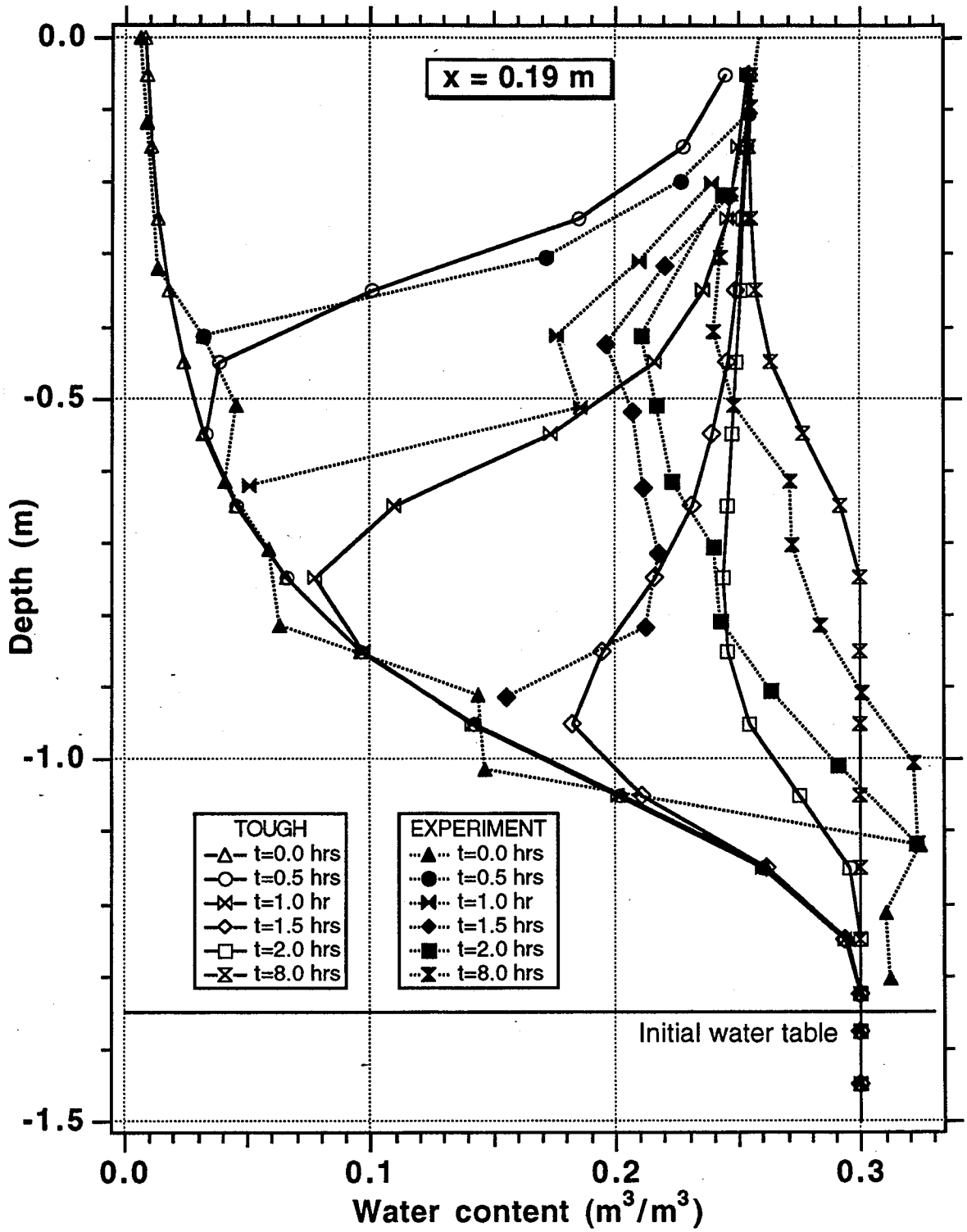

Figure 24(a). TOUGH predictions and experimental measurements at $x = 0.19\ m$ in Validation Problem 1.

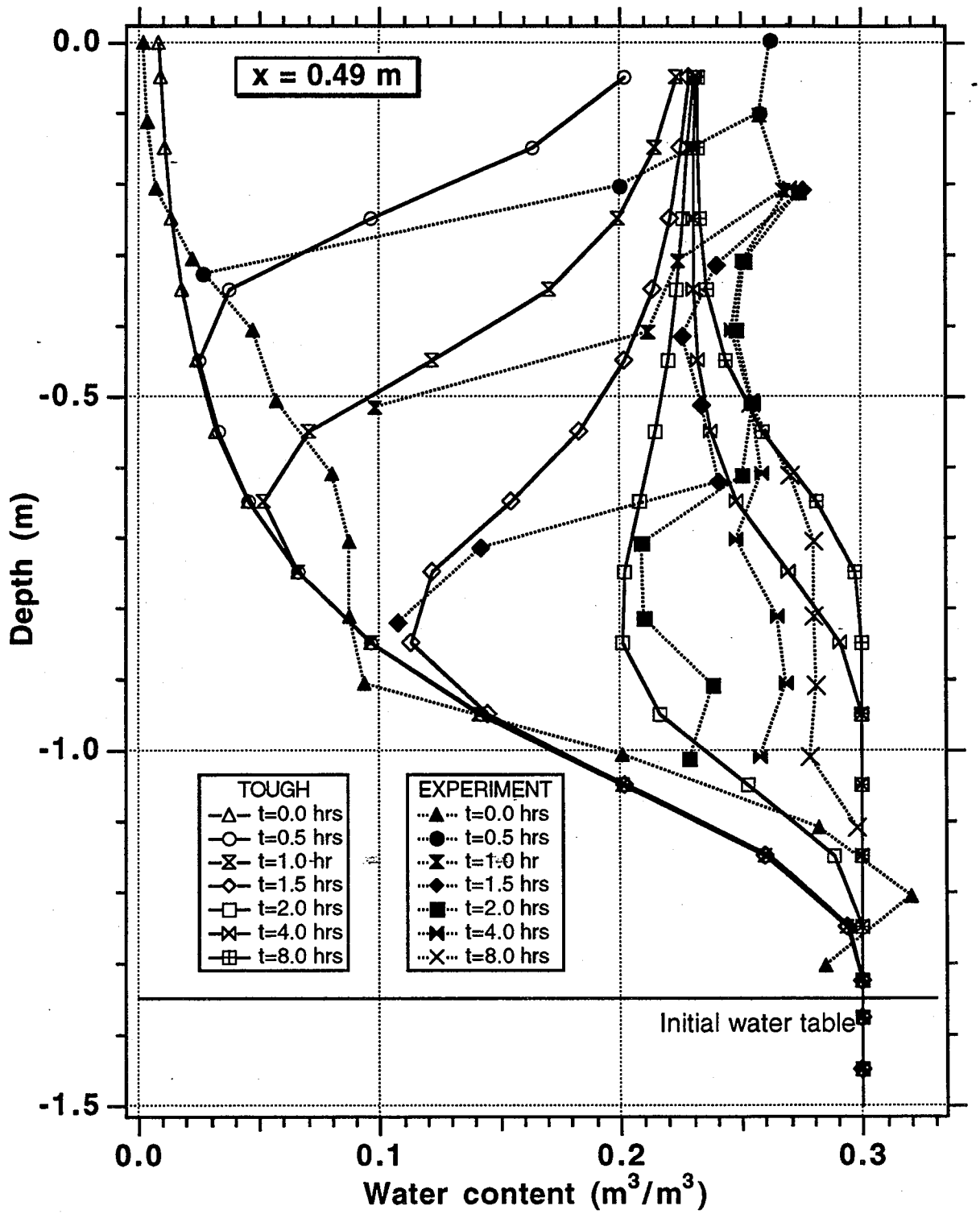

Figure 24(b). TOUGH predictions and experimental measurements at $x = 0.49\ m$ in Validation Problem 1.

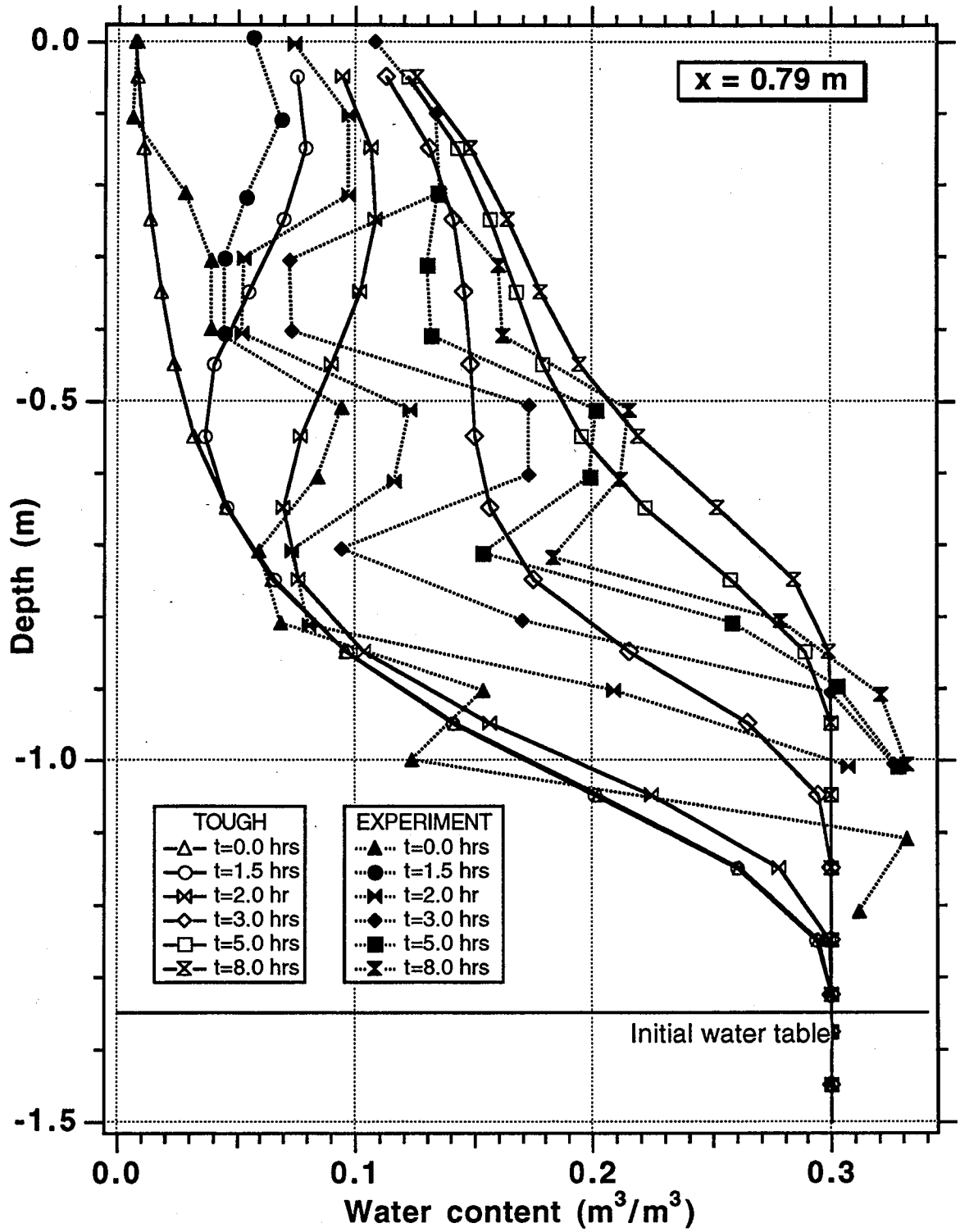

Figure 24(c). TOUGH predictions and experimental measurements at $x = 0.79\ m$ in Validation Problem 1.

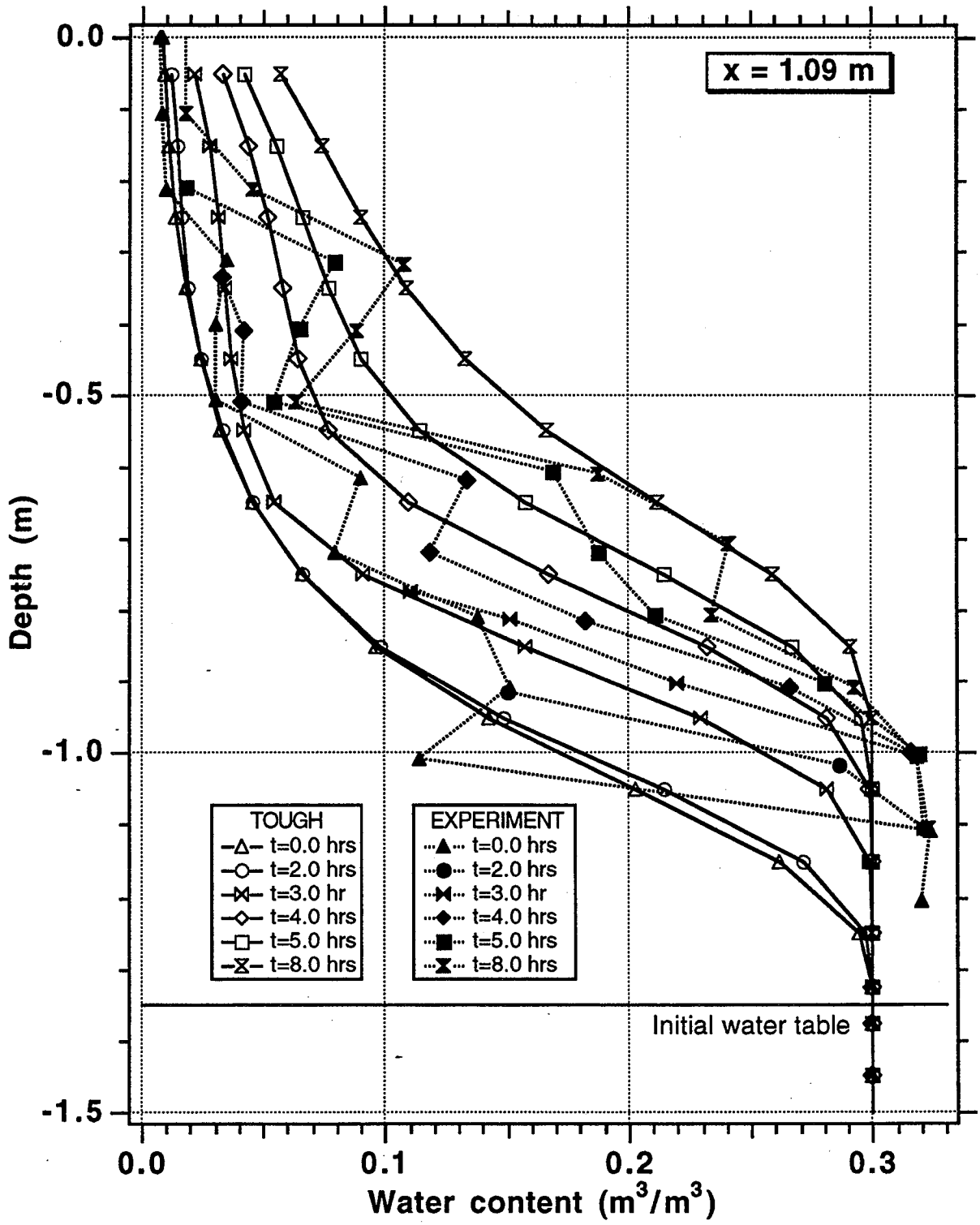

Figure 24(d). TOUGH predictions and experimental measurements at $x = 1.09\ m$ in Validation Problem 1.

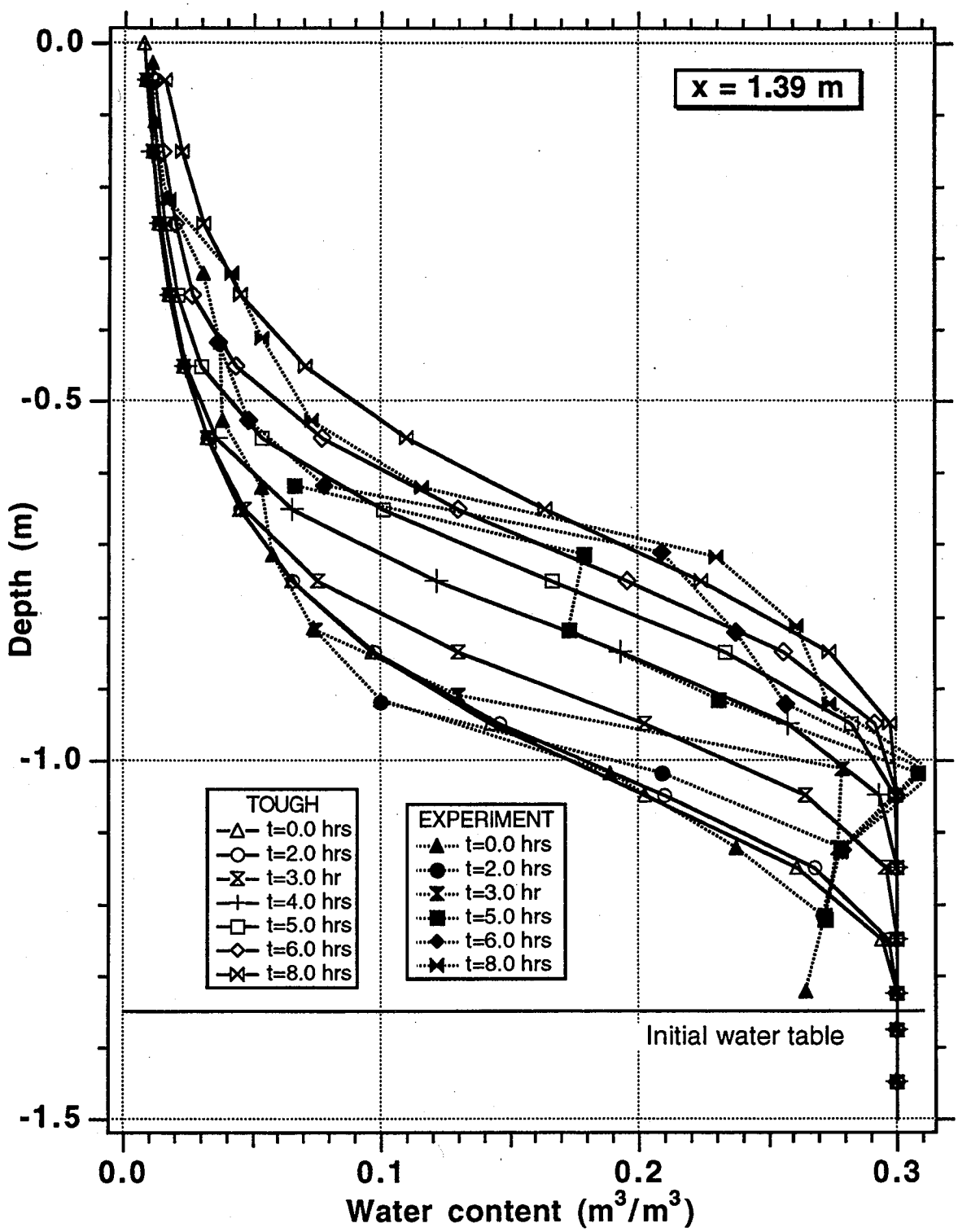

Figure 24(e). TOUGH predictions and experimental measurements at $x = 1.39\ m$ in Validation Problem 1.

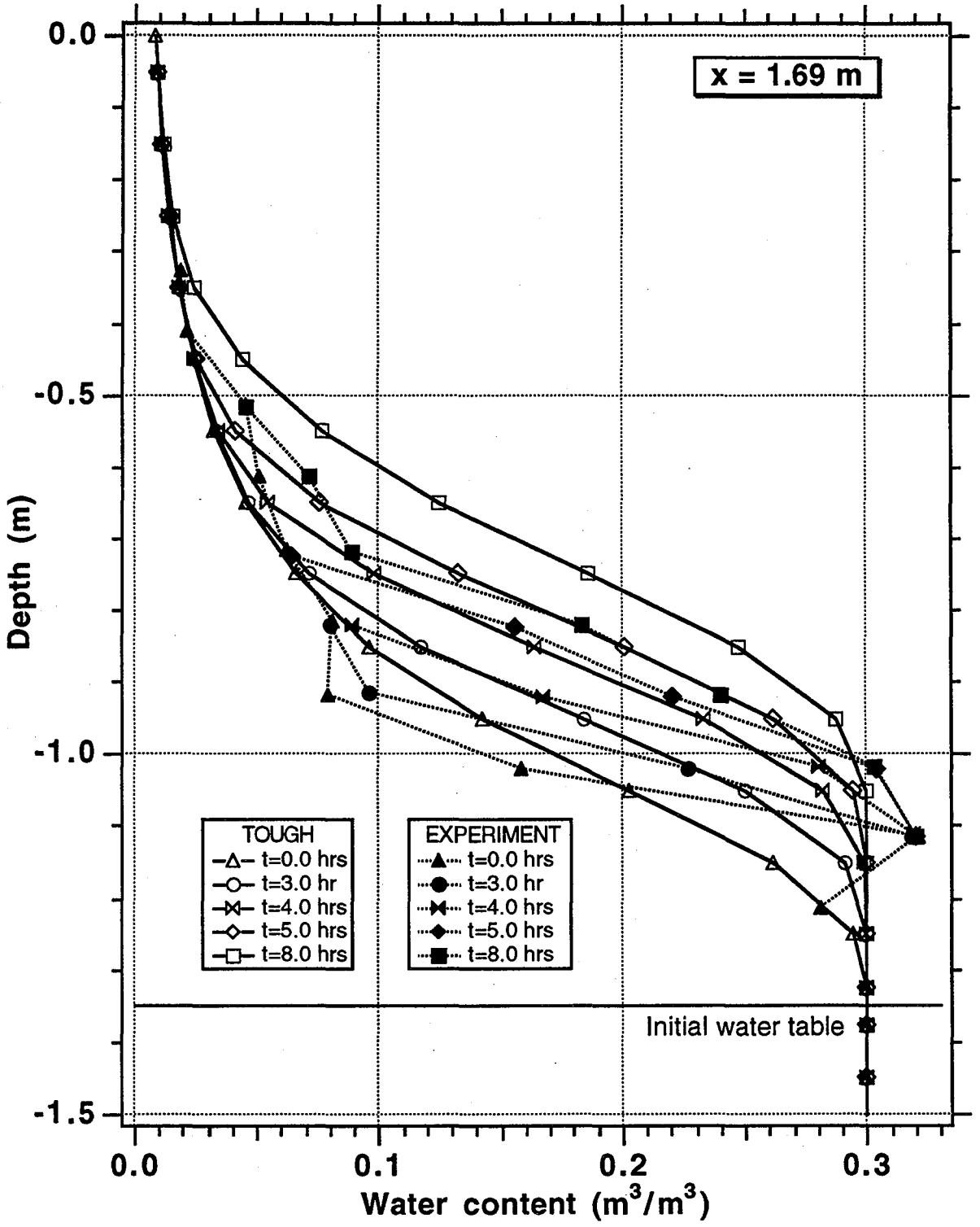

Figure 24(f). TOUGH predictions and experimental measurements at $x = 1.69\ m$ in Validation Problem 1.

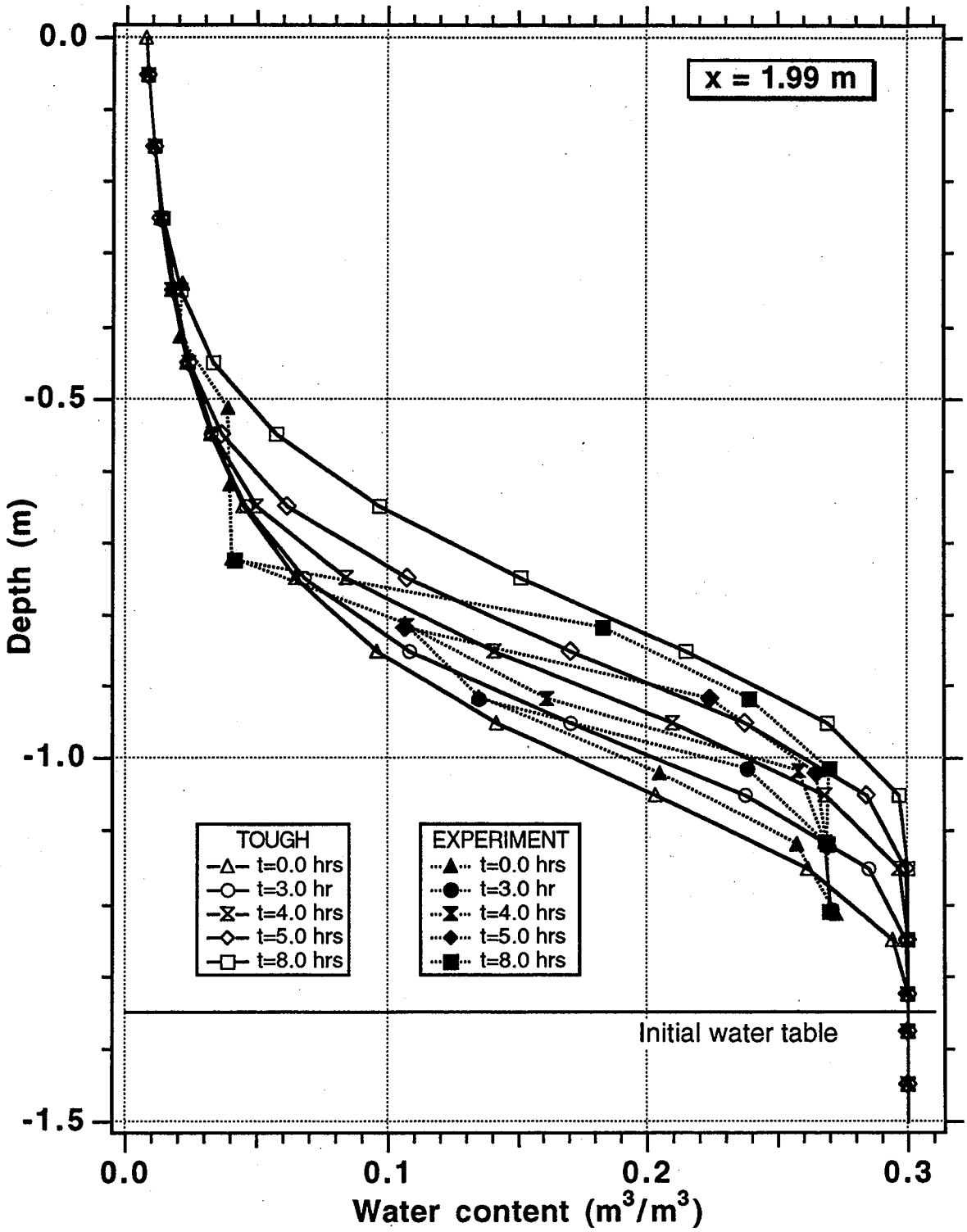

Figure 24(g). TOUGH predictions and experimental measurements at $x = 1.99\ m$ in Validation Problem 1.

times without any oscillations or any adverse reactions related to phase appearance or disappearance. The maximum timestep was not limited by code-imposed internal criteria but by the restriction on the maximum allowable size to *900 sec*. The number of time steps to reach the desired simulation time of *28,800 sec* was 144.

(c) TOUGH predictions agree well with the numerical simulation results given by *Vauclin et al.* [1979].

(d) Comparison of the experimental results and the TOUGH predictions in Figures 24(a) through 24(g) shows a very good overall agreement. The shape and the advance of the numerically predicted wetting fronts at all axes are consistent with expectations, and considering the heterogeneity of the system, they are deemed to accurately reproduce the experimental observations.

Observed discrepancies are attributed to two factors: (a) the heterogeneity in the soil and (b) the assumption of homogeneous and isotropic soil in the numerical simulation. The heterogeneity of the soil was briefly alluded to by *Vauclin et al.* [1979]; its effects are demonstrated by the jagged appearance of the water content profiles, the non-monotonic shape of curves, and the existence of points where the volumetric water contents are significantly larger than $0.3\ m^3/m^3$, i.e. the stated porosity of the medium. Since no information is available on the soil heterogeneity, it is unaccounted for in the simulations, in which isotropic and homogeneous conditions are assumed in accordance to the approach of *Vauclin et al.* [1979]. These assumptions produce the smooth numerical profiles in Figures 24(a) through 24(g).

A measure of the degree of heterogeneity is given by the deviation of the theoretically predicted distribution from the experimentally observed moisture profiles at the 7 observation axes. The discrepancies are especially pronounced at the $x = 0.79\ m$ and $x = 1.09\ m$ axes.

Another indication of heterogeneity is evident in Figure 24(b), where at $x = 0.49\ m$ (a) there are points with water contents exceeding those at the infiltration surface, and (b) there is no marked difference from the saturation profile at $x = 0.19\ m$ (especially at t = 0.5 hrs) despite the fact that these points lie next to dry soil and are expected to show markedly lower water contents. This shows an inconsistency in behavior which is not observed in the numerical results. There is a very good agreement between prediction and observation at $x = 0.19\ m$, which would normally lead us to anticipate a similar agreement at $x = 0.49\ m$. The numerical profile at $x = 0.49\ m$ conforms with our expectations (i.e. shows a similar pattern but lower saturations at the same times), but differs from the observations which exhibit marginal differences and occasionally higher saturations, which is most likely explained by heterogeneity.

Based on these results, we believe that existing discrepancies between experiment and prediction are due to the media heterogeneities for which no detailed data are available, and do not indicate limitations of TOUGH to address the complexity of the problem.

(e) Further support for our arguments is provided by Figure 25, which compares the experimental data to the TOUGH predictions of the evolution of water pressure heads at two points (1st point: $x = 0.11\ m$, $z = 0.11\ m$, and 2nd point: $x = 1.61\ m$, $z = 82\ m$) with time. These experimental data are available in the original paper by *Vauclin et al.* [1979].

At the 1st point (which lies under the infiltration area) and *at t = 0 hrs*, a head of $-0.9\ m$ was observed, which is significantly different from the expected value of $-1.24\ m$ (determined from the geometry of the system and the initial

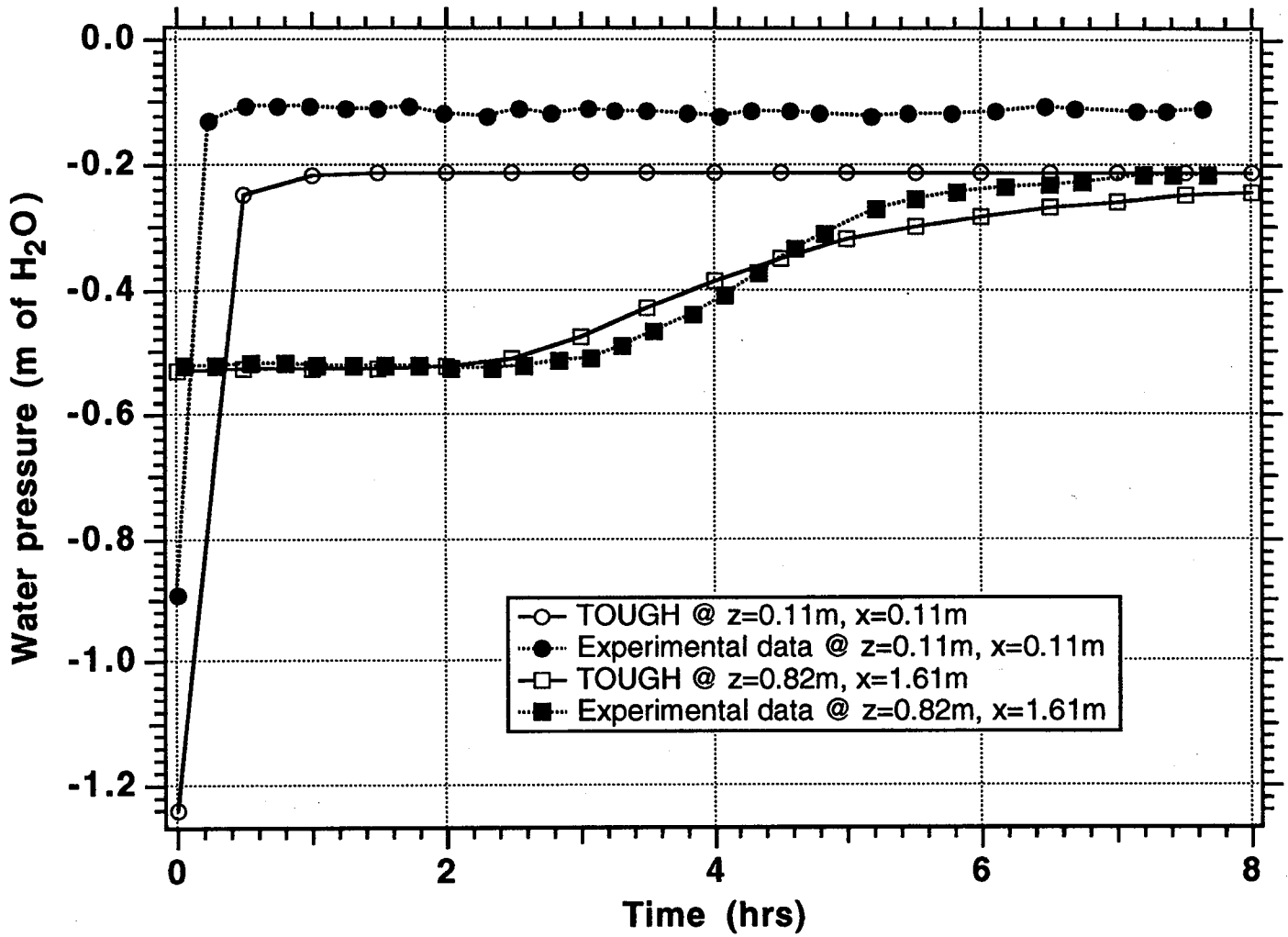

Figure 25. Comparison of TOUGH predictions and experimental data of water pressure in Validation Problem 1.

position of the water table). After the beginning of infiltration, a steady-state is reached within 1/2 hr with an observed water head of *-0.11 m*. The predicted water head for the steady-state is *-0.21145 m*, i.e. almost 100% higher (in an absolute sense). From the water head vs. water content relationship of this particular soil, the volumetric water content which corresponds to the steady-state water head of *-0.11 m* is $0.292\ m^3/m^3$ ($S_w = 0.975$). This is significantly larger than any water content measurement under the infiltration surface (the maximum of which was $0.27\ m^3/m^3$ in Figure 24(b)), and can only be explained by heterogeneity. On the other hand, the volumetric water content corresponding to the numerically obtained head of $-0.212\ m^3/m^3$ is 0.256 ($S_w = 0.853$), which is in excellent agreement with the maximum water content of $0.26\ m^3/m^3$ measured immediately below the infiltration surface (Figures 24(a) and 24(b)).

At the 2nd point (which lies outside the infiltration area), there is an excellent agreement between the initial measured and computed head. Comparison of the evolution of water head over time demonstrates a reasonably good agreement between experiments and predictions. The two curves have the same shapes, exhibit the same behavior, lie very close to each other, and exhibit a small discrepancy. The numerical results over-predict (in an absolute sense) water head, a tendency which is most obvious at steady-state. This discrepancy can be easily caused by a small variation in porosity, as is indicated by the fact that at $x = 1.69\ m$ (quite close to this point) the saturated water content exceeds the value of 0.30 quoted by *Vauclin et al.* [1979]. Such a higher saturated water content (i.e. porosity) could produce a behavior consistent with the observations.

7. CONVECTION CELL EXPERIMENT (VALIDATION PROBLEM 2)

7.1 Description

The second validation problem is a laboratory convection cell experiment described, performed, and modeled by *Reda* [1984]. Figure 26 shows a schematic of the experiment. A porous medium consisting of glass beads with an average diameter of *0.65 mm* fills the annular region between the two vertical concentric cylinders. Application of heat generates a thermal buoyancy force, giving rise to the development of convection cells. Figure 27 provides information on the system geometry, properties, as well as initial and boundary conditions. This problem is used to test the ability of TOUGH to simulate transient two-dimensional simultaneous heat and mass flow.

To evaluate TOUGH, numerical predictions are compared to measurements of the thermal response of the surface of the inner cylinder at the elevations $z = 0.4192, 0.6288, 0.7336,$ and 0.7860 *m* (i.e. $z/\Delta r = 2, 3, 3.5,$ and 3.75). These comparisons are made over a period of 10^5 seconds for a power level of *278.3 W/m.*

7.2 Updegraff's approach & results

The grid used in the *Updegraff* [1989] simulation appears in Figure 28. It consisted of 462 gridblocks, and included 62 boundary gridblocks. The heater was represented by gridblocks T0 to EE0, which controlled the heat flux into the system. A very large volume (10^{50} m^3) was assigned to gridblocks OO1 through OO10 (domain "BOUND") to maintain a constant temperature of *21.5* ^oC and a pressure of *200,000 Pa.* Gridblocks A11 through NN11 were designated as domain "TCOND"; they were assigned a very small volume (10^{-10} m^3) and a very large specific heat (10^{50} $J/kg\text{-}^oC$) in order to model zero mass flux and constant temperature boundary conditions. Zero mass and heat flux boundaries were assigned along the bottom and the left side of the grid. An initial temperature of *21.5* ^oC and a hydrostatic initial pressure distribution (based on a *200,000 Pa* pressure at the NN-OO interface) were assigned to the gridblocks of the system.

Updegraff's attempt to simulate this experiment with TOUGH failed, and he concluded that *"... TOUGH could not simulate the convection cell behavior of the experiment"*. The results of his simulation are compared to the experimental data in Figure 29, and seem to indicate that (a) TOUGH consistently and significantly over-predicts temperatures (by *15* to *30* ^oC), while (b) not exhibiting sufficient temperature differentials between the top and the bottom of the heating elements (less than 10 ^oC, when the observed difference was *30* ^oC).

The reasons for Updegraff's failure to successfully simulate this experiment were traced to inadequate and/or inappropriate data inputs. Examination of the report and the data input file identified the following sources of error:

(a) The discretization in the radial direction was excessively coarse for the requirements of this problem, and appeared to have been designed for maximum ease of implementation rather than for an accurate description of the temperature profile. Due to essentially cylindrical geometry, large temperature gradients are expected near the heater, and convective effects would be concentrated within a short distance from the heater.

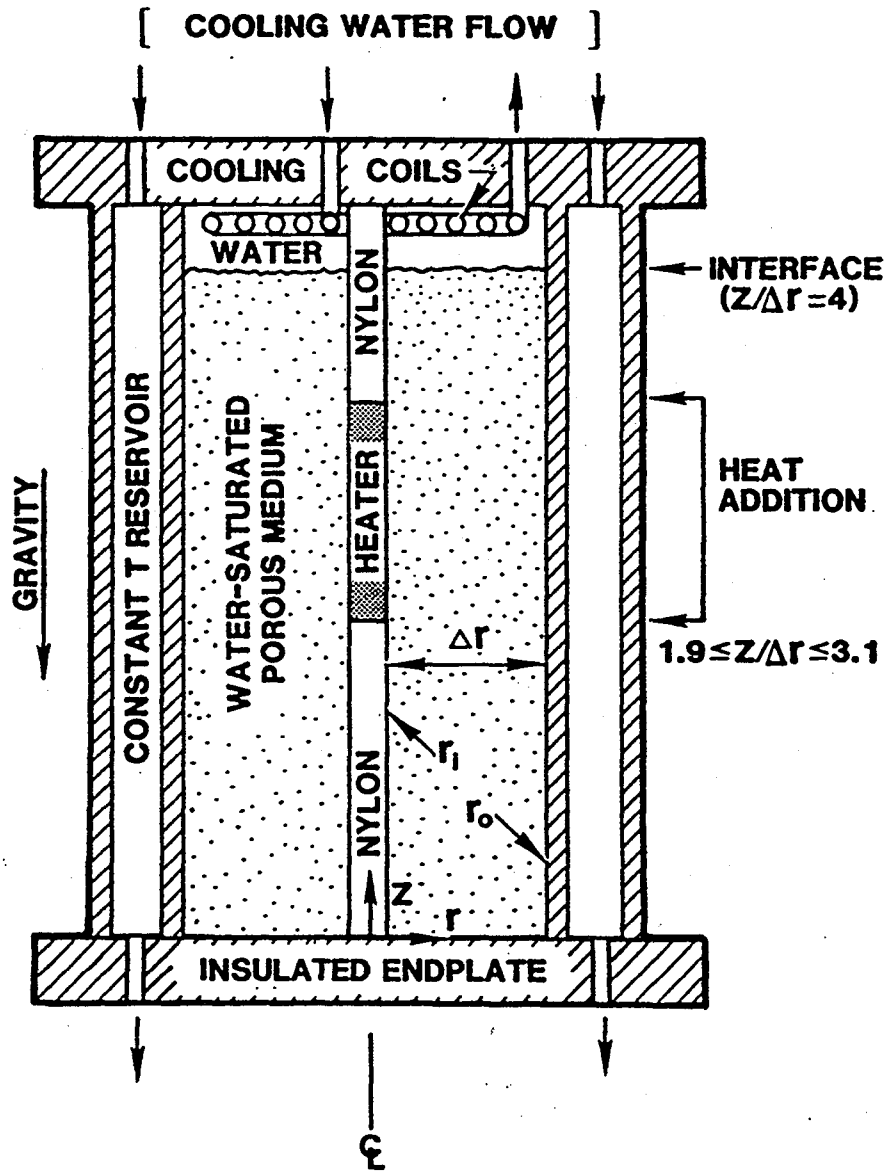

Figure 26. Schematic of the convection cell apparatus (from *Reda* [1984]).

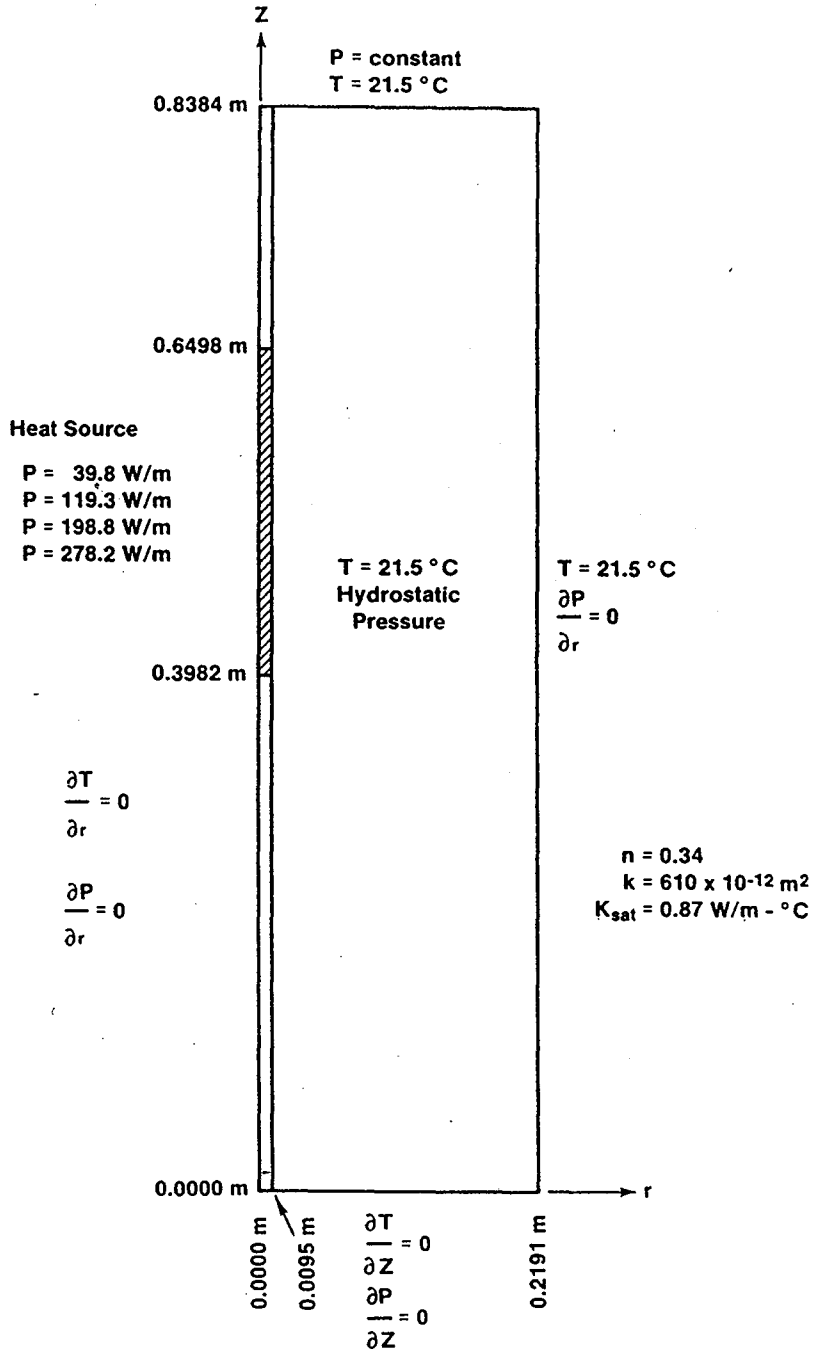

Figure 27. The convection cell experiment in Validation Problem 2 (from *Updegraff* [1989]).

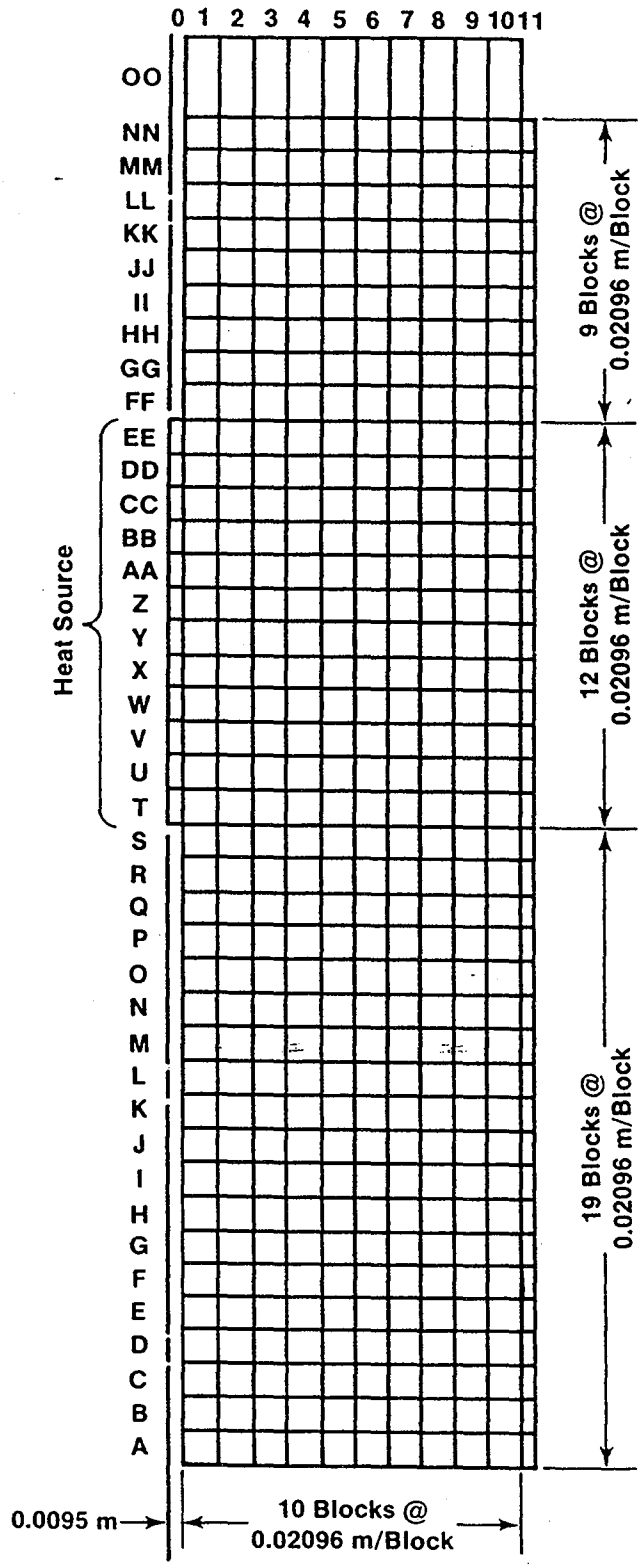

Figure 28. The TOUGH grid used by Updegraff in the simulation of Validation Problem 2 (from *Updegraff* [1989]).

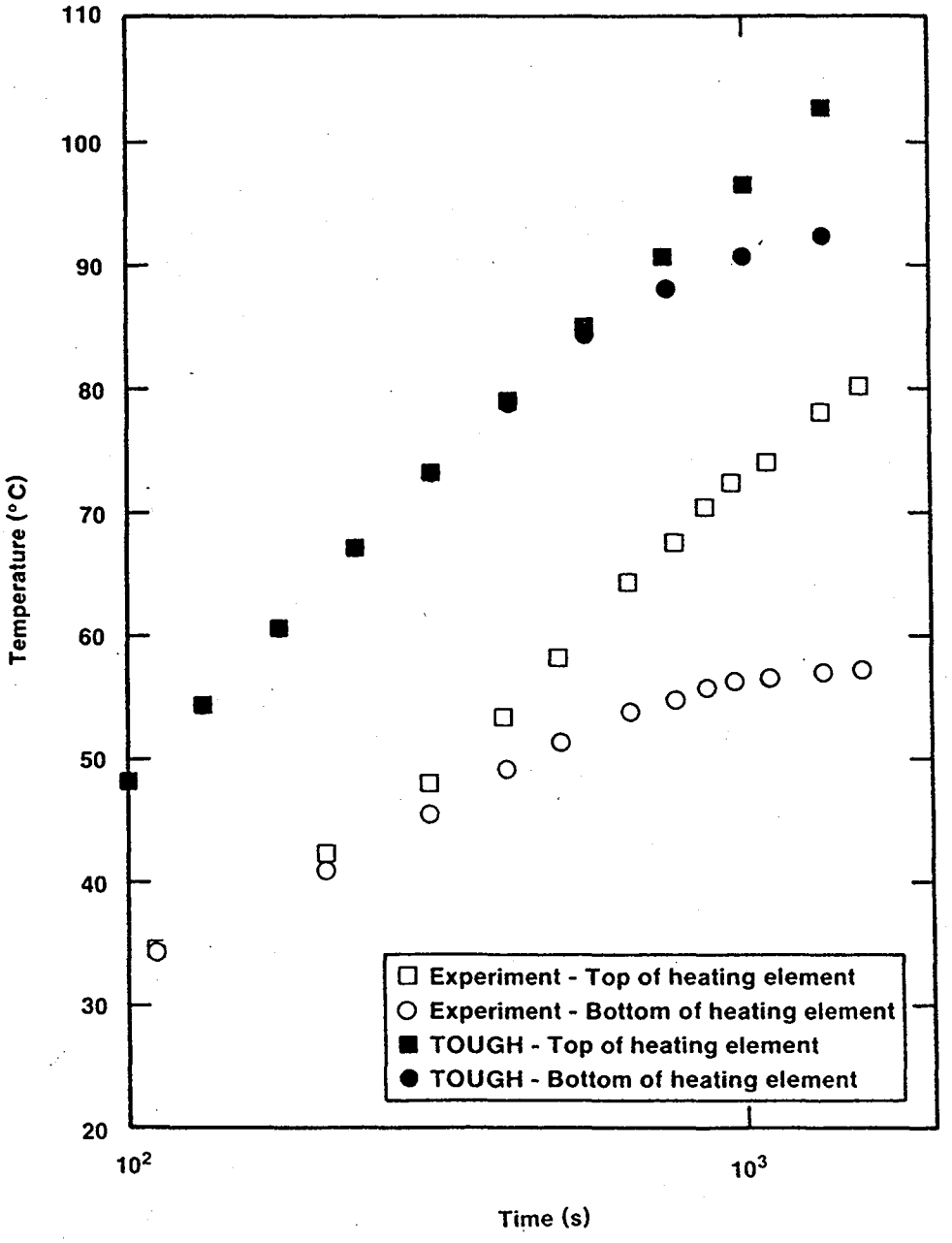

Figure 29. Comparison of Updegraff's TOUGH results with experimental data in Validation Problem 2 (from *Updegraff* [1989]).

This expectation was confirmed by the data and the analysis presented in the original report on the experiment [*Reda,* 1984]. Reda's finite element simulation employed a grid which was fine near the heater and grew progressively coarser away from the heater and towards the outer boundary. Moreover, *Reda* [1984] stated that the packing of the spherical particles (i.e. the glass beads used in his experiment) against the straight surface of the heater led to important flow channeling effects due to porosity and permeability enhancement. Reda modeled such effects by linearly increasing permeability from k_0 to $2k_0$ as the radial distance from the inner boundary decreases from $5d = 3.25$ *mm* to *0 mm* (where k_0 is the unenhanced "background" permeability, $d = 0.65$ *mm* is the average bead size in the experiment). Thus, this important permeability enhancement is localized in the critical region near the heater, where thermal buoyancy effects are most pronounced.

The entire region with an enhanced permeability is limited to a $\Delta r = 5\,d = 3.25$ *mm* beyond the inner radius r_i. Compared to this size, the radial increment Δr used by Updegraff to describe this region (i.e. the first gridblock in r) was *20.96 mm*. This was 6.45 times larger than the permeability enhancement zone, completely overwhelming its effects, and introducing very large discretization errors. The coarseness of the grid is the reason for the unacceptably large discrepancies between Updegraff's TOUGH predictions and the experimental data.

(b) The assignment of small volumes to the outer boundary (column 11) gridblocks in Updegraff's simulations is a rather awkward way to approximate the actual *"no-mass-flow"* boundary conditions. This approach results in a boundary with permeable connections to the flow domain, which, while small in magnitude, are not negligible and may have a noticeable impact on predicted convection behavior. Assigning a permeability of zero to these boundary gridblocks enforces strict *"no-mass-flow"* conditions, while being more physically correct and numerically less troublesome (TOUGH2 users are cautioned to be mindful of choices for interface permeability weighting when implementing impermeable boundaries).

(c) Permeability enhancement in the immediate vicinity of the heater was not accounted for in Updegraff's simulations. As we will later show (Subsection 7.4), the inclusion of permeability enhancement has a marked effect on predictions.

(d) The heater domain in Updegraff's simulation (column 0) was assigned porous medium properties, with (a) a porosity of *0.34*, (b) zero permeability in the r- and z-directions, (c) zero medium compressibility, and (d) a specific heat equal to that of the porous medium. These assumptions resulted in enormous pressures in the heater gridblocks because, due to zero permeabilities, they had no outlet and no compressibility other than that of water.

(e) Although a medium density and specific heat of $2{,}500\ kg/m^3$ and $740\ J/kg\text{-}^oC$ are quoted in the Updegraff report, there was a discrepancy in the input files provided to us, in which these values were $2200\ kg/m^3$ and $753\ J/kg\text{-}^oC$ respectively.

In our attempt to duplicate Updegraff's runs, we made a single run in which we used the input data file provided by S. Webb. This simulation was found to reproduce the results reported by *Updegraff* [1989] within the precision discernible from Figure 29. As compared to the experimental data, this TOUGH simulation predicted much higher temperatures (*15* to *30* ^oC higher) and much weaker and delayed convective effects. An additional problem was spotted in the selection of the location of the grid points at which the comparisons were made. Updegraff used information from the heater gridblocks,

which, in light of the treatment described in item (d) and its poor representation of the physics of this domain, makes the validity of these results questionable.

7.3 Modification of approach and data inputs

For our simulation we created two new data sets. The strong variation of temperature in the immediate vicinity of the heater, combined with the need to include permeability-enhancement effects in our simulations, necessitated a new grid with a sufficiently fine discretization in the all-important region near the heater. For simplicity we used the MESHMAKER facility of TOUGH2 [*Pruess,* 1991] to generate the grid. The grid specifications are given in Table 3.

The first radial grid block extends to *9.5 mm*, i.e. the radius of the heater (as well as of the nylon rods placed above and below). The next 5 radial gridblocks have a radial increment $\Delta r = 0.65$ *mm* each, corresponding to the mean glass bead size. Besides providing the desired fine spatial resolution near the heater, these blocks are also used to represent the enhanced permeability in the *5d* zone affected by wall effects. The next 4 gridblocks have progressively large Δr's and reach $r = 0.05$ *m*. These are followed by 5 more blocks with logarithmically increasing spacing, and a boundary gridblock with a $\Delta r = 10^{-5}$ *m*. This discretization results in 16 gridblocks in r (as opposed to 11 in Updegraff). Layer thickness in the region of the heater was chosen as $\Delta z = 0.02096$ *m*, as in Updegraff's simulation. Above and below the 12 grid layers representing the heater region there are 3 layers with the same $\Delta z = 0.02096$ *m*, followed by a coarser discretization. The top layer with a $\Delta z = 10^{-5}$ *m* is used to represent the top boundary conditions.

We use nine different sub-domains of porous media in the simulation. Sub-domain "SOIL1" remains as in Updegraff, and represents the unenhanced "background" permeability of $k_0 = 6.1 \times 10^{-10}\ m^2$. Soil types "SOIL2" through "SOIL6" represent the five sub-domains with channeling-induced enhanced permeability in the vicinity of the heater. Following *Reda* [1984], permeability in these domains is linearly interpolated between k_0 and $2k_0$ over the $\Delta r = 3.25$ *mm* region starting at the internal radius $r_i = 9.5$ *mm*. The soil density and specific heat of the six domains "SOIL1" through "SOIL6" are $2500\ kg/m^3$ and $740\ J/kg\text{-}^oC$ respectively. These values are taken from *Updegraff* [1989], and differ from the values we found in the input values (see item (e) in Subsection 7.2). It should be noted that these values appear to be relatively low for the porous medium (i.e. glass beads) used in the experiment. However, we decided to use them since the original paper by *Reda* [1984] makes no mention of the values of these quantities.

TABLE 3. Specifications of the refined 2-d *r-z* grid in Validation Problem 2.

Interface radii (m)	0.0000	0.0095	0.0102	0.0108	0.0115
	0.0121	0.0128	0.0150	0.0200	0.0300
	0.0500	0.0736	0.1015	0.1344	0.1732
	0.2191	0.21911			
Layer thickness (m)	0.0734	0.0734	0.0734	0.0734	0.0419
	0.0210	0.0210	0.0210	0.0210	0.0210
	0.0210	0.0210	0.0210	0.0210	0.0210
	0.0210	0.0210	0.0210	0.0210	0.0210
	0.0210	0.0210	0.0210	0.0419	0.0419
	0.0419	0.00001			

Domain "BOUND" is used to represent the top permeable boundary of the model and has the same properties as "SOIL1", with the exception of specific heat which is 10^4 $J/kg\text{-}^oC$ for this domain. This value is chosen to exclude the large volume blocks in domain BOUND from the mass and energy balances.

The gridblocks at the outer radial boundary belong to the domain "TCOND", which has a very low porosity (10^{-5}), zero permeability and a very high specific heat (10^{54} $J/kg\text{-}^oC$). This forces strict "no mass-flow" boundaries while maintaining a constant temperature. The gridblocks assigned to the heater belong to the domain "HEATR", which is characterized by a very low porosity (10^{-5}), zero permeability to impose a *"no-mass-flow"* boundary, and the properties of cast iron (as opposed to those of the porous medium used by Updegraff), i.e. a density of 7400 kg/m^3, a specific heat of 569.4 $J/kg\text{-}^oC$, and a thermal conductivity of 50.2 $W/m\text{-}^oC$ [*Carslaw and Jaeger*, 1959]. However, the use of cast iron is not expected to have a significant effect on the simulation, and is implemented in the spirit of conceptual consistency. An important aspect is the inclusion of a large compressibility (10^{-5} Pa^{-1}) for the tiny pore space in the "HEATR" domain. This feature prevents the build-up of excessive pore pressures in this domain due to thermal expansion of liquid water. Alternatively, the "HEATR" domain could have been initialized as containing gas, which at ambient temperature has a large compressibility of approximately 10^{-5} Pa^{-1}.

The initial pressure and temperature conditions for the TOUGH run are $2.0x10^5$ Pa and 21.5 ^oC respectively. No separate initial step of gravity equilibration was deemed necessary because it was determined that this process occurs extremely fast. More specifically, the pressure diffusivity $D = k/(c\phi\mu)$ is of order 10^3 m^2/sec, so that pressure equilibration would require only a fraction of a second.

The first data set accounted for permeability enhancement and had variable permeabilities in the domains "SOIL1" through "SOIL6". The second data set was used to investigate some of the results that appeared in a revised version of Reda's 1984 paper. In the revised paper [*Reda,* 1986] Reda stated that *"variable-porosity (flow channeling) effects ... adjacent to solid boundaries were found to have a negligible influence on the thermal field adjacent to such boundaries under conditions of Darcy flow..."*. Following up on this, we conducted a separate simulation in which the permeability throughout the glass bead pack (domains "SOIL1" through "SOIL6") was set to the constant value of "background" permeability $k_0 = 6.1x10^{-10}$ m^2. Everything else in this second data set remained as in the first input data set.

7.4 Discussion of the TOUGH output from the modified input files

We evaluated the performance of TOUGH by comparing the simulation results to the experimental measurements made by *Reda* [1984] at the locations $r = r_i$ and $z/\Delta r = 2, 3, 3.5,$ and 3.75 over time. The point at $z/\Delta r = 2$ marks the bottom of the heater and lies at the interface between layers of equal thickness (layers J and K); similarly, the point at $z/\Delta r = 3$ marks the top of the heater and lies at the interface between layers of equal thickness (layers 9 and A). The points at $z/\Delta r = 3.5$ and $z/\Delta r = 3.75$ lie above the top of the heater. Temperature predictions at these points are obtained by interpolation. The maximum simulation time was $t_{max} = 10^5$ sec. The evolution of temperature over time at the prescribed locations is presented in Figures 30(a) and 30(b). An examination of the simulation results and Figures 30(a) and 30(b) reveals that:

(a) Both input files produced very efficient runs. The first run (input data set with permeability enhancement) covered the desired simulation period in 40 time steps; the second run (without permeability enhancement) covered t_{max} in 32 time steps.

(b) Figure 30(a) shows the experimental measurements and the numerical predictions of the temporal variation of temperature at the bottom and the top of the heater. The numerical results with and without permeability enhancement are shown here. A very good agreement between experiment and prediction is observed for the period of transient convection, as well as for the eventual steady-state.

The numerical results in Figure 30(a) are obtained at the center of the second gridblock at $r = 9.825\ mm$, i.e. $0.325\ mm$ away from the inner radius r_i. Although this seems to practically coincide with the inner radius, our simulation indicates an extreme sensitivity of temperature to the radial distance r in the immediate vicinity of the inner radius. The temperature at r_i is also shown in Figure 30(a) as the upper limit of the range of the temperature at the points in the graphs. It can be seen that within 1 mm the temperature drops by as much as $2\ ^oC$. The very strong dependence of temperature on the radial distance suggests that the predicted surface temperature lies between the two temperatures at $r_i = 9.5\ mm.$ and $r = 9.825\ mm.$

(c) Comparison between predictions and observations and experiments at the points $r = r_i$ and $z/\Delta r = 3.5$, and 3.75 (i.e. above the top of the heater) in Figure 30(b) shows reasonable agreement. A far less dramatic dependence of temperature on radial distance r is expected at these two elevations z because they do not lie immediately next to the heater. A test run over the first $5000\ sec$ using smaller time steps and a finer grid in the z direction gave significantly improved results, but at the expense of larger execution times.

(d) Contrary to *Reda*'s [1986] assertions, we found a significant difference between the runs with and without permeability enhancement. Temperatures predicted without permeability enhancement are consistently higher both at the bottom and the top of the heater. This temperature differential is small initially, but keeps increasing during the transient period and stabilizes as the steady-state is approached at $3 - 3.1\ ^oC$. The temperature differential appears earlier and is more pronounced at the top of the heater. This indicates that without flow channeling there is a somewhat slower initiation of convection, and a weaker convection process at later times when steady-state is approached.

A closer investigation of Reda's publications on the subject reveals that his simulation results which supposedly do not include permeability enhancement effects [*Reda,* 1986] seem to be identical to those when permeability enhancement is included [*Reda,* 1984]. We find this hard to accept because our simulations indicate that permeability enhancement effects are significant, and predict measurable temperature differentials which should have been easily discernible on Reda's figures if they had been accounted for.

At the heater bottom ($z/\Delta r = 2$), the two runs produce practically the same results in the earlier part of the transient period, which agree very well with the laboratory observations; as steady-state is approached the run without permeability enhancement seems to agree better with the experimental data. At the heater top flow channeling produces results which agree better with the experimental data, but a better agreement between the results of the run without permeability enhancement is observed as steady-state is approached.

(e) However, it must be pointed out that despite its apparent better agreement with measurements (at least near steady-state), it is simply inappropriate to state that

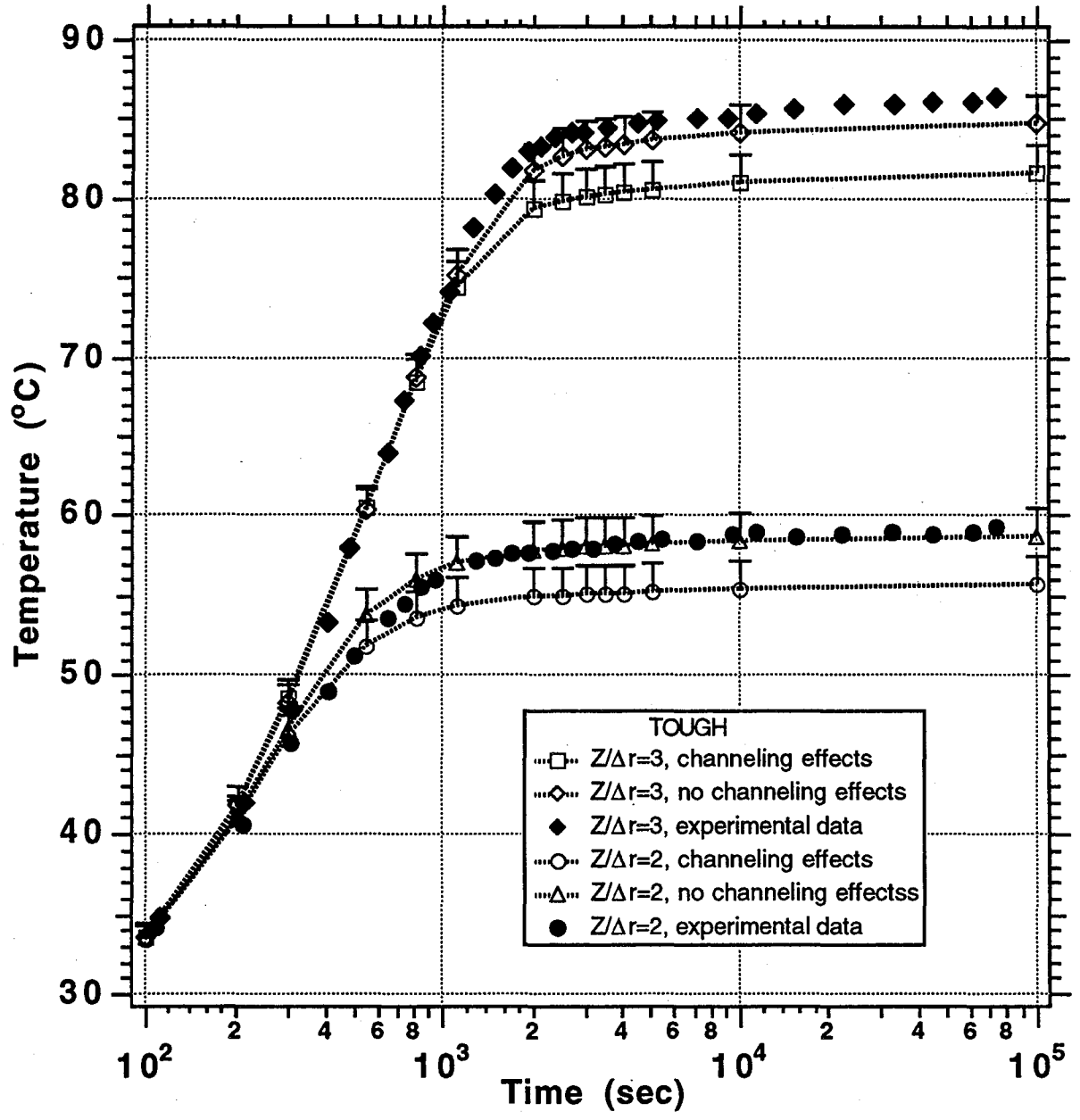

Figure 30(a). Comparison of TOUGH predictions with experimental data at the heater bottom ($z/\Delta r = 2$) and top ($z/\Delta r = 3$). The bars attached to the TOUGH curves indicate the predicted temperature in the first radial element (i.e. on the surface of the heating element).

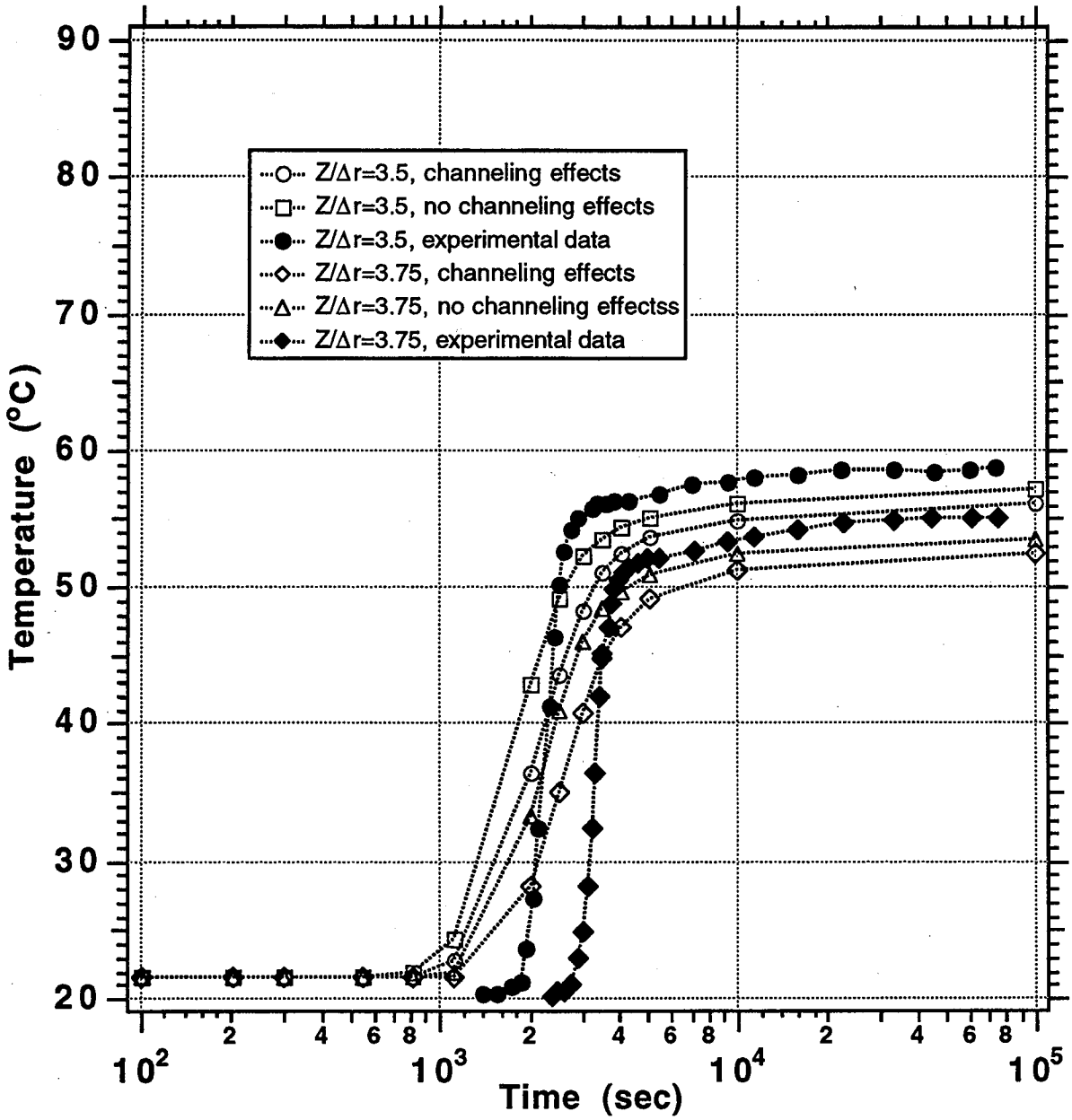

Figure 30(b). Comparison of TOUGH predictions with experimental data at $z/\Delta r = 3.5$ and $z/\Delta r = 3.75$.

neglecting channeling effects produces more accurate results because of extremely steep temperature gradients in the vicinity of the heater. This hyper-sensitivity has been demonstrated and discussed in item (b) above.

Figure 31 shows the temperature predictions *0.01048 m* above and below the bottom ($z/\Delta r = 2$) and the top ($z/\Delta r = 3$) of the heater. While this sensitivity is not as dramatic as the sensitivity to r (where temperature changes by several degrees within fractions of a mm), it is nevertheless important.

As was discussed earlier, the points $z/\Delta r = 2$ and $z/\Delta r = 3$ lie at the interface (and not the centers) of gridblocks (layers) of equal thickness of *0.2096 m*. Predictions at these points are obtained by averaging the predictions at the overlaying and underlying gridblocks. The differential in the predictions at the centers of these gridblocks gives the measure of temperature sensitivity to the vertical distance *z*.

Figure 31 shows the TOUGH results at the centers of the gridblocks immediately above and below the top and the bottom of the heater, as well as the corresponding averaged temperatures at the interfaces (marking the top and the bottom of the heater). All predictions are made at the centers of the second radial gridblocks, i.e. at $r = 9.825$ *mm*, as opposed to the first (heater) gridblock, for reasons explained in the preceding item (b). A dramatic dependence of temperature on the vertical distance z is evident at the top of the heater, where a temperature differential of *7.35* ^oC is evidenced within a vertical distance of *0.02096 m*. The temperature variation with z at the bottom of the heater is significant (*2.07* ^oC within *0.02096 m*), but far less dramatic then at the top.

It is obvious that even minute (i.e. sub-millimeter) changes in the position of the measuring device (sampling point) can effect sizable temperature differentials. This observation from our simulations adds further perspective on the comparison between experimental and numerical results.

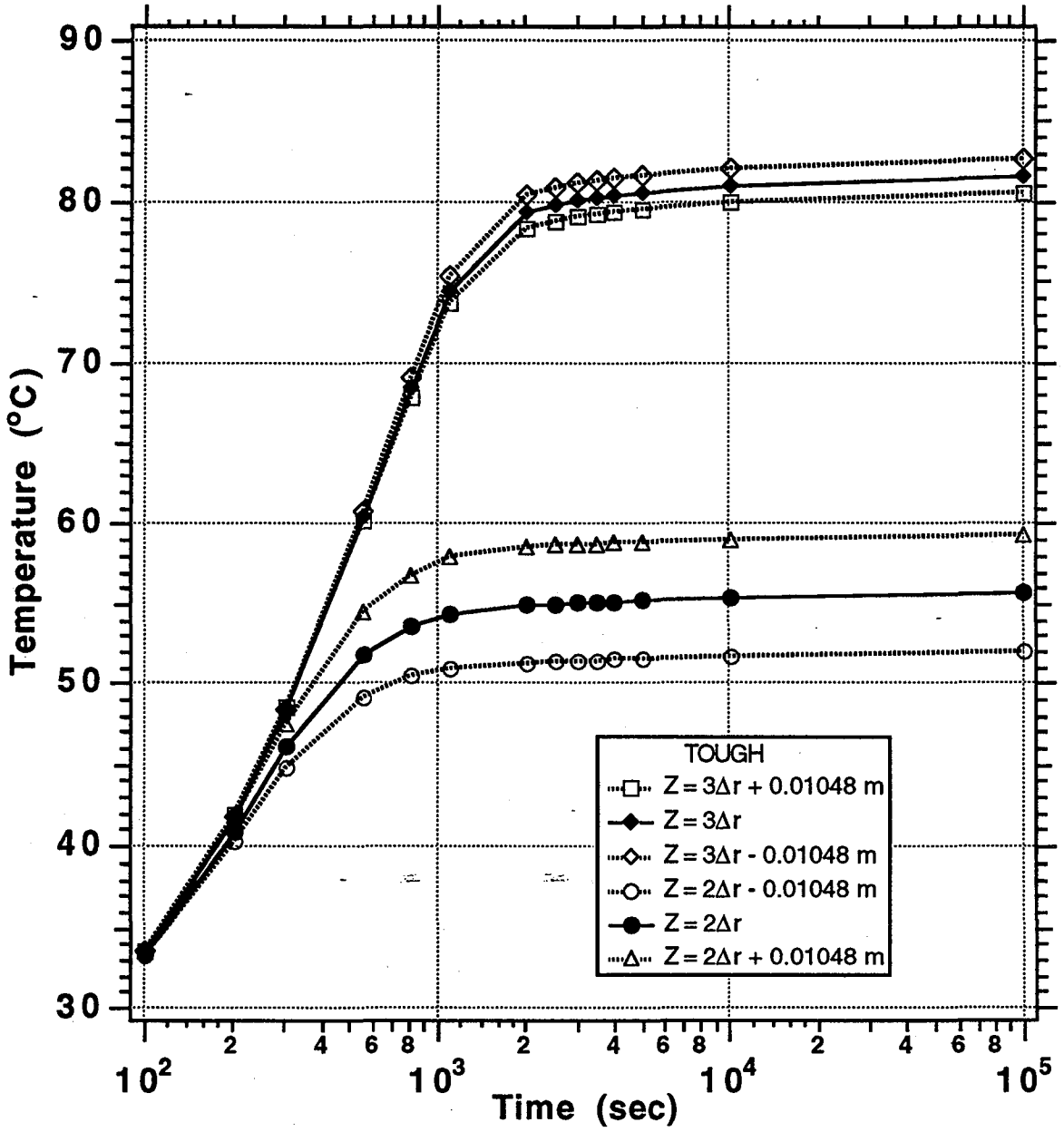

Figure 31. Temperature sensitivity to z at the heater bottom ($z/\Delta r = 2$) and top ($z/\Delta r = 3$).

8. TWO-PHASE FLOW EXPERIMENT (VALIDATION PROBLEM 3)

8.1 Description

The third validation problem sought to model flashing (vaporizing) flow from a synthetic sandstone core. The experiment was performed and modeled by *Kruger and Ramey* [1974]. *Faust and Mercer* [1979] later independently modeled the experiment. This problem is used to test the ability of TOUGH to simulate simultaneous heat and mass flow, as well as phase change (vaporization of water). Figure 32 shows a schematic of the experiment, as well as pertinent material property, boundary condition, and initial condition information. The saturated core cylinder in Figure 32 is placed in an oven and heated to *198.9 °C*. While the left boundary is insulated to prevent mass and energy flux, the right end of the core is a "time-variable-pressure" boundary with a pressure decline described by the equation (cited after *Updegraff* [1989])

$$P_r = P_0 + P_1 t + P_2 t^2,$$

with $P_0 = 1{,}840{,}965.0$, $P_1 = -\ 11{,}395.51972$, and $P_2 = 21.4064213$. Prior to emplacement in the oven, the saturated core is brought to an initial pressure of *1,840,965 Pa*, and heated in such a way as to effect a linear temperature variation between the left end (where the temperature is $T = 192.0\ ^oC$) and the right end (where $T = 184.0\ ^oC$).

The relative permeability curves in this experiment were described by Corey's equations [*Kruger and Ramey*, 1974]. To evaluate TOUGH, numerical predictions are compared to the measured temperature distribution along the length of the core cylinder at a time $t = 300\ sec$.

8.2 Updegraff's approach & results

The grid used by *Updegraff* [1989] to simulate this experiment appears in Figure 33. It consists of 100 gridblocks labeled A0 through A99, each *5.969 mm* wide, as well as a boundary gridblock (labeled YY1) for the right end boundary. The lack of a boundary gridblock on the left end of the core automatically imposes zero mass and energy flux at this end. A very large volume ($10^{50}\ m^3$) was assigned to gridblock YY1 on the right-hand boundary to maintain a constant temperature, pressure, and gas saturation boundary conditions. The temperature, pressure and gas saturation assigned to YY1 were a constant *20 °C*, *101,330 Pa*, and *1* respectively. The initial conditions assigned to the core were a pressure of *1,840,965 Pa*, a liquid saturation of *1*, as well as a linear temperature distribution between *192 °C* at the left end and *184 °C* at the right end.

The modeled system is significantly different from the experiment described above. The boundary conditions of Updegraff's approach do not even approximate the ones described in the *Kruger and Ramey* [1974] experiment. The results of a simulation using Updegraff's input file (which we reproduced with an input file supplied by S. Webb) showed a similar temperature trend as in the experiment, but they consistently under-predicted temperatures along the length of the core by *4-15 °C*. Such discrepancies were entirely expected in light of the large differences between the experimental and the simulated conditions, and were attributed by Updegraff to three reasons, all related to boundary conditions.

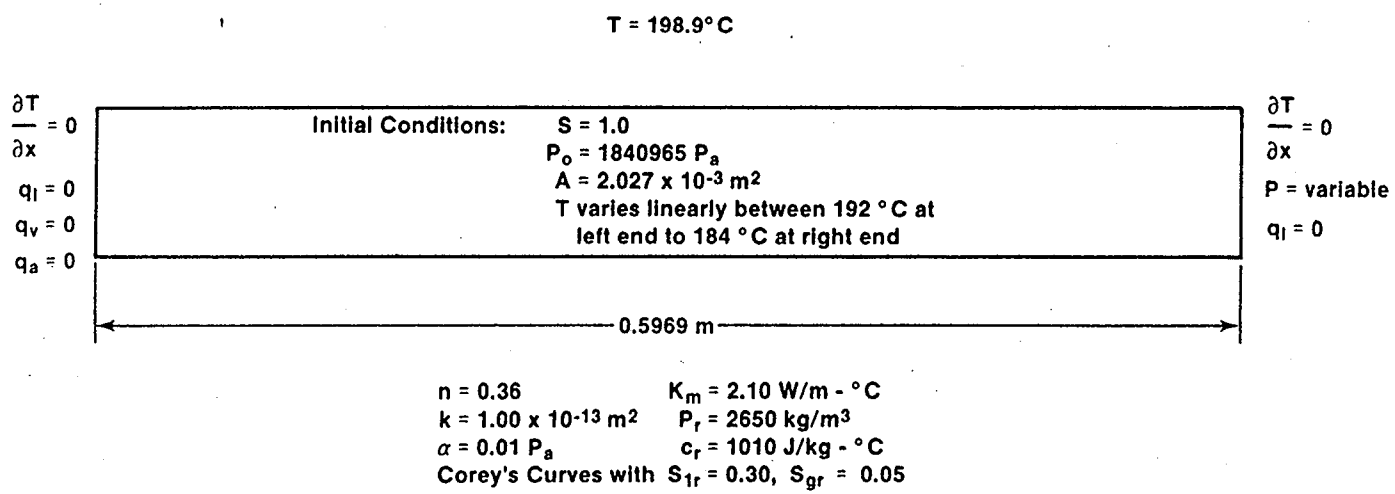

Figure 32. A schematic of the two-phase flow problem (from *Updegraff* [1989]).

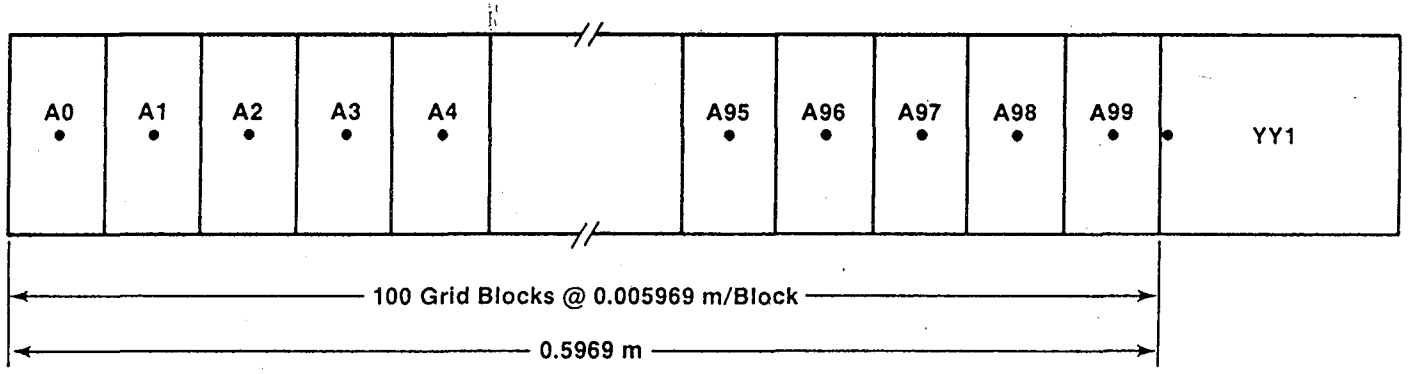

Figure 33. TOUGH grid used by Updegraff for the simulation of Validation Problem 3 (from *Updegraff* [1989]).

The first reason was the failure to include the constant-temperature boundary condition on the periphery of the core imposed by its placement inside the oven. Updegraff stated that *"attempts to include a constant temperature boundary condition at the outside edge of the core failed because extremely small time steps were required and, consequently, the solution progressed very slowly making the computer cost prohibitive."*.

The second problem surmised by Updegraff was related to the very large volume at the right-end boundary, which *"...was inconsistent with the zero temperature gradient boundary condition."* Being unable to describe this condition, he arbitrarily set the temperature at this boundary to 20 °C. He further indicated that attempts to force a *"zero-heat"* flux condition by setting the thermal conductivity of the YY1 boundary to zero failed because this approach required a large number of small time steps.

The third problem according to *Updegraff* [1989] was that *"...TOUGH cannot directly handle a transient pressure boundary condition."*. To deal with this perceived problem, he suggested a series of restarts with an adjusted boundary pressure after each time step, but he correctly indicated that such an approach, although more accurate, would be cumbersome and time consuming.

A close examination of the report and the input data files failed to detect an obvious, *"smoking-gun"* type of problem that could cause the discrepancies reported by Updegraff. Small inconsistencies were spotted. For example, the initial pressure of the core (as reported by *Faust and Mercer* [1979]) was $2.17x10^6$ *Pa*, and not *1,840,965 Pa* as indicated in the report; however, the original input file supplied by S. Webb had an initial pressure of $2.17x10^6$ *Pa*.

Further investigation into the matter determined the source of the problems in the treatment of the boundary conditions, and more specifically in the unacceptably inaccurate approximations and simplifications which Updegraff introduced in the belief that TOUGH could not address this type of problem. Contrary to his assertions, TOUGH can very easily handle all the boundary conditions present in the experiment, including the transient pressure boundaries. A detailed explanation of our approach to successfully simulate the experiment is presented in the following Sub-section 8.3.

8.3 Modification of approach and data inputs

We created two new data sets for our simulation, in which we maintained the space discretization of Updegraff's, as well as the right-hand side boundary gridblock. In the first data set the properties of the core domain remain as in Updegraff. The boundary gridblock YY1 had the same density and permeability as the core, a porosity of *0.1*, a zero thermal conductivity to enforce a "no-heat-flux" condition, and a very large specific heat (10^{30} *J/kg-°C*). As in Updegraff, a Corey-type curve described the relative permeabilities in the core, while a zero capillary pressure was assigned to both the core and YY1. A very large volume (10^{51} m^3) was assigned to YY1, as well as liquid and gas relative permeabilities of *1*.

To simulate the *"constant-temperature"* boundary imposed by the insertion of the core into the oven, we added a second set of gridblocks (B0 through B99), which formed a ring surrounding the cylindrical core (gridblocks A0 through A99) and had the same space discretization. This new domain had the same density, porosity, and thermal conductivity as the core (allowing the flow of heat from the oven into the core), zero permeability (thus preventing any mass flow), and a large specific heat (10^6 *J/kg-°C*). To maintain a constant

temperature, a very large volume ($10^{30}\ m^3$) was assigned to each of the gridblocks of this domain. The addition of this new domain was not unimportant because conduction into the core was calculated to be significant. More specifically, the thermal diffusivity for heat conduction (neglecting fluid contributions) is obtained as

$$D_H = K_H/[(1-\phi)\rho C] = 2.1/[(1-0.36)x2650x1010] = 1.226x10^{-6}\ m^2/s,$$

from which for $t = 100\ sec$ we calculate a thermal penetration of

$$x(t=100) = (D_H t)^{0.5} = 1.11x10^{-2}\ m.$$

This is a significant quantity when compared to the core radius of $2.54x10^{-2}\ m$.

The addition of the *"ring"* boundary created in essence a two-dimensional problem. The center of the gridblocks (A and B) in the x-direction (along the length of the core) was located in the geometric center of the gridblocks. In the radial direction the centers of the B gridblocks were placed at a distance of $5x10^{-3}\ m$ from the interface with the A gridblocks; the A gridblock centers were placed at a distance of $r(1-1/\sqrt{2}) = 7.44\ mm$ from the interface, i.e. at a radius which divided the cylinder volume in half. The initial conditions in the core and the YY1 boundary remain as in Updegraff, while an initial temperature of $198.9\ ^oC$ (i.e. the oven temperature) is assigned to the ring.

The introduction of transient-pressure boundary conditions was accomplished by exploiting the simplicity of the pressure-density relationship of ideal gases. The air component in TOUGH is treated as an ideal gas. By introducing a large boundary block in air-only, single-phase gas conditions, and subjecting it to suitable time-dependent rates of air injection or withdrawal, very general time-dependent pressure conditions can be realized. The ideal gas law written for a mass m of air is

$$m = M\,V\,(R\,T)^{-1}\,P = F\,P, \text{ where } F = M\,V\,(R\,T)^{-1},$$

$M = 28.96\ kg/kmole$ is the molecular weight of air, V is its volume, $R = 8314.56\ J/kmole^o\text{-}C$ is the universal gas constant, T is the temperature, and P is the gas pressure. The evolution of pressure at the right hand boundary is described by a quadratic equation (see Sub-section 8.1), which combined with the equation of air mass yields:

$$m = F(P_0 + P_1\,t + P_2\,t^2) = m_0 + m_1\,t + m_2\,t^2,$$

where P_0, P_1, P_2 are the polynomial coefficients in the boundary pressure equation. A time-dependent change in mass m corresponds to an injection or production rate Q, and is given by

$$Q = dm/dt = F\,dP/dt = m_1 + 2\,m_2\,t.$$

Thus, a time-dependent pressure condition can be translated into a time-dependent rate condition by simple differentiation. This way, the TOUGH facility to specify time-dependent generation can be utilized to achieve any desired time-dependent pressure conditions. Applying these equations to the boundary gridblock YY1 where $V = 10^{50}\ m^3$, $T = 20\ ^oC = 293.17\ ^oK$, yields

$$m_1 = -1.35395x10^{49}\ kg/sec \text{ and } m_2 = 2.54339x10^{46}\ kg/sec^2$$

This indicates that the transient-pressure boundary condition is easily transformed into a simple case of combined injection/production, in which gas is (a) removed from the gridblock YY1 at a constant rate of $-1.35395x10^{49}$ *kg/sec*, and (b) is injected into YY1 at a linearly increasing rate which starts at 0 kg/sec at t = 0 and increases to $2\ m_2\ t = 1.526036x10^{49}$ *kg/sec* at $t = 300$ *sec*.

The second data set was identical to the first, but did not include the steady-temperature *"ring"* boundary. The purpose of this run was to determine the effect of heat conduction from the oven into the core.

8.4 Discussion of the TOUGH output from the modified input files

We made two TOUGH runs using the new data files. With the treatment of the boundaries described in the previous Sub-section (8.3), we eliminated all of the problems encountered by Updegraff. We evaluated the TOUGH simulations by comparison with the laboratory measurements of *Kruger and Ramey* [1974]. Figure 34 shows the numerical and experimental results. Based on the simulation performance, the following conclusions are reached:

(a) TOUGH was able to simulate this problem of coupled mass and heat transport with multi-phase flow and phase change. Using the approach described in Sub-section 8.3, the problems encountered by Updegraff were avoided.

(b) The TOUGH simulation was very efficient, and required only 152 and 159 time steps (in the first and second run respectively) to reach the desired maximum simulation time of *300 sec*. This number of time steps is deemed very reasonable considering the complexity of the processes involved in this simulation (i.e. phase appearance and disappearance).

(c) As is shown in Figure 34, the effect of heat conduction from the oven into the core is not insignificant. When the boundary *"ring"* is not included, TOUGH underpredicts temperatures (especially near the left boundary). The experimental data lie in the narrow band between the two TOUGH curves. Note that inclusion of a ring of elements will give a somewhat crude approximation of axial heat transfer. A more accurate model would use a fully two-dimensional *r-x* grid, but this was not considered necessary in the present problem.

(d) Figure 34 reveals a satisfactory agreement between the experimental data and the TOUGH numerical predictions. The observed discrepancies are not considered significant; they may reflect that experimentally achieved boundary conditions at the core outlet may be more complex than presumed in the somewhat idealized one-dimensional model.

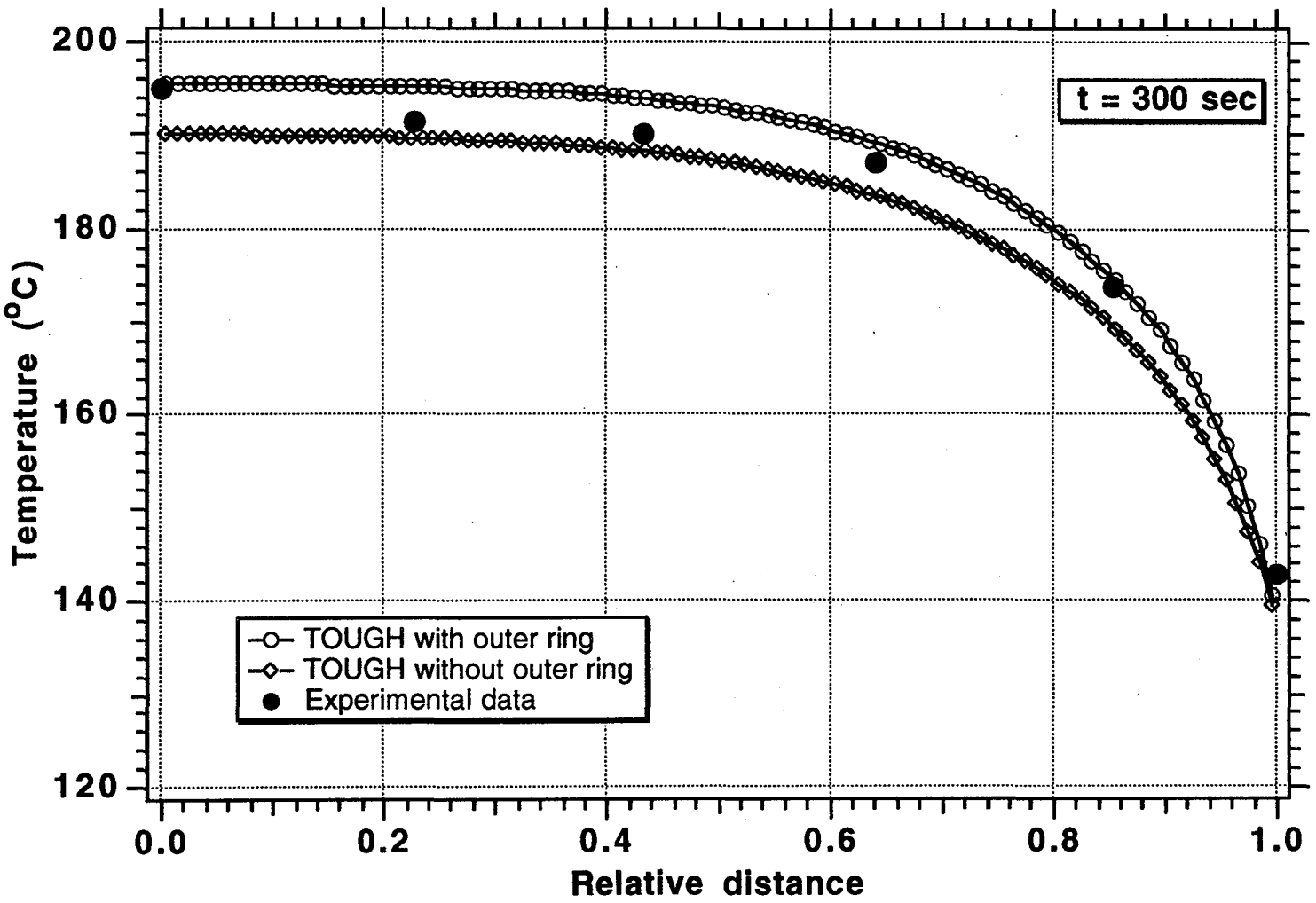

Figure 34. Comparison of TOUGH predictions and experimental data in Validation Problem 3.

9. FURTHER CODE VERIFICATIONS AND VALIDATIONS

9.1 The MULKOM/TOUGH family of codes

In the present context it is of interest to briefly summarize other verification and validation problems that have been run with the MULKOM/TOUGH family of multiphase flow codes. Before doing so a few remarks about the interrelationships between these codes are in order.

The "ancestor" to TOUGH is a code known as MULKOM which first became operational in the early 80's [*Pruess,* 1983]. MULKOM was built on the recognition that the governing equations for non-isothermal, multi-phase, multi-component flow are the same, regardless of the nature and number of fluid components present. Accordingly, MULKOM featured a modular architecture, in which a central module for flow and transport could be interfaced with several different fluid property modules to model systems with different fluid mixtures. The development of MULKOM was driven by research applications primarily in geothermal reservoir engineering, and later also in nuclear waste-related studies. The coding of MULKOM was never finalized; rather, it consisted of a continually evolving collection of program modules for specialized applications, with only sketchy documentation. The needs of nuclear-waste oriented applications then prompted an effort to finalize and document a specialized version of MULKOM for nonisothermal two-phase flows of water and air, which in 1987 was released under the name TOUGH (for Transport Of Unsaturated Ground-water and Heat; [*Pruess,* 1987]). A number of enhanced versions of TOUGH have subsequently been developed at the Lawrence Berkeley Laboratory, as well as in other places [*Pruess,* 1990]. The methodological choices made in the development of MULKOM and their relationship to an earlier code SHAFT79 [*Pruess and Schroeder,* 1980] have been discussed in a laboratory report [*Pruess,* 1988].

With its "hardwiring" of the two fluid components water and air, TOUGH traded-in some of MULKOM's flexibility against greater robustness and ease of use. The recently released TOUGH2 code [*Pruess,* 1991; *ESTSC,* 1992] is an upwardly-compatible successor to TOUGH. It is actually subroutine-for-subroutine very similar to TOUGH, but offers added new features (internal mesh generation, embedded fractured-media capability with the "MINC" method of *"Multiple INteracting Continua"*, version control), and it provides the full multi-component, multi-phase flexibility previously only available in the undocumented MULKOM collection of research modules. The name "MULKOM" is now used to refer to the particular modular architecture of these codes, while actual coding implementations are referred to as TOUGH and TOUGH2.

Throughout the development of the MULKOM/TOUGH codes an effort was made to maintain continuity in numerical performance, i.e., different code variations were always exercised on several earlier benchmark problems to guard against occurrence of coding errors. Therefore, verification or validation exercises performed with any one member of the MULKOM/TOUGH family are significant in establishing credibility for all the other members as well. Accordingly, our summary of verification and validation work will cover all of the MULKOM/TOUGH variations developed at LBL.

9.2 Summary of verifications and validations

An early comparative evaluation of geothermal reservoir simulation codes under the auspices of DOE established important benchmarks for subsequent code developments [*Stanford,* 1980]. MULKOM was extensively cross-checked against the SHAFT79 solutions developed for the DOE code comparison study. An analytical solution obtained by *Lauwerier*

[1955] for non-isothermal flow in a homogeneous reservoir with conductive heat exchange to caprock and baserock was closely matched by a MULKOM simulation [*Pruess and Bodvarsson,* 1984].

Using the method of "multiple interacting continua" (MINC), *Pruess and Narasimhan* [1985] demonstrated excellent agreement between MULKOM simulations and the *Warren and Root* [1963] double-porosity solution for isothermal single-phase flow in a naturally fractured reservoir. *Pruess et al.* [1987] developed an analytical solution for the propagation of a boiling front during water injection into a depleted vapor zone in one-dimensional radial flow geometry. Numerical simulations with MULKOM closely matched the analytically predicted vaporization fraction, pressures and temperatures at the boiling front, and the time-dependent front location. *Verma et al.* [1985] numerically simulated a laboratory two-phase flow experiment for measuring steam-water relative permeability, obtaining good agreement with experimental data. *Lam et al.* [1988] successfully used MULKOM and the MINC method to model laboratory heat sweep experiments in a pressure vessel containing a configuration of regularly-shaped granite blocks.

McKibbin and Pruess [1989] presented analytical solutions for steady-state geothermal heat pipes with CO_2, which closely agreed with results of MULKOM simulations. *Wu et al.* [1990] developed a Buckley-Leverett type solution for immiscible displacement in composite porous media. Satisfactory agreement was obtained with numerical simulations using MULKOM-GWF, a specialized version of MULKOM for three-phase flow of gas, water, and foam [*Pruess and Wu,* 1988]. *Doughty and Pruess* [1990] investigated thermohydrologic conditions near heat-generating high-level nuclear waste packages. For the idealized problem of an infinite linear string of waste packages in a homogeneous porous medium with single-component water they obtained a semi-analytical similarity solution which was closely matched by numerical simulations with TOUGH.

Bodvarsson et al. [1990] reported three-dimensional well-by-well numerical simulations with MULKOM of the Olkaria, Kenya, geothermal reservoir. Using actual well performance data (flow rates and enthalpies) for the period from 1977 to 1983 to calibrate the reservoir model, performance predictions were developed that matched observed behavior of most wells from 1984 to 1987. A number of successful simulations of field observations and laboratory experiments, as well as code verifications, were presented at the TOUGH workshop [*Pruess,* 1990]. *Wu et al.* [1991] developed an analytical solution for immiscible displacement of non-Newtonian fluids, which was closely matched by numerical simulations with MULKOM-GWF.

Falta et al. [1991; 1992*a*; *b*] developed an enhanced version of TOUGH for three-phase three-component flow of water, air, and volatile organic compounds, known as "STMVOC". They modeled steam injection experiments in one-dimensional laboratory cores performed by *Hunt et al.* [1988], and successfully predicted the migration of the steam condensation front, as well as profiles of temperature and pressure, and the removal of trichloroethylene from the column over time. *Doughty and Pruess* [1992] extended their earlier work on a similarity solution for fluid and heat flow near a linear heat source to a pore fluid consisting of water and air. The only simplifications made in their treatment involved flow geometry. The process complexities of highly non-linear fully transient two-phase two-component fluid and heat flow with phase change were rigorously accounted for, making this the most difficult solvable two-phase fluid and heat flow problem presently available. Numerical simulations with TOUGH2 showed excellent agreement with the semi-analytical similarity solution.

10. CONCLUSIONS AND DISCUSSION

TOUGH has performed well on a series of fluid and heat flow problems that involved one- and two-dimensional flows, with varying degrees of non-linearity, coupling between fluid and heat flows, and complexity of boundary conditions. These results, as well as additional verification and validation problems for the MULKOM/TOUGH codes reprted elsewhere (see Section 9), substantiate the accuracy of the physics model employed in the code, and the mathematical and numerical approaches used. As the number of successfully executed verification and validation problems increases, the likelihood that significant coding errors may still be present is diminished. However, we wish to emphasize that we know of no test or procedure that will establish absence of coding errors with certainty.

The two-phase two-component fluid and heat flow capability offered by TOUGH, and the flexibility of the space discretization by means of integral finite differences, make possible applications to a great diversity of flow problems on different space and time scales [*Pruess,* 1990]. Key to successful application of TOUGH is a careful consideration of the physical processes that are involved in a given flow problem. In particular, space discretization, time stepping, and interface weighting procedures need to be carefully selected so that accurate results may be obtained. Application of TOUGH (or, for that matter, of any other two-phase fluid and heat flow code) without due attention to these issues may result in poor (inefficient) performance, inaccurate results, or both.

In the appendix we show that, for regular grid systems referred to global coordinates, the integral finite difference method used in TOUGH is mathematically equivalent to conventional (Taylor-series based) finite difference formulations, in which derivatives in the governing partial differential equations are approximated as finite differences. This mathematical equivalence makes established techniques for estimating space and time discretization errors applicable to integral finite difference simulations [*Peaceman,* 1977]. Theoretical estimates of these errors may not always be easy to make. However, discretization errors in practical applications can always be checked by re-running a simulation with finer space and time discretizations.

An important aspect of discretization is the interface and time weighting procedure. TOUGH was designed for robustness and stability in difficult non-linear problems with phase change and propagating phase fronts. The appropriate weighting procedures for such problems are fully upstream weighting in space, and "fully implicit" first-order backward finite differences in time. Users should be cautioned that for simpler sub-classes of problems - such as non-isothermal single phase flows - these default choices are not necessarily optimal in terms of accuracy and efficiency.

Some of the problems and limitations in TOUGH with regard to ease of use and description of physical processes that were noted by *Updegraff* [1989] were overcome with the recently released successor code, TOUGH2 [*Pruess,* 1991; *ESTSC,* 1992]. TOUGH2 is upward compatible with TOUGH, with additional capabilities and user-friendly features; these include an internal version control system, more convenient facilities for specifying boundary conditions, and internal mesh processing and generating capabilities (used for mesh generation in Verification Problem 3 and Validation Problems 1 and 2). TOUGH2 offers a multiple interacting continua capability (MINC) for fractured media simulations, a simplified description of Knudsen diffusion by means of a Klinkenberg factor for permeability, and an ability to handle different fluid mixtures.

Further enhancements of process description, such as a capability for multi-component dispersion and diffusion in multi-phase flow, will be included in future releases

of TOUGH2. We also expect to release a set of efficient conjugate gradient solvers for use with TOUGH2 which, compared with the presently employed direct solution technique, will drastically shorten execution times for large 3-D problems.

ACKNOWLEDGEMENTS

This work was supported, in part, by the WIPP project, Sandia National Laboratories, and by the Director, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, under Contract No. DE-AC03-76SF00098. The authors would like to thank Dr. Stephen Webb of Sandia National Laboratories for helpful technical support and discussions throughout the course of this study, as well as for supplying the reference input data sets and a careful review of this report. For the internal review of this manuscript and thoughtful comments, we are indebted to Dr. Teklu Hadgu and Christine Doughty.

REFERENCES

Avdonin, N. A., "Some Formulas for Calculating the Temperature Field of a Stratum Subject to Thermal Injection," Neft'i Gaz 3, 37-41, 1964.

Aziz, K. and A. Settari, Petroleum Reservoir Simulation, Elsevier, London and New York, 1979

Bear, J., and A. Verruijt, Modeling Groundwater Flow and Pollution, 414 pp., D. Reidel Publishing Co., Boston MA, 1987.

Bixler, N. E., "NORIA - A Finite Element Computer Program for Analyzing Water, Vapor, and Energy Transport in Porous Media," SAND84-2057, Sandia National Laboratories, Albuquerque NM, August 1985.

Bodvarsson, G. S., K. Pruess, C. Haukwa and S. B. Ojiambo, "Evaluation of Reservoir Model Predictions for the Olkaria Geothermal Field, Kenya," Geothermics, 19(5) 399-414, 1990.

Carslaw, M. S. and J. C. Jaeger, Conduction of Heat in Solids, Oxford University Press, Oxford, England, Second Edition, 1959.

Doughty, C. and K. Pruess, "A Similarity Solution for Two-Phase Fluid and Heat Flow near High-Level Nuclear Waste Packages Emplaced in Porous Media," International Journal of Heat and Mass Transfer, 33(6) 1205-1222, 1990.

Doughty, C. and K. Pruess, "Numerical Modeling of a Porous Heat Pipe: Comparison with a Semianalytical solution", in: Earth Sciences Division, Annual Report 1986, Lawrence Berkeley Laboratory Report LBL-22090, August 1987.

Doughty, C. and K. Pruess, "A Similarity Solution for Two-Phase Water, Air and Heat Flow Near a Linear Heat Source in a Porous Medium," Journal of Geophysical Research, 97(B2) 1821-1838, 1992.

ESTSC, Energy Science and Technology Software Center, Software Listing, May 1992, Report ESTSC-2, Energy Science and Technology Software Center, Oak Ridge, TN, May 1992.

Falta, R. W. and K. Pruess, STMVOC User's Guide, Lawrence Berkeley Laboratory, Report LBL-30758, June 1991.

Falta, R. W., K. Pruess, I. Javandel and P. A. Witherspoon, "Numerical Modeling of Steam Injection for the Removal of Nonaqueous Phase Liquids from the Subsurface. 1. Numerical Formulation," Water Resources Research, 28(2) 433-449, 1992.

Falta, R. W., K. Pruess, I. Javandel and P. A. Witherspoon, "Numerical Modeling of Steam Injection for the Removal of Nonaqueous Phase Liquids from the Subsurface. 2. Code Validation and Application," Water Resources Research, 28(2) 451-465, 1992.

Faust, C. R., and J. W. Mercer, "Geothermal Reservoir Simulation 2. Numerical Solution Techniques for Liquid- and Vapor-Dominated Hydrothermal Systems," Water Resources Research, 15, 31-46, 1979.

Garg, S. K., "Pressure Transient Analysis for Two-Phase (Water/Steam) Geothermal Reservoirs," Society of Petroleum Engineers Journal, 206-214, June 1980.

Hadley, G. R., "PETROS - A Program for Calculating Transport of Heat, Water, Water Vapor, and Air Through a Porous Material," SAND84-0878, Sandia National Laboratories, Albuquerque, NM, May 1985.

Hunt, J. R., N. Sitar and K. S. Udell, "Nonaqueous Phase Liquid Transport and Cleanup, 2, Experimental Studies," Water Resources Research, 24(8) 1259-1269, 1988.

International Formulation Committee, "A Formulation of the Thermodynamic Properties of Ordinary Water Substance," IFC Secretariat, Dusseldorf, Germany, 1967.

Kruger, P., and H. J. Ramey, "Stimulation and Reservoir Engineering of Geothermal Resources," Stanford Geothermal Program Report SGR-TR-1, Stanford University, Stanford, CA, June 1974.

Lam, S. T., A. Hunsbedt, P. Kruger and K. Pruess, "Analysis of the Stanford Geothermal Reservoir Model Experiments Using the LBL Reservoir Simulator," Geothermics, 17(4) 595-605, 1988.

Lauwerier, H. A., The Transport of Heat in an Oil Layer Caused by the Injection of Hot Fluid," Applied Science Research, 5, Section A (2-3) 145-150, Martinus Nijhoff, Publisher, The Hague, 1955.

McKibbin, R. and K. Pruess, "Some Effects of Non-Condensible Gas in Geothermal Reservoirs with Steam-Water Counterflow," Geothermics, 18(3) 367-375, 1989.

O'Sullivan, M. J., "A Similarity Method for Geothermal Well Test Analysis," Water Resources Research, 17(2), 390-398, 1981.

Peaceman, D. W., Fundamentals of Numerical Reservoir Simulation, Elsevier, Amsterdam, 1977.

Philip, J. R., "Numerical Solution of Equations of the Diffusive Type with Diffusivity Concentration Dependent," Transactions. Faraday Society, 51, 885-892, 1955.

Pruess, K., TOUGH2 - A General-Purpose Numerical Simulator for Multiphase Fluid and Heat Flow, Lawrence Berkeley Laboratory Report LBL-29400, May 1991.

Pruess, K. (editor) Proceedings of the TOUGH Workshop, Lawrence Berkeley Laboratory Report LBL-29710, September 1990.

Pruess, K., "SHAFT, MULKOM, TOUGH: A Set of Numerical Simulators for Multiphase Fluid and Heat Flow," Geotermia, Rev. Mex. Geoenergia, 4(1) 185-202, 1988 (also Lawrence Berkeley Laboratory Report LBL-24430).

Pruess, K., TOUGH User's Guide, NUREG/CR-4645, SAND86-7104, LBL-20700, Lawrence Berkeley Laboratory, Berkeley, California, June 1987.

Pruess, K., "Development of the General Purpose Simulator MULKOM," Annual Report 1982, Earth Sciences Division, Lawrence Berkeley Laboratory, LBL-15500, 1983.

Pruess, K., and G. S. Bodvarsson, "Thermal Effects of Reinjection in Geothermal Reservoirs with Major Vertical Fractures," Journal of Petroleum Technology, 36(10) 1567-1578, September 1984.

Pruess, K., C. Calore, R. Celati and Y. S. Wu, "An Analytical Solution for Heat Transfer at a Boiling Front Moving through a Porous Medium," International Journal of Heat and Mass Transfer, 30(12) 2595-2602, 1987.

Pruess, K., and T. N. Narasimhan, "A Practical Method for Modeling Fluid and Heat Flow in Fractured Porous Media," Society of Petroleum Engineers Journal, 25(1), 14-26, 1985.

Pruess, K., and R. C. Schroeder, SHAFT79, User's Manual, Lawrence Berkeley Laboratory Report LBL-10861, Berkeley, CA, March 1980.

Pruess, K., and Y. S. Wu, On PVT-Data, Well Treatment, and The Preparation of Input Data for an Isothermal Gas-Water-Foam Version of MULKOM, Lawrence Berkeley Laboratory Report LBL-25783, August 1988.

Reda, D. C., "Natural Convection Experiments with a Finite-Length, Vertical, Cylindrical Heat Source in a Water-Saturated Porous Medium," Nuclear and Chemical Waste Management, 6, 3-14, 1986.

Reda, D. C., "Natural Convection Experiments about a Finite-Length Cylindrical Heat Source in a Liquid-Saturated Porous Medium," SAND83-2209C, Sandia National Laboratories, Albuquerque, NM, November 1984; presented at AIChE 1984 Annual Meeting, San Francisco, CA.

Reeves, M., D. S. Ward, N. D. Johns, and R. M. Cranwell, "Theory and Implementation for SWIFT II, The Sandia Waste-Isolation Flow and Transport Model for Fractured Media, Release 4.84," NUREG/CR-3328, SAND83-1159, Sandia National Laboratories, Albuquerque, NM, August 1986.

Ross, B., J. W. Mercer, S. D. Thomas, and B. H. Lester, "Benchmark Problems for Repository Siting Models," NUREG/CR-3097, Geotrans, Inc., Reston, VA, December 1982.

Stanford Geothermal Program (ed.), Proceedings Special Panel on Geothermal Model Intercomparison Study, presented at Sixth Workshop on Geothermal Reservoir Engineering, Rept SGP-TR-42, Stanford University, December 1980.

Udell, K. S., and J. S. Fitch, "Heat and Mass Transfer in Capillary Porous Media Considering Evaporation, Condensation and Non-Condensible Gas Effects," paper presented at the 23rd ASME/AIChE National Heat Transfer Conference, Denver, CO, 103-110, American Society of Mechanical Engineers, New York, August 1985.

Updegraff, C. D., Comparison of Strongly Heat-Driven Flow Codes for Unsaturated Media, Sandia National Laboratories, Report SAND 88-7145, Albuquerque, NM, August 1989.

Updegraff, C. D. and E. J. Bonano, Comparison of Strongly Heat-Driven Flow Codes for Unsaturated Media, Presented at International Conference and Workshop on the Validation of Flow and Transport Models for the Unsaturated Zone, Ruidoso, New Mexico, May 1988.

vanLeer, B., "Towards the Ultimate Conservative Difference Scheme, IV. A New Approach to Numerical Convection," Journal of Computational Physics, 23, 276-299, 1977.

Vauclin, M., D. Khanji, and G. Vachaud, "Experimental and Numerical Study of a Transient, Two-Dimensional Unsaturated-Saturated Water Table Recharge Problem", Water Resources Research", 15, 1089-1101, 1979.

Verma, A. K., K. Pruess, C. F. Tsang and P. A. Witherspoon, "A Study of Two-Phase Concurrent Flow of Steam and Water in an Unconsolidated Porous Medium," Proc., 23rd National Heat Transfer Conference, Am. Society of Mechanical Engineers, pp. 135-143, Denver, CO, August 1985.

Ward, D. S., M. Reeves, and L. E. Duda, Verification and Field Comparison of the Sandia Waste-Isolation Flow and Transport Model (SWIFT), NUREG/CR-3316, SAND83-1154, Sandia National Laboratories, Albuquerque, NM, April 1984.

Warren, J. E. and P. J. Root, "The Behavior of Naturally Fractured Reservoirs", Society Petroleum Engineers Journal", 245-255, September 1963; Transactions, AIME, 228.

Wu, Y. S., K. Pruess and P. A. Witherspoon, "Displacement of a Newtonian Fluid by a Non-Newtonian Fluid in a Porous Medium", Transport in Porous Media, 6, 115-142, 1991.

Wu, Y. S., K. Pruess and Z. X. Chen, Buckley-Leverett Flow in Composite Porous Media, Lawrence Berkeley Laboratory Report LBL-28937, April 1990.

APPENDIX: **Local Truncation Error in the Integral Finite Difference Method**

Consider heat conduction in a homogeneous isotropic solid. The heat content (internal energy) per unit volume is

$$M = \rho\, c\, T \qquad \text{(A.1)}$$

where ρ and c are, respectively, the density and the specific heat of the medium, and T is the temperature. Heat flux is given by

$$\bar{F} = -K\, \nabla T \qquad \text{(A.1)}$$

where K is the thermal conductivity. The rate at which the heat content of a sub-domain with volume V_n changes is given by the total rate of heat flow across the closed surface Γ_n around V_n (see Figure 35)

$$\frac{d}{dt}\int_{V_n} M dV = \int_{\Gamma_n} \bar{F}\cdot\bar{n}\, d\Gamma \qquad \text{(A.3)}$$

Here n denotes the inward unit normal vector, and for simplicity we have neglected sinks and sources in V_n. Applying Gauss' divergence theorem to the right hand side and placing the time derivative on the left hand side inside the integral, we obtain the partial differential equation for heat conduction [*Carslaw and Jaeger,* 1959] as

$$\frac{\partial T}{\partial t} = D\, \Delta T \qquad \text{(A.4)}$$

where $D = K/\rho c$ is the thermal diffusivity, assumed here for simplicity to be constant, independent of temperature. The integral finite difference approximation to Eq. (A.3) is written

$$V_n \frac{dM_n}{dt} = \sum_m A_{nm}\, F_{nm} \qquad \text{(A.5)}$$

where A_{nm} denotes surface segments between V_n and neigboring subdomains V_m. For a one-dimensional domain V partitioned into rectangular gridblocks V_n (see Figure 36), the first-order finite difference approximation to the flux term in Eq. (A.5) becomes

$$F_{nm} = K\, \frac{T_m - T_n}{\Delta x} \qquad \text{(A.6)}$$

Introducing also a first-order finite approximation of the time derivative,

$$\frac{dM_n}{dt} \approx \rho\, c\, \frac{T_n^{k+1} - T_n^k}{\Delta t} \qquad \text{(A.7)}$$

Eq. (A.5) becomes

$$T_n^{k+1} - T_n^k = D\frac{\Delta t}{\Delta x}\left(\frac{T_{n+1}^{k+1} - T_n^{k+1}}{\Delta x} + \frac{T_{n-1}^{k+1} - T_n^{k+1}}{\Delta x}\right) = D\frac{\Delta t}{\Delta x^2}\left(T_{n+1}^{k+1} - 2T_n^{k+1} + T_{n-1}^{k+1}\right) \quad \text{.....(A.8)}$$

Here we have indicated "fully implicit" time differencing by evaluating temperatures in the flux terms at the new time level $k+1$. Eq. (A.8) is identical to the "conventional" finite difference approximation of Eq. (A.4) [*Peaceman,* 1977]. Completely analogous but notationally more complicated derivations can be made when Eq. (A.3) is interpreted as general balance equations for multi-phase fluid and heat flows of multi-component mixtures. The mathematical identity between integral and conventional finite difference formulations holds not only for one-dimensional grid systems, but also for two- and three-dimensional regular grids referred to a global coordinate system.

For the one-dimensional heat conduction equation, the discretization error from replacing time and space derivatives by the finite difference equations (A.7) and (A.8) can be identified as [*Peaceman,* 1977]

$$\varepsilon = \frac{\Delta x^2}{12}\frac{\partial^4 T}{\partial x^4} - \frac{\Delta t}{2D}\frac{\partial^2 T}{\partial t^2} \quad \text{.....(A.9)}$$

where the derivatives are taken at an interior point of the discretization interval (t^k, $t^{k+1} = t^k + Dt$), (x_n-Dx, x_n+Dx).

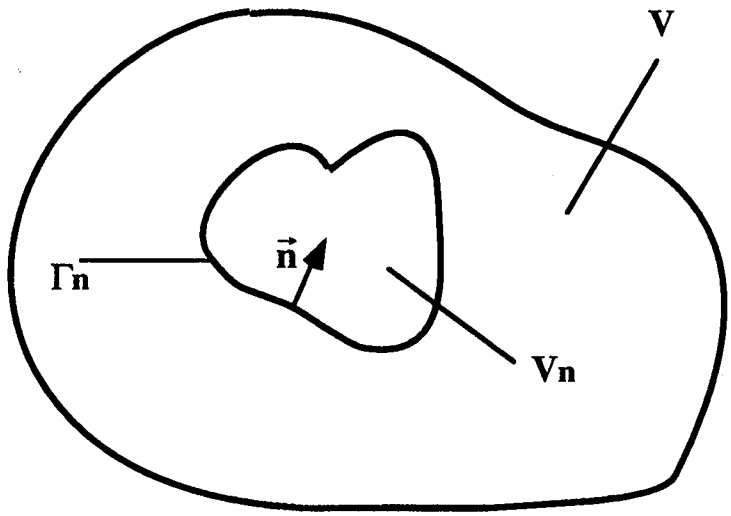

Figure 35. A flow domain *V* with sub-domain *Vn*.

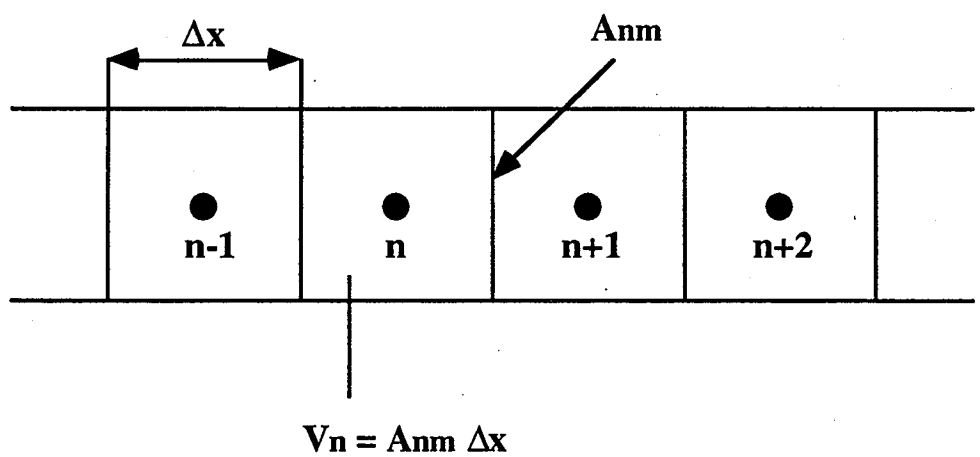

Figure 36. One-dimensional block-centered grid.

REPORT DISTRIBUTION

Dr. Adeyinka Adenekan
Exxon Production Research Comp.
Mail Stop SW 526, P.O. Box 2189
Houston, TX 77252-2189

Peter Airey
Australian Atomic Energy Commision
Private Mail Bag
Sutherland, NSW 2232
AUSTRALIA

Gerald W. Allen
Kansas Dept. Of Health & Envirn
Bureau Of Environ. Health Services
109 SW 9th-Mills Bldg., Suite 602
Topeka, KS 66612

Larry Anderson, Director
Utah Dept. Of Health, Bureau Of Radiation Control
PO Box 16690
Salt Lake City, UT 84116

John A Apps
Lawrence Berkeley Lab.
One Cyclotron Rd, ESD, 50E
Berkeley, CA 94720

Michael Apted
Intera Sciences
3609 S. Wadsworth Blvd., 5th Floor
Denver, CO 80235

Argonne National Lab
Report Section, 9700 S Cass Ave., 203-CE125
Argonne, IL 60439

Dr. Paul Atkinson
UNOCAL
3576 Unocal Place
Santa Rosa, CA 95401

Prem Attanayake
Bechtel Corp.
Geotechnical and Hydraulic Engineering Services
P.O. Box 193965
San Francisco, CA 94119-3965

Dr. Khalid Aziz
Dept. of Petroleum Engineering
Mitchell 359
Stanford University
Stanford, CA 94305

Michael J Barainca
Technical Asst.
Dept. Of Energy
Defense Waste and Transport, GP-12
Washington, DC 20585

Harry Babad
Westinghouse Hanford Co
PO Box 1970, H4-17
Richland, WA 99352

Ralston Barnard
Sandia National Laboratories
Division 6313
PO Box 5800
Albuquerque, NM 87185

Battelle Memorial Inst.
505 King Ave
Columbus, OH 43201

Dr. Alfredo Battistelli
AQUATER
61047 S. Lorenzo in Campo
(Pesaro) ITALY

Dr. John Baum
Brookhaven National Lab.
Dept Of Nuclear Energy
Radiological Sciences Div.
Bldg 703M
Upton, NY 11973

Michael A Bauser
Newman & Holtzinger
1615 L St NW, Suite 1000
Washington, DC 20036

Eugene P Binnall
Lawrence Berkeley Lab.
Bldg 50B, Room 4235
Berkeley, CA 94720

Jerry Boak
U.S. Department of Energy
Yucca Mountain Project
101 Convention Center Drive
Las Vegas, NV 89109

Peter Bogorinski
Gesellschaft fuer Reaktorsicherheit
Schwertnergasse 1
5000 Koeln 1
GERMANY

Dr. E.J. Bonano
Division 6431
Sandia National Labs.
Albuquerque, NM 87185

Harold Borchert
Nebraska Dept. Of Health, Div. Of Radiological Health
301 Centennial Mall South
Box 95007
Lincoln, NE 68509

Robert B Borsum
B&W Nuclear Tech., Nuclear Power Division
1700 Rockville Fike, Suite 525
Rockville, MD 20852

Tom Box
Calpine Corp.
1160 No. Dutton, Suite 200
Santa Rosa, CA 95401-4606

Francis J Bradley, Ph.D.
Principal Radiophysicist
New York Dept. Of Labor, Radiological Health Unit
1 Main Street, Room 813
Brooklyn, NY 11201

Albin Brandsetter
Science Apps. Int. Corp.
101 Convention Center Dr.
Las Vegas, NV 89109

Dr. John Bredehoeft
USGS, Mail Stop 439
345 Middlefield Road
Menlo Park, CA 94025

Douglas G Brookins
Dept. of Geology
University Of New Mexico
Albuquerque, NM 87131

Dr. David Bullivant
Dept. of Theor. and Appl. Mech.
University of Auckland
Private Bag
Auckland
NEW ZEALAND

Dr. John Burnell
Industrial Research Ltd.
Gracefield Road
PO Box 31-310, Lower Hutt
NEW ZEALAND

Dr. T. A. Buscheck
Earth Sciences Division, MS L-206
Lawrence Livermore National Lab.
Livermore, CA 94550

Jerrold T Bushberg
Asst. Professor-Diagnositc Rad., Nuclear Medicine
University Of California
2315 Stockton Blvd.
Sacramento, CA 905817

George Butler
INTERA Inc.
6850 Austin Center Blvd., Ste 300
Austin, TX 78723

Dr. Claudio Calore
Istituto Internazionale per le Ricerche Geotermiche
Piazza Solferino, 2
56126 Pisa
ITALY

Chalon Carnahan
Lawrence Berkeley Lab.
One Cyclotron Rd.,. 50E
Berkeley, CA 94720

Jon Carter
Governor's Office
Statehouse
Boise, ID 83720

Dr. Ivan Catton
US NRC-ACRS
5731 Boelter Hall-Univ Of California
Los Angeles, CA 90024

Neil Chapman
INTERA-ECL
Park View House
14B Burton St, Melton Mowbray
Leicester LE131AE, U.K.

Dr. John C. Chen
Lehigh University
111 Research Dr., Bldg A
Bethlehem, PA 18015

Dr. Dwayne Chesnut
Lawrence Livermore National Lab.
P.O. Box 808, L-202
Livermore, CA 94550

Mary Clark
Public Health Physicist Mgr
Florida Dept. Of Health & Rehab., Office Of Radiation Control
1317 Winewood Blvd.
Tallahassee, FL 32399

Jess M. Cleveland
US Geological Survey
PO Box 25046
Lakewood, CO 80225

John Coady
Atomic Energy Control Board
Box 1046, Ottawa K1P 5S9
CANADA

Stewart J. Cobbett
Hot Cell Services Corp., Licensing & Nuclear Safety
12201 SE 65th St.
Bellevue, WA 98006

Lewis H. Cohen
Dept. Of Earth Sciences
University Of California
Riverside, CA 92521

P. Colombo
Brookhaven National Laboratory
Nuclear Waste Research Group, Bldg 703
Upton, NY 11973

John P Corley
2213 Torbett St.
Richland, WA 99352

Dr. John R. Counsil
1148 Shadyoak Place
Santa Rosa, CA 95404

J. J. K. Daemen
Department Mining and Geological Engineering
University of Arizona
Tucson, AZ 85721.

P. B. Davies
Sandia National Laboratories
Division 6344
PO Box 5800
Albuquerque, NM 87185

J. D. Davis
Westinghouse Hanford Co.
PO Box 1970
Richland, WA 99352

P. A. Davis
Sandia National Laboratories
Division 6416
PO Box 5800
Albuquerque, NM 87185

R. Dayal, Senior Geochemist
Ontario Hydro, Research Division
800 Kipling Ave.
Toronto, Ontario
CANADA

T. K. Deboer, Director
New York ERDA, West Valley Program
2 Rockefeller Plaza
Albany, NY 12223

Jim Devine, Data Administrator
US Geological Survey
12201 Sunrise Valley Dr., MS 106
Reston, VA 22092

Greta J. Dicus, Director
Arkansas Dept. Of Health, Div. Of Rad. Cntrl. & Emer. Mgmt.
4815 W Markham St
Little Rock, AR 72205

Frank Dodge
Center for Nuclear Waste Regulatory Analyses
Southwest Reseach Institute
6220 Culebra Rd.
P.O. Drawer 28510
San Antonio, TX 78284

T. W. Donnelly
New York State University
Geological Sciences
Binghamton, NY 13901

William Dornsife
Pennsylvania Dept. Of Envir. Res.
Bureau of Radiation Health
PO Box 2063
Harrisburg, PA 17120

Christine Doughty
Lawrence Berkeley Lab.
One Cyclotron Rd, ESD, 50E
Berkeley, CA 94720

Laurie Duncan
NY Dept Of Health, WCLR
Esp Tower Rm B940, Rm C236
Albany, NY 12201

C. F. Eason
American Ecology Inc.
540 N St. SW
Washington, DC 20024

EG&G Idaho Inc
INEL Tech Library
PO Box 1625-2300
Idaho Falls, ID 83415

Steve Enedy
Northern California Power Agency
P.O. Box 663
Middletown, CA 95461

Bruce Erdal
Sandia National Laboratory
INC-DO
PO Box 1663, J519
Los Alamos, NM 87545

Dr. Iraj Ershagi
Dept. of Chemical Engineering
University of Southern California
University Park
Los Angeles, CA 90089-1211

EURATOM
A. Avogadro
I-21020
Ispra-Varese
ITALY

Daniel C Evans
Dept. Hydrology & Water Res.
University Of Arizona
Tucson, AZ 85721

Dr. Ron Falta
Earth Sciences Dept., Bracket Hall
Clemson University
Clemson, SC 29634-1908

David Faulder
Quantitative Hydrology Unit
Idaho National Engineering Lab.
P.O. Box 1625
Idaho Falls, ID 83415-2107

John M. Farr
Levine-Fricke, Inc.
1900 Powell St., 12th Fl.
Emeryville, CA 94608

Dr. Eckhard Fein
GSF
Theodor-Heuss-Str. 4
3300 Braunschweig
GERMANY

Stefan Finsterle
Versuchsanstal für Wasserbau
VAW DOL C13
ETH-Zentrum
CH-8092 Zürich
SWITZERLAND

Dr. Abbas Firoozabadi
Reservoir Engineering Research Inst.
845 Page Mill Rd.
Palo Alto, CA 94304

Donald A Flater, Chief
Bureau of Radiological Health
Iowa Dept. Of Health
Lucas State Office Bldg.
Des Moines, IA 50319

Dr. T. Fogwell
IT Corp.
4585 Pacheco Blvd.
Martinez, CA 94553

John Forth
Kennecott Corp.
10 East South Temple
P.O. Box 11248
Salt Lake City, UT 84147

Christopher Frietas
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
6220 Culebra Rd.
P.O. Drawer 28510
San Antonio, TX 78284

Eddie S. Fuente, Director
Mississippi Board Of Health
Div. Of Radiological Health
PO Box 1700
Jackson, MS 39215

W. S. Fyfe
University Of Western Ontario
Dept Of Geology
London N6A5B7
CANADA

M. Garamszegy
Ontario Hydro
Design and Development Div.
700 University Ave.
HS-H11F18
Toronto, Ontario M5G 1X6
CANADA

Berito Garcia, Bureau Chief
New Mexico Environ. Improv. Div.
Health & Env. Dept, Env. Imp. Div.
PO Box 968
Santa Fe, NM 87504

Dr. Sabodh Garg
S-Cubed
P.O. Box 1620
LaJolla, CA 92038-1620

Professor Lynn W. Gelhar
MIT
Department of Civil Engineering
Room 48-329
Cambridge, MA 02139

John Gibbons
Remote Sensing Systems
4300 San Mateo Blvd., NE
Albuquerque, NM 87110

Gilbert/Commonwealth Inc
Library
B Le Boulch
PO Box 1498
Reading, PA 19603

Herschel W Godbee,
Oak Ridge National Lab., Chemical Technology
Bldg K-1037, PO Box 2003
Oak Ridge, TN 37831

Aubrey Godwin
Chief, Bureau Of Radiation Health
Alabama Dept Of Public Health
Environmental Health Admin.
510 State Office Bldg.
Montgomery, AL 36130

Michael T. Goodrich
GRAM, Inc.
1709 Moon St., NE
Albuquerque, NM 87112

Dr. Keshav Goyal
Calpine Corporation
1160 N. Dutton, Ste. 200
Santa Rosa, CA 95401

Dr. Ronald T. Green
SRI, Center for Nuclear Waste Regulatory Analyses
6220 Culebra Rd.
San Antonio, TX 78284

Sharon Green, Director
Executive Office, Environmental Affairs
100 Cambridge - Room 2000
Boston, MA 02202

Rainer Helmig
Institut fuer Stroemungsmechanik
Universitaet Hannover
Appelstr. 9A
3000 Hannover 1
GERMANY

Her Majesty's Insp. Pollution
Head, Radioactive Substances Div.
RP, Ney House, 43 Narsham St.
London SW1P3PY
U.K.

Thomas E Hill
Dept of Natural Resources, Radioactive Materials Prgrm
4244 International Pkwy, Ste 114
Atlanta, GA 30354

Dr. W. J. Hinze
US NRC-ACNW
30 Brook Hollow
W. Lafayette, IN 47906

Dr. Diana J. Holford
Battelle Pacific Northwest Lab.
MS K6-77
PO Box 999
Richland, WA 99352

William Holman
DOE-SAN
1333 Broadway
Oakland, CA 94612

Polly L. Hopkins
Sandia National Laboratories
Org. 1511
PO Box 5800
Albuquerque, NM 87185

Instituto Superiore Di Sanita
Laboratorio Delle Radiazoni
Viale Regina Elena 299
00161-Rome
ITALY

Dr. T. Ishido
Geological Survey of Japan
1-1-3 Higashi
Tsukuba, Ibaraki 103
JAPAN

ISPRA Establishment
Joint Research Center Radiochem. & Nuclear Chem. Division
21020 Ispra (Varese)
ITALY

Robert R. Jackson
Principal Staff Scientist
Science Applications Intl Corp
1845 Terminal Dr., Suite 202
Richland, WA 99352

Vicki Jeff, Manager
Dept. Of Health Services
Radiation Control Branch
275 E. Main St.
Frankfort, KY 40621

Tomas Johannesson
ORKUSTOFNUN
Grensasvegur 9
108 Reykjavik
ICELAND

Jerry Johnson, Librarian
E R Johnson Associated Inc.
10461 White Granite Dr #204
Oakton, VA 22124

Lamar Johnson
INEL Sci & Tech Dept.
PO Box 1625, MS 2203
Idaho Falls, ID 83415

A. D. Kelmers
Oak Ridge National Lab
PO Box 2008-Bldg 4500N, MS 6268
Oak Ridge, TN 37831

Edwin M. Kidd
Energy Science and Technology Software Center
P.O. Box 1020
Oak Ridge, TN 37831

Sharon L Kittle
West Valley Nuclear Services
Technical Library
Rock Springs Rd - Box 19145
West Valley, NY 14171

Dr. Alexey Kiryukhin
Institute of Volcanology
Petropavlovsk-Kamchatsky
683006 RUSSIA

Micheal J. Knight
University Of New South Wales
School Of Applied Geology
P.O. Box 1 Kensington
Sydney NSW 2033
AUSTRALIA

Nancy P Knox
Martin Marietta Energy Systems
PO Box 2003-Bldg K1210, MS 6050
Oak Ridge, TN 37831

Dr. Paul Kruger
Civil Engineering Dept.
Stanford University
Stanford, CA 94305

Francis A. Kulacki
Office of the Dean
College of Engineering
Colorado State University
Fort Collins, CO 80523

KY Environmental Protection
Doyle Mills
18 Reilly Rd
Frankfort, KY 40601

David K Lacker, Chief
Texas Dept. Of Health
Bureau Of Radiation Control
1100 W. 49th St.
Austin, TX 78756

S. Lamanna, Consultant
Babock & Wolcox Co.
PO Box 158
Amherst, VA 24521

Donald Langmuir, Professor
Colorado School of Mines
Dept. of Chem. & Geochem.
Golden, CO 80401

Robert A. Levich
Yucca Mountain Site Characterization Project Office
P.O. Box 98608
Las Vegas, NV 89193-8608

Kay Lie
Maxwell Lab/S-Cubed
San Diego, CA 92123

Ning Lu
Disposal Safety, Inc.
1660 L Str., Ste. 314
Washington, DC 20036

Dr. Ronald H. Martin
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
6220 Culebra Rd.
San Antonio, TX 78284

Paul A. Mattingly
Science Applications International Corp.
2109 Air Park Rd., SE
Albuquerque, NM 87106

C. McCombie
NAGRA
CH-5430 Wettingen
Hardstrasse 73
SWITZERLAND

Dr. Jim McCord
Sandia National Laboratories
Division 6416
PO Box 5800
Albuquerque, NM 87185

Dr. Thomas V. McEvilly, Director
Earth Sciences Division
Lawrence Berkeley Lab.
One Cyclotron Rd, 50E
Berkeley, CA 94720

Dr. Mark McGuinness
Mathematics Department
Victoria University
P.O. Box 600
Wellington
NEW ZEALAND

William F McKenzie
Lawrence Livermore Natl Lab
PO Box 808, L-204
Livermore, CA 94550

Dr. Robert McKibbin
Dept. of Mathematics, Massey University
Private Bag 11222
Palmerston North
NEW ZEALAND

Dennis McLaughlin, Professor
MIT
Department of Civil Engineering, Room 48-329
Cambridge, MA 02139

Charles McMahon, Chief
Rhode Island Dept. of Health
Div. of Occupational Health & Radiation Control
75 Davis St., Cannon Bldg.
Providence, RI 02908

Dr. Tim J. McMartin
US NRC
MS NLS/260
Washington, DC 20555

Ben Mehta
Project Manager, CAES Technology
Electric Power Research Institute
P.O. Box 10412
Palo Alto, CA 94303

Dr. Anthony J. Menzies
Geothermex, Inc.
5221 Central Ave., Ste. 201
Richmond, CA 94804

Dr Paul J. Merges
New York Dept. Of Environ. Consv.
Hazardous Substances Regul.
Room 510, Bureau Of Radiation
50 Wolf Rd.
Albany, NY 12233

R E Meyer
Oak Ridge National Lab, Chemistry Div.
PO Box 2008-Bldg 4500N, MS 6201
Oak Ridge, TN 37831

Tom E. Michener
Battelle Pacific Northwest Lab.
PO Box 999
Richland, WA 99352

T. K. Mills
EG&G Mound Applied Tech., W D Technology
PO Box 32, BD-79
Miamisburg, OH 45342

William Milne-Home
University of New South Wales
Kensington, NSW 2033
AUSTRALIA

Dade W. Moeller, ACNW Member
US NRC-ACNW
27 Wildwood Dr.
Bedford, MA 01730

Dr. Parvis Montazer
Fluor-Daniel, 552 M
3333 Michelson Dr.
Irvine, CA 92730

Dr. Luis Moreno
Dept. of Chemical Engineering
Royal Institute of Technology
S-100 44 Stockholm
SWEDEN

Dana Mount
N. Dakota Dept. Of Health
Div. Of Environmntal Engineering
1200 Missouri Avenue, Rm 304
Bismarck, ND 58501

Jim Muckerheide
State Nuclear Engineer
Massachusetts Emer Mgmt Agency
400 Worcester Rd - BOX 1496
Framingham, MA 01701

Mohammed G. Mustafa
Nuclear Chemistry Division
Lawrence Livermore National Lab.
Livermore, CA 94550

Prasad K. Nair
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
6220 Culebra Rd.
P.O. Drawer 28510
San Antonio, TX 78284

Dr. T. N. Narasimhan
Lawrence Berkeley Lab., ESD
One Cyclotrol Rd., Bldg 50E
Berkeley, CA 94720

Shlomo P. Neuman
Department of Hydrology and Water Resources
University of Arizona
Tucson, Arizona 85721

Gretchen C. Newman
GRAM, Inc.
1709 Moon St., NE
Albuquerque, NM 87112

Dr. Long X. Nghiem
Computer Modeling Group
3512 33St., N.W.
Calgary, Alberta
CANADA T2L 2A6

Thomas J. Nicholson
US NRC
RES/WMB NL/S-260
Washington, DC 20555

Dr. John J. Nitao
Earth Sciences Division, MS L-206
Lawrence Livermore National Lab.
Livermore, CA 94550

Dr. Heino Nitsche
Lawrence Berkeley Lab.
Bldg 70A, Room 2255E
Berkeley, CA 94720

Oak Ridge National Lab.
Central Research Library
PO Box 2008, Bldg 4500N, MS 6286
Oak Ridge, TN 37831

OECD Nuclear Energy Agency
Library
38 Boulevard Suchet
75016 Paris
FRANCE

Dr. Takashi Okabe
GERD Ltd.
Kyodo Bldg., 11-7 Kabuto-cho
Nihonbashi, Chuo-ku
Tokyo, 103
JAPAN

David Okrent
Consultant
48-121 D Engineering W
Los Angeles, CA 90024

John Osnes
Re/Spec Inc.
P.O. Box 725
Rapid City, SD 57709

Dr. Michael O'Sullivan
Dept. of Theoretical and Applied Mechanics
The University of Auckland, Auckland
NEW ZEALAND

Thomas Overcamp, Professor
Clemson University
Envir. System Engineering
Clemson, SC 29634

Park T. Owen
Martin Marietta Energy Sys Inc
Environmental Restoration Div
PO Box 2003, MS 7256, K-1210
Oak Ridge, TN 37831

L. C. Oyen
Division Head
Sargent & Lundy
55 E Monroe St., 30D33
Chicago, IL 60603

Ray D Paris
Oregon Dept. Of Human Resources
Div. Of Health-Radiation Control Svc.
800 Oregon St. NE #21, Ste 705
Portland, OR 97232

Dr. U-Sun Park
SAIC
101 Convention Center Dr.
Las Vegas, NV 89109

Alva M. Parsons
GRAM, Inc.
1709 Moon St., NE
Albuquerque, NM 87112

Wesley C. Patrick
Center for Nuclear Waste Regulatory Analysis
Southwest Research Institute
6220 Culebra Rd., P.O. Drawer 28510
San Antonio, TX 78284

S. J . Phillips
Westinghouse Hanford Co.
Defense Waste Management
PO Box 1970, L7-10
Richland, WA 99352

Mel G. Piepho
Technadyne Engineering Consultants, Inc.
P.O. Box 13928
Albuquerque, NM 87192

Dr. Paul W. Pomeroy
ACNW Member, US NRC-ACNW
Roundout Associates Inc-BOX 224
Stone Ridge, NY 12484

Dr. Joachim Poppei
Geothermie-Engineering Neubrandenburg
Gerstenstr. 9
O-2000 Neubrandenburg
GERMANY

Max Power
Washington State Dept. Of Ecol.
Nuclear & Mixed Waste
PV-11
Olympia, WA 98504

J. Pradel
Centre D'etudes Nucleaires
Boite Postale 6, F-92260
Fontenay-Aux-Roses
FRANCE

Norman Pratt, Program Manager
Arizona Radiation Regulatory Agcy
4814 South 40 St.
Phoenix, AZ 85040

John Pritchett
S-Cubed
P.O. Box 1620
LaJolla, CA 92038

Peter M. Pyle
BGI
27 San Francisco Blvd.
San Anselmo, CA 94960

Dr. Magdi Ragher
University Of Illinois
Dept. Of Nuclear Engrg
103 S. Boodwin Ave, 223 NEL
Urbana, IL 61801

Dr. Hank Ramey
Petroleum Engineering Dept.
360 Mitchell Building
Stanford University
Stanford, CA 94305

Dr. Donald L. Reddell
Agricultural Engineering Dept.
Texas A&M University
College Station, TX 77843-2117

Dr. Marshall Reed
Geothermal Technology Division
U.S. Department of Energy - CE 122
Washington, D.C. 20585

Dr. Mark Reeves
Intera, Inc.
6850 Austin Center Blvd.
Austin, TX 78731

Dr. Georg Resele
Colenco Power Consulting Ltd.
Mellingerstr. 207
CH-5405 Baden
SWITZERLAND

Karim Rimawi
New York Dept Of Health
Env. Radiation Protection
Two University Plaza, Rm 375
Albany, NY 12203

A. E. Ringwood
Australian National University-
Research School-Earth Sciences
Canberra, ACT2600
AUSTRALIA

Dave Robertson
Battelle Pacific Northwest Lab.
PO Box 999
Richland, WA 99352

Gary Robertson, Section Head
Waste Management
Washington Dept. Of Soc. & Health, LE 13
Olympia, WA 98504

Vern C. Rogers, President
Rogers & Associates Engr. Corp.
Po Box 330
Salt Lake City, UT 84110

Dr. Benjamin Ross
Disposal Safety, Inc.
1660 L Street NW, Suite 314
Washington, DC 20036

John Russell
Southwest Research Institute
Center for Nuclear Waste Regulatory Analyses
6220 Culebra Rd., P.O. Drawer 28510
San Antonio, TX 78284

Dr. Budhi Sagar
Southwest Research Institute
Center for Nuclear Waste Regulatory Analyses
6220 Culebra Rd., P.O. Drawer 28510
San Antonio, TX 78228-0510

Dr. Jean-Pierre Sauty
BRGM
B.P. 6009
45060 Orleans Cedex 2
FRANCE

Science Applications Intl. Corp.
14062 Denver West, Suite 255
Golden, CO 80401

Kathey Scott
Task Leader
NUS Corp., Licensing Information Svc.
2650 Mccormick Dr
Clearwater, FL 34619

Jeff Serne
Battelle Pacific Northwest Lab.
PO Box 999 Sigma V Bldg., K6081
Richland, WA 99352

Heyward G Shealy, Chief
Bureau Of Radiological Health
S. Carolina Dept. Hlth Envir Ctl
2600 Bull St.
Columbia, SC 29201

Mike Shook
Idaho National Engineering Lab.
P.O. Box 1625
Idaho Falls, ID 83415-2107

Malcolm Siegel
Sandia National Laboratories
Division 6331
PO Box 5800
Albuquerque, NM 87185

Geive Simmons
Hager-Richter Geoscience Dept.
Earth & Planetary Science
8 Industrial Way D-10, 54-316
Salem, NH 03079

Dr. Allan Spivak
Intera West
11444 West Olympic Blvd., 10th Fl.
Los Angeles, CA 90064

John Starmer,
ERM, Program Management
7926 Jones Branch Dr.
McLean, VA 22102

Dr. Martin J. Steindler
Argonne National Laboratory
Chemical Technology Div.
9700 South Cass Ave., Bldg 205
Argonne, IL 60439

David A. Stewart-Smith, Administrator
Oregon Dept Of Energy
Nuclear Safety & Energy Fac.
625 Marion St. NE
Salem, OR 97310

Joseph E Stiegler, Dept. Manager
Sandia National Laboratories
Dept 6320
PO Box 5800
Albuquerque, NM 87185

Stephen H Stow
Oak Ridge National Lab.
PO Box 2008 Bldg 1505, MS 6038
Oak Ridge, TN 37831

Dr. Cesar Suarez
CFE, A.P. 31-C
A.Volta 655
58290 Morelia, Michoacan
MEXICO

Swedish Nuclear Fuel & Waste Management (SKB)
Library
Box 5864
S-10248 Stockholm
SWEDEN

Dr. Shinji Takasugi
GERD Co., Ltd.
Kyodo Bldg.
11-7, Kabuto-Cho Nihonbashi
Chuo-Ku
Tokyo 103
JAPAN

T. Tamura
Martin Marietta Energy Systems
PO Box 2003-Tri County Mall
Oak Ridge, TN 37831

Edmund C. Tarnuzzer, Senior Radiological Engineer
Yankee Atomic Electric Co
PO Box 8000
Bolton, MA 01740

Diane E. Tefft, Administrator
New Hampshire Radiation Health Program
Div. Of Public Health Service
Health & Welfare Bldg, Hazen Dr
Concord, NH 03301

Clough W. Toppan, Manager
Radiological Health Program
State House
Augusta, ME 04333

Kenneth E. Torrance
Sibley School of Mechanical and Aerospace Engineering
Upson and Grumman Halls
Cornell University
Ithaca, NY 14850

N. Trask
US Geological Survey, Water Resources Division
410 National Center
Reston, VA 22092

Alex H. Treadway
Sandia National Laboratories, Dept 6313
PO Box 5800
Albuquerque, NM 87185

Dr. Kent Udell
6165 Etcheverry
University of California
Berkeley, CA 94720

C. David Updegraff
GRAM, Inc.
1709 Moon St., NE
Albuquerque, NM 87112

US DOE
Office Of Nuclear Safety
NS-10.1 (GTN)
Washington, DC 20585

US EPA
Criteria & Standards Div.
Waste Mgmt & Standards Br.
401 M St. NW, ANR-460
Washington, DC 20460

US NRC-AEOD
Technical Training Center
Chief, Spec Training Center Staff
5700 Brainerd Rd
Chattanooga, TN 37411

US NRC-NMSS
Office Director
W/F 6-E-6
Washington, DC 20555

US NRC-NMSS
Div. of HL Waste Mgmt
Division Director
W/F 4-H-3
Washington, DC 20555

US NRC-NMSS
Deputy Director, Div of HL Waste Mgmt
W/F 4-H-3
Washington, DC 20555

US NRC-NMSS
Div. of HL Waste Mgmt.
Project Director
Repository Licensing Proj. Dir.
W/F 4-H-3
Washington, DC 20555

US NRC-NMSS
Div. of LLWaste Mgmt
Division Director W/F 5-E-2
Washington, DC 20555

US NRC-OPP
Director
W/F 1-F-22
Washington, DC 20555

US NRC-RES
Office Director
NL-007
Washington, DC 20555

US NRC-RES
Div. Of Engineering
Branch Chief, Waste Mgmt Branch
Nl/S-260
Washington, DC 20555

US NRC, Reg. I
Regional Administrator
475 Allendale Rd
King Of Prussia, PA 19406

US NRC-Reg II
Branch Chief
Div. Of Rad Sfty & Sfgds
Emerg Prep. & Rad. Prot. Br.
101 Marietta St.
Atlanta, GA 30323

US NRC-Reg IV
Regional Administrator
611 Ryan Plaza Dr., Suite 400
Arlington, TX 76011

US NRC-Reg. V
Regional Administrator
1450 Maria Lane, Suite 210
Walnut Creek, CA 94596

Elgan H Usrey
Tennesse Emergency Mgmt Agency
Emergency Ops Center
3041 Sidco Dr.
Nashville, TN 37204

T. T. Vandergraaf
Whiteshell Nuclear Research
Atomic Energy Of Canada Ltd
R0E 1L0
Pinawa Minitoba
CANADA

Dr. Kaz Vinsome
Dyad Engineering
610 8th Ave. S.W., Suite 915
Calgary, Alberta
CANADA T2P 1G5

Marina Voskanian
State Lands Commission
245 W. Broadway, Ste. 425
Long beach, CA 90802

Krishan K. Wahi
GRAM, Inc.
1709 Moon St., NE
Albuquerque, NM

Kenneth Weaver, Director
Radiation Control Div.
Colorado Dept Of Health
4210 East 11th Ave.
Denver, CO 80220

Dr. Stephen W. Webb
Sandia National Laboratories
Dept. 6344
PO Box 5800
Albuquerque, NM 87185

Rex G. Wescott
US NRC
Washington, DC 20555

Dr. Mark D. White
Battelle Pacific Northwest Lab.
PO Box 999
Richland, WA 99352

Dr. Stephen P. White
Applied Mathematics Div., DSIR
PO Box 1335
Wellington
NEW ZEALAND

Paul C Williams
Paul Williams & Associates
3364 East Smith Road
Medina, OH 44256

Isaac J. Winograd
Research Hydrologist
US Geological Surey
National Center, MS 432
Reston, VA 22092

P A Witherspoon
Lawrence Berkeley Lab., ESD
One Cyclotrol Rd., Bldg 50E
Berkeley, CA 94720

W B White
Pennsylvania State University
210 Materials Research Lab
University Park, PA 16802

Dr. Frank Wobber
US DOE
Ecological Research Division
Office of Energy Research, ER-75
Washington, DC 20585

H. Wollenberg
Lawrence Berkeley Lab.
1 Cyclotron Rd.
Earth Sciences Div., Bldg 50E
Berkeley, CA 94720

Don J. Womeldorf
Dept. Of Health Services
Environmental Health
701 N 7th St. -Box 942732, Room 616
Sacramento, CA 94234

Dr. Werner Zielke
Institut fuer Stroemungsmechanik
Universitaet Hannover
Appelstr. 9A
3000 Hannover 1
GERMANY

Dr. George Zyvoloski
MS F 665
Los Alamos National Lab.
Los Alamos, NM 87545

This diskette contains the files used for the simulation of Updegraff's problems. A list of the names of the data input files and a brief explanation follow:

(1) File "ver1a": Verification Problem #1
1-d infiltration (Philip, 1955)
Data file as in TOUGH's User Guide (Pruess, 1987)
Upstream weighting and a second row of cells

(2) File "ver1b": Verification Problem #1
Modified
Upstream weighting and removal of second row of cells

(3) File "ver1c": Verification Problem #1
Modified
Midpoint weighting and removal of second row of cells

(4) File "ver2a": Verification Problem #2
1-d heat transport (Avdonin, 1964)
Upstream weighting and fluid injection

(5) File "ver2b": Verification Problem #2
1-d heat transport (Avdonin, 1964)
Midpoint weighting and fluid injection

(6) File "ver3a": Verification Problem #3
1-d radial heat transport (Avdonin, 1964)
Upstream weighting and fluid injection
Includes the MESHMAKER data input file (appended at the end of the regular data file) for grid generation using the MESHMAKER facility of TOUGH2.

(7) File "ver3b": Verification Problem #3
1-d radial heat transport (Avdonin, 1964)
Midpoint weighting and fluid injection
Includes the MESHMAKER data input file (appended at the end of the regular data file) for grid generation using the MESHMAKER facility of TOUGH2.

(8) File "ver4": Verification Problem #4
Flow to a geothermal well (Garg, 1980)
Data file as in TOUGH's User Guide (Pruess, 1987)

(9) File "ver5": Verification Problem #5
Heat pipe problem (Udell and Fitch, 1985)
Data file as in TOUGH's User Guide (Pruess, 1987)

(10) File "val1": Validation Problem #1
2-d infiltration (Vauclin et al., 1979)
Includes the MESHMAKER data input file (appended at the end of the regular data file) for grid generation using the MESHMAKER facility of TOUGH2.

(11) File "val2a": Validation Problem #2
2-d convection cell in r-z (Reda, 1984)
Flow channeling effects included
Includes the MESHMAKER data input file (appended at the end of the regular data file) for grid generation using the MESHMAKER facility of TOUGH2.

(12) File "val2b": Validation Problem #2
2-d convection cell in r-z (Reda, 1984)
Flow channeling effects neglected
Includes the MESHMAKER data input file (appended at the end of the regular data file) for grid generation using the MESHMAKER facility of TOUGH2.

(13) File "val3a": Validation Problem #3
Heat and mass flow with phase change (Kruger and Ramey, 1974)

Boundary ring included

(14) File "val3b": Validation Problem #2

Heat and mass flow with phase change (Kruger and Ramey, 1974)

Boundary ring omitted

Moreover, this diskette includes the file RELP, which is the relative permeability subroutine. The addition of Vauclin's equation for Validation Problem 1 is clearly marked.

```
C***********************************************************************
C@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
C***********************************************************************
C
C
C
      SUBROUTINE RELP(SG,REPL,REPG,NMAT,K,NLOC,SG0)
C
C-----THIS ROUTINE COMPUTES RELATIVE PERMEABILITIES FOR LIQUID
C     AND GASEOUS PHASES.
C
      COMMON/P3/DELX(1)
      COMMON/RPCAP/IRP(27),RP(7,27),ICP(27),CP(7,27),IRPD,RPD(7),
     1  ICPD,CPD(7)
C
      SL=1.-SG
      GO TO (10,11,12,12,13,14,15,16,17),IRP(NMAT)
   10 CONTINUE
C-----LINEAR FUNCTIONS.
C
C     CHECK IF INCREMENT NEEDS TO BE ADJUSTED AT LOWER LIQUID CUTOFF.
      IF (K.NE.3) GO TO 20
      IF ((SL-RP(1,NMAT))*(1.-SG0-RP(1,NMAT)).GE.0.) GO TO 20
C     ADJUST INCREMENT.
      DELX(NLOC+2)=-DELX(NLOC+2)
      SG=SG0+DELX(NLOC+2)
      SL=1.-SG
   20 CONTINUE
      REPL=(SL-RP(1,NMAT))/(RP(3,NMAT)-RP(1,NMAT))
      IF (SL.GE.RP(3,NMAT)) REPL=1.
      IF (SL.LE.RP(1,NMAT)) REPL=0.
      REPG=(SG-RP(2,NMAT))/(RP(4,NMAT)-RP(2,NMAT))
      IF (SG.GE.RP(4,NMAT)) REPG=1.
      IF (SG.LE.RP(2,NMAT)) REPG=0.
      RETURN
C
   11 CONTINUE
C-----RELATIVE PERMEABILITY OF PICKENS ET AL.
C
      REPG=1.
      REPL=(1.-SG)**RP(1,NMAT)
C
      RETURN
C
   12 CONTINUE
C-----COREY'S OR GRANT'S CURVES.
C
      SSTAR=(SL-RP(1,NMAT))/(1.-RP(1,NMAT)-RP(2,NMAT))
      REPL=SSTAR**4
      REPG=(1.-SSTAR**2)*(1.-SSTAR)**2
      IF (SG.GE.RP(2,NMAT)) GO TO 50
      REPG=0.
      REPL=1.
      GO TO 102
   50 IF (SG.LT.(1.-RP(1,NMAT))) GO TO 102
      REPL=0.
      REPG=1.
```

```
  102 CONTINUE
      IF (IRP(NMAT).EQ.4) REPG=1.-REPL
      RETURN
C
   13 CONTINUE
C-----BOTH PHASES ARE PERFECTLY MOBILE.
C
      REPL=1.
      REPG=1.
C
      RETURN
   14 CONTINUE
C-----RELATIVE PERMEABILITIES OF FATT AND KLIKOFF (1959), AS REPORTED
C     BY K. UDELL (BERKELEY, 1982).
C
      SS=0.
      IF (SL.GT.RP(1,NMAT)) SS=(SL-RP(1,NMAT))/(1.-RP(1,NMAT))
      REPL=SS**3
      REPG=(1.-SS)**3
      RETURN
C
C
   15 CONTINUE
C-----RELATIVE PERMEABILITY OF VAN GENUCHTEN, SOIL SCI. SOC. AM. J. 44,
C     PP. 892-898, 1980.
C
      IF (SL.GE.RP(3,NMAT)) GO TO 150
      SS=(SL-RP(2,NMAT))/(RP(3,NMAT)-RP(2,NMAT))
      REPL=0.
      IF (SS.GT.0.)
     1   REPL=SQRT(SS)*(1.-(1.-SS**(1./RP(1,NMAT)))**RP(1,NMAT))**2
      REPG=1.-REPL
      RETURN
C
  150 REPL=1.
      REPG=0.
      RETURN
C
   16 CONTINUE
C     RELATIVE PERMEABILITIES AS MEASURED BY VERMA ET AL. IN
C     LABORATORY FLOW EXPERIMENTS FOR STEAM-WATER MIXTURES
C
      SS=(SL-RP(1,NMAT))/(RP(2,NMAT)-RP(1,NMAT))
      IF(SS.GT.1.) SS=1.
      IF(SS.LT.0.) SS=0.
      REPL=SS**3
      REPG=RP(3,NMAT)+RP(4,NMAT)*SS+RP(5,NMAT)*SS*SS
      IF(REPG.GT.1.) REPG=1.
      IF(REPG.LT.0.) REPG=0.
      RETURN
C
C***********************************************************************
C         ADDITION OF VAUCLIN'S FUNCTION
C***********************************************************************
C

   17 CONTINUE
```

```
C     RELATIVE PERMEABILITIES AS MEASURED BY VAUCLIN ET AL.(1979)
C
      TERM1 = (1.0E0 - SL)/SL
      BOT   = 1.0E0 + RP(1,NMAT)*TERM1**RP(3,NMAT)
      REPL  = 1.0E0/BOT
      REPG  = 1.0E0 - REPL
      RETURN
C
C***********************************************************************
C         END OF ADDITION
C***********************************************************************
C
C
      END
C
C
C
C***********************************************************************
C@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
C***********************************************************************
```

```
*val1* ... Validation Problem No.1.
START     2-d infiltration - Vauclin et al. (1979)
START     2nd modification; upstream weighting + injection
START     7-10-92: George's latest data file
START              grid generation using MESHMAKER from TOUGH2
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
SOIL     2  2242.857       0.3  9.95E-12  9.95E-12  9.95E-12       1.0     700.0
       0.0       0.0       1.0       1.0
    9      28.768353       0.0 1.7241379       0.0
    3      3783.0145       0.0       2.9
BOUN     2  2242.857       0.3  9.95E-12  9.95E-12  9.95E-12       1.0     700.0
       0.0       0.0       1.0       1.0
    1            1.0      -0.1       1.1       0.0
    1            0.0       0.0       1.0
SAT      2  2242.857       0.3  9.95E-12  9.95E-12  9.95E-12       1.0     700.0
       0.0       0.0       1.0       1.0
    9      28.768353       0.0 1.7241379       0.0
    3      3783.0145       0.0       2.9

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 19999360050001000001 0001 0 40          2.13E-5       1.8
        0.    28800.        .1      900.A11 1          9.807        2.        1.
     5.E-7        1.       0.1        1.        1.     1.E-8
             101330.                  1.                 20.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1   16     1800.    1800.
     1800.
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A11 1          SOIL  .1150E-01 .1150E+00           .5750E-01 .5000E+00-.5000E-01
A21 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.1500E+00
A31 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.2500E+00
A41 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.3500E+00
A51 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.4500E+00
A61 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.5500E+00
A71 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.6500E+00
A81 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.7500E+00
A91 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.8500E+00
AA1 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.9500E+00
AB1 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.1050E+01
AC1 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.1150E+01
AD1 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.1250E+01
AE1 1          SOIL  .5750E-02 .0000E+00           .5750E-01 .5000E+00-.1325E+01
AF1 1          SOIL  .5750E-02 .0000E+00           .5750E-01 .5000E+00-.1375E+01
AG1 1          SOIL  .1150E-01 .0000E+00           .5750E-01 .5000E+00-.1450E+01
AH1 1          SOIL  .2300E-01 .0000E+00           .5750E-01 .5000E+00-.1600E+01
AI1 1          SOIL  .3450E-01 .1150E+00           .5750E-01 .5000E+00-.1850E+01
A11 2          SOIL  .1500E-01 .1500E+00           .1900E+00 .5000E+00-.5000E-01
A21 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.1500E+00
A31 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.2500E+00
A41 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.3500E+00
A51 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.4500E+00
A61 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.5500E+00
A71 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.6500E+00
A81 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.7500E+00
A91 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.8500E+00
AA1 2          SOIL  .1500E-01 .0000E+00           .1900E+00 .5000E+00-.9500E+00
```

AB1	2	SOIL	.1500E-01	.0000E+00	.1900E+00	.5000E+00-.1050E+01
AC1	2	SOIL	.1500E-01	.0000E+00	.1900E+00	.5000E+00-.1150E+01
AD1	2	SOIL	.1500E-01	.0000E+00	.1900E+00	.5000E+00-.1250E+01
AE1	2	SOIL	.7500E-02	.0000E+00	.1900E+00	.5000E+00-.1325E+01
AF1	2	SOIL	.7500E-02	.0000E+00	.1900E+00	.5000E+00-.1375E+01
AG1	2	SOIL	.1500E-01	.0000E+00	.1900E+00	.5000E+00-.1450E+01
AH1	2	SOIL	.3000E-01	.0000E+00	.1900E+00	.5000E+00-.1600E+01
AI1	2	SOIL	.4500E-01	.1500E+00	.1900E+00	.5000E+00-.1850E+01
A11	3	SOIL	.1500E-01	.1500E+00	.3400E+00	.5000E+00-.5000E-01
A21	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.1500E+00
A31	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.2500E+00
A41	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.3500E+00
A51	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.4500E+00
A61	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.5500E+00
A71	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.6500E+00
A81	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.7500E+00
A91	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.8500E+00
AA1	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.9500E+00
AB1	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.1050E+01
AC1	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.1150E+01
AD1	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.1250E+01
AE1	3	SOIL	.7500E-02	.0000E+00	.3400E+00	.5000E+00-.1325E+01
AF1	3	SOIL	.7500E-02	.0000E+00	.3400E+00	.5000E+00-.1375E+01
AG1	3	SOIL	.1500E-01	.0000E+00	.3400E+00	.5000E+00-.1450E+01
AH1	3	SOIL	.3000E-01	.0000E+00	.3400E+00	.5000E+00-.1600E+01
AI1	3	SOIL	.4500E-01	.1500E+00	.3400E+00	.5000E+00-.1850E+01
A11	4	SOIL	.8500E-02	.8500E-01	.4575E+00	.5000E+00-.5000E-01
A21	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.1500E+00
A31	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.2500E+00
A41	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.3500E+00
A51	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.4500E+00
A61	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.5500E+00
A71	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.6500E+00
A81	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.7500E+00
A91	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.8500E+00
AA1	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.9500E+00
AB1	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.1050E+01
AC1	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.1150E+01
AD1	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.1250E+01
AE1	4	SOIL	.4250E-02	.0000E+00	.4575E+00	.5000E+00-.1325E+01
AF1	4	SOIL	.4250E-02	.0000E+00	.4575E+00	.5000E+00-.1375E+01
AG1	4	SOIL	.8500E-02	.0000E+00	.4575E+00	.5000E+00-.1450E+01
AH1	4	SOIL	.1700E-01	.0000E+00	.4575E+00	.5000E+00-.1600E+01
AI1	4	SOIL	.2550E-01	.8500E-01	.4575E+00	.5000E+00-.1850E+01
A11	5	SOIL	.7500E-02	.7500E-01	.5375E+00	.5000E+00-.5000E-01
A21	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.1500E+00
A31	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.2500E+00
A41	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.3500E+00
A51	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.4500E+00
A61	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.5500E+00
A71	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.6500E+00
A81	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.7500E+00
A91	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.8500E+00
AA1	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.9500E+00
AB1	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.1050E+01
AC1	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.1150E+01
AD1	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.1250E+01

AE1	5	SOIL	.3750E-02	.0000E+00	.5375E+00	.5000E+00-.1325E+01
AF1	5	SOIL	.3750E-02	.0000E+00	.5375E+00	.5000E+00-.1375E+01
AG1	5	SOIL	.7500E-02	.0000E+00	.5375E+00	.5000E+00-.1450E+01
AH1	5	SOIL	.1500E-01	.0000E+00	.5375E+00	.5000E+00-.1600E+01
AI1	5	SOIL	.2250E-01	.7500E-01	.5375E+00	.5000E+00-.1850E+01
A11	6	SOIL	.1400E-01	.1400E+00	.6450E+00	.5000E+00-.5000E-01
A21	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.1500E+00
A31	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.2500E+00
A41	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.3500E+00
A51	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.4500E+00
A61	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.5500E+00
A71	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.6500E+00
A81	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.7500E+00
A91	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.8500E+00
AA1	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.9500E+00
AB1	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.1050E+01
AC1	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.1150E+01
AD1	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.1250E+01
AE1	6	SOIL	.7000E-02	.0000E+00	.6450E+00	.5000E+00-.1325E+01
AF1	6	SOIL	.7000E-02	.0000E+00	.6450E+00	.5000E+00-.1375E+01
AG1	6	SOIL	.1400E-01	.0000E+00	.6450E+00	.5000E+00-.1450E+01
AH1	6	SOIL	.2800E-01	.0000E+00	.6450E+00	.5000E+00-.1600E+01
AI1	6	SOIL	.4200E-01	.1400E+00	.6450E+00	.5000E+00-.1850E+01
A11	7	SOIL	.1500E-01	.1500E+00	.7900E+00	.5000E+00-.5000E-01
A21	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.1500E+00
A31	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.2500E+00
A41	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.3500E+00
A51	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.4500E+00
A61	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.5500E+00
A71	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.6500E+00
A81	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.7500E+00
A91	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.8500E+00
AA1	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.9500E+00
AB1	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.1050E+01
AC1	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.1150E+01
AD1	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.1250E+01
AE1	7	SOIL	.7500E-02	.0000E+00	.7900E+00	.5000E+00-.1325E+01
AF1	7	SOIL	.7500E-02	.0000E+00	.7900E+00	.5000E+00-.1375E+01
AG1	7	SOIL	.1500E-01	.0000E+00	.7900E+00	.5000E+00-.1450E+01
AH1	7	SOIL	.3000E-01	.0000E+00	.7900E+00	.5000E+00-.1600E+01
AI1	7	SOIL	.4500E-01	.1500E+00	.7900E+00	.5000E+00-.1850E+01
A11	8	SOIL	.1500E-01	.1500E+00	.9400E+00	.5000E+00-.5000E-01
A21	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.1500E+00
A31	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.2500E+00
A41	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.3500E+00
A51	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.4500E+00
A61	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.5500E+00
A71	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.6500E+00
A81	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.7500E+00
A91	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.8500E+00
AA1	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.9500E+00
AB1	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.1050E+01
AC1	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.1150E+01
AD1	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.1250E+01
AE1	8	SOIL	.7500E-02	.0000E+00	.9400E+00	.5000E+00-.1325E+01
AF1	8	SOIL	.7500E-02	.0000E+00	.9400E+00	.5000E+00-.1375E+01
AG1	8	SOIL	.1500E-01	.0000E+00	.9400E+00	.5000E+00-.1450E+01

AH1 8	SOIL	.3000E-01	.0000E+00	.9400E+00	.5000E+00	-.1600E+01
AI1 8	SOIL	.4500E-01	.1500E+00	.9400E+00	.5000E+00	-.1850E+01
A11 9	SOIL	.1500E-01	.1500E+00	.1090E+01	.5000E+00	-.5000E-01
A21 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.1500E+00
A31 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.2500E+00
A41 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.3500E+00
A51 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.4500E+00
A61 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.5500E+00
A71 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.6500E+00
A81 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.7500E+00
A91 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.8500E+00
AA1 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.9500E+00
AB1 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.1050E+01
AC1 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.1150E+01
AD1 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.1250E+01
AE1 9	SOIL	.7500E-02	.0000E+00	.1090E+01	.5000E+00	-.1325E+01
AF1 9	SOIL	.7500E-02	.0000E+00	.1090E+01	.5000E+00	-.1375E+01
AG1 9	SOIL	.1500E-01	.0000E+00	.1090E+01	.5000E+00	-.1450E+01
AH1 9	SOIL	.3000E-01	.0000E+00	.1090E+01	.5000E+00	-.1600E+01
AI1 9	SOIL	.4500E-01	.1500E+00	.1090E+01	.5000E+00	-.1850E+01
A1110	SOIL	.1500E-01	.1500E+00	.1240E+01	.5000E+00	-.5000E-01
A2110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.1500E+00
A3110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.2500E+00
A4110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.3500E+00
A5110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.4500E+00
A6110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.5500E+00
A7110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.6500E+00
A8110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.7500E+00
A9110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.8500E+00
AA110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.9500E+00
AB110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.1050E+01
AC110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.1150E+01
AD110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.1250E+01
AE110	SOIL	.7500E-02	.0000E+00	.1240E+01	.5000E+00	-.1325E+01
AF110	SOIL	.7500E-02	.0000E+00	.1240E+01	.5000E+00	-.1375E+01
AG110	SOIL	.1500E-01	.0000E+00	.1240E+01	.5000E+00	-.1450E+01
AH110	SOIL	.3000E-01	.0000E+00	.1240E+01	.5000E+00	-.1600E+01
AI110	SOIL	.4500E-01	.1500E+00	.1240E+01	.5000E+00	-.1850E+01
A1111	SOIL	.1500E-01	.1500E+00	.1390E+01	.5000E+00	-.5000E-01
A2111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.1500E+00
A3111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.2500E+00
A4111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.3500E+00
A5111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.4500E+00
A6111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.5500E+00
A7111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.6500E+00
A8111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.7500E+00
A9111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.8500E+00
AA111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.9500E+00
AB111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.1050E+01
AC111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.1150E+01
AD111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.1250E+01
AE111	SOIL	.7500E-02	.0000E+00	.1390E+01	.5000E+00	-.1325E+01
AF111	SOIL	.7500E-02	.0000E+00	.1390E+01	.5000E+00	-.1375E+01
AG111	SOIL	.1500E-01	.0000E+00	.1390E+01	.5000E+00	-.1450E+01
AH111	SOIL	.3000E-01	.0000E+00	.1390E+01	.5000E+00	-.1600E+01
AI111	SOIL	.4500E-01	.1500E+00	.1390E+01	.5000E+00	-.1850E+01
A1112	SOIL	.1500E-01	.1500E+00	.1540E+01	.5000E+00	-.5000E-01

A2112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.1500E+00
A3112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.2500E+00
A4112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.3500E+00
A5112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.4500E+00
A6112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.5500E+00
A7112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.6500E+00
A8112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.7500E+00
A9112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.8500E+00
AA112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.9500E+00
AB112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.1050E+01
AC112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.1150E+01
AD112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.1250E+01
AE112	SOIL	.7500E-02	.0000E+00	.1540E+01	.5000E+00	-.1325E+01
AF112	SOIL	.7500E-02	.0000E+00	.1540E+01	.5000E+00	-.1375E+01
AG112	SOIL	.1500E-01	.0000E+00	.1540E+01	.5000E+00	-.1450E+01
AH112	SOIL	.3000E-01	.0000E+00	.1540E+01	.5000E+00	-.1600E+01
AI112	SOIL	.4500E-01	.1500E+00	.1540E+01	.5000E+00	-.1850E+01
A1113	SOIL	.1500E-01	.1500E+00	.1690E+01	.5000E+00	-.5000E-01
A2113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.1500E+00
A3113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.2500E+00
A4113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.3500E+00
A5113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.4500E+00
A6113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.5500E+00
A7113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.6500E+00
A8113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.7500E+00
A9113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.8500E+00
AA113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.9500E+00
AB113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.1050E+01
AC113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.1150E+01
AD113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.1250E+01
AE113	SOIL	.7500E-02	.0000E+00	.1690E+01	.5000E+00	-.1325E+01
AF113	SOIL	.7500E-02	.0000E+00	.1690E+01	.5000E+00	-.1375E+01
AG113	SOIL	.1500E-01	.0000E+00	.1690E+01	.5000E+00	-.1450E+01
AH113	SOIL	.3000E-01	.0000E+00	.1690E+01	.5000E+00	-.1600E+01
AI113	SOIL	.4500E-01	.1500E+00	.1690E+01	.5000E+00	-.1850E+01
A1114	SOIL	.1500E-01	.1500E+00	.1840E+01	.5000E+00	-.5000E-01
A2114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.1500E+00
A3114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.2500E+00
A4114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.3500E+00
A5114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.4500E+00
A6114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.5500E+00
A7114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.6500E+00
A8114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.7500E+00
A9114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.8500E+00
AA114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.9500E+00
AB114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.1050E+01
AC114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.1150E+01
AD114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.1250E+01
AE114	SOIL	.7500E-02	.0000E+00	.1840E+01	.5000E+00	-.1325E+01
AF114	SOIL	.7500E-02	.0000E+00	.1840E+01	.5000E+00	-.1375E+01
AG114	SOIL	.1500E-01	.0000E+00	.1840E+01	.5000E+00	-.1450E+01
AH114	SOIL	.3000E-01	.0000E+00	.1840E+01	.5000E+00	-.1600E+01
AI114	SOIL	.4500E-01	.1500E+00	.1840E+01	.5000E+00	-.1850E+01
A1115	SOIL	.1500E-01	.1500E+00	.1990E+01	.5000E+00	-.5000E-01
A2115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00	-.1500E+00
A3115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00	-.2500E+00
A4115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00	-.3500E+00

A5115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.4500E+00
A6115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.5500E+00
A7115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.6500E+00
A8115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.7500E+00
A9115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.8500E+00
AA115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.9500E+00
AB115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.1050E+01
AC115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.1150E+01
AD115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.1250E+01
AE115	SOIL	.7500E-02	.0000E+00	.1990E+01	.5000E+00-.1325E+01
AF115	SOIL	.7500E-02	.0000E+00	.1990E+01	.5000E+00-.1375E+01
AG115	SOIL	.1500E-01	.0000E+00	.1990E+01	.5000E+00-.1450E+01
AH115	SOIL	.3000E-01	.0000E+00	.1990E+01	.5000E+00-.1600E+01
AI115	SOIL	.4500E-01	.1500E+00	.1990E+01	.5000E+00-.1850E+01
A1116	SOIL	.1550E-01	.1550E+00	.2142E+01	.5000E+00-.5000E-01
A2116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.1500E+00
A3116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.2500E+00
A4116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.3500E+00
A5116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.4500E+00
A6116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.5500E+00
A7116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.6500E+00
A8116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.7500E+00
A9116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.8500E+00
AA116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.9500E+00
AB116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.1050E+01
AC116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.1150E+01
AD116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.1250E+01
AE116	SOIL	.7750E-02	.0000E+00	.2142E+01	.5000E+00-.1325E+01
AF116	SOIL	.7750E-02	.0000E+00	.2142E+01	.5000E+00-.1375E+01
AG116	SOIL	.1550E-01	.0000E+00	.2142E+01	.5000E+00-.1450E+01
AH116	SOIL	.3100E-01	.0000E+00	.2142E+01	.5000E+00-.1600E+01
AI116	SOIL	.4650E-01	.1550E+00	.2142E+01	.5000E+00-.1850E+01
A1117	SOIL	.1800E-01	.1800E+00	.2310E+01	.5000E+00-.5000E-01
A2117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.1500E+00
A3117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.2500E+00
A4117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.3500E+00
A5117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.4500E+00
A6117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.5500E+00
A7117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.6500E+00
A8117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.7500E+00
A9117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.8500E+00
AA117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.9500E+00
AB117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.1050E+01
AC117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.1150E+01
AD117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.1250E+01
AE117	SOIL	.9000E-02	.0000E+00	.2310E+01	.5000E+00-.1325E+01
AF117	SOIL	.9000E-02	.0000E+00	.2310E+01	.5000E+00-.1375E+01
AG117	SOIL	.1800E-01	.0000E+00	.2310E+01	.5000E+00-.1450E+01
AH117	SOIL	.3600E-01	.0000E+00	.2310E+01	.5000E+00-.1600E+01
AI117	SOIL	.5400E-01	.1800E+00	.2310E+01	.5000E+00-.1850E+01
A1118	SOIL	.2000E-01	.2000E+00	.2500E+01	.5000E+00-.5000E-01
A2118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.1500E+00
A3118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.2500E+00
A4118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.3500E+00
A5118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.4500E+00
A6118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.5500E+00
A7118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.6500E+00

A8118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.7500E+00
A9118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.8500E+00
AA118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.9500E+00
AB118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.1050E+01
AC118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.1150E+01
AD118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.1250E+01
AE118	SOIL	.1000E-01	.0000E+00	.2500E+01	.5000E+00-.1325E+01
AF118	SOIL	.1000E-01	.0000E+00	.2500E+01	.5000E+00-.1375E+01
AG118	SOIL	.2000E-01	.0000E+00	.2500E+01	.5000E+00-.1450E+01
AH118	SOIL	.4000E-01	.0000E+00	.2500E+01	.5000E+00-.1600E+01
AI118	SOIL	.6000E-01	.2000E+00	.2500E+01	.5000E+00-.1850E+01
A1119	SOIL	.2000E-01	.2000E+00	.2700E+01	.5000E+00-.5000E-01
A2119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.1500E+00
A3119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.2500E+00
A4119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.3500E+00
A5119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.4500E+00
A6119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.5500E+00
A7119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.6500E+00
A8119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.7500E+00
A9119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.8500E+00
AA119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.9500E+00
AB119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.1050E+01
AC119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.1150E+01
AD119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.1250E+01
AE119	SOIL	.1000E-01	.0000E+00	.2700E+01	.5000E+00-.1325E+01
AF119	SOIL	.1000E-01	.0000E+00	.2700E+01	.5000E+00-.1375E+01
AG119	SOIL	.2000E-01	.0000E+00	.2700E+01	.5000E+00-.1450E+01
AH119	SOIL	.4000E-01	.0000E+00	.2700E+01	.5000E+00-.1600E+01
AI119	SOIL	.6000E-01	.2000E+00	.2700E+01	.5000E+00-.1850E+01
A1120	SOIL	.2000E-01	.2000E+00	.2900E+01	.5000E+00-.5000E-01
A2120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.1500E+00
A3120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.2500E+00
A4120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.3500E+00
A5120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.4500E+00
A6120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.5500E+00
A7120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.6500E+00
A8120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.7500E+00
A9120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.8500E+00
AA120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.9500E+00
AB120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.1050E+01
AC120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.1150E+01
AD120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.1250E+01
AE120	SOIL	.1000E-01	.0000E+00	.2900E+01	.5000E+00-.1325E+01
AF120	SOIL	.1000E-01	.0000E+00	.2900E+01	.5000E+00-.1375E+01
AG120	SOIL	.2000E-01	.0000E+00	.2900E+01	.5000E+00-.1450E+01
AH120	SOIL	.4000E-01	.0000E+00	.2900E+01	.5000E+00-.1600E+01
AI120	SOIL	.6000E-01	.2000E+00	.2900E+01	.5000E+00-.1850E+01
A1121	BOUN	.1000E+30	.1000E-03	.3000E+01	.5000E+00-.5000E-01
A2121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.1500E+00
A3121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.2500E+00
A4121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.3500E+00
A5121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.4500E+00
A6121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.5500E+00
A7121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.6500E+00
A8121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.7500E+00
A9121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.8500E+00
AA121	BOUN	.1000E+30	.0000E+00	.3000E+01	.5000E+00-.9500E+00

```
AB121          BOUN  .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1050E+01
AC121          BOUN  .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1150E+01
AD121          BOUN  .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1250E+01
AE121          BOUN  .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1325E+01
AF121          SAT   .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1375E+01
AG121          SAT   .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1450E+01
AH121          SAT   .1000E+30 .0000E+00           .3000E+01 .5000E+00-.1600E+01
AI121          SAT   .1000E+30 .1000E-03           .3000E+01 .5000E+00-.1850E+01

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A11 1A11 2                  1 .5750E-01 .7500E-01 .1000E+00
A11 1A21 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A21 1A21 2                  1 .5750E-01 .7500E-01 .1000E+00
A21 1A31 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A31 1A31 2                  1 .5750E-01 .7500E-01 .1000E+00
A31 1A41 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A41 1A41 2                  1 .5750E-01 .7500E-01 .1000E+00
A41 1A51 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A51 1A51 2                  1 .5750E-01 .7500E-01 .1000E+00
A51 1A61 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A61 1A61 2                  1 .5750E-01 .7500E-01 .1000E+00
A61 1A71 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A71 1A71 2                  1 .5750E-01 .7500E-01 .1000E+00
A71 1A81 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A81 1A81 2                  1 .5750E-01 .7500E-01 .1000E+00
A81 1A91 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
A91 1A91 2                  1 .5750E-01 .7500E-01 .1000E+00
A91 1AA1 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
AA1 1AA1 2                  1 .5750E-01 .7500E-01 .1000E+00
AA1 1AB1 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
AB1 1AB1 2                  1 .5750E-01 .7500E-01 .1000E+00
AB1 1AC1 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
AC1 1AC1 2                  1 .5750E-01 .7500E-01 .1000E+00
AC1 1AD1 1                  3 .5000E-01 .5000E-01 .1150E+00 .1000E+01
AD1 1AD1 2                  1 .5750E-01 .7500E-01 .1000E+00
AD1 1AE1 1                  3 .5000E-01 .2500E-01 .1150E+00 .1000E+01
AE1 1AE1 2                  1 .5750E-01 .7500E-01 .5000E-01
AE1 1AF1 1                  3 .2500E-01 .2500E-01 .1150E+00 .1000E+01
AF1 1AF1 2                  1 .5750E-01 .7500E-01 .5000E-01
AF1 1AG1 1                  3 .2500E-01 .5000E-01 .1150E+00 .1000E+01
AG1 1AG1 2                  1 .5750E-01 .7500E-01 .1000E+00
AG1 1AH1 1                  3 .5000E-01 .1000E+00 .1150E+00 .1000E+01
AH1 1AH1 2                  1 .5750E-01 .7500E-01 .2000E+00
AH1 1AI1 1                  3 .1000E+00 .1500E+00 .1150E+00 .1000E+01
AI1 1AI1 2                  1 .5750E-01 .7500E-01 .3000E+00
A11 2A11 3                  1 .7500E-01 .7500E-01 .1000E+00
A11 2A21 2                  3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A21 2A21 3                  1 .7500E-01 .7500E-01 .1000E+00
A21 2A31 2                  3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A31 2A31 3                  1 .7500E-01 .7500E-01 .1000E+00
A31 2A41 2                  3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A41 2A41 3                  1 .7500E-01 .7500E-01 .1000E+00
A41 2A51 2                  3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A51 2A51 3                  1 .7500E-01 .7500E-01 .1000E+00
A51 2A61 2                  3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A61 2A61 3                  1 .7500E-01 .7500E-01 .1000E+00
A61 2A71 2                  3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
```

A71	2A71	3	1	.7500E-01	.7500E-01	.1000E+00	
A71	2A81	2	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A81	2A81	3	1	.7500E-01	.7500E-01	.1000E+00	
A81	2A91	2	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A91	2A91	3	1	.7500E-01	.7500E-01	.1000E+00	
A91	2AA1	2	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA1	2AA1	3	1	.7500E-01	.7500E-01	.1000E+00	
AA1	2AB1	2	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB1	2AB1	3	1	.7500E-01	.7500E-01	.1000E+00	
AB1	2AC1	2	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC1	2AC1	3	1	.7500E-01	.7500E-01	.1000E+00	
AC1	2AD1	2	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD1	2AD1	3	1	.7500E-01	.7500E-01	.1000E+00	
AD1	2AE1	2	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE1	2AE1	3	1	.7500E-01	.7500E-01	.5000E-01	
AE1	2AF1	2	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF1	2AF1	3	1	.7500E-01	.7500E-01	.5000E-01	
AF1	2AG1	2	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG1	2AG1	3	1	.7500E-01	.7500E-01	.1000E+00	
AG1	2AH1	2	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH1	2AH1	3	1	.7500E-01	.7500E-01	.2000E+00	
AH1	2AI1	2	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI1	2AI1	3	1	.7500E-01	.7500E-01	.3000E+00	
A11	3A11	4	1	.7500E-01	.4250E-01	.1000E+00	
A11	3A21	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A21	3A21	4	1	.7500E-01	.4250E-01	.1000E+00	
A21	3A31	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A31	3A31	4	1	.7500E-01	.4250E-01	.1000E+00	
A31	3A41	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A41	3A41	4	1	.7500E-01	.4250E-01	.1000E+00	
A41	3A51	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A51	3A51	4	1	.7500E-01	.4250E-01	.1000E+00	
A51	3A61	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A61	3A61	4	1	.7500E-01	.4250E-01	.1000E+00	
A61	3A71	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A71	3A71	4	1	.7500E-01	.4250E-01	.1000E+00	
A71	3A81	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A81	3A81	4	1	.7500E-01	.4250E-01	.1000E+00	
A81	3A91	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A91	3A91	4	1	.7500E-01	.4250E-01	.1000E+00	
A91	3AA1	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA1	3AA1	4	1	.7500E-01	.4250E-01	.1000E+00	
AA1	3AB1	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB1	3AB1	4	1	.7500E-01	.4250E-01	.1000E+00	
AB1	3AC1	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC1	3AC1	4	1	.7500E-01	.4250E-01	.1000E+00	
AC1	3AD1	3	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD1	3AD1	4	1	.7500E-01	.4250E-01	.1000E+00	
AD1	3AE1	3	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE1	3AE1	4	1	.7500E-01	.4250E-01	.5000E-01	
AE1	3AF1	3	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF1	3AF1	4	1	.7500E-01	.4250E-01	.5000E-01	
AF1	3AG1	3	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG1	3AG1	4	1	.7500E-01	.4250E-01	.1000E+00	
AG1	3AH1	3	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH1	3AH1	4	1	.7500E-01	.4250E-01	.2000E+00	
AH1	3AI1	3	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01

AI1	3AI1	4	1	.7500E-01	.4250E-01	.3000E+00	
A11	4A11	5	1	.4250E-01	.3750E-01	.1000E+00	
A11	4A21	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A21	4A21	5	1	.4250E-01	.3750E-01	.1000E+00	
A21	4A31	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A31	4A31	5	1	.4250E-01	.3750E-01	.1000E+00	
A31	4A41	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A41	4A41	5	1	.4250E-01	.3750E-01	.1000E+00	
A41	4A51	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A51	4A51	5	1	.4250E-01	.3750E-01	.1000E+00	
A51	4A61	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A61	4A61	5	1	.4250E-01	.3750E-01	.1000E+00	
A61	4A71	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A71	4A71	5	1	.4250E-01	.3750E-01	.1000E+00	
A71	4A81	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A81	4A81	5	1	.4250E-01	.3750E-01	.1000E+00	
A81	4A91	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
A91	4A91	5	1	.4250E-01	.3750E-01	.1000E+00	
A91	4AA1	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
AA1	4AA1	5	1	.4250E-01	.3750E-01	.1000E+00	
AA1	4AB1	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
AB1	4AB1	5	1	.4250E-01	.3750E-01	.1000E+00	
AB1	4AC1	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
AC1	4AC1	5	1	.4250E-01	.3750E-01	.1000E+00	
AC1	4AD1	4	3	.5000E-01	.5000E-01	.8500E-01	.1000E+01
AD1	4AD1	5	1	.4250E-01	.3750E-01	.1000E+00	
AD1	4AE1	4	3	.5000E-01	.2500E-01	.8500E-01	.1000E+01
AE1	4AE1	5	1	.4250E-01	.3750E-01	.5000E-01	
AE1	4AF1	4	3	.2500E-01	.2500E-01	.8500E-01	.1000E+01
AF1	4AF1	5	1	.4250E-01	.3750E-01	.5000E-01	
AF1	4AG1	4	3	.2500E-01	.5000E-01	.8500E-01	.1000E+01
AG1	4AG1	5	1	.4250E-01	.3750E-01	.1000E+00	
AG1	4AH1	4	3	.5000E-01	.1000E+00	.8500E-01	.1000E+01
AH1	4AH1	5	1	.4250E-01	.3750E-01	.2000E+00	
AH1	4AI1	4	3	.1000E+00	.1500E+00	.8500E-01	.1000E+01
AI1	4AI1	5	1	.4250E-01	.3750E-01	.3000E+00	
A11	5A11	6	1	.3750E-01	.7000E-01	.1000E+00	
A11	5A21	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A21	5A21	6	1	.3750E-01	.7000E-01	.1000E+00	
A21	5A31	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A31	5A31	6	1	.3750E-01	.7000E-01	.1000E+00	
A31	5A41	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A41	5A41	6	1	.3750E-01	.7000E-01	.1000E+00	
A41	5A51	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A51	5A51	6	1	.3750E-01	.7000E-01	.1000E+00	
A51	5A61	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A61	5A61	6	1	.3750E-01	.7000E-01	.1000E+00	
A61	5A71	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A71	5A71	6	1	.3750E-01	.7000E-01	.1000E+00	
A71	5A81	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A81	5A81	6	1	.3750E-01	.7000E-01	.1000E+00	
A81	5A91	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
A91	5A91	6	1	.3750E-01	.7000E-01	.1000E+00	
A91	5AA1	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
AA1	5AA1	6	1	.3750E-01	.7000E-01	.1000E+00	
AA1	5AB1	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
AB1	5AB1	6	1	.3750E-01	.7000E-01	.1000E+00	

AB1	5AC1	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
AC1	5AC1	6	1	.3750E-01	.7000E-01	.1000E+00	
AC1	5AD1	5	3	.5000E-01	.5000E-01	.7500E-01	.1000E+01
AD1	5AD1	6	1	.3750E-01	.7000E-01	.1000E+00	
AD1	5AE1	5	3	.5000E-01	.2500E-01	.7500E-01	.1000E+01
AE1	5AE1	6	1	.3750E-01	.7000E-01	.5000E-01	
AE1	5AF1	5	3	.2500E-01	.2500E-01	.7500E-01	.1000E+01
AF1	5AF1	6	1	.3750E-01	.7000E-01	.5000E-01	
AF1	5AG1	5	3	.2500E-01	.5000E-01	.7500E-01	.1000E+01
AG1	5AG1	6	1	.3750E-01	.7000E-01	.1000E+00	
AG1	5AH1	5	3	.5000E-01	.1000E+00	.7500E-01	.1000E+01
AH1	5AH1	6	1	.3750E-01	.7000E-01	.2000E+00	
AH1	5AI1	5	3	.1000E+00	.1500E+00	.7500E-01	.1000E+01
AI1	5AI1	6	1	.3750E-01	.7000E-01	.3000E+00	
A11	6A11	7	1	.7000E-01	.7500E-01	.1000E+00	
A11	6A21	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A21	6A21	7	1	.7000E-01	.7500E-01	.1000E+00	
A21	6A31	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A31	6A31	7	1	.7000E-01	.7500E-01	.1000E+00	
A31	6A41	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A41	6A41	7	1	.7000E-01	.7500E-01	.1000E+00	
A41	6A51	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A51	6A51	7	1	.7000E-01	.7500E-01	.1000E+00	
A51	6A61	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A61	6A61	7	1	.7000E-01	.7500E-01	.1000E+00	
A61	6A71	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A71	6A71	7	1	.7000E-01	.7500E-01	.1000E+00	
A71	6A81	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A81	6A81	7	1	.7000E-01	.7500E-01	.1000E+00	
A81	6A91	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
A91	6A91	7	1	.7000E-01	.7500E-01	.1000E+00	
A91	6AA1	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
AA1	6AA1	7	1	.7000E-01	.7500E-01	.1000E+00	
AA1	6AB1	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
AB1	6AB1	7	1	.7000E-01	.7500E-01	.1000E+00	
AB1	6AC1	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
AC1	6AC1	7	1	.7000E-01	.7500E-01	.1000E+00	
AC1	6AD1	6	3	.5000E-01	.5000E-01	.1400E+00	.1000E+01
AD1	6AD1	7	1	.7000E-01	.7500E-01	.1000E+00	
AD1	6AE1	6	3	.5000E-01	.2500E-01	.1400E+00	.1000E+01
AE1	6AE1	7	1	.7000E-01	.7500E-01	.5000E-01	
AE1	6AF1	6	3	.2500E-01	.2500E-01	.1400E+00	.1000E+01
AF1	6AF1	7	1	.7000E-01	.7500E-01	.5000E-01	
AF1	6AG1	6	3	.2500E-01	.5000E-01	.1400E+00	.1000E+01
AG1	6AG1	7	1	.7000E-01	.7500E-01	.1000E+00	
AG1	6AH1	6	3	.5000E-01	.1000E+00	.1400E+00	.1000E+01
AH1	6AH1	7	1	.7000E-01	.7500E-01	.2000E+00	
AH1	6AI1	6	3	.1000E+00	.1500E+00	.1400E+00	.1000E+01
AI1	6AI1	7	1	.7000E-01	.7500E-01	.3000E+00	
A11	7A11	8	1	.7500E-01	.7500E-01	.1000E+00	
A11	7A21	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A21	7A21	8	1	.7500E-01	.7500E-01	.1000E+00	
A21	7A31	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A31	7A31	8	1	.7500E-01	.7500E-01	.1000E+00	
A31	7A41	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A41	7A41	8	1	.7500E-01	.7500E-01	.1000E+00	
A41	7A51	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01

A51	7A51	8	1	.7500E-01	.7500E-01	.1000E+00	
A51	7A61	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A61	7A61	8	1	.7500E-01	.7500E-01	.1000E+00	
A61	7A71	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A71	7A71	8	1	.7500E-01	.7500E-01	.1000E+00	
A71	7A81	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A81	7A81	8	1	.7500E-01	.7500E-01	.1000E+00	
A81	7A91	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A91	7A91	8	1	.7500E-01	.7500E-01	.1000E+00	
A91	7AA1	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA1	7AA1	8	1	.7500E-01	.7500E-01	.1000E+00	
AA1	7AB1	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB1	7AB1	8	1	.7500E-01	.7500E-01	.1000E+00	
AB1	7AC1	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC1	7AC1	8	1	.7500E-01	.7500E-01	.1000E+00	
AC1	7AD1	7	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD1	7AD1	8	1	.7500E-01	.7500E-01	.1000E+00	
AD1	7AE1	7	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE1	7AE1	8	1	.7500E-01	.7500E-01	.5000E-01	
AE1	7AF1	7	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF1	7AF1	8	1	.7500E-01	.7500E-01	.5000E-01	
AF1	7AG1	7	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG1	7AG1	8	1	.7500E-01	.7500E-01	.1000E+00	
AG1	7AH1	7	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH1	7AH1	8	1	.7500E-01	.7500E-01	.2000E+00	
AH1	7AI1	7	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI1	7AI1	8	1	.7500E-01	.7500E-01	.3000E+00	
A11	8A11	9	1	.7500E-01	.7500E-01	.1000E+00	
A11	8A21	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A21	8A21	9	1	.7500E-01	.7500E-01	.1000E+00	
A21	8A31	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A31	8A31	9	1	.7500E-01	.7500E-01	.1000E+00	
A31	8A41	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A41	8A41	9	1	.7500E-01	.7500E-01	.1000E+00	
A41	8A51	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A51	8A51	9	1	.7500E-01	.7500E-01	.1000E+00	
A51	8A61	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A61	8A61	9	1	.7500E-01	.7500E-01	.1000E+00	
A61	8A71	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A71	8A71	9	1	.7500E-01	.7500E-01	.1000E+00	
A71	8A81	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A81	8A81	9	1	.7500E-01	.7500E-01	.1000E+00	
A81	8A91	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A91	8A91	9	1	.7500E-01	.7500E-01	.1000E+00	
A91	8AA1	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA1	8AA1	9	1	.7500E-01	.7500E-01	.1000E+00	
AA1	8AB1	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB1	8AB1	9	1	.7500E-01	.7500E-01	.1000E+00	
AB1	8AC1	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC1	8AC1	9	1	.7500E-01	.7500E-01	.1000E+00	
AC1	8AD1	8	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD1	8AD1	9	1	.7500E-01	.7500E-01	.1000E+00	
AD1	8AE1	8	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE1	8AE1	9	1	.7500E-01	.7500E-01	.5000E-01	
AE1	8AF1	8	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF1	8AF1	9	1	.7500E-01	.7500E-01	.5000E-01	
AF1	8AG1	8	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01

```
AG1 8AG1 9                    1 .7500E-01 .7500E-01 .1000E+00
AG1 8AH1 8                    3 .5000E-01 .1000E+00 .1500E+00 .1000E+01
AH1 8AH1 9                    1 .7500E-01 .7500E-01 .2000E+00
AH1 8AI1 8                    3 .1000E+00 .1500E+00 .1500E+00 .1000E+01
AI1 8AI1 9                    1 .7500E-01 .7500E-01 .3000E+00
A11 9A1110                    1 .7500E-01 .7500E-01 .1000E+00
A11 9A21 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A21 9A2110                    1 .7500E-01 .7500E-01 .1000E+00
A21 9A31 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A31 9A3110                    1 .7500E-01 .7500E-01 .1000E+00
A31 9A41 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A41 9A4110                    1 .7500E-01 .7500E-01 .1000E+00
A41 9A51 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A51 9A5110                    1 .7500E-01 .7500E-01 .1000E+00
A51 9A61 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A61 9A6110                    1 .7500E-01 .7500E-01 .1000E+00
A61 9A71 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A71 9A7110                    1 .7500E-01 .7500E-01 .1000E+00
A71 9A81 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A81 9A8110                    1 .7500E-01 .7500E-01 .1000E+00
A81 9A91 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A91 9A9110                    1 .7500E-01 .7500E-01 .1000E+00
A91 9AA1 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
AA1 9AA110                    1 .7500E-01 .7500E-01 .1000E+00
AA1 9AB1 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
AB1 9AB110                    1 .7500E-01 .7500E-01 .1000E+00
AB1 9AC1 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
AC1 9AC110                    1 .7500E-01 .7500E-01 .1000E+00
AC1 9AD1 9                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
AD1 9AD110                    1 .7500E-01 .7500E-01 .1000E+00
AD1 9AE1 9                    3 .5000E-01 .2500E-01 .1500E+00 .1000E+01
AE1 9AE110                    1 .7500E-01 .7500E-01 .5000E-01
AE1 9AF1 9                    3 .2500E-01 .2500E-01 .1500E+00 .1000E+01
AF1 9AF110                    1 .7500E-01 .7500E-01 .5000E-01
AF1 9AG1 9                    3 .2500E-01 .5000E-01 .1500E+00 .1000E+01
AG1 9AG110                    1 .7500E-01 .7500E-01 .1000E+00
AG1 9AH1 9                    3 .5000E-01 .1000E+00 .1500E+00 .1000E+01
AH1 9AH110                    1 .7500E-01 .7500E-01 .2000E+00
AH1 9AI1 9                    3 .1000E+00 .1500E+00 .1500E+00 .1000E+01
AI1 9AI110                    1 .7500E-01 .7500E-01 .3000E+00
A1110A1111                    1 .7500E-01 .7500E-01 .1000E+00
A1110A2110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A2110A2111                    1 .7500E-01 .7500E-01 .1000E+00
A2110A3110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A3110A3111                    1 .7500E-01 .7500E-01 .1000E+00
A3110A4110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A4110A4111                    1 .7500E-01 .7500E-01 .1000E+00
A4110A5110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A5110A5111                    1 .7500E-01 .7500E-01 .1000E+00
A5110A6110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A6110A6111                    1 .7500E-01 .7500E-01 .1000E+00
A6110A7110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A7110A7111                    1 .7500E-01 .7500E-01 .1000E+00
A7110A8110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A8110A8111                    1 .7500E-01 .7500E-01 .1000E+00
A8110A9110                    3 .5000E-01 .5000E-01 .1500E+00 .1000E+01
A9110A9111                    1 .7500E-01 .7500E-01 .1000E+00
```

A9110AA110	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA110AA111	1	.7500E-01	.7500E-01	.1000E+00	
AA110AB110	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB110AB111	1	.7500E-01	.7500E-01	.1000E+00	
AB110AC110	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC110AC111	1	.7500E-01	.7500E-01	.1000E+00	
AC110AD110	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD110AD111	1	.7500E-01	.7500E-01	.1000E+00	
AD110AE110	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE110AE111	1	.7500E-01	.7500E-01	.5000E-01	
AE110AF110	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF110AF111	1	.7500E-01	.7500E-01	.5000E-01	
AF110AG110	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG110AG111	1	.7500E-01	.7500E-01	.1000E+00	
AG110AH110	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH110AH111	1	.7500E-01	.7500E-01	.2000E+00	
AH110AI110	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI110AI111	1	.7500E-01	.7500E-01	.3000E+00	
A1111A1112	1	.7500E-01	.7500E-01	.1000E+00	
A1111A2111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A2111A2112	1	.7500E-01	.7500E-01	.1000E+00	
A2111A3111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A3111A3112	1	.7500E-01	.7500E-01	.1000E+00	
A3111A4111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A4111A4112	1	.7500E-01	.7500E-01	.1000E+00	
A4111A5111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A5111A5112	1	.7500E-01	.7500E-01	.1000E+00	
A5111A6111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A6111A6112	1	.7500E-01	.7500E-01	.1000E+00	
A6111A7111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A7111A7112	1	.7500E-01	.7500E-01	.1000E+00	
A7111A8111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A8111A8112	1	.7500E-01	.7500E-01	.1000E+00	
A8111A9111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A9111A9112	1	.7500E-01	.7500E-01	.1000E+00	
A9111AA111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA111AA112	1	.7500E-01	.7500E-01	.1000E+00	
AA111AB111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB111AB112	1	.7500E-01	.7500E-01	.1000E+00	
AB111AC111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC111AC112	1	.7500E-01	.7500E-01	.1000E+00	
AC111AD111	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD111AD112	1	.7500E-01	.7500E-01	.1000E+00	
AD111AE111	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE111AE112	1	.7500E-01	.7500E-01	.5000E-01	
AE111AF111	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF111AF112	1	.7500E-01	.7500E-01	.5000E-01	
AF111AG111	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG111AG112	1	.7500E-01	.7500E-01	.1000E+00	
AG111AH111	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH111AH112	1	.7500E-01	.7500E-01	.2000E+00	
AH111AI111	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI111AI112	1	.7500E-01	.7500E-01	.3000E+00	
A1112A1113	1	.7500E-01	.7500E-01	.1000E+00	
A1112A2112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A2112A2113	1	.7500E-01	.7500E-01	.1000E+00	
A2112A3112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01

A3112A3113	1	.7500E-01	.7500E-01	.1000E+00	
A3112A4112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A4112A4113	1	.7500E-01	.7500E-01	.1000E+00	
A4112A5112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A5112A5113	1	.7500E-01	.7500E-01	.1000E+00	
A5112A6112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A6112A6113	1	.7500E-01	.7500E-01	.1000E+00	
A6112A7112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A7112A7113	1	.7500E-01	.7500E-01	.1000E+00	
A7112A8112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A8112A8113	1	.7500E-01	.7500E-01	.1000E+00	
A8112A9112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A9112A9113	1	.7500E-01	.7500E-01	.1000E+00	
A9112AA112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA112AA113	1	.7500E-01	.7500E-01	.1000E+00	
AA112AB112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB112AB113	1	.7500E-01	.7500E-01	.1000E+00	
AB112AC112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC112AC113	1	.7500E-01	.7500E-01	.1000E+00	
AC112AD112	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD112AD113	1	.7500E-01	.7500E-01	.1000E+00	
AD112AE112	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE112AE113	1	.7500E-01	.7500E-01	.5000E-01	
AE112AF112	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF112AF113	1	.7500E-01	.7500E-01	.5000E-01	
AF112AG112	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG112AG113	1	.7500E-01	.7500E-01	.1000E+00	
AG112AH112	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH112AH113	1	.7500E-01	.7500E-01	.2000E+00	
AH112AI112	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI112AI113	1	.7500E-01	.7500E-01	.3000E+00	
A1113A1114	1	.7500E-01	.7500E-01	.1000E+00	
A1113A2113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A2113A2114	1	.7500E-01	.7500E-01	.1000E+00	
A2113A3113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A3113A3114	1	.7500E-01	.7500E-01	.1000E+00	
A3113A4113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A4113A4114	1	.7500E-01	.7500E-01	.1000E+00	
A4113A5113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A5113A5114	1	.7500E-01	.7500E-01	.1000E+00	
A5113A6113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A6113A6114	1	.7500E-01	.7500E-01	.1000E+00	
A6113A7113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A7113A7114	1	.7500E-01	.7500E-01	.1000E+00	
A7113A8113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A8113A8114	1	.7500E-01	.7500E-01	.1000E+00	
A8113A9113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A9113A9114	1	.7500E-01	.7500E-01	.1000E+00	
A9113AA113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA113AA114	1	.7500E-01	.7500E-01	.1000E+00	
AA113AB113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB113AB114	1	.7500E-01	.7500E-01	.1000E+00	
AB113AC113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC113AC114	1	.7500E-01	.7500E-01	.1000E+00	
AC113AD113	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD113AD114	1	.7500E-01	.7500E-01	.1000E+00	
AD113AE113	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01

AE113AE114	1	.7500E-01	.7500E-01	.5000E-01	
AE113AF113	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF113AF114	1	.7500E-01	.7500E-01	.5000E-01	
AF113AG113	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG113AG114	1	.7500E-01	.7500E-01	.1000E+00	
AG113AH113	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH113AH114	1	.7500E-01	.7500E-01	.2000E+00	
AH113AI113	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI113AI114	1	.7500E-01	.7500E-01	.3000E+00	
A1114A1115	1	.7500E-01	.7500E-01	.1000E+00	
A1114A2114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A2114A2115	1	.7500E-01	.7500E-01	.1000E+00	
A2114A3114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A3114A3115	1	.7500E-01	.7500E-01	.1000E+00	
A3114A4114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A4114A4115	1	.7500E-01	.7500E-01	.1000E+00	
A4114A5114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A5114A5115	1	.7500E-01	.7500E-01	.1000E+00	
A5114A6114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A6114A6115	1	.7500E-01	.7500E-01	.1000E+00	
A6114A7114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A7114A7115	1	.7500E-01	.7500E-01	.1000E+00	
A7114A8114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A8114A8115	1	.7500E-01	.7500E-01	.1000E+00	
A8114A9114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A9114A9115	1	.7500E-01	.7500E-01	.1000E+00	
A9114AA114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA114AA115	1	.7500E-01	.7500E-01	.1000E+00	
AA114AB114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB114AB115	1	.7500E-01	.7500E-01	.1000E+00	
AB114AC114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC114AC115	1	.7500E-01	.7500E-01	.1000E+00	
AC114AD114	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD114AD115	1	.7500E-01	.7500E-01	.1000E+00	
AD114AE114	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE114AE115	1	.7500E-01	.7500E-01	.5000E-01	
AE114AF114	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF114AF115	1	.7500E-01	.7500E-01	.5000E-01	
AF114AG114	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG114AG115	1	.7500E-01	.7500E-01	.1000E+00	
AG114AH114	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH114AH115	1	.7500E-01	.7500E-01	.2000E+00	
AH114AI114	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI114AI115	1	.7500E-01	.7500E-01	.3000E+00	
A1115A1116	1	.7500E-01	.7750E-01	.1000E+00	
A1115A2115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A2115A2116	1	.7500E-01	.7750E-01	.1000E+00	
A2115A3115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A3115A3116	1	.7500E-01	.7750E-01	.1000E+00	
A3115A4115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A4115A4116	1	.7500E-01	.7750E-01	.1000E+00	
A4115A5115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A5115A5116	1	.7500E-01	.7750E-01	.1000E+00	
A5115A6115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A6115A6116	1	.7500E-01	.7750E-01	.1000E+00	
A6115A7115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A7115A7116	1	.7500E-01	.7750E-01	.1000E+00	

A7115A8115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A8115A8116	1	.7500E-01	.7750E-01	.1000E+00	
A8115A9115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
A9115A9116	1	.7500E-01	.7750E-01	.1000E+00	
A9115AA115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AA115AA116	1	.7500E-01	.7750E-01	.1000E+00	
AA115AB115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AB115AB116	1	.7500E-01	.7750E-01	.1000E+00	
AB115AC115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AC115AC116	1	.7500E-01	.7750E-01	.1000E+00	
AC115AD115	3	.5000E-01	.5000E-01	.1500E+00	.1000E+01
AD115AD116	1	.7500E-01	.7750E-01	.1000E+00	
AD115AE115	3	.5000E-01	.2500E-01	.1500E+00	.1000E+01
AE115AE116	1	.7500E-01	.7750E-01	.5000E-01	
AE115AF115	3	.2500E-01	.2500E-01	.1500E+00	.1000E+01
AF115AF116	1	.7500E-01	.7750E-01	.5000E-01	
AF115AG115	3	.2500E-01	.5000E-01	.1500E+00	.1000E+01
AG115AG116	1	.7500E-01	.7750E-01	.1000E+00	
AG115AH115	3	.5000E-01	.1000E+00	.1500E+00	.1000E+01
AH115AH116	1	.7500E-01	.7750E-01	.2000E+00	
AH115AI115	3	.1000E+00	.1500E+00	.1500E+00	.1000E+01
AI115AI116	1	.7500E-01	.7750E-01	.3000E+00	
A1116A1117	1	.7750E-01	.9000E-01	.1000E+00	
A1116A2116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A2116A2117	1	.7750E-01	.9000E-01	.1000E+00	
A2116A3116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A3116A3117	1	.7750E-01	.9000E-01	.1000E+00	
A3116A4116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A4116A4117	1	.7750E-01	.9000E-01	.1000E+00	
A4116A5116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A5116A5117	1	.7750E-01	.9000E-01	.1000E+00	
A5116A6116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A6116A6117	1	.7750E-01	.9000E-01	.1000E+00	
A6116A7116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A7116A7117	1	.7750E-01	.9000E-01	.1000E+00	
A7116A8116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A8116A8117	1	.7750E-01	.9000E-01	.1000E+00	
A8116A9116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
A9116A9117	1	.7750E-01	.9000E-01	.1000E+00	
A9116AA116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
AA116AA117	1	.7750E-01	.9000E-01	.1000E+00	
AA116AB116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
AB116AB117	1	.7750E-01	.9000E-01	.1000E+00	
AB116AC116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
AC116AC117	1	.7750E-01	.9000E-01	.1000E+00	
AC116AD116	3	.5000E-01	.5000E-01	.1550E+00	.1000E+01
AD116AD117	1	.7750E-01	.9000E-01	.1000E+00	
AD116AE116	3	.5000E-01	.2500E-01	.1550E+00	.1000E+01
AE116AE117	1	.7750E-01	.9000E-01	.5000E-01	
AE116AF116	3	.2500E-01	.2500E-01	.1550E+00	.1000E+01
AF116AF117	1	.7750E-01	.9000E-01	.5000E-01	
AF116AG116	3	.2500E-01	.5000E-01	.1550E+00	.1000E+01
AG116AG117	1	.7750E-01	.9000E-01	.1000E+00	
AG116AH116	3	.5000E-01	.1000E+00	.1550E+00	.1000E+01
AH116AH117	1	.7750E-01	.9000E-01	.2000E+00	
AH116AI116	3	.1000E+00	.1500E+00	.1550E+00	.1000E+01
AI116AI117	1	.7750E-01	.9000E-01	.3000E+00	

A1117A1118	1	.9000E-01	.1000E+00	.1000E+00	
A1117A2117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A2117A2118	1	.9000E-01	.1000E+00	.1000E+00	
A2117A3117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A3117A3118	1	.9000E-01	.1000E+00	.1000E+00	
A3117A4117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A4117A4118	1	.9000E-01	.1000E+00	.1000E+00	
A4117A5117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A5117A5118	1	.9000E-01	.1000E+00	.1000E+00	
A5117A6117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A6117A6118	1	.9000E-01	.1000E+00	.1000E+00	
A6117A7117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A7117A7118	1	.9000E-01	.1000E+00	.1000E+00	
A7117A8117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A8117A8118	1	.9000E-01	.1000E+00	.1000E+00	
A8117A9117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
A9117A9118	1	.9000E-01	.1000E+00	.1000E+00	
A9117AA117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
AA117AA118	1	.9000E-01	.1000E+00	.1000E+00	
AA117AB117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
AB117AB118	1	.9000E-01	.1000E+00	.1000E+00	
AB117AC117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
AC117AC118	1	.9000E-01	.1000E+00	.1000E+00	
AC117AD117	3	.5000E-01	.5000E-01	.1800E+00	.1000E+01
AD117AD118	1	.9000E-01	.1000E+00	.1000E+00	
AD117AE117	3	.5000E-01	.2500E-01	.1800E+00	.1000E+01
AE117AE118	1	.9000E-01	.1000E+00	.5000E-01	
AE117AF117	3	.2500E-01	.2500E-01	.1800E+00	.1000E+01
AF117AF118	1	.9000E-01	.1000E+00	.5000E-01	
AF117AG117	3	.2500E-01	.5000E-01	.1800E+00	.1000E+01
AG117AG118	1	.9000E-01	.1000E+00	.1000E+00	
AG117AH117	3	.5000E-01	.1000E+00	.1800E+00	.1000E+01
AH117AH118	1	.9000E-01	.1000E+00	.2000E+00	
AH117AI117	3	.1000E+00	.1500E+00	.1800E+00	.1000E+01
AI117AI118	1	.9000E-01	.1000E+00	.3000E+00	
A1118A1119	1	.1000E+00	.1000E+00	.1000E+00	
A1118A2118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A2118A2119	1	.1000E+00	.1000E+00	.1000E+00	
A2118A3118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A3118A3119	1	.1000E+00	.1000E+00	.1000E+00	
A3118A4118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A4118A4119	1	.1000E+00	.1000E+00	.1000E+00	
A4118A5118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A5118A5119	1	.1000E+00	.1000E+00	.1000E+00	
A5118A6118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A6118A6119	1	.1000E+00	.1000E+00	.1000E+00	
A6118A7118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A7118A7119	1	.1000E+00	.1000E+00	.1000E+00	
A7118A8118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A8118A8119	1	.1000E+00	.1000E+00	.1000E+00	
A8118A9118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A9118A9119	1	.1000E+00	.1000E+00	.1000E+00	
A9118AA118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AA118AA119	1	.1000E+00	.1000E+00	.1000E+00	
AA118AB118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AB118AB119	1	.1000E+00	.1000E+00	.1000E+00	
AB118AC118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01

AC118AC119	1	.1000E+00	.1000E+00	.1000E+00	
AC118AD118	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AD118AD119	1	.1000E+00	.1000E+00	.1000E+00	
AD118AE118	3	.5000E-01	.2500E-01	.2000E+00	.1000E+01
AE118AE119	1	.1000E+00	.1000E+00	.5000E-01	
AE118AF118	3	.2500E-01	.2500E-01	.2000E+00	.1000E+01
AF118AF119	1	.1000E+00	.1000E+00	.5000E-01	
AF118AG118	3	.2500E-01	.5000E-01	.2000E+00	.1000E+01
AG118AG119	1	.1000E+00	.1000E+00	.1000E+00	
AG118AH118	3	.5000E-01	.1000E+00	.2000E+00	.1000E+01
AH118AH119	1	.1000E+00	.1000E+00	.2000E+00	
AH118AI118	3	.1000E+00	.1500E+00	.2000E+00	.1000E+01
AI118AI119	1	.1000E+00	.1000E+00	.3000E+00	
A1119A1120	1	.1000E+00	.1000E+00	.1000E+00	
A1119A2119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A2119A2120	1	.1000E+00	.1000E+00	.1000E+00	
A2119A3119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A3119A3120	1	.1000E+00	.1000E+00	.1000E+00	
A3119A4119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A4119A4120	1	.1000E+00	.1000E+00	.1000E+00	
A4119A5119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A5119A5120	1	.1000E+00	.1000E+00	.1000E+00	
A5119A6119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A6119A6120	1	.1000E+00	.1000E+00	.1000E+00	
A6119A7119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A7119A7120	1	.1000E+00	.1000E+00	.1000E+00	
A7119A8119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A8119A8120	1	.1000E+00	.1000E+00	.1000E+00	
A8119A9119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A9119A9120	1	.1000E+00	.1000E+00	.1000E+00	
A9119AA119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AA119AA120	1	.1000E+00	.1000E+00	.1000E+00	
AA119AB119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AB119AB120	1	.1000E+00	.1000E+00	.1000E+00	
AB119AC119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AC119AC120	1	.1000E+00	.1000E+00	.1000E+00	
AC119AD119	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
AD119AD120	1	.1000E+00	.1000E+00	.1000E+00	
AD119AE119	3	.5000E-01	.2500E-01	.2000E+00	.1000E+01
AE119AE120	1	.1000E+00	.1000E+00	.5000E-01	
AE119AF119	3	.2500E-01	.2500E-01	.2000E+00	.1000E+01
AF119AF120	1	.1000E+00	.1000E+00	.5000E-01	
AF119AG119	3	.2500E-01	.5000E-01	.2000E+00	.1000E+01
AG119AG120	1	.1000E+00	.1000E+00	.1000E+00	
AG119AH119	3	.5000E-01	.1000E+00	.2000E+00	.1000E+01
AH119AH120	1	.1000E+00	.1000E+00	.2000E+00	
AH119AI119	3	.1000E+00	.1500E+00	.2000E+00	.1000E+01
AI119AI120	1	.1000E+00	.1000E+00	.3000E+00	
A1120A1121	1	.1000E+00	.1000E-09	.1000E+00	
A1120A2120	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A2120A2121	1	.1000E+00	.1000E-09	.1000E+00	
A2120A3120	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A3120A3121	1	.1000E+00	.1000E-09	.1000E+00	
A3120A4120	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A4120A4121	1	.1000E+00	.1000E-09	.1000E+00	
A4120A5120	3	.5000E-01	.5000E-01	.2000E+00	.1000E+01
A5120A5121	1	.1000E+00	.1000E-09	.1000E+00	

```
A5120A6120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
A6120A6121                    1 .1000E+00 .1000E-09 .1000E+00
A6120A7120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
A7120A7121                    1 .1000E+00 .1000E-09 .1000E+00
A7120A8120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
A8120A8121                    1 .1000E+00 .1000E-09 .1000E+00
A8120A9120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
A9120A9121                    1 .1000E+00 .1000E-09 .1000E+00
A9120AA120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
AA120AA121                    1 .1000E+00 .1000E-09 .1000E+00
AA120AB120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
AB120AB121                    1 .1000E+00 .1000E-09 .1000E+00
AB120AC120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
AC120AC121                    1 .1000E+00 .1000E-09 .1000E+00
AC120AD120                    3 .5000E-01 .5000E-01 .2000E+00 .1000E+01
AD120AD121                    1 .1000E+00 .1000E-09 .1000E+00
AD120AE120                    3 .5000E-01 .2500E-01 .2000E+00 .1000E+01
AE120AE121                    1 .1000E+00 .1000E-09 .5000E-01
AE120AF120                    3 .2500E-01 .2500E-01 .2000E+00 .1000E+01
AF120AF121                    1 .1000E+00 .1000E-09 .5000E-01
AF120AG120                    3 .2500E-01 .5000E-01 .2000E+00 .1000E+01
AG120AG121                    1 .1000E+00 .1000E-09 .1000E+00
AG120AH120                    3 .5000E-01 .1000E+00 .2000E+00 .1000E+01
AH120AH121                    1 .1000E+00 .1000E-09 .2000E+00
AH120AI120                    3 .1000E+00 .1500E+00 .2000E+00 .1000E+01
AI120AI121                    1 .1000E+00 .1000E-09 .3000E+00
A1121A2121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A2121A3121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A3121A4121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A4121A5121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A5121A6121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A6121A7121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A7121A8121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A8121A9121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
A9121AA121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
AA121AB121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
AB121AC121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
AC121AD121                    3 .5000E-01 .5000E-01 .1000E-03 .1000E+01
AD121AE121                    3 .5000E-01 .2500E-01 .1000E-03 .1000E+01
AE121AF121                    3 .2500E-01 .2500E-01 .1000E-03 .1000E+01
AF121AG121                    3 .2500E-01 .5000E-01 .1000E-03 .1000E+01
AG121AH121                    3 .5000E-01 .1000E+00 .1000E-03 .1000E+01
AH121AI121                    3 .1000E+00 .1500E+00 .1000E-03 .1000E+01

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A11 1INF 1    0    0    0    0     WATE 4.72006E-3   83996.3
A11 2INF 2    0    0    0    0     WATE  6.1566E-3   83996.3
A11 3INF 3    0    0    0    0     WATE  6.1566E-3   83996.3
A11 4INF 4    0    0    0    0     WATE 3.48874E-3   83996.3

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A11 1   19    1
            101330.          0.97122958                 20.
A1121    0    0
            101330.                20.                   1.
A21 1   19    1
            101330.          0.96398330                 20.
```

```
A2121     0    0
             101330.                20.                 1.
A31 1    19    1
             101330.          0.95411992               20.
A3121     0    0
             101330.                20.                 1.
A41 1    19    1
             101330.          0.94038369               20.
A4121     0    0
             101330.                20.                 1.
A51 1    19    1
             101330.          0.92076694               20.
A5121     0    0
             101330.                20.                 1.
A61 1    19    1
             101330.          0.89199109               20.
A6121     0    0
             101330.                20.                 1.
A71 1    19    1
             101330.          0.84864353               20.
A7121     0    0
             101330.                20.                 1.
A81 1    19    1
             101330.          0.78193262               20.
A8121     0    0
             101330.                20.                 1.
A91 1    19    1
             101330.          0.67879333               20.
A9121     0    0
             101330.                20.                 1.
AA1 1    19    1
             101330.          0.52525740               20.
AA121     0    0
             101330.                20.                 1.
AB1 1    19    1
             101330.          0.32450116               20.
AB121     0    0
             101330.                20.                 1.
AC1 1    19    1
             101330.          0.12909198               20.
AC121     0    0
             101330.                20.                 1.
AD1 1    19    1
             101330.          0.01947154               20.
AD121     0    0
             101330.                20.                 1.
AE1 1    19    1
             101330.        3.562964E-4                20.
AE121     0    0
             101330.                20.                 1.
AF1 1    20    1
            101574.76               20.                00.
AG1 1    20    1
            102309.03               20.                00.
AH1 1    20    1
            103777.59               20.                00.
AI1 1    20    1
```

```
          106225.19                 20.                 00.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
MESHM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
XYZ  ----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
       0.0
NX      21
     0.115      0.15     0.155      0.09      0.08      0.14      0.15      0.15
      0.15      0.15      0.15      0.15      0.15      0.15      0.15      0.16
      0.18      0.20      0.20      0.20     1.E-4
NZ      21
      0.10      0.10      0.10      0.10      0.10      0.10      0.10      0.10
      0.10      0.10      0.10      0.10      0.10      0.05      0.05      0.10
      0.20      0.30

ENDFI----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*val2a* ... Validation Problem No.2.
START     2-d convection cell in r-z; Reda (1984)
START     7-10-92: George's latest data file
START              grid generation using MESHMAKER from TOUGH2
START              flow channeling accounted for
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
SOIL1    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
SOIL2    0    2500.0      0.34 1159.E-12 1159.E-12 1159.E-12      0.87      740.
SOIL3    0    2500.0      0.34 1037.E-12 1037.E-12 1037.E-12      0.87      740.
SOIL4    0    2500.0      0.34  915.E-12  915.E-12  915.E-12      0.87      740.
SOIL5    0    2500.0      0.34  793.E-12  793.E-12  793.E-12      0.87      740.
SOIL6    0    2500.0      0.34  671.E-12  671.E-12  671.E-12      0.87      740.
BOUND    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87     1.E04
TCOND    0    2500.0     1.e-5  000.E-12  000.E-12  000.E-12      0.87     1.E54
HEATR    1    7400.0     1.e-5       0.0       0.0       0.0      50.2    569.40
     1.e-5

START
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 1 900     9001000000 0000 0 41          2.13E-5      1.80
        0.      1.e5       -1.      1.e4A1  2         -9.807        4.        1.
        .1        .9        9.
     1.E-5        1.       0.1        1.        1.     1.E-8
                 2.e5                21.5                  0.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
   14   14
      100.      200.      300.      550.      800.     1100.     2000.     2500.
     3000.     3500.     4000.     5000.      1.e4      1.e5
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1             0.        0.       0.1       0.1
    1             0.        0.       0.1
GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A9  1HEA 1    0    0    0    1     HEAT  5.8331680
AA  1HEA 2    0    0    0    1     HEAT  5.8331680
AB  1HEA 3    0    0    0    1     HEAT  5.8331680
AC  1HEA 4    0    0    0    1     HEAT  5.8331680
AD  1HEA 5    0    0    0    1     HEAT  5.8331680
AE  1HEA 6    0    0    0    1     HEAT  5.8331680
AF  1HEA 7    0    0    0    1     HEAT  5.8331680
AG  1HEA 8    0    0    0    1     HEAT  5.8331680
AH  1HEA 9    0    0    0    1     HEAT  5.8331680
AI  1HEA10    0    0    0    1     HEAT  5.8331680
AJ  1HEA11    0    0    0    1     HEAT  5.8331680
AK  1HEA12    0    0    0    1     HEAT  5.8331680

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8

ELEME ---     16   11    1    5   0.00000     0.219
A9  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4087E+00
AA  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4297E+00
AB  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4506E+00
AC  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4716E+00
AD  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4926E+00
AE  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5135E+00
AF  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5345E+00
AG  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5554E+00
AH  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5764E+00
```

AI	1	HEATR0.5943E-050.0000E+00	0.4750E-02	-.5974E+00
AJ	1	HEATR0.5943E-050.0000E+00	0.4750E-02	-.6183E+00
AK	1	HEATR0.5943E-050.0000E+00	0.4750E-02	-.6393E+00
A1	2	SOIL20.2944E-050.4013E-04	0.9825E-02	-.3668E-01
A2	2	SOIL20.2944E-050.0000E+00	0.9825E-02	-.1100E+00
A3	2	SOIL20.2944E-050.0000E+00	0.9825E-02	-.1834E+00
A4	2	SOIL20.2944E-050.0000E+00	0.9825E-02	-.2568E+00
A5	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.3144E+00
A6	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.3458E+00
A7	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.3668E+00
A8	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.3878E+00
A9	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4087E+00
AA	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4297E+00
AB	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4506E+00
AC	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4716E+00
AD	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4926E+00
AE	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5135E+00
AF	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5345E+00
AG	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5554E+00
AH	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5764E+00
AI	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5974E+00
AJ	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6183E+00
AK	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6393E+00
AL	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6602E+00
AM	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6812E+00
AN	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.7022E+00
AO	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.7336E+00
AP	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.7755E+00
AQ	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.8174E+00
AR	2	BOUND0.4013E+490.4013E-04	0.9825E-02	-.8384E+00
A1	3	SOIL30.3138E-050.4278E-04	0.1047E-01	-.3668E-01
A2	3	SOIL30.3138E-050.0000E+00	0.1047E-01	-.1100E+00
A3	3	SOIL30.3138E-050.0000E+00	0.1047E-01	-.1834E+00
A4	3	SOIL30.3138E-050.0000E+00	0.1047E-01	-.2568E+00
A5	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.3144E+00
A6	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.3458E+00
A7	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.3668E+00
A8	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.3878E+00
A9	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4087E+00
AA	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4297E+00
AB	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4506E+00
AC	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4716E+00
AD	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4926E+00
AE	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5135E+00
AF	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5345E+00
AG	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5554E+00
AH	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5764E+00
AI	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5974E+00
AJ	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6183E+00
AK	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6393E+00
AL	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6602E+00
AM	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6812E+00
AN	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.7022E+00
AO	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.7336E+00
AP	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.7755E+00
AQ	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.8174E+00
AR	3	BOUND0.4278E+490.4278E-04	0.1047E-01	-.8384E+00

A1	4	SOIL40.3333E-050.4544E-04	0.1112E-01	-.3668E-01
A2	4	SOIL40.3333E-050.0000E+00	0.1112E-01	-.1100E+00
A3	4	SOIL40.3333E-050.0000E+00	0.1112E-01	-.1834E+00
A4	4	SOIL40.3333E-050.0000E+00	0.1112E-01	-.2568E+00
A5	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.3144E+00
A6	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.3458E+00
A7	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.3668E+00
A8	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.3878E+00
A9	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4087E+00
AA	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4297E+00
AB	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4506E+00
AC	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4716E+00
AD	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4926E+00
AE	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5135E+00
AF	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5345E+00
AG	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5554E+00
AH	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5764E+00
AI	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5974E+00
AJ	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6183E+00
AK	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6393E+00
AL	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6602E+00
AM	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6812E+00
AN	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.7022E+00
AO	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.7336E+00
AP	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.7755E+00
AQ	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.8174E+00
AR	4	BOUND0.4544E+490.4544E-04	0.1112E-01	-.8384E+00
A1	5	SOIL50.3528E-050.4809E-04	0.1177E-01	-.3668E-01
A2	5	SOIL50.3528E-050.0000E+00	0.1177E-01	-.1100E+00
A3	5	SOIL50.3528E-050.0000E+00	0.1177E-01	-.1834E+00
A4	5	SOIL50.3528E-050.0000E+00	0.1177E-01	-.2568E+00
A5	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.3144E+00
A6	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.3458E+00
A7	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.3668E+00
A8	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.3878E+00
A9	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4087E+00
AA	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4297E+00
AB	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4506E+00
AC	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4716E+00
AD	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4926E+00
AE	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5135E+00
AF	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5345E+00
AG	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5554E+00
AH	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5764E+00
AI	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5974E+00
AJ	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6183E+00
AK	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6393E+00
AL	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6602E+00
AM	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6812E+00
AN	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.7022E+00
AO	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.7336E+00
AP	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.7755E+00
AQ	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.8174E+00
AR	5	BOUND0.4809E+490.4809E-04	0.1177E-01	-.8384E+00
A1	6	SOIL60.3723E-050.5074E-04	0.1242E-01	-.3668E-01
A2	6	SOIL60.3723E-050.0000E+00	0.1242E-01	-.1100E+00
A3	6	SOIL60.3723E-050.0000E+00	0.1242E-01	-.1834E+00

A4	6	SOIL60.3723E-050.0000E+00	0.1242E-01	-.2568E+00
A5	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.3144E+00
A6	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.3458E+00
A7	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.3668E+00
A8	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.3878E+00
A9	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4087E+00
AA	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4297E+00
AB	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4506E+00
AC	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4716E+00
AD	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4926E+00
AE	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5135E+00
AF	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5345E+00
AG	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5554E+00
AH	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5764E+00
AI	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5974E+00
AJ	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6183E+00
AK	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6393E+00
AL	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6602E+00
AM	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6812E+00
AN	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.7022E+00
AO	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.7336E+00
AP	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.7755E+00
AQ	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.8174E+00
AR	6	BOUND0.5074E+490.5074E-04	0.1242E-01	-.8384E+00
A1	7	10.1439E-040.1962E-03	0.1387E-01	-.3668E-01
A2	7	10.1439E-040.0000E+00	0.1387E-01	-.1100E+00
A3	7	10.1439E-040.0000E+00	0.1387E-01	-.1834E+00
A4	7	10.1439E-040.0000E+00	0.1387E-01	-.2568E+00
A5	7	10.8223E-050.0000E+00	0.1387E-01	-.3144E+00
A6	7	10.4111E-050.0000E+00	0.1387E-01	-.3458E+00
A7	7	10.4111E-050.0000E+00	0.1387E-01	-.3668E+00
A8	7	10.4111E-050.0000E+00	0.1387E-01	-.3878E+00
A9	7	10.4111E-050.0000E+00	0.1387E-01	-.4087E+00
AA	7	10.4111E-050.0000E+00	0.1387E-01	-.4297E+00
AB	7	10.4111E-050.0000E+00	0.1387E-01	-.4506E+00
AC	7	10.4111E-050.0000E+00	0.1387E-01	-.4716E+00
AD	7	10.4111E-050.0000E+00	0.1387E-01	-.4926E+00
AE	7	10.4111E-050.0000E+00	0.1387E-01	-.5135E+00
AF	7	10.4111E-050.0000E+00	0.1387E-01	-.5345E+00
AG	7	10.4111E-050.0000E+00	0.1387E-01	-.5554E+00
AH	7	10.4111E-050.0000E+00	0.1387E-01	-.5764E+00
AI	7	10.4111E-050.0000E+00	0.1387E-01	-.5974E+00
AJ	7	10.4111E-050.0000E+00	0.1387E-01	-.6183E+00
AK	7	10.4111E-050.0000E+00	0.1387E-01	-.6393E+00
AL	7	10.4111E-050.0000E+00	0.1387E-01	-.6602E+00
AM	7	10.4111E-050.0000E+00	0.1387E-01	-.6812E+00
AN	7	10.4111E-050.0000E+00	0.1387E-01	-.7022E+00
AO	7	10.8223E-050.0000E+00	0.1387E-01	-.7336E+00
AP	7	10.8223E-050.0000E+00	0.1387E-01	-.7755E+00
AQ	7	10.8223E-050.0000E+00	0.1387E-01	-.8174E+00
AR	7	BOUND0.1962E+480.1962E-03	0.1387E-01	-.8384E+00
A1	8	10.4033E-040.5498E-03	0.1750E-01	-.3668E-01
A2	8	10.4033E-040.0000E+00	0.1750E-01	-.1100E+00
A3	8	10.4033E-040.0000E+00	0.1750E-01	-.1834E+00
A4	8	10.4033E-040.0000E+00	0.1750E-01	-.2568E+00
A5	8	10.2305E-040.0000E+00	0.1750E-01	-.3144E+00
A6	8	10.1152E-040.0000E+00	0.1750E-01	-.3458E+00

A7	8	10.1152E-040.0000E+00	0.1750E-01	-.3668E+00
A8	8	10.1152E-040.0000E+00	0.1750E-01	-.3878E+00
A9	8	10.1152E-040.0000E+00	0.1750E-01	-.4087E+00
AA	8	10.1152E-040.0000E+00	0.1750E-01	-.4297E+00
AB	8	10.1152E-040.0000E+00	0.1750E-01	-.4506E+00
AC	8	10.1152E-040.0000E+00	0.1750E-01	-.4716E+00
AD	8	10.1152E-040.0000E+00	0.1750E-01	-.4926E+00
AE	8	10.1152E-040.0000E+00	0.1750E-01	-.5135E+00
AF	8	10.1152E-040.0000E+00	0.1750E-01	-.5345E+00
AG	8	10.1152E-040.0000E+00	0.1750E-01	-.5554E+00
AH	8	10.1152E-040.0000E+00	0.1750E-01	-.5764E+00
AI	8	10.1152E-040.0000E+00	0.1750E-01	-.5974E+00
AJ	8	10.1152E-040.0000E+00	0.1750E-01	-.6183E+00
AK	8	10.1152E-040.0000E+00	0.1750E-01	-.6393E+00
AL	8	10.1152E-040.0000E+00	0.1750E-01	-.6602E+00
AM	8	10.1152E-040.0000E+00	0.1750E-01	-.6812E+00
AN	8	10.1152E-040.0000E+00	0.1750E-01	-.7022E+00
AO	8	10.2305E-040.0000E+00	0.1750E-01	-.7336E+00
AP	8	10.2305E-040.0000E+00	0.1750E-01	-.7755E+00
AQ	8	10.2305E-040.0000E+00	0.1750E-01	-.8174E+00
AR	8	BOUND0.5498E+480.5498E-03	0.1750E-01	-.8384E+00
A1	9	10.1152E-030.1571E-02	0.2500E-01	-.3668E-01
A2	9	10.1152E-030.0000E+00	0.2500E-01	-.1100E+00
A3	9	10.1152E-030.0000E+00	0.2500E-01	-.1834E+00
A4	9	10.1152E-030.0000E+00	0.2500E-01	-.2568E+00
A5	9	10.6585E-040.0000E+00	0.2500E-01	-.3144E+00
A6	9	10.3292E-040.0000E+00	0.2500E-01	-.3458E+00
A7	9	10.3292E-040.0000E+00	0.2500E-01	-.3668E+00
A8	9	10.3292E-040.0000E+00	0.2500E-01	-.3878E+00
A9	9	10.3292E-040.0000E+00	0.2500E-01	-.4087E+00
AA	9	10.3292E-040.0000E+00	0.2500E-01	-.4297E+00
AB	9	10.3292E-040.0000E+00	0.2500E-01	-.4506E+00
AC	9	10.3292E-040.0000E+00	0.2500E-01	-.4716E+00
AD	9	10.3292E-040.0000E+00	0.2500E-01	-.4926E+00
AE	9	10.3292E-040.0000E+00	0.2500E-01	-.5135E+00
AF	9	10.3292E-040.0000E+00	0.2500E-01	-.5345E+00
AG	9	10.3292E-040.0000E+00	0.2500E-01	-.5554E+00
AH	9	10.3292E-040.0000E+00	0.2500E-01	-.5764E+00
AI	9	10.3292E-040.0000E+00	0.2500E-01	-.5974E+00
AJ	9	10.3292E-040.0000E+00	0.2500E-01	-.6183E+00
AK	9	10.3292E-040.0000E+00	0.2500E-01	-.6393E+00
AL	9	10.3292E-040.0000E+00	0.2500E-01	-.6602E+00
AM	9	10.3292E-040.0000E+00	0.2500E-01	-.6812E+00
AN	9	10.3292E-040.0000E+00	0.2500E-01	-.7022E+00
AO	9	10.6585E-040.0000E+00	0.2500E-01	-.7336E+00
AP	9	10.6585E-040.0000E+00	0.2500E-01	-.7755E+00
AQ	9	10.6585E-040.0000E+00	0.2500E-01	-.8174E+00
AR	9	BOUND0.1571E+470.1571E-02	0.2500E-01	-.8384E+00
A1	10	10.3687E-030.5027E-02	0.4000E-01	-.3668E-01
A2	10	10.3687E-030.0000E+00	0.4000E-01	-.1100E+00
A3	10	10.3687E-030.0000E+00	0.4000E-01	-.1834E+00
A4	10	10.3687E-030.0000E+00	0.4000E-01	-.2568E+00
A5	10	10.2107E-030.0000E+00	0.4000E-01	-.3144E+00
A6	10	10.1054E-030.0000E+00	0.4000E-01	-.3458E+00
A7	10	10.1054E-030.0000E+00	0.4000E-01	-.3668E+00
A8	10	10.1054E-030.0000E+00	0.4000E-01	-.3878E+00
A9	10	10.1054E-030.0000E+00	0.4000E-01	-.4087E+00

AA 10	10.1054E-030.0000E+00	0.4000E-01	-.4297E+00
AB 10	10.1054E-030.0000E+00	0.4000E-01	-.4506E+00
AC 10	10.1054E-030.0000E+00	0.4000E-01	-.4716E+00
AD 10	10.1054E-030.0000E+00	0.4000E-01	-.4926E+00
AE 10	10.1054E-030.0000E+00	0.4000E-01	-.5135E+00
AF 10	10.1054E-030.0000E+00	0.4000E-01	-.5345E+00
AG 10	10.1054E-030.0000E+00	0.4000E-01	-.5554E+00
AH 10	10.1054E-030.0000E+00	0.4000E-01	-.5764E+00
AI 10	10.1054E-030.0000E+00	0.4000E-01	-.5974E+00
AJ 10	10.1054E-030.0000E+00	0.4000E-01	-.6183E+00
AK 10	10.1054E-030.0000E+00	0.4000E-01	-.6393E+00
AL 10	10.1054E-030.0000E+00	0.4000E-01	-.6602E+00
AM 10	10.1054E-030.0000E+00	0.4000E-01	-.6812E+00
AN 10	10.1054E-030.0000E+00	0.4000E-01	-.7022E+00
AO 10	10.2107E-030.0000E+00	0.4000E-01	-.7336E+00
AP 10	10.2107E-030.0000E+00	0.4000E-01	-.7755E+00
AQ 10	10.2107E-030.0000E+00	0.4000E-01	-.8174E+00
AR 10	BOUND0.5027E+470.5027E-02	0.4000E-01	-.8384E+00
A1 11	10.6726E-030.9169E-02	0.6181E-01	-.3668E-01
A2 11	10.6726E-030.0000E+00	0.6181E-01	-.1100E+00
A3 11	10.6726E-030.0000E+00	0.6181E-01	-.1834E+00
A4 11	10.6726E-030.0000E+00	0.6181E-01	-.2568E+00
A5 11	10.3844E-030.0000E+00	0.6181E-01	-.3144E+00
A6 11	10.1922E-030.0000E+00	0.6181E-01	-.3458E+00
A7 11	10.1922E-030.0000E+00	0.6181E-01	-.3668E+00
A8 11	10.1922E-030.0000E+00	0.6181E-01	-.3878E+00
A9 11	10.1922E-030.0000E+00	0.6181E-01	-.4087E+00
AA 11	10.1922E-030.0000E+00	0.6181E-01	-.4297E+00
AB 11	10.1922E-030.0000E+00	0.6181E-01	-.4506E+00
AC 11	10.1922E-030.0000E+00	0.6181E-01	-.4716E+00
AD 11	10.1922E-030.0000E+00	0.6181E-01	-.4926E+00
AE 11	10.1922E-030.0000E+00	0.6181E-01	-.5135E+00
AF 11	10.1922E-030.0000E+00	0.6181E-01	-.5345E+00
AG 11	10.1922E-030.0000E+00	0.6181E-01	-.5554E+00
AH 11	10.1922E-030.0000E+00	0.6181E-01	-.5764E+00
AI 11	10.1922E-030.0000E+00	0.6181E-01	-.5974E+00
AJ 11	10.1922E-030.0000E+00	0.6181E-01	-.6183E+00
AK 11	10.1922E-030.0000E+00	0.6181E-01	-.6393E+00
AL 11	10.1922E-030.0000E+00	0.6181E-01	-.6602E+00
AM 11	10.1922E-030.0000E+00	0.6181E-01	-.6812E+00
AN 11	10.1922E-030.0000E+00	0.6181E-01	-.7022E+00
AO 11	10.3844E-030.0000E+00	0.6181E-01	-.7336E+00
AP 11	10.3844E-030.0000E+00	0.6181E-01	-.7755E+00
AQ 11	10.3844E-030.0000E+00	0.6181E-01	-.8174E+00
AR 11	BOUND0.9169E+470.9169E-02	0.6181E-01	-.8384E+00
A1 12	10.1125E-020.1533E-01	0.8755E-01	-.3668E-01
A2 12	10.1125E-020.0000E+00	0.8755E-01	-.1100E+00
A3 12	10.1125E-020.0000E+00	0.8755E-01	-.1834E+00
A4 12	10.1125E-020.0000E+00	0.8755E-01	-.2568E+00
A5 12	10.6428E-030.0000E+00	0.8755E-01	-.3144E+00
A6 12	10.3214E-030.0000E+00	0.8755E-01	-.3458E+00
A7 12	10.3214E-030.0000E+00	0.8755E-01	-.3668E+00
A8 12	10.3214E-030.0000E+00	0.8755E-01	-.3878E+00
A9 12	10.3214E-030.0000E+00	0.8755E-01	-.4087E+00
AA 12	10.3214E-030.0000E+00	0.8755E-01	-.4297E+00
AB 12	10.3214E-030.0000E+00	0.8755E-01	-.4506E+00
AC 12	10.3214E-030.0000E+00	0.8755E-01	-.4716E+00

AD 12	10.3214E-030.0000E+00	0.8755E-01	-.4926E+00
AE 12	10.3214E-030.0000E+00	0.8755E-01	-.5135E+00
AF 12	10.3214E-030.0000E+00	0.8755E-01	-.5345E+00
AG 12	10.3214E-030.0000E+00	0.8755E-01	-.5554E+00
AH 12	10.3214E-030.0000E+00	0.8755E-01	-.5764E+00
AI 12	10.3214E-030.0000E+00	0.8755E-01	-.5974E+00
AJ 12	10.3214E-030.0000E+00	0.8755E-01	-.6183E+00
AK 12	10.3214E-030.0000E+00	0.8755E-01	-.6393E+00
AL 12	10.3214E-030.0000E+00	0.8755E-01	-.6602E+00
AM 12	10.3214E-030.0000E+00	0.8755E-01	-.6812E+00
AN 12	10.3214E-030.0000E+00	0.8755E-01	-.7022E+00
AO 12	10.6428E-030.0000E+00	0.8755E-01	-.7336E+00
AP 12	10.6428E-030.0000E+00	0.8755E-01	-.7755E+00
AQ 12	10.6428E-030.0000E+00	0.8755E-01	-.8174E+00
AR 12	BOUND0.1533E+460.1533E-01	0.8755E-01	-.8384E+00
A1 13	10.1789E-020.2438E-01	0.1179E+00	-.3668E-01
A2 13	10.1789E-020.0000E+00	0.1179E+00	-.1100E+00
A3 13	10.1789E-020.0000E+00	0.1179E+00	-.1834E+00
A4 13	10.1789E-020.0000E+00	0.1179E+00	-.2568E+00
A5 13	10.1022E-020.0000E+00	0.1179E+00	-.3144E+00
A6 13	10.5111E-030.0000E+00	0.1179E+00	-.3458E+00
A7 13	10.5111E-030.0000E+00	0.1179E+00	-.3668E+00
A8 13	10.5111E-030.0000E+00	0.1179E+00	-.3878E+00
A9 13	10.5111E-030.0000E+00	0.1179E+00	-.4087E+00
AA 13	10.5111E-030.0000E+00	0.1179E+00	-.4297E+00
AB 13	10.5111E-030.0000E+00	0.1179E+00	-.4506E+00
AC 13	10.5111E-030.0000E+00	0.1179E+00	-.4716E+00
AD 13	10.5111E-030.0000E+00	0.1179E+00	-.4926E+00
AE 13	10.5111E-030.0000E+00	0.1179E+00	-.5135E+00
AF 13	10.5111E-030.0000E+00	0.1179E+00	-.5345E+00
AG 13	10.5111E-030.0000E+00	0.1179E+00	-.5554E+00
AH 13	10.5111E-030.0000E+00	0.1179E+00	-.5764E+00
AI 13	10.5111E-030.0000E+00	0.1179E+00	-.5974E+00
AJ 13	10.5111E-030.0000E+00	0.1179E+00	-.6183E+00
AK 13	10.5111E-030.0000E+00	0.1179E+00	-.6393E+00
AL 13	10.5111E-030.0000E+00	0.1179E+00	-.6602E+00
AM 13	10.5111E-030.0000E+00	0.1179E+00	-.6812E+00
AN 13	10.5111E-030.0000E+00	0.1179E+00	-.7022E+00
AO 13	10.1022E-020.0000E+00	0.1179E+00	-.7336E+00
AP 13	10.1022E-020.0000E+00	0.1179E+00	-.7755E+00
AQ 13	10.1022E-020.0000E+00	0.1179E+00	-.8174E+00
AR 13	BOUND0.2438E+460.2438E-01	0.1179E+00	-.8384E+00
A1 14	10.2754E-020.3754E-01	0.1538E+00	-.3668E-01
A2 14	10.2754E-020.0000E+00	0.1538E+00	-.1100E+00
A3 14	10.2754E-020.0000E+00	0.1538E+00	-.1834E+00
A4 14	10.2754E-020.0000E+00	0.1538E+00	-.2568E+00
A5 14	10.1574E-020.0000E+00	0.1538E+00	-.3144E+00
A6 14	10.7869E-030.0000E+00	0.1538E+00	-.3458E+00
A7 14	10.7869E-030.0000E+00	0.1538E+00	-.3668E+00
A8 14	10.7869E-030.0000E+00	0.1538E+00	-.3878E+00
A9 14	10.7869E-030.0000E+00	0.1538E+00	-.4087E+00
AA 14	10.7869E-030.0000E+00	0.1538E+00	-.4297E+00
AB 14	10.7869E-030.0000E+00	0.1538E+00	-.4506E+00
AC 14	10.7869E-030.0000E+00	0.1538E+00	-.4716E+00
AD 14	10.7869E-030.0000E+00	0.1538E+00	-.4926E+00
AE 14	10.7869E-030.0000E+00	0.1538E+00	-.5135E+00
AF 14	10.7869E-030.0000E+00	0.1538E+00	-.5345E+00

AG 14	10.7869E-030.0000E+00	0.1538E+00	-.5554E+00
AH 14	10.7869E-030.0000E+00	0.1538E+00	-.5764E+00
AI 14	10.7869E-030.0000E+00	0.1538E+00	-.5974E+00
AJ 14	10.7869E-030.0000E+00	0.1538E+00	-.6183E+00
AK 14	10.7869E-030.0000E+00	0.1538E+00	-.6393E+00
AL 14	10.7869E-030.0000E+00	0.1538E+00	-.6602E+00
AM 14	10.7869E-030.0000E+00	0.1538E+00	-.6812E+00
AN 14	10.7869E-030.0000E+00	0.1538E+00	-.7022E+00
AO 14	10.1574E-020.0000E+00	0.1538E+00	-.7336E+00
AP 14	10.1574E-020.0000E+00	0.1538E+00	-.7755E+00
AQ 14	10.1574E-020.0000E+00	0.1538E+00	-.8174E+00
AR 14	BOUND0.3754E+460.3754E-01	0.1538E+00	-.8384E+00
A1 15	10.4147E-020.5653E-01	0.1962E+00	-.3668E-01
A2 15	10.4147E-020.0000E+00	0.1962E+00	-.1100E+00
A3 15	10.4147E-020.0000E+00	0.1962E+00	-.1834E+00
A4 15	10.4147E-020.0000E+00	0.1962E+00	-.2568E+00
A5 15	10.2370E-020.0000E+00	0.1962E+00	-.3144E+00
A6 15	10.1185E-020.0000E+00	0.1962E+00	-.3458E+00
A7 15	10.1185E-020.0000E+00	0.1962E+00	-.3668E+00
A8 15	10.1185E-020.0000E+00	0.1962E+00	-.3878E+00
A9 15	10.1185E-020.0000E+00	0.1962E+00	-.4087E+00
AA 15	10.1185E-020.0000E+00	0.1962E+00	-.4297E+00
AB 15	10.1185E-020.0000E+00	0.1962E+00	-.4506E+00
AC 15	10.1185E-020.0000E+00	0.1962E+00	-.4716E+00
AD 15	10.1185E-020.0000E+00	0.1962E+00	-.4926E+00
AE 15	10.1185E-020.0000E+00	0.1962E+00	-.5135E+00
AF 15	10.1185E-020.0000E+00	0.1962E+00	-.5345E+00
AG 15	10.1185E-020.0000E+00	0.1962E+00	-.5554E+00
AH 15	10.1185E-020.0000E+00	0.1962E+00	-.5764E+00
AI 15	10.1185E-020.0000E+00	0.1962E+00	-.5974E+00
AJ 15	10.1185E-020.0000E+00	0.1962E+00	-.6183E+00
AK 15	10.1185E-020.0000E+00	0.1962E+00	-.6393E+00
AL 15	10.1185E-020.0000E+00	0.1962E+00	-.6602E+00
AM 15	10.1185E-020.0000E+00	0.1962E+00	-.6812E+00
AN 15	10.1185E-020.0000E+00	0.1962E+00	-.7022E+00
AO 15	10.2370E-020.0000E+00	0.1962E+00	-.7336E+00
AP 15	10.2370E-020.0000E+00	0.1962E+00	-.7755E+00
AQ 15	10.2370E-020.0000E+00	0.1962E+00	-.8174E+00
AR 15	BOUND0.5653E+460.5653E-01	0.1962E+00	-.8384E+00
A1 16	TCOND0.1010E-050.1377E-04	0.2191E+00	-.3668E-01
A2 16	TCOND0.1010E-050.0000E+00	0.2191E+00	-.1100E+00
A3 16	TCOND0.1010E-050.0000E+00	0.2191E+00	-.1834E+00
A4 16	TCOND0.1010E-050.0000E+00	0.2191E+00	-.2568E+00
A5 16	TCOND0.5771E-060.0000E+00	0.2191E+00	-.3144E+00
A6 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.3458E+00
A7 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.3668E+00
A8 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.3878E+00
A9 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4087E+00
AA 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4297E+00
AB 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4506E+00
AC 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4716E+00
AD 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4926E+00
AE 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5135E+00
AF 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5345E+00
AG 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5554E+00
AH 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5764E+00
AI 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5974E+00

```
AJ 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6183E+00
AK 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6393E+00
AL 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6602E+00
AM 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6812E+00
AN 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.7022E+00
AO 16          TCOND0.5771E-060.0000E+00          0.2191E+00          -.7336E+00
AP 16          TCOND0.5771E-060.0000E+00          0.2191E+00          -.7755E+00
AQ 16          TCOND0.5771E-060.0000E+00          0.2191E+00          -.8174E+00

CONNE
A9  1A9  2                  1    1.e-100.3250E-030.1251E-02
AA  1AA  2                  1    1.e-100.3250E-030.1251E-02
AB  1AB  2                  1    1.e-100.3250E-030.1251E-02
AC  1AC  2                  1    1.e-100.3250E-030.1251E-02
AD  1AD  2                  1    1.e-100.3250E-030.1251E-02
AE  1AE  2                  1    1.e-100.3250E-030.1251E-02
AF  1AF  2                  1    1.e-100.3250E-030.1251E-02
AG  1AG  2                  1    1.e-100.3250E-030.1251E-02
AH  1AH  2                  1    1.e-100.3250E-030.1251E-02
AI  1AI  2                  1    1.e-100.3250E-030.1251E-02
AJ  1AJ  2                  1    1.e-100.3250E-030.1251E-02
AK  1AK  2                  1    1.e-100.3250E-030.1251E-02
A1  2A1  3                 10.3250E-030.3250E-030.4678E-02
A2  2A2  3                 10.3250E-030.3250E-030.4678E-02
A3  2A3  3                 10.3250E-030.3250E-030.4678E-02
A4  2A4  3                 10.3250E-030.3250E-030.4678E-02
A5  2A5  3                 10.3250E-030.3250E-030.2673E-02
A6  2A6  3                 10.3250E-030.3250E-030.1337E-02
A7  2A7  3                 10.3250E-030.3250E-030.1337E-02
A8  2A8  3                 10.3250E-030.3250E-030.1337E-02
A9  2A9  3                 10.3250E-030.3250E-030.1337E-02
AA  2AA  3                 10.3250E-030.3250E-030.1337E-02
AB  2AB  3                 10.3250E-030.3250E-030.1337E-02
AC  2AC  3                 10.3250E-030.3250E-030.1337E-02
AD  2AD  3                 10.3250E-030.3250E-030.1337E-02
AE  2AE  3                 10.3250E-030.3250E-030.1337E-02
AF  2AF  3                 10.3250E-030.3250E-030.1337E-02
AG  2AG  3                 10.3250E-030.3250E-030.1337E-02
AH  2AH  3                 10.3250E-030.3250E-030.1337E-02
AI  2AI  3                 10.3250E-030.3250E-030.1337E-02
AJ  2AJ  3                 10.3250E-030.3250E-030.1337E-02
AK  2AK  3                 10.3250E-030.3250E-030.1337E-02
AL  2AL  3                 10.3250E-030.3250E-030.1337E-02
AM  2AM  3                 10.3250E-030.3250E-030.1337E-02
AN  2AN  3                 10.3250E-030.3250E-030.1337E-02
AO  2AO  3                 10.3250E-030.3250E-030.2673E-02
AP  2AP  3                 10.3250E-030.3250E-030.2673E-02
AQ  2AQ  3                 10.3250E-030.3250E-030.2673E-02
A1  3A1  4                 10.3250E-030.3250E-030.4978E-02
A2  3A2  4                 10.3250E-030.3250E-030.4978E-02
A3  3A3  4                 10.3250E-030.3250E-030.4978E-02
A4  3A4  4                 10.3250E-030.3250E-030.4978E-02
A5  3A5  4                 10.3250E-030.3250E-030.2845E-02
A6  3A6  4                 10.3250E-030.3250E-030.1422E-02
A7  3A7  4                 10.3250E-030.3250E-030.1422E-02
A8  3A8  4                 10.3250E-030.3250E-030.1422E-02
A9  3A9  4                 10.3250E-030.3250E-030.1422E-02
```

AA	3AA	4	10.3250E-030.3250E-030.1422E-02
AB	3AB	4	10.3250E-030.3250E-030.1422E-02
AC	3AC	4	10.3250E-030.3250E-030.1422E-02
AD	3AD	4	10.3250E-030.3250E-030.1422E-02
AE	3AE	4	10.3250E-030.3250E-030.1422E-02
AF	3AF	4	10.3250E-030.3250E-030.1422E-02
AG	3AG	4	10.3250E-030.3250E-030.1422E-02
AH	3AH	4	10.3250E-030.3250E-030.1422E-02
AI	3AI	4	10.3250E-030.3250E-030.1422E-02
AJ	3AJ	4	10.3250E-030.3250E-030.1422E-02
AK	3AK	4	10.3250E-030.3250E-030.1422E-02
AL	3AL	4	10.3250E-030.3250E-030.1422E-02
AM	3AM	4	10.3250E-030.3250E-030.1422E-02
AN	3AN	4	10.3250E-030.3250E-030.1422E-02
AO	3AO	4	10.3250E-030.3250E-030.2845E-02
AP	3AP	4	10.3250E-030.3250E-030.2845E-02
AQ	3AQ	4	10.3250E-030.3250E-030.2845E-02
A1	4A1	5	10.3250E-030.3250E-030.5278E-02
A2	4A2	5	10.3250E-030.3250E-030.5278E-02
A3	4A3	5	10.3250E-030.3250E-030.5278E-02
A4	4A4	5	10.3250E-030.3250E-030.5278E-02
A5	4A5	5	10.3250E-030.3250E-030.3016E-02
A6	4A6	5	10.3250E-030.3250E-030.1508E-02
A7	4A7	5	10.3250E-030.3250E-030.1508E-02
A8	4A8	5	10.3250E-030.3250E-030.1508E-02
A9	4A9	5	10.3250E-030.3250E-030.1508E-02
AA	4AA	5	10.3250E-030.3250E-030.1508E-02
AB	4AB	5	10.3250E-030.3250E-030.1508E-02
AC	4AC	5	10.3250E-030.3250E-030.1508E-02
AD	4AD	5	10.3250E-030.3250E-030.1508E-02
AE	4AE	5	10.3250E-030.3250E-030.1508E-02
AF	4AF	5	10.3250E-030.3250E-030.1508E-02
AG	4AG	5	10.3250E-030.3250E-030.1508E-02
AH	4AH	5	10.3250E-030.3250E-030.1508E-02
AI	4AI	5	10.3250E-030.3250E-030.1508E-02
AJ	4AJ	5	10.3250E-030.3250E-030.1508E-02
AK	4AK	5	10.3250E-030.3250E-030.1508E-02
AL	4AL	5	10.3250E-030.3250E-030.1508E-02
AM	4AM	5	10.3250E-030.3250E-030.1508E-02
AN	4AN	5	10.3250E-030.3250E-030.1508E-02
AO	4AO	5	10.3250E-030.3250E-030.3016E-02
AP	4AP	5	10.3250E-030.3250E-030.3016E-02
AQ	4AQ	5	10.3250E-030.3250E-030.3016E-02
A1	5A1	6	10.3250E-030.3250E-030.5577E-02
A2	5A2	6	10.3250E-030.3250E-030.5577E-02
A3	5A3	6	10.3250E-030.3250E-030.5577E-02
A4	5A4	6	10.3250E-030.3250E-030.5577E-02
A5	5A5	6	10.3250E-030.3250E-030.3187E-02
A6	5A6	6	10.3250E-030.3250E-030.1594E-02
A7	5A7	6	10.3250E-030.3250E-030.1594E-02
A8	5A8	6	10.3250E-030.3250E-030.1594E-02
A9	5A9	6	10.3250E-030.3250E-030.1594E-02
AA	5AA	6	10.3250E-030.3250E-030.1594E-02
AB	5AB	6	10.3250E-030.3250E-030.1594E-02
AC	5AC	6	10.3250E-030.3250E-030.1594E-02
AD	5AD	6	10.3250E-030.3250E-030.1594E-02
AE	5AE	6	10.3250E-030.3250E-030.1594E-02

AF	5AF	6	10.3250E-030.3250E-030.1594E-02
AG	5AG	6	10.3250E-030.3250E-030.1594E-02
AH	5AH	6	10.3250E-030.3250E-030.1594E-02
AI	5AI	6	10.3250E-030.3250E-030.1594E-02
AJ	5AJ	6	10.3250E-030.3250E-030.1594E-02
AK	5AK	6	10.3250E-030.3250E-030.1594E-02
AL	5AL	6	10.3250E-030.3250E-030.1594E-02
AM	5AM	6	10.3250E-030.3250E-030.1594E-02
AN	5AN	6	10.3250E-030.3250E-030.1594E-02
AO	5AO	6	10.3250E-030.3250E-030.3187E-02
AP	5AP	6	10.3250E-030.3250E-030.3187E-02
AQ	5AQ	6	10.3250E-030.3250E-030.3187E-02
A1	6A1	7	10.3250E-030.1125E-020.5877E-02
A2	6A2	7	10.3250E-030.1125E-020.5877E-02
A3	6A3	7	10.3250E-030.1125E-020.5877E-02
A4	6A4	7	10.3250E-030.1125E-020.5877E-02
A5	6A5	7	10.3250E-030.1125E-020.3358E-02
A6	6A6	7	10.3250E-030.1125E-020.1679E-02
A7	6A7	7	10.3250E-030.1125E-020.1679E-02
A8	6A8	7	10.3250E-030.1125E-020.1679E-02
A9	6A9	7	10.3250E-030.1125E-020.1679E-02
AA	6AA	7	10.3250E-030.1125E-020.1679E-02
AB	6AB	7	10.3250E-030.1125E-020.1679E-02
AC	6AC	7	10.3250E-030.1125E-020.1679E-02
AD	6AD	7	10.3250E-030.1125E-020.1679E-02
AE	6AE	7	10.3250E-030.1125E-020.1679E-02
AF	6AF	7	10.3250E-030.1125E-020.1679E-02
AG	6AG	7	10.3250E-030.1125E-020.1679E-02
AH	6AH	7	10.3250E-030.1125E-020.1679E-02
AI	6AI	7	10.3250E-030.1125E-020.1679E-02
AJ	6AJ	7	10.3250E-030.1125E-020.1679E-02
AK	6AK	7	10.3250E-030.1125E-020.1679E-02
AL	6AL	7	10.3250E-030.1125E-020.1679E-02
AM	6AM	7	10.3250E-030.1125E-020.1679E-02
AN	6AN	7	10.3250E-030.1125E-020.1679E-02
AO	6AO	7	10.3250E-030.1125E-020.3358E-02
AP	6AP	7	10.3250E-030.1125E-020.3358E-02
AQ	6AQ	7	10.3250E-030.1125E-020.3358E-02
A1	7A1	8	10.1125E-020.2500E-020.6914E-02
A2	7A2	8	10.1125E-020.2500E-020.6914E-02
A3	7A3	8	10.1125E-020.2500E-020.6914E-02
A4	7A4	8	10.1125E-020.2500E-020.6914E-02
A5	7A5	8	10.1125E-020.2500E-020.3951E-02
A6	7A6	8	10.1125E-020.2500E-020.1975E-02
A7	7A7	8	10.1125E-020.2500E-020.1975E-02
A8	7A8	8	10.1125E-020.2500E-020.1975E-02
A9	7A9	8	10.1125E-020.2500E-020.1975E-02
AA	7AA	8	10.1125E-020.2500E-020.1975E-02
AB	7AB	8	10.1125E-020.2500E-020.1975E-02
AC	7AC	8	10.1125E-020.2500E-020.1975E-02
AD	7AD	8	10.1125E-020.2500E-020.1975E-02
AE	7AE	8	10.1125E-020.2500E-020.1975E-02
AF	7AF	8	10.1125E-020.2500E-020.1975E-02
AG	7AG	8	10.1125E-020.2500E-020.1975E-02
AH	7AH	8	10.1125E-020.2500E-020.1975E-02
AI	7AI	8	10.1125E-020.2500E-020.1975E-02
AJ	7AJ	8	10.1125E-020.2500E-020.1975E-02

AK	7AK	8	10.1125E-020.2500E-020.1975E-02
AL	7AL	8	10.1125E-020.2500E-020.1975E-02
AM	7AM	8	10.1125E-020.2500E-020.1975E-02
AN	7AN	8	10.1125E-020.2500E-020.1975E-02
AO	7AO	8	10.1125E-020.2500E-020.3951E-02
AP	7AP	8	10.1125E-020.2500E-020.3951E-02
AQ	7AQ	8	10.1125E-020.2500E-020.3951E-02
A1	8A1	9	10.2500E-020.5000E-020.9219E-02
A2	8A2	9	10.2500E-020.5000E-020.9219E-02
A3	8A3	9	10.2500E-020.5000E-020.9219E-02
A4	8A4	9	10.2500E-020.5000E-020.9219E-02
A5	8A5	9	10.2500E-020.5000E-020.5268E-02
A6	8A6	9	10.2500E-020.5000E-020.2634E-02
A7	8A7	9	10.2500E-020.5000E-020.2634E-02
A8	8A8	9	10.2500E-020.5000E-020.2634E-02
A9	8A9	9	10.2500E-020.5000E-020.2634E-02
AA	8AA	9	10.2500E-020.5000E-020.2634E-02
AB	8AB	9	10.2500E-020.5000E-020.2634E-02
AC	8AC	9	10.2500E-020.5000E-020.2634E-02
AD	8AD	9	10.2500E-020.5000E-020.2634E-02
AE	8AE	9	10.2500E-020.5000E-020.2634E-02
AF	8AF	9	10.2500E-020.5000E-020.2634E-02
AG	8AG	9	10.2500E-020.5000E-020.2634E-02
AH	8AH	9	10.2500E-020.5000E-020.2634E-02
AI	8AI	9	10.2500E-020.5000E-020.2634E-02
AJ	8AJ	9	10.2500E-020.5000E-020.2634E-02
AK	8AK	9	10.2500E-020.5000E-020.2634E-02
AL	8AL	9	10.2500E-020.5000E-020.2634E-02
AM	8AM	9	10.2500E-020.5000E-020.2634E-02
AN	8AN	9	10.2500E-020.5000E-020.2634E-02
AO	8AO	9	10.2500E-020.5000E-020.5268E-02
AP	8AP	9	10.2500E-020.5000E-020.5268E-02
AQ	8AQ	9	10.2500E-020.5000E-020.5268E-02
A1	9A1	10	10.5000E-020.1000E-010.1383E-01
A2	9A2	10	10.5000E-020.1000E-010.1383E-01
A3	9A3	10	10.5000E-020.1000E-010.1383E-01
A4	9A4	10	10.5000E-020.1000E-010.1383E-01
A5	9A5	10	10.5000E-020.1000E-010.7902E-02
A6	9A6	10	10.5000E-020.1000E-010.3951E-02
A7	9A7	10	10.5000E-020.1000E-010.3951E-02
A8	9A8	10	10.5000E-020.1000E-010.3951E-02
A9	9A9	10	10.5000E-020.1000E-010.3951E-02
AA	9AA	10	10.5000E-020.1000E-010.3951E-02
AB	9AB	10	10.5000E-020.1000E-010.3951E-02
AC	9AC	10	10.5000E-020.1000E-010.3951E-02
AD	9AD	10	10.5000E-020.1000E-010.3951E-02
AE	9AE	10	10.5000E-020.1000E-010.3951E-02
AF	9AF	10	10.5000E-020.1000E-010.3951E-02
AG	9AG	10	10.5000E-020.1000E-010.3951E-02
AH	9AH	10	10.5000E-020.1000E-010.3951E-02
AI	9AI	10	10.5000E-020.1000E-010.3951E-02
AJ	9AJ	10	10.5000E-020.1000E-010.3951E-02
AK	9AK	10	10.5000E-020.1000E-010.3951E-02
AL	9AL	10	10.5000E-020.1000E-010.3951E-02
AM	9AM	10	10.5000E-020.1000E-010.3951E-02
AN	9AN	10	10.5000E-020.1000E-010.3951E-02
AO	9AO	10	10.5000E-020.1000E-010.7902E-02

AP	9AP	10	10.5000E-020.1000E-010.7902E-02
AQ	9AQ	10	10.5000E-020.1000E-010.7902E-02
A1	10A1	11	10.1000E-010.1181E-010.2305E-01
A2	10A2	11	10.1000E-010.1181E-010.2305E-01
A3	10A3	11	10.1000E-010.1181E-010.2305E-01
A4	10A4	11	10.1000E-010.1181E-010.2305E-01
A5	10A5	11	10.1000E-010.1181E-010.1317E-01
A6	10A6	11	10.1000E-010.1181E-010.6585E-02
A7	10A7	11	10.1000E-010.1181E-010.6585E-02
A8	10A8	11	10.1000E-010.1181E-010.6585E-02
A9	10A9	11	10.1000E-010.1181E-010.6585E-02
AA	10AA	11	10.1000E-010.1181E-010.6585E-02
AB	10AB	11	10.1000E-010.1181E-010.6585E-02
AC	10AC	11	10.1000E-010.1181E-010.6585E-02
AD	10AD	11	10.1000E-010.1181E-010.6585E-02
AE	10AE	11	10.1000E-010.1181E-010.6585E-02
AF	10AF	11	10.1000E-010.1181E-010.6585E-02
AG	10AG	11	10.1000E-010.1181E-010.6585E-02
AH	10AH	11	10.1000E-010.1181E-010.6585E-02
AI	10AI	11	10.1000E-010.1181E-010.6585E-02
AJ	10AJ	11	10.1000E-010.1181E-010.6585E-02
AK	10AK	11	10.1000E-010.1181E-010.6585E-02
AL	10AL	11	10.1000E-010.1181E-010.6585E-02
AM	10AM	11	10.1000E-010.1181E-010.6585E-02
AN	10AN	11	10.1000E-010.1181E-010.6585E-02
AO	10AO	11	10.1000E-010.1181E-010.1317E-01
AP	10AP	11	10.1000E-010.1181E-010.1317E-01
AQ	10AQ	11	10.1000E-010.1181E-010.1317E-01
A1	11A1	12	10.1181E-010.1394E-010.3393E-01
A2	11A2	12	10.1181E-010.1394E-010.3393E-01
A3	11A3	12	10.1181E-010.1394E-010.3393E-01
A4	11A4	12	10.1181E-010.1394E-010.3393E-01
A5	11A5	12	10.1181E-010.1394E-010.1939E-01
A6	11A6	12	10.1181E-010.1394E-010.9694E-02
A7	11A7	12	10.1181E-010.1394E-010.9694E-02
A8	11A8	12	10.1181E-010.1394E-010.9694E-02
A9	11A9	12	10.1181E-010.1394E-010.9694E-02
AA	11AA	12	10.1181E-010.1394E-010.9694E-02
AB	11AB	12	10.1181E-010.1394E-010.9694E-02
AC	11AC	12	10.1181E-010.1394E-010.9694E-02
AD	11AD	12	10.1181E-010.1394E-010.9694E-02
AE	11AE	12	10.1181E-010.1394E-010.9694E-02
AF	11AF	12	10.1181E-010.1394E-010.9694E-02
AG	11AG	12	10.1181E-010.1394E-010.9694E-02
AH	11AH	12	10.1181E-010.1394E-010.9694E-02
AI	11AI	12	10.1181E-010.1394E-010.9694E-02
AJ	11AJ	12	10.1181E-010.1394E-010.9694E-02
AK	11AK	12	10.1181E-010.1394E-010.9694E-02
AL	11AL	12	10.1181E-010.1394E-010.9694E-02
AM	11AM	12	10.1181E-010.1394E-010.9694E-02
AN	11AN	12	10.1181E-010.1394E-010.9694E-02
AO	11AO	12	10.1181E-010.1394E-010.1939E-01
AP	11AP	12	10.1181E-010.1394E-010.1939E-01
AQ	11AQ	12	10.1181E-010.1394E-010.1939E-01
A1	12A1	13	10.1394E-010.1645E-010.4678E-01
A2	12A2	13	10.1394E-010.1645E-010.4678E-01
A3	12A3	13	10.1394E-010.1645E-010.4678E-01

A4	12A4	13	10.1394E-010.1645E-010.4678E-01
A5	12A5	13	10.1394E-010.1645E-010.2673E-01
A6	12A6	13	10.1394E-010.1645E-010.1337E-01
A7	12A7	13	10.1394E-010.1645E-010.1337E-01
A8	12A8	13	10.1394E-010.1645E-010.1337E-01
A9	12A9	13	10.1394E-010.1645E-010.1337E-01
AA	12AA	13	10.1394E-010.1645E-010.1337E-01
AB	12AB	13	10.1394E-010.1645E-010.1337E-01
AC	12AC	13	10.1394E-010.1645E-010.1337E-01
AD	12AD	13	10.1394E-010.1645E-010.1337E-01
AE	12AE	13	10.1394E-010.1645E-010.1337E-01
AF	12AF	13	10.1394E-010.1645E-010.1337E-01
AG	12AG	13	10.1394E-010.1645E-010.1337E-01
AH	12AH	13	10.1394E-010.1645E-010.1337E-01
AI	12AI	13	10.1394E-010.1645E-010.1337E-01
AJ	12AJ	13	10.1394E-010.1645E-010.1337E-01
AK	12AK	13	10.1394E-010.1645E-010.1337E-01
AL	12AL	13	10.1394E-010.1645E-010.1337E-01
AM	12AM	13	10.1394E-010.1645E-010.1337E-01
AN	12AN	13	10.1394E-010.1645E-010.1337E-01
AO	12AO	13	10.1394E-010.1645E-010.2673E-01
AP	12AP	13	10.1394E-010.1645E-010.2673E-01
AQ	12AQ	13	10.1394E-010.1645E-010.2673E-01
A1	13A1	14	10.1645E-010.1942E-010.6195E-01
A2	13A2	14	10.1645E-010.1942E-010.6195E-01
A3	13A3	14	10.1645E-010.1942E-010.6195E-01
A4	13A4	14	10.1645E-010.1942E-010.6195E-01
A5	13A5	14	10.1645E-010.1942E-010.3540E-01
A6	13A6	14	10.1645E-010.1942E-010.1770E-01
A7	13A7	14	10.1645E-010.1942E-010.1770E-01
A8	13A8	14	10.1645E-010.1942E-010.1770E-01
A9	13A9	14	10.1645E-010.1942E-010.1770E-01
AA	13AA	14	10.1645E-010.1942E-010.1770E-01
AB	13AB	14	10.1645E-010.1942E-010.1770E-01
AC	13AC	14	10.1645E-010.1942E-010.1770E-01
AD	13AD	14	10.1645E-010.1942E-010.1770E-01
AE	13AE	14	10.1645E-010.1942E-010.1770E-01
AF	13AF	14	10.1645E-010.1942E-010.1770E-01
AG	13AG	14	10.1645E-010.1942E-010.1770E-01
AH	13AH	14	10.1645E-010.1942E-010.1770E-01
AI	13AI	14	10.1645E-010.1942E-010.1770E-01
AJ	13AJ	14	10.1645E-010.1942E-010.1770E-01
AK	13AK	14	10.1645E-010.1942E-010.1770E-01
AL	13AL	14	10.1645E-010.1942E-010.1770E-01
AM	13AM	14	10.1645E-010.1942E-010.1770E-01
AN	13AN	14	10.1645E-010.1942E-010.1770E-01
AO	13AO	14	10.1645E-010.1942E-010.3540E-01
AP	13AP	14	10.1645E-010.1942E-010.3540E-01
AQ	13AQ	14	10.1645E-010.1942E-010.3540E-01
A1	14A1	15	10.1942E-010.2293E-010.7985E-01
A2	14A2	15	10.1942E-010.2293E-010.7985E-01
A3	14A3	15	10.1942E-010.2293E-010.7985E-01
A4	14A4	15	10.1942E-010.2293E-010.7985E-01
A5	14A5	15	10.1942E-010.2293E-010.4563E-01
A6	14A6	15	10.1942E-010.2293E-010.2281E-01
A7	14A7	15	10.1942E-010.2293E-010.2281E-01
A8	14A8	15	10.1942E-010.2293E-010.2281E-01

```
A9 14A9 15                    10.1942E-010.2293E-010.2281E-01
AA 14AA 15                    10.1942E-010.2293E-010.2281E-01
AB 14AB 15                    10.1942E-010.2293E-010.2281E-01
AC 14AC 15                    10.1942E-010.2293E-010.2281E-01
AD 14AD 15                    10.1942E-010.2293E-010.2281E-01
AE 14AE 15                    10.1942E-010.2293E-010.2281E-01
AF 14AF 15                    10.1942E-010.2293E-010.2281E-01
AG 14AG 15                    10.1942E-010.2293E-010.2281E-01
AH 14AH 15                    10.1942E-010.2293E-010.2281E-01
AI 14AI 15                    10.1942E-010.2293E-010.2281E-01
AJ 14AJ 15                    10.1942E-010.2293E-010.2281E-01
AK 14AK 15                    10.1942E-010.2293E-010.2281E-01
AL 14AL 15                    10.1942E-010.2293E-010.2281E-01
AM 14AM 15                    10.1942E-010.2293E-010.2281E-01
AN 14AN 15                    10.1942E-010.2293E-010.2281E-01
AO 14AO 15                    10.1942E-010.2293E-010.4563E-01
AP 14AP 15                    10.1942E-010.2293E-010.4563E-01
AQ 14AQ 15                    10.1942E-010.2293E-010.4563E-01
A1 15A1 16                    10.2293E-010.5000E-050.1010E+00
A2 15A2 16                    10.2293E-010.5000E-050.1010E+00
A3 15A3 16                    10.2293E-010.5000E-050.1010E+00
A4 15A4 16                    10.2293E-010.5000E-050.1010E+00
A5 15A5 16                    10.2293E-010.5000E-050.5771E-01
A6 15A6 16                    10.2293E-010.5000E-050.2885E-01
A7 15A7 16                    10.2293E-010.5000E-050.2885E-01
A8 15A8 16                    10.2293E-010.5000E-050.2885E-01
A9 15A9 16                    10.2293E-010.5000E-050.2885E-01
AA 15AA 16                    10.2293E-010.5000E-050.2885E-01
AB 15AB 16                    10.2293E-010.5000E-050.2885E-01
AC 15AC 16                    10.2293E-010.5000E-050.2885E-01
AD 15AD 16                    10.2293E-010.5000E-050.2885E-01
AE 15AE 16                    10.2293E-010.5000E-050.2885E-01
AF 15AF 16                    10.2293E-010.5000E-050.2885E-01
AG 15AG 16                    10.2293E-010.5000E-050.2885E-01
AH 15AH 16                    10.2293E-010.5000E-050.2885E-01
AI 15AI 16                    10.2293E-010.5000E-050.2885E-01
AJ 15AJ 16                    10.2293E-010.5000E-050.2885E-01
AK 15AK 16                    10.2293E-010.5000E-050.2885E-01
AL 15AL 16                    10.2293E-010.5000E-050.2885E-01
AM 15AM 16                    10.2293E-010.5000E-050.2885E-01
AN 15AN 16                    10.2293E-010.5000E-050.2885E-01
AO 15AO 16                    10.2293E-010.5000E-050.5771E-01
AP 15AP 16                    10.2293E-010.5000E-050.5771E-01
AQ 15AQ 16                    10.2293E-010.5000E-050.5771E-01
A1  2A2  2                    30.3668E-010.3668E-010.4013E-041.
A2  2A3  2                    30.3668E-010.3668E-010.4013E-041.
A3  2A4  2                    30.3668E-010.3668E-010.4013E-041.
A4  2A5  2                    30.3668E-010.2096E-010.4013E-041.
A5  2A6  2                    30.2096E-010.1048E-010.4013E-041.
A6  2A7  2                    30.1048E-010.1048E-010.4013E-041.
A7  2A8  2                    30.1048E-010.1048E-010.4013E-041.
A8  2A9  2                    30.1048E-010.1048E-010.4013E-041.
A9  2AA  2                    30.1048E-010.1048E-010.4013E-041.
AA  2AB  2                    30.1048E-010.1048E-010.4013E-041.
AB  2AC  2                    30.1048E-010.1048E-010.4013E-041.
AC  2AD  2                    30.1048E-010.1048E-010.4013E-041.
AD  2AE  2                    30.1048E-010.1048E-010.4013E-041.
```

AE	2AF	2	30.1048E-010.1048E-010.4013E-041.
AF	2AG	2	30.1048E-010.1048E-010.4013E-041.
AG	2AH	2	30.1048E-010.1048E-010.4013E-041.
AH	2AI	2	30.1048E-010.1048E-010.4013E-041.
AI	2AJ	2	30.1048E-010.1048E-010.4013E-041.
AJ	2AK	2	30.1048E-010.1048E-010.4013E-041.
AK	2AL	2	30.1048E-010.1048E-010.4013E-041.
AL	2AM	2	30.1048E-010.1048E-010.4013E-041.
AM	2AN	2	30.1048E-010.1048E-010.4013E-041.
AN	2AO	2	30.1048E-010.2096E-010.4013E-041.
AO	2AP	2	30.2096E-010.2096E-010.4013E-041.
AP	2AQ	2	30.2096E-010.2096E-010.4013E-041.
AQ	2AR	2	30.2096E-010.5000E-050.4013E-041.
A1	3A2	3	30.3668E-010.3668E-010.4278E-041.
A2	3A3	3	30.3668E-010.3668E-010.4278E-041.
A3	3A4	3	30.3668E-010.3668E-010.4278E-041.
A4	3A5	3	30.3668E-010.2096E-010.4278E-041.
A5	3A6	3	30.2096E-010.1048E-010.4278E-041.
A6	3A7	3	30.1048E-010.1048E-010.4278E-041.
A7	3A8	3	30.1048E-010.1048E-010.4278E-041.
A8	3A9	3	30.1048E-010.1048E-010.4278E-041.
A9	3AA	3	30.1048E-010.1048E-010.4278E-041.
AA	3AB	3	30.1048E-010.1048E-010.4278E-041.
AB	3AC	3	30.1048E-010.1048E-010.4278E-041.
AC	3AD	3	30.1048E-010.1048E-010.4278E-041.
AD	3AE	3	30.1048E-010.1048E-010.4278E-041.
AE	3AF	3	30.1048E-010.1048E-010.4278E-041.
AF	3AG	3	30.1048E-010.1048E-010.4278E-041.
AG	3AH	3	30.1048E-010.1048E-010.4278E-041.
AH	3AI	3	30.1048E-010.1048E-010.4278E-041.
AI	3AJ	3	30.1048E-010.1048E-010.4278E-041.
AJ	3AK	3	30.1048E-010.1048E-010.4278E-041.
AK	3AL	3	30.1048E-010.1048E-010.4278E-041.
AL	3AM	3	30.1048E-010.1048E-010.4278E-041.
AM	3AN	3	30.1048E-010.1048E-010.4278E-041.
AN	3AO	3	30.1048E-010.2096E-010.4278E-041.
AO	3AP	3	30.2096E-010.2096E-010.4278E-041.
AP	3AQ	3	30.2096E-010.2096E-010.4278E-041.
AQ	3AR	3	30.2096E-010.5000E-050.4278E-041.
A1	4A2	4	30.3668E-010.3668E-010.4544E-041.
A2	4A3	4	30.3668E-010.3668E-010.4544E-041.
A3	4A4	4	30.3668E-010.3668E-010.4544E-041.
A4	4A5	4	30.3668E-010.2096E-010.4544E-041.
A5	4A6	4	30.2096E-010.1048E-010.4544E-041.
A6	4A7	4	30.1048E-010.1048E-010.4544E-041.
A7	4A8	4	30.1048E-010.1048E-010.4544E-041.
A8	4A9	4	30.1048E-010.1048E-010.4544E-041.
A9	4AA	4	30.1048E-010.1048E-010.4544E-041.
AA	4AB	4	30.1048E-010.1048E-010.4544E-041.
AB	4AC	4	30.1048E-010.1048E-010.4544E-041.
AC	4AD	4	30.1048E-010.1048E-010.4544E-041.
AD	4AE	4	30.1048E-010.1048E-010.4544E-041.
AE	4AF	4	30.1048E-010.1048E-010.4544E-041.
AF	4AG	4	30.1048E-010.1048E-010.4544E-041.
AG	4AH	4	30.1048E-010.1048E-010.4544E-041.
AH	4AI	4	30.1048E-010.1048E-010.4544E-041.
AI	4AJ	4	30.1048E-010.1048E-010.4544E-041.

AJ	4AK	4	30.1048E-010.1048E-010.4544E-041.
AK	4AL	4	30.1048E-010.1048E-010.4544E-041.
AL	4AM	4	30.1048E-010.1048E-010.4544E-041.
AM	4AN	4	30.1048E-010.1048E-010.4544E-041.
AN	4AO	4	30.1048E-010.2096E-010.4544E-041.
AO	4AP	4	30.2096E-010.2096E-010.4544E-041.
AP	4AQ	4	30.2096E-010.2096E-010.4544E-041.
AQ	4AR	4	30.2096E-010.5000E-050.4544E-041.
A1	5A2	5	30.3668E-010.3668E-010.4809E-041.
A2	5A3	5	30.3668E-010.3668E-010.4809E-041.
A3	5A4	5	30.3668E-010.3668E-010.4809E-041.
A4	5A5	5	30.3668E-010.2096E-010.4809E-041.
A5	5A6	5	30.2096E-010.1048E-010.4809E-041.
A6	5A7	5	30.1048E-010.1048E-010.4809E-041.
A7	5A8	5	30.1048E-010.1048E-010.4809E-041.
A8	5A9	5	30.1048E-010.1048E-010.4809E-041.
A9	5AA	5	30.1048E-010.1048E-010.4809E-041.
AA	5AB	5	30.1048E-010.1048E-010.4809E-041.
AB	5AC	5	30.1048E-010.1048E-010.4809E-041.
AC	5AD	5	30.1048E-010.1048E-010.4809E-041.
AD	5AE	5	30.1048E-010.1048E-010.4809E-041.
AE	5AF	5	30.1048E-010.1048E-010.4809E-041.
AF	5AG	5	30.1048E-010.1048E-010.4809E-041.
AG	5AH	5	30.1048E-010.1048E-010.4809E-041.
AH	5AI	5	30.1048E-010.1048E-010.4809E-041.
AI	5AJ	5	30.1048E-010.1048E-010.4809E-041.
AJ	5AK	5	30.1048E-010.1048E-010.4809E-041.
AK	5AL	5	30.1048E-010.1048E-010.4809E-041.
AL	5AM	5	30.1048E-010.1048E-010.4809E-041.
AM	5AN	5	30.1048E-010.1048E-010.4809E-041.
AN	5AO	5	30.1048E-010.2096E-010.4809E-041.
AO	5AP	5	30.2096E-010.2096E-010.4809E-041.
AP	5AQ	5	30.2096E-010.2096E-010.4809E-041.
AQ	5AR	5	30.2096E-010.5000E-050.4809E-041.
A1	6A2	6	30.3668E-010.3668E-010.5074E-041.
A2	6A3	6	30.3668E-010.3668E-010.5074E-041.
A3	6A4	6	30.3668E-010.3668E-010.5074E-041.
A4	6A5	6	30.3668E-010.2096E-010.5074E-041.
A5	6A6	6	30.2096E-010.1048E-010.5074E-041.
A6	6A7	6	30.1048E-010.1048E-010.5074E-041.
A7	6A8	6	30.1048E-010.1048E-010.5074E-041.
A8	6A9	6	30.1048E-010.1048E-010.5074E-041.
A9	6AA	6	30.1048E-010.1048E-010.5074E-041.
AA	6AB	6	30.1048E-010.1048E-010.5074E-041.
AB	6AC	6	30.1048E-010.1048E-010.5074E-041.
AC	6AD	6	30.1048E-010.1048E-010.5074E-041.
AD	6AE	6	30.1048E-010.1048E-010.5074E-041.
AE	6AF	6	30.1048E-010.1048E-010.5074E-041.
AF	6AG	6	30.1048E-010.1048E-010.5074E-041.
AG	6AH	6	30.1048E-010.1048E-010.5074E-041.
AH	6AI	6	30.1048E-010.1048E-010.5074E-041.
AI	6AJ	6	30.1048E-010.1048E-010.5074E-041.
AJ	6AK	6	30.1048E-010.1048E-010.5074E-041.
AK	6AL	6	30.1048E-010.1048E-010.5074E-041.
AL	6AM	6	30.1048E-010.1048E-010.5074E-041.
AM	6AN	6	30.1048E-010.1048E-010.5074E-041.
AN	6AO	6	30.1048E-010.2096E-010.5074E-041.

```
AO  6AP  6                    30.2096E-010.2096E-010.5074E-041.
AP  6AQ  6                    30.2096E-010.2096E-010.5074E-041.
AQ  6AR  6                    30.2096E-010.5000E-050.5074E-041.
A1  7A2  7                    30.3668E-010.3668E-010.1962E-031.
A2  7A3  7                    30.3668E-010.3668E-010.1962E-031.
A3  7A4  7                    30.3668E-010.3668E-010.1962E-031.
A4  7A5  7                    30.3668E-010.2096E-010.1962E-031.
A5  7A6  7                    30.2096E-010.1048E-010.1962E-031.
A6  7A7  7                    30.1048E-010.1048E-010.1962E-031.
A7  7A8  7                    30.1048E-010.1048E-010.1962E-031.
A8  7A9  7                    30.1048E-010.1048E-010.1962E-031.
A9  7AA  7                    30.1048E-010.1048E-010.1962E-031.
AA  7AB  7                    30.1048E-010.1048E-010.1962E-031.
AB  7AC  7                    30.1048E-010.1048E-010.1962E-031.
AC  7AD  7                    30.1048E-010.1048E-010.1962E-031.
AD  7AE  7                    30.1048E-010.1048E-010.1962E-031.
AE  7AF  7                    30.1048E-010.1048E-010.1962E-031.
AF  7AG  7                    30.1048E-010.1048E-010.1962E-031.
AG  7AH  7                    30.1048E-010.1048E-010.1962E-031.
AH  7AI  7                    30.1048E-010.1048E-010.1962E-031.
AI  7AJ  7                    30.1048E-010.1048E-010.1962E-031.
AJ  7AK  7                    30.1048E-010.1048E-010.1962E-031.
AK  7AL  7                    30.1048E-010.1048E-010.1962E-031.
AL  7AM  7                    30.1048E-010.1048E-010.1962E-031.
AM  7AN  7                    30.1048E-010.1048E-010.1962E-031.
AN  7AO  7                    30.1048E-010.2096E-010.1962E-031.
AO  7AP  7                    30.2096E-010.2096E-010.1962E-031.
AP  7AQ  7                    30.2096E-010.2096E-010.1962E-031.
AQ  7AR  7                    30.2096E-010.5000E-050.1962E-031.
A1  8A2  8                    30.3668E-010.3668E-010.5498E-031.
A2  8A3  8                    30.3668E-010.3668E-010.5498E-031.
A3  8A4  8                    30.3668E-010.3668E-010.5498E-031.
A4  8A5  8                    30.3668E-010.2096E-010.5498E-031.
A5  8A6  8                    30.2096E-010.1048E-010.5498E-031.
A6  8A7  8                    30.1048E-010.1048E-010.5498E-031.
A7  8A8  8                    30.1048E-010.1048E-010.5498E-031.
A8  8A9  8                    30.1048E-010.1048E-010.5498E-031.
A9  8AA  8                    30.1048E-010.1048E-010.5498E-031.
AA  8AB  8                    30.1048E-010.1048E-010.5498E-031.
AB  8AC  8                    30.1048E-010.1048E-010.5498E-031.
AC  8AD  8                    30.1048E-010.1048E-010.5498E-031.
AD  8AE  8                    30.1048E-010.1048E-010.5498E-031.
AE  8AF  8                    30.1048E-010.1048E-010.5498E-031.
AF  8AG  8                    30.1048E-010.1048E-010.5498E-031.
AG  8AH  8                    30.1048E-010.1048E-010.5498E-031.
AH  8AI  8                    30.1048E-010.1048E-010.5498E-031.
AI  8AJ  8                    30.1048E-010.1048E-010.5498E-031.
AJ  8AK  8                    30.1048E-010.1048E-010.5498E-031.
AK  8AL  8                    30.1048E-010.1048E-010.5498E-031.
AL  8AM  8                    30.1048E-010.1048E-010.5498E-031.
AM  8AN  8                    30.1048E-010.1048E-010.5498E-031.
AN  8AO  8                    30.1048E-010.2096E-010.5498E-031.
AO  8AP  8                    30.2096E-010.2096E-010.5498E-031.
AP  8AQ  8                    30.2096E-010.2096E-010.5498E-031.
AQ  8AR  8                    30.2096E-010.5000E-050.5498E-031.
A1  9A2  9                    30.3668E-010.3668E-010.1571E-021.
A2  9A3  9                    30.3668E-010.3668E-010.1571E-021.
```

```
A3  9A4  9                    30.3668E-010.3668E-010.1571E-021.
A4  9A5  9                    30.3668E-010.2096E-010.1571E-021.
A5  9A6  9                    30.2096E-010.1048E-010.1571E-021.
A6  9A7  9                    30.1048E-010.1048E-010.1571E-021.
A7  9A8  9                    30.1048E-010.1048E-010.1571E-021.
A8  9A9  9                    30.1048E-010.1048E-010.1571E-021.
A9  9AA  9                    30.1048E-010.1048E-010.1571E-021.
AA  9AB  9                    30.1048E-010.1048E-010.1571E-021.
AB  9AC  9                    30.1048E-010.1048E-010.1571E-021.
AC  9AD  9                    30.1048E-010.1048E-010.1571E-021.
AD  9AE  9                    30.1048E-010.1048E-010.1571E-021.
AE  9AF  9                    30.1048E-010.1048E-010.1571E-021.
AF  9AG  9                    30.1048E-010.1048E-010.1571E-021.
AG  9AH  9                    30.1048E-010.1048E-010.1571E-021.
AH  9AI  9                    30.1048E-010.1048E-010.1571E-021.
AI  9AJ  9                    30.1048E-010.1048E-010.1571E-021.
AJ  9AK  9                    30.1048E-010.1048E-010.1571E-021.
AK  9AL  9                    30.1048E-010.1048E-010.1571E-021.
AL  9AM  9                    30.1048E-010.1048E-010.1571E-021.
AM  9AN  9                    30.1048E-010.1048E-010.1571E-021.
AN  9AO  9                    30.1048E-010.2096E-010.1571E-021.
AO  9AP  9                    30.2096E-010.2096E-010.1571E-021.
AP  9AQ  9                    30.2096E-010.2096E-010.1571E-021.
AQ  9AR  9                    30.2096E-010.5000E-050.1571E-021.
A1 10A2 10                    30.3668E-010.3668E-010.5027E-021.
A2 10A3 10                    30.3668E-010.3668E-010.5027E-021.
A3 10A4 10                    30.3668E-010.3668E-010.5027E-021.
A4 10A5 10                    30.3668E-010.2096E-010.5027E-021.
A5 10A6 10                    30.2096E-010.1048E-010.5027E-021.
A6 10A7 10                    30.1048E-010.1048E-010.5027E-021.
A7 10A8 10                    30.1048E-010.1048E-010.5027E-021.
A8 10A9 10                    30.1048E-010.1048E-010.5027E-021.
A9 10AA 10                    30.1048E-010.1048E-010.5027E-021.
AA 10AB 10                    30.1048E-010.1048E-010.5027E-021.
AB 10AC 10                    30.1048E-010.1048E-010.5027E-021.
AC 10AD 10                    30.1048E-010.1048E-010.5027E-021.
AD 10AE 10                    30.1048E-010.1048E-010.5027E-021.
AE 10AF 10                    30.1048E-010.1048E-010.5027E-021.
AF 10AG 10                    30.1048E-010.1048E-010.5027E-021.
AG 10AH 10                    30.1048E-010.1048E-010.5027E-021.
AH 10AI 10                    30.1048E-010.1048E-010.5027E-021.
AI 10AJ 10                    30.1048E-010.1048E-010.5027E-021.
AJ 10AK 10                    30.1048E-010.1048E-010.5027E-021.
AK 10AL 10                    30.1048E-010.1048E-010.5027E-021.
AL 10AM 10                    30.1048E-010.1048E-010.5027E-021.
AM 10AN 10                    30.1048E-010.1048E-010.5027E-021.
AN 10AO 10                    30.1048E-010.2096E-010.5027E-021.
AO 10AP 10                    30.2096E-010.2096E-010.5027E-021.
AP 10AQ 10                    30.2096E-010.2096E-010.5027E-021.
AQ 10AR 10                    30.2096E-010.5000E-050.5027E-021.
A1 11A2 11                    30.3668E-010.3668E-010.9169E-021.
A2 11A3 11                    30.3668E-010.3668E-010.9169E-021.
A3 11A4 11                    30.3668E-010.3668E-010.9169E-021.
A4 11A5 11                    30.3668E-010.2096E-010.9169E-021.
A5 11A6 11                    30.2096E-010.1048E-010.9169E-021.
A6 11A7 11                    30.1048E-010.1048E-010.9169E-021.
A7 11A8 11                    30.1048E-010.1048E-010.9169E-021.
```

```
A8 11A9 11                    30.1048E-010.1048E-010.9169E-021.
A9 11AA 11                    30.1048E-010.1048E-010.9169E-021.
AA 11AB 11                    30.1048E-010.1048E-010.9169E-021.
AB 11AC 11                    30.1048E-010.1048E-010.9169E-021.
AC 11AD 11                    30.1048E-010.1048E-010.9169E-021.
AD 11AE 11                    30.1048E-010.1048E-010.9169E-021.
AE 11AF 11                    30.1048E-010.1048E-010.9169E-021.
AF 11AG 11                    30.1048E-010.1048E-010.9169E-021.
AG 11AH 11                    30.1048E-010.1048E-010.9169E-021.
AH 11AI 11                    30.1048E-010.1048E-010.9169E-021.
AI 11AJ 11                    30.1048E-010.1048E-010.9169E-021.
AJ 11AK 11                    30.1048E-010.1048E-010.9169E-021.
AK 11AL 11                    30.1048E-010.1048E-010.9169E-021.
AL 11AM 11                    30.1048E-010.1048E-010.9169E-021.
AM 11AN 11                    30.1048E-010.1048E-010.9169E-021.
AN 11AO 11                    30.1048E-010.2096E-010.9169E-021.
AO 11AP 11                    30.2096E-010.2096E-010.9169E-021.
AP 11AQ 11                    30.2096E-010.2096E-010.9169E-021.
AQ 11AR 11                    30.2096E-010.5000E-050.9169E-021.
A1 12A2 12                    30.3668E-010.3668E-010.1533E-011.
A2 12A3 12                    30.3668E-010.3668E-010.1533E-011.
A3 12A4 12                    30.3668E-010.3668E-010.1533E-011.
A4 12A5 12                    30.3668E-010.2096E-010.1533E-011.
A5 12A6 12                    30.2096E-010.1048E-010.1533E-011.
A6 12A7 12                    30.1048E-010.1048E-010.1533E-011.
A7 12A8 12                    30.1048E-010.1048E-010.1533E-011.
A8 12A9 12                    30.1048E-010.1048E-010.1533E-011.
A9 12AA 12                    30.1048E-010.1048E-010.1533E-011.
AA 12AB 12                    30.1048E-010.1048E-010.1533E-011.
AB 12AC 12                    30.1048E-010.1048E-010.1533E-011.
AC 12AD 12                    30.1048E-010.1048E-010.1533E-011.
AD 12AE 12                    30.1048E-010.1048E-010.1533E-011.
AE 12AF 12                    30.1048E-010.1048E-010.1533E-011.
AF 12AG 12                    30.1048E-010.1048E-010.1533E-011.
AG 12AH 12                    30.1048E-010.1048E-010.1533E-011.
AH 12AI 12                    30.1048E-010.1048E-010.1533E-011.
AI 12AJ 12                    30.1048E-010.1048E-010.1533E-011.
AJ 12AK 12                    30.1048E-010.1048E-010.1533E-011.
AK 12AL 12                    30.1048E-010.1048E-010.1533E-011.
AL 12AM 12                    30.1048E-010.1048E-010.1533E-011.
AM 12AN 12                    30.1048E-010.1048E-010.1533E-011.
AN 12AO 12                    30.1048E-010.2096E-010.1533E-011.
AO 12AP 12                    30.2096E-010.2096E-010.1533E-011.
AP 12AQ 12                    30.2096E-010.2096E-010.1533E-011.
AQ 12AR 12                    30.2096E-010.5000E-050.1533E-011.
A1 13A2 13                    30.3668E-010.3668E-010.2438E-011.
A2 13A3 13                    30.3668E-010.3668E-010.2438E-011.
A3 13A4 13                    30.3668E-010.3668E-010.2438E-011.
A4 13A5 13                    30.3668E-010.2096E-010.2438E-011.
A5 13A6 13                    30.2096E-010.1048E-010.2438E-011.
A6 13A7 13                    30.1048E-010.1048E-010.2438E-011.
A7 13A8 13                    30.1048E-010.1048E-010.2438E-011.
A8 13A9 13                    30.1048E-010.1048E-010.2438E-011.
A9 13AA 13                    30.1048E-010.1048E-010.2438E-011.
AA 13AB 13                    30.1048E-010.1048E-010.2438E-011.
AB 13AC 13                    30.1048E-010.1048E-010.2438E-011.
AC 13AD 13                    30.1048E-010.1048E-010.2438E-011.
```

```
AD 13AE 13                    30.1048E-010.1048E-010.2438E-011.
AE 13AF 13                    30.1048E-010.1048E-010.2438E-011.
AF 13AG 13                    30.1048E-010.1048E-010.2438E-011.
AG 13AH 13                    30.1048E-010.1048E-010.2438E-011.
AH 13AI 13                    30.1048E-010.1048E-010.2438E-011.
AI 13AJ 13                    30.1048E-010.1048E-010.2438E-011.
AJ 13AK 13                    30.1048E-010.1048E-010.2438E-011.
AK 13AL 13                    30.1048E-010.1048E-010.2438E-011.
AL 13AM 13                    30.1048E-010.1048E-010.2438E-011.
AM 13AN 13                    30.1048E-010.1048E-010.2438E-011.
AN 13AO 13                    30.1048E-010.2096E-010.2438E-011.
AO 13AP 13                    30.2096E-010.2096E-010.2438E-011.
AP 13AQ 13                    30.2096E-010.2096E-010.2438E-011.
AQ 13AR 13                    30.2096E-010.5000E-050.2438E-011.
A1 14A2 14                    30.3668E-010.3668E-010.3754E-011.
A2 14A3 14                    30.3668E-010.3668E-010.3754E-011.
A3 14A4 14                    30.3668E-010.3668E-010.3754E-011.
A4 14A5 14                    30.3668E-010.2096E-010.3754E-011.
A5 14A6 14                    30.2096E-010.1048E-010.3754E-011.
A6 14A7 14                    30.1048E-010.1048E-010.3754E-011.
A7 14A8 14                    30.1048E-010.1048E-010.3754E-011.
A8 14A9 14                    30.1048E-010.1048E-010.3754E-011.
A9 14AA 14                    30.1048E-010.1048E-010.3754E-011.
AA 14AB 14                    30.1048E-010.1048E-010.3754E-011.
AB 14AC 14                    30.1048E-010.1048E-010.3754E-011.
AC 14AD 14                    30.1048E-010.1048E-010.3754E-011.
AD 14AE 14                    30.1048E-010.1048E-010.3754E-011.
AE 14AF 14                    30.1048E-010.1048E-010.3754E-011.
AF 14AG 14                    30.1048E-010.1048E-010.3754E-011.
AG 14AH 14                    30.1048E-010.1048E-010.3754E-011.
AH 14AI 14                    30.1048E-010.1048E-010.3754E-011.
AI 14AJ 14                    30.1048E-010.1048E-010.3754E-011.
AJ 14AK 14                    30.1048E-010.1048E-010.3754E-011.
AK 14AL 14                    30.1048E-010.1048E-010.3754E-011.
AL 14AM 14                    30.1048E-010.1048E-010.3754E-011.
AM 14AN 14                    30.1048E-010.1048E-010.3754E-011.
AN 14AO 14                    30.1048E-010.2096E-010.3754E-011.
AO 14AP 14                    30.2096E-010.2096E-010.3754E-011.
AP 14AQ 14                    30.2096E-010.2096E-010.3754E-011.
AQ 14AR 14                    30.2096E-010.5000E-050.3754E-011.
A1 15A2 15                    30.3668E-010.3668E-010.5653E-011.
A2 15A3 15                    30.3668E-010.3668E-010.5653E-011.
A3 15A4 15                    30.3668E-010.3668E-010.5653E-011.
A4 15A5 15                    30.3668E-010.2096E-010.5653E-011.
A5 15A6 15                    30.2096E-010.1048E-010.5653E-011.
A6 15A7 15                    30.1048E-010.1048E-010.5653E-011.
A7 15A8 15                    30.1048E-010.1048E-010.5653E-011.
A8 15A9 15                    30.1048E-010.1048E-010.5653E-011.
A9 15AA 15                    30.1048E-010.1048E-010.5653E-011.
AA 15AB 15                    30.1048E-010.1048E-010.5653E-011.
AB 15AC 15                    30.1048E-010.1048E-010.5653E-011.
AC 15AD 15                    30.1048E-010.1048E-010.5653E-011.
AD 15AE 15                    30.1048E-010.1048E-010.5653E-011.
AE 15AF 15                    30.1048E-010.1048E-010.5653E-011.
AF 15AG 15                    30.1048E-010.1048E-010.5653E-011.
AG 15AH 15                    30.1048E-010.1048E-010.5653E-011.
AH 15AI 15                    30.1048E-010.1048E-010.5653E-011.
```

```
AI 15AJ 15                    30.1048E-010.1048E-010.5653E-011.
AJ 15AK 15                    30.1048E-010.1048E-010.5653E-011.
AK 15AL 15                    30.1048E-010.1048E-010.5653E-011.
AL 15AM 15                    30.1048E-010.1048E-010.5653E-011.
AM 15AN 15                    30.1048E-010.1048E-010.5653E-011.
AN 15AO 15                    30.1048E-010.2096E-010.5653E-011.
AO 15AP 15                    30.2096E-010.2096E-010.5653E-011.
AP 15AQ 15                    30.2096E-010.2096E-010.5653E-011.
AQ 15AR 15                    30.2096E-010.5000E-050.5653E-011.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
MESHM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RZ2D ----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RADII
   11
        0.     .0095   .010150   .010800   .011450   .012100   .012750      .015
      .020       .03       .05
LOGAR----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5          .2191
EQUID
    1          1.e-5
LAYER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
   27
    .07336                                  .04192    .02096

                                                                          .04192
                          1.e-5

ENDFI----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*val2b* ... Validation Problem No.2.
START     2-d convection cell in r-z; Reda (1984)
START     7-10-92: George's latest data file
START              grid generation using MESHMAKER from TOUGH2
START              flow channeling neglected
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
SOIL1    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
SOIL2    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
SOIL3    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
SOIL4    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
SOIL5    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
SOIL6    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87      740.
BOUND    0    2500.0      0.34  610.E-12  610.E-12  610.E-12      0.87     1.E04
TCOND    0    2500.0     1.e-5  000.E-12  000.E-12  000.E-12      0.87     1.E54
HEATR    1    7400.0     1.e-5       0.0       0.0       0.0      50.2    569.40
     1.e-5

START
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 1 350     3500000000 0000 0 41          2.13E-5      1.80
        0.      1.e5       -1.      1.e4A9  1         -9.807        4.        1.
       10.
     1.E-5        1.       0.1        1.        1.     1.E-8
                 2.e5                21.5                  0.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
   14   14
      100.      200.      300.      550.      800.     1100.     2000.     2500.
     3000.     3500.     4000.     5000.      1.e4      1.e5
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1             0.        0.       0.1       0.1
    1             0.        0.       0.1
GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A9  1HEA 1    0    0    0    1     HEAT  5.8331680
AA  1HEA 2    0    0    0    1     HEAT  5.8331680
AB  1HEA 3    0    0    0    1     HEAT  5.8331680
AC  1HEA 4    0    0    0    1     HEAT  5.8331680
AD  1HEA 5    0    0    0    1     HEAT  5.8331680
AE  1HEA 6    0    0    0    1     HEAT  5.8331680
AF  1HEA 7    0    0    0    1     HEAT  5.8331680
AG  1HEA 8    0    0    0    1     HEAT  5.8331680
AH  1HEA 9    0    0    0    1     HEAT  5.8331680
AI  1HEA10    0    0    0    1     HEAT  5.8331680
AJ  1HEA11    0    0    0    1     HEAT  5.8331680
AK  1HEA12    0    0    0    1     HEAT  5.8331680

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8

ELEME ---     16   11    1    5   0.00000     0.219
A9  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4087E+00
AA  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4297E+00
AB  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4506E+00
AC  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4716E+00
AD  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.4926E+00
AE  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5135E+00
AF  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5345E+00
AG  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5554E+00
AH  1          HEATR0.5943E-050.0000E+00          0.4750E-02          -.5764E+00
```

AI	1	HEATR0.5943E-050.0000E+00	0.4750E-02	-.5974E+00
AJ	1	HEATR0.5943E-050.0000E+00	0.4750E-02	-.6183E+00
AK	1	HEATR0.5943E-050.0000E+00	0.4750E-02	-.6393E+00
A1	2	SOIL20.2944E-050.4013E-04	0.9825E-02	-.3668E-01
A2	2	SOIL20.2944E-050.0000E+00	0.9825E-02	-.1100E+00
A3	2	SOIL20.2944E-050.0000E+00	0.9825E-02	-.1834E+00
A4	2	SOIL20.2944E-050.0000E+00	0.9825E-02	-.2568E+00
A5	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.3144E+00
A6	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.3458E+00
A7	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.3668E+00
A8	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.3878E+00
A9	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4087E+00
AA	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4297E+00
AB	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4506E+00
AC	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4716E+00
AD	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.4926E+00
AE	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5135E+00
AF	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5345E+00
AG	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5554E+00
AH	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5764E+00
AI	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.5974E+00
AJ	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6183E+00
AK	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6393E+00
AL	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6602E+00
AM	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.6812E+00
AN	2	SOIL20.8410E-060.0000E+00	0.9825E-02	-.7022E+00
AO	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.7336E+00
AP	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.7755E+00
AQ	2	SOIL20.1682E-050.0000E+00	0.9825E-02	-.8174E+00
AR	2	BOUND0.4013E+490.4013E-04	0.9825E-02	-.8384E+00
A1	3	SOIL30.3138E-050.4278E-04	0.1047E-01	-.3668E-01
A2	3	SOIL30.3138E-050.0000E+00	0.1047E-01	-.1100E+00
A3	3	SOIL30.3138E-050.0000E+00	0.1047E-01	-.1834E+00
A4	3	SOIL30.3138E-050.0000E+00	0.1047E-01	-.2568E+00
A5	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.3144E+00
A6	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.3458E+00
A7	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.3668E+00
A8	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.3878E+00
A9	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4087E+00
AA	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4297E+00
AB	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4506E+00
AC	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4716E+00
AD	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.4926E+00
AE	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5135E+00
AF	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5345E+00
AG	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5554E+00
AH	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5764E+00
AI	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.5974E+00
AJ	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6183E+00
AK	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6393E+00
AL	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6602E+00
AM	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.6812E+00
AN	3	SOIL30.8967E-060.0000E+00	0.1047E-01	-.7022E+00
AO	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.7336E+00
AP	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.7755E+00
AQ	3	SOIL30.1793E-050.0000E+00	0.1047E-01	-.8174E+00
AR	3	BOUND0.4278E+490.4278E-04	0.1047E-01	-.8384E+00

A1	4	SOIL40.3333E-050.4544E-04	0.1112E-01	-.3668E-01
A2	4	SOIL40.3333E-050.0000E+00	0.1112E-01	-.1100E+00
A3	4	SOIL40.3333E-050.0000E+00	0.1112E-01	-.1834E+00
A4	4	SOIL40.3333E-050.0000E+00	0.1112E-01	-.2568E+00
A5	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.3144E+00
A6	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.3458E+00
A7	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.3668E+00
A8	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.3878E+00
A9	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4087E+00
AA	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4297E+00
AB	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4506E+00
AC	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4716E+00
AD	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.4926E+00
AE	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5135E+00
AF	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5345E+00
AG	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5554E+00
AH	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5764E+00
AI	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.5974E+00
AJ	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6183E+00
AK	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6393E+00
AL	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6602E+00
AM	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.6812E+00
AN	4	SOIL40.9523E-060.0000E+00	0.1112E-01	-.7022E+00
AO	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.7336E+00
AP	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.7755E+00
AQ	4	SOIL40.1905E-050.0000E+00	0.1112E-01	-.8174E+00
AR	4	BOUND0.4544E+490.4544E-04	0.1112E-01	-.8384E+00
A1	5	SOIL50.3528E-050.4809E-04	0.1177E-01	-.3668E-01
A2	5	SOIL50.3528E-050.0000E+00	0.1177E-01	-.1100E+00
A3	5	SOIL50.3528E-050.0000E+00	0.1177E-01	-.1834E+00
A4	5	SOIL50.3528E-050.0000E+00	0.1177E-01	-.2568E+00
A5	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.3144E+00
A6	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.3458E+00
A7	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.3668E+00
A8	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.3878E+00
A9	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4087E+00
AA	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4297E+00
AB	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4506E+00
AC	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4716E+00
AD	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.4926E+00
AE	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5135E+00
AF	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5345E+00
AG	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5554E+00
AH	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5764E+00
AI	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.5974E+00
AJ	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6183E+00
AK	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6393E+00
AL	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6602E+00
AM	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.6812E+00
AN	5	SOIL50.1008E-050.0000E+00	0.1177E-01	-.7022E+00
AO	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.7336E+00
AP	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.7755E+00
AQ	5	SOIL50.2016E-050.0000E+00	0.1177E-01	-.8174E+00
AR	5	BOUND0.4809E+490.4809E-04	0.1177E-01	-.8384E+00
A1	6	SOIL60.3723E-050.5074E-04	0.1242E-01	-.3668E-01
A2	6	SOIL60.3723E-050.0000E+00	0.1242E-01	-.1100E+00
A3	6	SOIL60.3723E-050.0000E+00	0.1242E-01	-.1834E+00

A4	6	SOIL60.3723E-050.0000E+00	0.1242E-01	-.2568E+00
A5	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.3144E+00
A6	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.3458E+00
A7	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.3668E+00
A8	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.3878E+00
A9	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4087E+00
AA	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4297E+00
AB	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4506E+00
AC	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4716E+00
AD	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.4926E+00
AE	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5135E+00
AF	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5345E+00
AG	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5554E+00
AH	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5764E+00
AI	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.5974E+00
AJ	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6183E+00
AK	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6393E+00
AL	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6602E+00
AM	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.6812E+00
AN	6	SOIL60.1064E-050.0000E+00	0.1242E-01	-.7022E+00
AO	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.7336E+00
AP	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.7755E+00
AQ	6	SOIL60.2127E-050.0000E+00	0.1242E-01	-.8174E+00
AR	6	BOUND0.5074E+490.5074E-04	0.1242E-01	-.8384E+00
A1	7	10.1439E-040.1962E-03	0.1387E-01	-.3668E-01
A2	7	10.1439E-040.0000E+00	0.1387E-01	-.1100E+00
A3	7	10.1439E-040.0000E+00	0.1387E-01	-.1834E+00
A4	7	10.1439E-040.0000E+00	0.1387E-01	-.2568E+00
A5	7	10.8223E-050.0000E+00	0.1387E-01	-.3144E+00
A6	7	10.4111E-050.0000E+00	0.1387E-01	-.3458E+00
A7	7	10.4111E-050.0000E+00	0.1387E-01	-.3668E+00
A8	7	10.4111E-050.0000E+00	0.1387E-01	-.3878E+00
A9	7	10.4111E-050.0000E+00	0.1387E-01	-.4087E+00
AA	7	10.4111E-050.0000E+00	0.1387E-01	-.4297E+00
AB	7	10.4111E-050.0000E+00	0.1387E-01	-.4506E+00
AC	7	10.4111E-050.0000E+00	0.1387E-01	-.4716E+00
AD	7	10.4111E-050.0000E+00	0.1387E-01	-.4926E+00
AE	7	10.4111E-050.0000E+00	0.1387E-01	-.5135E+00
AF	7	10.4111E-050.0000E+00	0.1387E-01	-.5345E+00
AG	7	10.4111E-050.0000E+00	0.1387E-01	-.5554E+00
AH	7	10.4111E-050.0000E+00	0.1387E-01	-.5764E+00
AI	7	10.4111E-050.0000E+00	0.1387E-01	-.5974E+00
AJ	7	10.4111E-050.0000E+00	0.1387E-01	-.6183E+00
AK	7	10.4111E-050.0000E+00	0.1387E-01	-.6393E+00
AL	7	10.4111E-050.0000E+00	0.1387E-01	-.6602E+00
AM	7	10.4111E-050.0000E+00	0.1387E-01	-.6812E+00
AN	7	10.4111E-050.0000E+00	0.1387E-01	-.7022E+00
AO	7	10.8223E-050.0000E+00	0.1387E-01	-.7336E+00
AP	7	10.8223E-050.0000E+00	0.1387E-01	-.7755E+00
AQ	7	10.8223E-050.0000E+00	0.1387E-01	-.8174E+00
AR	7	BOUND0.1962E+480.1962E-03	0.1387E-01	-.8384E+00
A1	8	10.4033E-040.5498E-03	0.1750E-01	-.3668E-01
A2	8	10.4033E-040.0000E+00	0.1750E-01	-.1100E+00
A3	8	10.4033E-040.0000E+00	0.1750E-01	-.1834E+00
A4	8	10.4033E-040.0000E+00	0.1750E-01	-.2568E+00
A5	8	10.2305E-040.0000E+00	0.1750E-01	-.3144E+00
A6	8	10.1152E-040.0000E+00	0.1750E-01	-.3458E+00

A7	8	10.1152E-040.0000E+00	0.1750E-01	-.3668E+00
A8	8	10.1152E-040.0000E+00	0.1750E-01	-.3878E+00
A9	8	10.1152E-040.0000E+00	0.1750E-01	-.4087E+00
AA	8	10.1152E-040.0000E+00	0.1750E-01	-.4297E+00
AB	8	10.1152E-040.0000E+00	0.1750E-01	-.4506E+00
AC	8	10.1152E-040.0000E+00	0.1750E-01	-.4716E+00
AD	8	10.1152E-040.0000E+00	0.1750E-01	-.4926E+00
AE	8	10.1152E-040.0000E+00	0.1750E-01	-.5135E+00
AF	8	10.1152E-040.0000E+00	0.1750E-01	-.5345E+00
AG	8	10.1152E-040.0000E+00	0.1750E-01	-.5554E+00
AH	8	10.1152E-040.0000E+00	0.1750E-01	-.5764E+00
AI	8	10.1152E-040.0000E+00	0.1750E-01	-.5974E+00
AJ	8	10.1152E-040.0000E+00	0.1750E-01	-.6183E+00
AK	8	10.1152E-040.0000E+00	0.1750E-01	-.6393E+00
AL	8	10.1152E-040.0000E+00	0.1750E-01	-.6602E+00
AM	8	10.1152E-040.0000E+00	0.1750E-01	-.6812E+00
AN	8	10.1152E-040.0000E+00	0.1750E-01	-.7022E+00
AO	8	10.2305E-040.0000E+00	0.1750E-01	-.7336E+00
AP	8	10.2305E-040.0000E+00	0.1750E-01	-.7755E+00
AQ	8	10.2305E-040.0000E+00	0.1750E-01	-.8174E+00
AR	8	BOUND0.5498E+480.5498E-03	0.1750E-01	-.8384E+00
A1	9	10.1152E-030.1571E-02	0.2500E-01	-.3668E-01
A2	9	10.1152E-030.0000E+00	0.2500E-01	-.1100E+00
A3	9	10.1152E-030.0000E+00	0.2500E-01	-.1834E+00
A4	9	10.1152E-030.0000E+00	0.2500E-01	-.2568E+00
A5	9	10.6585E-040.0000E+00	0.2500E-01	-.3144E+00
A6	9	10.3292E-040.0000E+00	0.2500E-01	-.3458E+00
A7	9	10.3292E-040.0000E+00	0.2500E-01	-.3668E+00
A8	9	10.3292E-040.0000E+00	0.2500E-01	-.3878E+00
A9	9	10.3292E-040.0000E+00	0.2500E-01	-.4087E+00
AA	9	10.3292E-040.0000E+00	0.2500E-01	-.4297E+00
AB	9	10.3292E-040.0000E+00	0.2500E-01	-.4506E+00
AC	9	10.3292E-040.0000E+00	0.2500E-01	-.4716E+00
AD	9	10.3292E-040.0000E+00	0.2500E-01	-.4926E+00
AE	9	10.3292E-040.0000E+00	0.2500E-01	-.5135E+00
AF	9	10.3292E-040.0000E+00	0.2500E-01	-.5345E+00
AG	9	10.3292E-040.0000E+00	0.2500E-01	-.5554E+00
AH	9	10.3292E-040.0000E+00	0.2500E-01	-.5764E+00
AI	9	10.3292E-040.0000E+00	0.2500E-01	-.5974E+00
AJ	9	10.3292E-040.0000E+00	0.2500E-01	-.6183E+00
AK	9	10.3292E-040.0000E+00	0.2500E-01	-.6393E+00
AL	9	10.3292E-040.0000E+00	0.2500E-01	-.6602E+00
AM	9	10.3292E-040.0000E+00	0.2500E-01	-.6812E+00
AN	9	10.3292E-040.0000E+00	0.2500E-01	-.7022E+00
AO	9	10.6585E-040.0000E+00	0.2500E-01	-.7336E+00
AP	9	10.6585E-040.0000E+00	0.2500E-01	-.7755E+00
AQ	9	10.6585E-040.0000E+00	0.2500E-01	-.8174E+00
AR	9	BOUND0.1571E+470.1571E-02	0.2500E-01	-.8384E+00
A1	10	10.3687E-030.5027E-02	0.4000E-01	-.3668E-01
A2	10	10.3687E-030.0000E+00	0.4000E-01	-.1100E+00
A3	10	10.3687E-030.0000E+00	0.4000E-01	-.1834E+00
A4	10	10.3687E-030.0000E+00	0.4000E-01	-.2568E+00
A5	10	10.2107E-030.0000E+00	0.4000E-01	-.3144E+00
A6	10	10.1054E-030.0000E+00	0.4000E-01	-.3458E+00
A7	10	10.1054E-030.0000E+00	0.4000E-01	-.3668E+00
A8	10	10.1054E-030.0000E+00	0.4000E-01	-.3878E+00
A9	10	10.1054E-030.0000E+00	0.4000E-01	-.4087E+00

AA 10	10.1054E-030.0000E+00	0.4000E-01	-.4297E+00
AB 10	10.1054E-030.0000E+00	0.4000E-01	-.4506E+00
AC 10	10.1054E-030.0000E+00	0.4000E-01	-.4716E+00
AD 10	10.1054E-030.0000E+00	0.4000E-01	-.4926E+00
AE 10	10.1054E-030.0000E+00	0.4000E-01	-.5135E+00
AF 10	10.1054E-030.0000E+00	0.4000E-01	-.5345E+00
AG 10	10.1054E-030.0000E+00	0.4000E-01	-.5554E+00
AH 10	10.1054E-030.0000E+00	0.4000E-01	-.5764E+00
AI 10	10.1054E-030.0000E+00	0.4000E-01	-.5974E+00
AJ 10	10.1054E-030.0000E+00	0.4000E-01	-.6183E+00
AK 10	10.1054E-030.0000E+00	0.4000E-01	-.6393E+00
AL 10	10.1054E-030.0000E+00	0.4000E-01	-.6602E+00
AM 10	10.1054E-030.0000E+00	0.4000E-01	-.6812E+00
AN 10	10.1054E-030.0000E+00	0.4000E-01	-.7022E+00
AO 10	10.2107E-030.0000E+00	0.4000E-01	-.7336E+00
AP 10	10.2107E-030.0000E+00	0.4000E-01	-.7755E+00
AQ 10	10.2107E-030.0000E+00	0.4000E-01	-.8174E+00
AR 10	BOUND0.5027E+470.5027E-02	0.4000E-01	-.8384E+00
A1 11	10.6726E-030.9169E-02	0.6181E-01	-.3668E-01
A2 11	10.6726E-030.0000E+00	0.6181E-01	-.1100E+00
A3 11	10.6726E-030.0000E+00	0.6181E-01	-.1834E+00
A4 11	10.6726E-030.0000E+00	0.6181E-01	-.2568E+00
A5 11	10.3844E-030.0000E+00	0.6181E-01	-.3144E+00
A6 11	10.1922E-030.0000E+00	0.6181E-01	-.3458E+00
A7 11	10.1922E-030.0000E+00	0.6181E-01	-.3668E+00
A8 11	10.1922E-030.0000E+00	0.6181E-01	-.3878E+00
A9 11	10.1922E-030.0000E+00	0.6181E-01	-.4087E+00
AA 11	10.1922E-030.0000E+00	0.6181E-01	-.4297E+00
AB 11	10.1922E-030.0000E+00	0.6181E-01	-.4506E+00
AC 11	10.1922E-030.0000E+00	0.6181E-01	-.4716E+00
AD 11	10.1922E-030.0000E+00	0.6181E-01	-.4926E+00
AE 11	10.1922E-030.0000E+00	0.6181E-01	-.5135E+00
AF 11	10.1922E-030.0000E+00	0.6181E-01	-.5345E+00
AG 11	10.1922E-030.0000E+00	0.6181E-01	-.5554E+00
AH 11	10.1922E-030.0000E+00	0.6181E-01	-.5764E+00
AI 11	10.1922E-030.0000E+00	0.6181E-01	-.5974E+00
AJ 11	10.1922E-030.0000E+00	0.6181E-01	-.6183E+00
AK 11	10.1922E-030.0000E+00	0.6181E-01	-.6393E+00
AL 11	10.1922E-030.0000E+00	0.6181E-01	-.6602E+00
AM 11	10.1922E-030.0000E+00	0.6181E-01	-.6812E+00
AN 11	10.1922E-030.0000E+00	0.6181E-01	-.7022E+00
AO 11	10.3844E-030.0000E+00	0.6181E-01	-.7336E+00
AP 11	10.3844E-030.0000E+00	0.6181E-01	-.7755E+00
AQ 11	10.3844E-030.0000E+00	0.6181E-01	-.8174E+00
AR 11	BOUND0.9169E+470.9169E-02	0.6181E-01	-.8384E+00
A1 12	10.1125E-020.1533E-01	0.8755E-01	-.3668E-01
A2 12	10.1125E-020.0000E+00	0.8755E-01	-.1100E+00
A3 12	10.1125E-020.0000E+00	0.8755E-01	-.1834E+00
A4 12	10.1125E-020.0000E+00	0.8755E-01	-.2568E+00
A5 12	10.6428E-030.0000E+00	0.8755E-01	-.3144E+00
A6 12	10.3214E-030.0000E+00	0.8755E-01	-.3458E+00
A7 12	10.3214E-030.0000E+00	0.8755E-01	-.3668E+00
A8 12	10.3214E-030.0000E+00	0.8755E-01	-.3878E+00
A9 12	10.3214E-030.0000E+00	0.8755E-01	-.4087E+00
AA 12	10.3214E-030.0000E+00	0.8755E-01	-.4297E+00
AB 12	10.3214E-030.0000E+00	0.8755E-01	-.4506E+00
AC 12	10.3214E-030.0000E+00	0.8755E-01	-.4716E+00

AD 12	10.3214E-030.0000E+00	0.8755E-01	-.4926E+00
AE 12	10.3214E-030.0000E+00	0.8755E-01	-.5135E+00
AF 12	10.3214E-030.0000E+00	0.8755E-01	-.5345E+00
AG 12	10.3214E-030.0000E+00	0.8755E-01	-.5554E+00
AH 12	10.3214E-030.0000E+00	0.8755E-01	-.5764E+00
AI 12	10.3214E-030.0000E+00	0.8755E-01	-.5974E+00
AJ 12	10.3214E-030.0000E+00	0.8755E-01	-.6183E+00
AK 12	10.3214E-030.0000E+00	0.8755E-01	-.6393E+00
AL 12	10.3214E-030.0000E+00	0.8755E-01	-.6602E+00
AM 12	10.3214E-030.0000E+00	0.8755E-01	-.6812E+00
AN 12	10.3214E-030.0000E+00	0.8755E-01	-.7022E+00
AO 12	10.6428E-030.0000E+00	0.8755E-01	-.7336E+00
AP 12	10.6428E-030.0000E+00	0.8755E-01	-.7755E+00
AQ 12	10.6428E-030.0000E+00	0.8755E-01	-.8174E+00
AR 12	BOUND0.1533E+460.1533E-01	0.8755E-01	-.8384E+00
A1 13	10.1789E-020.2438E-01	0.1179E+00	-.3668E-01
A2 13	10.1789E-020.0000E+00	0.1179E+00	-.1100E+00
A3 13	10.1789E-020.0000E+00	0.1179E+00	-.1834E+00
A4 13	10.1789E-020.0000E+00	0.1179E+00	-.2568E+00
A5 13	10.1022E-020.0000E+00	0.1179E+00	-.3144E+00
A6 13	10.5111E-030.0000E+00	0.1179E+00	-.3458E+00
A7 13	10.5111E-030.0000E+00	0.1179E+00	-.3668E+00
A8 13	10.5111E-030.0000E+00	0.1179E+00	-.3878E+00
A9 13	10.5111E-030.0000E+00	0.1179E+00	-.4087E+00
AA 13	10.5111E-030.0000E+00	0.1179E+00	-.4297E+00
AB 13	10.5111E-030.0000E+00	0.1179E+00	-.4506E+00
AC 13	10.5111E-030.0000E+00	0.1179E+00	-.4716E+00
AD 13	10.5111E-030.0000E+00	0.1179E+00	-.4926E+00
AE 13	10.5111E-030.0000E+00	0.1179E+00	-.5135E+00
AF 13	10.5111E-030.0000E+00	0.1179E+00	-.5345E+00
AG 13	10.5111E-030.0000E+00	0.1179E+00	-.5554E+00
AH 13	10.5111E-030.0000E+00	0.1179E+00	-.5764E+00
AI 13	10.5111E-030.0000E+00	0.1179E+00	-.5974E+00
AJ 13	10.5111E-030.0000E+00	0.1179E+00	-.6183E+00
AK 13	10.5111E-030.0000E+00	0.1179E+00	-.6393E+00
AL 13	10.5111E-030.0000E+00	0.1179E+00	-.6602E+00
AM 13	10.5111E-030.0000E+00	0.1179E+00	-.6812E+00
AN 13	10.5111E-030.0000E+00	0.1179E+00	-.7022E+00
AO 13	10.1022E-020.0000E+00	0.1179E+00	-.7336E+00
AP 13	10.1022E-020.0000E+00	0.1179E+00	-.7755E+00
AQ 13	10.1022E-020.0000E+00	0.1179E+00	-.8174E+00
AR 13	BOUND0.2438E+460.2438E-01	0.1179E+00	-.8384E+00
A1 14	10.2754E-020.3754E-01	0.1538E+00	-.3668E-01
A2 14	10.2754E-020.0000E+00	0.1538E+00	-.1100E+00
A3 14	10.2754E-020.0000E+00	0.1538E+00	-.1834E+00
A4 14	10.2754E-020.0000E+00	0.1538E+00	-.2568E+00
A5 14	10.1574E-020.0000E+00	0.1538E+00	-.3144E+00
A6 14	10.7869E-030.0000E+00	0.1538E+00	-.3458E+00
A7 14	10.7869E-030.0000E+00	0.1538E+00	-.3668E+00
A8 14	10.7869E-030.0000E+00	0.1538E+00	-.3878E+00
A9 14	10.7869E-030.0000E+00	0.1538E+00	-.4087E+00
AA 14	10.7869E-030.0000E+00	0.1538E+00	-.4297E+00
AB 14	10.7869E-030.0000E+00	0.1538E+00	-.4506E+00
AC 14	10.7869E-030.0000E+00	0.1538E+00	-.4716E+00
AD 14	10.7869E-030.0000E+00	0.1538E+00	-.4926E+00
AE 14	10.7869E-030.0000E+00	0.1538E+00	-.5135E+00
AF 14	10.7869E-030.0000E+00	0.1538E+00	-.5345E+00

AG 14	10.7869E-030.0000E+00	0.1538E+00	-.5554E+00
AH 14	10.7869E-030.0000E+00	0.1538E+00	-.5764E+00
AI 14	10.7869E-030.0000E+00	0.1538E+00	-.5974E+00
AJ 14	10.7869E-030.0000E+00	0.1538E+00	-.6183E+00
AK 14	10.7869E-030.0000E+00	0.1538E+00	-.6393E+00
AL 14	10.7869E-030.0000E+00	0.1538E+00	-.6602E+00
AM 14	10.7869E-030.0000E+00	0.1538E+00	-.6812E+00
AN 14	10.7869E-030.0000E+00	0.1538E+00	-.7022E+00
AO 14	10.1574E-020.0000E+00	0.1538E+00	-.7336E+00
AP 14	10.1574E-020.0000E+00	0.1538E+00	-.7755E+00
AQ 14	10.1574E-020.0000E+00	0.1538E+00	-.8174E+00
AR 14	BOUND0.3754E+460.3754E-01	0.1538E+00	-.8384E+00
A1 15	10.4147E-020.5653E-01	0.1962E+00	-.3668E-01
A2 15	10.4147E-020.0000E+00	0.1962E+00	-.1100E+00
A3 15	10.4147E-020.0000E+00	0.1962E+00	-.1834E+00
A4 15	10.4147E-020.0000E+00	0.1962E+00	-.2568E+00
A5 15	10.2370E-020.0000E+00	0.1962E+00	-.3144E+00
A6 15	10.1185E-020.0000E+00	0.1962E+00	-.3458E+00
A7 15	10.1185E-020.0000E+00	0.1962E+00	-.3668E+00
A8 15	10.1185E-020.0000E+00	0.1962E+00	-.3878E+00
A9 15	10.1185E-020.0000E+00	0.1962E+00	-.4087E+00
AA 15	10.1185E-020.0000E+00	0.1962E+00	-.4297E+00
AB 15	10.1185E-020.0000E+00	0.1962E+00	-.4506E+00
AC 15	10.1185E-020.0000E+00	0.1962E+00	-.4716E+00
AD 15	10.1185E-020.0000E+00	0.1962E+00	-.4926E+00
AE 15	10.1185E-020.0000E+00	0.1962E+00	-.5135E+00
AF 15	10.1185E-020.0000E+00	0.1962E+00	-.5345E+00
AG 15	10.1185E-020.0000E+00	0.1962E+00	-.5554E+00
AH 15	10.1185E-020.0000E+00	0.1962E+00	-.5764E+00
AI 15	10.1185E-020.0000E+00	0.1962E+00	-.5974E+00
AJ 15	10.1185E-020.0000E+00	0.1962E+00	-.6183E+00
AK 15	10.1185E-020.0000E+00	0.1962E+00	-.6393E+00
AL 15	10.1185E-020.0000E+00	0.1962E+00	-.6602E+00
AM 15	10.1185E-020.0000E+00	0.1962E+00	-.6812E+00
AN 15	10.1185E-020.0000E+00	0.1962E+00	-.7022E+00
AO 15	10.2370E-020.0000E+00	0.1962E+00	-.7336E+00
AP 15	10.2370E-020.0000E+00	0.1962E+00	-.7755E+00
AQ 15	10.2370E-020.0000E+00	0.1962E+00	-.8174E+00
AR 15	BOUND0.5653E+460.5653E-01	0.1962E+00	-.8384E+00
A1 16	TCOND0.1010E-050.1377E-04	0.2191E+00	-.3668E-01
A2 16	TCOND0.1010E-050.0000E+00	0.2191E+00	-.1100E+00
A3 16	TCOND0.1010E-050.0000E+00	0.2191E+00	-.1834E+00
A4 16	TCOND0.1010E-050.0000E+00	0.2191E+00	-.2568E+00
A5 16	TCOND0.5771E-060.0000E+00	0.2191E+00	-.3144E+00
A6 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.3458E+00
A7 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.3668E+00
A8 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.3878E+00
A9 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4087E+00
AA 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4297E+00
AB 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4506E+00
AC 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4716E+00
AD 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.4926E+00
AE 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5135E+00
AF 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5345E+00
AG 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5554E+00
AH 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5764E+00
AI 16	TCOND0.2886E-060.0000E+00	0.2191E+00	-.5974E+00

```
AJ 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6183E+00
AK 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6393E+00
AL 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6602E+00
AM 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.6812E+00
AN 16          TCOND0.2886E-060.0000E+00          0.2191E+00          -.7022E+00
AO 16          TCOND0.5771E-060.0000E+00          0.2191E+00          -.7336E+00
AP 16          TCOND0.5771E-060.0000E+00          0.2191E+00          -.7755E+00
AQ 16          TCOND0.5771E-060.0000E+00          0.2191E+00          -.8174E+00

CONNE
A9  1A9  2                  1    1.e-100.3250E-030.1251E-02
AA  1AA  2                  1    1.e-100.3250E-030.1251E-02
AB  1AB  2                  1    1.e-100.3250E-030.1251E-02
AC  1AC  2                  1    1.e-100.3250E-030.1251E-02
AD  1AD  2                  1    1.e-100.3250E-030.1251E-02
AE  1AE  2                  1    1.e-100.3250E-030.1251E-02
AF  1AF  2                  1    1.e-100.3250E-030.1251E-02
AG  1AG  2                  1    1.e-100.3250E-030.1251E-02
AH  1AH  2                  1    1.e-100.3250E-030.1251E-02
AI  1AI  2                  1    1.e-100.3250E-030.1251E-02
AJ  1AJ  2                  1    1.e-100.3250E-030.1251E-02
AK  1AK  2                  1    1.e-100.3250E-030.1251E-02
A1  2A1  3                 10.3250E-030.3250E-030.4678E-02
A2  2A2  3                 10.3250E-030.3250E-030.4678E-02
A3  2A3  3                 10.3250E-030.3250E-030.4678E-02
A4  2A4  3                 10.3250E-030.3250E-030.4678E-02
A5  2A5  3                 10.3250E-030.3250E-030.2673E-02
A6  2A6  3                 10.3250E-030.3250E-030.1337E-02
A7  2A7  3                 10.3250E-030.3250E-030.1337E-02
A8  2A8  3                 10.3250E-030.3250E-030.1337E-02
A9  2A9  3                 10.3250E-030.3250E-030.1337E-02
AA  2AA  3                 10.3250E-030.3250E-030.1337E-02
AB  2AB  3                 10.3250E-030.3250E-030.1337E-02
AC  2AC  3                 10.3250E-030.3250E-030.1337E-02
AD  2AD  3                 10.3250E-030.3250E-030.1337E-02
AE  2AE  3                 10.3250E-030.3250E-030.1337E-02
AF  2AF  3                 10.3250E-030.3250E-030.1337E-02
AG  2AG  3                 10.3250E-030.3250E-030.1337E-02
AH  2AH  3                 10.3250E-030.3250E-030.1337E-02
AI  2AI  3                 10.3250E-030.3250E-030.1337E-02
AJ  2AJ  3                 10.3250E-030.3250E-030.1337E-02
AK  2AK  3                 10.3250E-030.3250E-030.1337E-02
AL  2AL  3                 10.3250E-030.3250E-030.1337E-02
AM  2AM  3                 10.3250E-030.3250E-030.1337E-02
AN  2AN  3                 10.3250E-030.3250E-030.1337E-02
AO  2AO  3                 10.3250E-030.3250E-030.2673E-02
AP  2AP  3                 10.3250E-030.3250E-030.2673E-02
AQ  2AQ  3                 10.3250E-030.3250E-030.2673E-02
A1  3A1  4                 10.3250E-030.3250E-030.4978E-02
A2  3A2  4                 10.3250E-030.3250E-030.4978E-02
A3  3A3  4                 10.3250E-030.3250E-030.4978E-02
A4  3A4  4                 10.3250E-030.3250E-030.4978E-02
A5  3A5  4                 10.3250E-030.3250E-030.2845E-02
A6  3A6  4                 10.3250E-030.3250E-030.1422E-02
A7  3A7  4                 10.3250E-030.3250E-030.1422E-02
A8  3A8  4                 10.3250E-030.3250E-030.1422E-02
A9  3A9  4                 10.3250E-030.3250E-030.1422E-02
```

AA	3AA	4	10.3250E-030.3250E-030.1422E-02
AB	3AB	4	10.3250E-030.3250E-030.1422E-02
AC	3AC	4	10.3250E-030.3250E-030.1422E-02
AD	3AD	4	10.3250E-030.3250E-030.1422E-02
AE	3AE	4	10.3250E-030.3250E-030.1422E-02
AF	3AF	4	10.3250E-030.3250E-030.1422E-02
AG	3AG	4	10.3250E-030.3250E-030.1422E-02
AH	3AH	4	10.3250E-030.3250E-030.1422E-02
AI	3AI	4	10.3250E-030.3250E-030.1422E-02
AJ	3AJ	4	10.3250E-030.3250E-030.1422E-02
AK	3AK	4	10.3250E-030.3250E-030.1422E-02
AL	3AL	4	10.3250E-030.3250E-030.1422E-02
AM	3AM	4	10.3250E-030.3250E-030.1422E-02
AN	3AN	4	10.3250E-030.3250E-030.1422E-02
AO	3AO	4	10.3250E-030.3250E-030.2845E-02
AP	3AP	4	10.3250E-030.3250E-030.2845E-02
AQ	3AQ	4	10.3250E-030.3250E-030.2845E-02
A1	4A1	5	10.3250E-030.3250E-030.5278E-02
A2	4A2	5	10.3250E-030.3250E-030.5278E-02
A3	4A3	5	10.3250E-030.3250E-030.5278E-02
A4	4A4	5	10.3250E-030.3250E-030.5278E-02
A5	4A5	5	10.3250E-030.3250E-030.3016E-02
A6	4A6	5	10.3250E-030.3250E-030.1508E-02
A7	4A7	5	10.3250E-030.3250E-030.1508E-02
A8	4A8	5	10.3250E-030.3250E-030.1508E-02
A9	4A9	5	10.3250E-030.3250E-030.1508E-02
AA	4AA	5	10.3250E-030.3250E-030.1508E-02
AB	4AB	5	10.3250E-030.3250E-030.1508E-02
AC	4AC	5	10.3250E-030.3250E-030.1508E-02
AD	4AD	5	10.3250E-030.3250E-030.1508E-02
AE	4AE	5	10.3250E-030.3250E-030.1508E-02
AF	4AF	5	10.3250E-030.3250E-030.1508E-02
AG	4AG	5	10.3250E-030.3250E-030.1508E-02
AH	4AH	5	10.3250E-030.3250E-030.1508E-02
AI	4AI	5	10.3250E-030.3250E-030.1508E-02
AJ	4AJ	5	10.3250E-030.3250E-030.1508E-02
AK	4AK	5	10.3250E-030.3250E-030.1508E-02
AL	4AL	5	10.3250E-030.3250E-030.1508E-02
AM	4AM	5	10.3250E-030.3250E-030.1508E-02
AN	4AN	5	10.3250E-030.3250E-030.1508E-02
AO	4AO	5	10.3250E-030.3250E-030.3016E-02
AP	4AP	5	10.3250E-030.3250E-030.3016E-02
AQ	4AQ	5	10.3250E-030.3250E-030.3016E-02
A1	5A1	6	10.3250E-030.3250E-030.5577E-02
A2	5A2	6	10.3250E-030.3250E-030.5577E-02
A3	5A3	6	10.3250E-030.3250E-030.5577E-02
A4	5A4	6	10.3250E-030.3250E-030.5577E-02
A5	5A5	6	10.3250E-030.3250E-030.3187E-02
A6	5A6	6	10.3250E-030.3250E-030.1594E-02
A7	5A7	6	10.3250E-030.3250E-030.1594E-02
A8	5A8	6	10.3250E-030.3250E-030.1594E-02
A9	5A9	6	10.3250E-030.3250E-030.1594E-02
AA	5AA	6	10.3250E-030.3250E-030.1594E-02
AB	5AB	6	10.3250E-030.3250E-030.1594E-02
AC	5AC	6	10.3250E-030.3250E-030.1594E-02
AD	5AD	6	10.3250E-030.3250E-030.1594E-02
AE	5AE	6	10.3250E-030.3250E-030.1594E-02

AF	5AF	6	10.3250E-030.3250E-030.1594E-02
AG	5AG	6	10.3250E-030.3250E-030.1594E-02
AH	5AH	6	10.3250E-030.3250E-030.1594E-02
AI	5AI	6	10.3250E-030.3250E-030.1594E-02
AJ	5AJ	6	10.3250E-030.3250E-030.1594E-02
AK	5AK	6	10.3250E-030.3250E-030.1594E-02
AL	5AL	6	10.3250E-030.3250E-030.1594E-02
AM	5AM	6	10.3250E-030.3250E-030.1594E-02
AN	5AN	6	10.3250E-030.3250E-030.1594E-02
AO	5AO	6	10.3250E-030.3250E-030.3187E-02
AP	5AP	6	10.3250E-030.3250E-030.3187E-02
AQ	5AQ	6	10.3250E-030.3250E-030.3187E-02
A1	6A1	7	10.3250E-030.1125E-020.5877E-02
A2	6A2	7	10.3250E-030.1125E-020.5877E-02
A3	6A3	7	10.3250E-030.1125E-020.5877E-02
A4	6A4	7	10.3250E-030.1125E-020.5877E-02
A5	6A5	7	10.3250E-030.1125E-020.3358E-02
A6	6A6	7	10.3250E-030.1125E-020.1679E-02
A7	6A7	7	10.3250E-030.1125E-020.1679E-02
A8	6A8	7	10.3250E-030.1125E-020.1679E-02
A9	6A9	7	10.3250E-030.1125E-020.1679E-02
AA	6AA	7	10.3250E-030.1125E-020.1679E-02
AB	6AB	7	10.3250E-030.1125E-020.1679E-02
AC	6AC	7	10.3250E-030.1125E-020.1679E-02
AD	6AD	7	10.3250E-030.1125E-020.1679E-02
AE	6AE	7	10.3250E-030.1125E-020.1679E-02
AF	6AF	7	10.3250E-030.1125E-020.1679E-02
AG	6AG	7	10.3250E-030.1125E-020.1679E-02
AH	6AH	7	10.3250E-030.1125E-020.1679E-02
AI	6AI	7	10.3250E-030.1125E-020.1679E-02
AJ	6AJ	7	10.3250E-030.1125E-020.1679E-02
AK	6AK	7	10.3250E-030.1125E-020.1679E-02
AL	6AL	7	10.3250E-030.1125E-020.1679E-02
AM	6AM	7	10.3250E-030.1125E-020.1679E-02
AN	6AN	7	10.3250E-030.1125E-020.1679E-02
AO	6AO	7	10.3250E-030.1125E-020.3358E-02
AP	6AP	7	10.3250E-030.1125E-020.3358E-02
AQ	6AQ	7	10.3250E-030.1125E-020.3358E-02
A1	7A1	8	10.1125E-020.2500E-020.6914E-02
A2	7A2	8	10.1125E-020.2500E-020.6914E-02
A3	7A3	8	10.1125E-020.2500E-020.6914E-02
A4	7A4	8	10.1125E-020.2500E-020.6914E-02
A5	7A5	8	10.1125E-020.2500E-020.3951E-02
A6	7A6	8	10.1125E-020.2500E-020.1975E-02
A7	7A7	8	10.1125E-020.2500E-020.1975E-02
A8	7A8	8	10.1125E-020.2500E-020.1975E-02
A9	7A9	8	10.1125E-020.2500E-020.1975E-02
AA	7AA	8	10.1125E-020.2500E-020.1975E-02
AB	7AB	8	10.1125E-020.2500E-020.1975E-02
AC	7AC	8	10.1125E-020.2500E-020.1975E-02
AD	7AD	8	10.1125E-020.2500E-020.1975E-02
AE	7AE	8	10.1125E-020.2500E-020.1975E-02
AF	7AF	8	10.1125E-020.2500E-020.1975E-02
AG	7AG	8	10.1125E-020.2500E-020.1975E-02
AH	7AH	8	10.1125E-020.2500E-020.1975E-02
AI	7AI	8	10.1125E-020.2500E-020.1975E-02
AJ	7AJ	8	10.1125E-020.2500E-020.1975E-02

AK	7AK	8	10.1125E-020.2500E-020.1975E-02
AL	7AL	8	10.1125E-020.2500E-020.1975E-02
AM	7AM	8	10.1125E-020.2500E-020.1975E-02
AN	7AN	8	10.1125E-020.2500E-020.1975E-02
AO	7AO	8	10.1125E-020.2500E-020.3951E-02
AP	7AP	8	10.1125E-020.2500E-020.3951E-02
AQ	7AQ	8	10.1125E-020.2500E-020.3951E-02
A1	8A1	9	10.2500E-020.5000E-020.9219E-02
A2	8A2	9	10.2500E-020.5000E-020.9219E-02
A3	8A3	9	10.2500E-020.5000E-020.9219E-02
A4	8A4	9	10.2500E-020.5000E-020.9219E-02
A5	8A5	9	10.2500E-020.5000E-020.5268E-02
A6	8A6	9	10.2500E-020.5000E-020.2634E-02
A7	8A7	9	10.2500E-020.5000E-020.2634E-02
A8	8A8	9	10.2500E-020.5000E-020.2634E-02
A9	8A9	9	10.2500E-020.5000E-020.2634E-02
AA	8AA	9	10.2500E-020.5000E-020.2634E-02
AB	8AB	9	10.2500E-020.5000E-020.2634E-02
AC	8AC	9	10.2500E-020.5000E-020.2634E-02
AD	8AD	9	10.2500E-020.5000E-020.2634E-02
AE	8AE	9	10.2500E-020.5000E-020.2634E-02
AF	8AF	9	10.2500E-020.5000E-020.2634E-02
AG	8AG	9	10.2500E-020.5000E-020.2634E-02
AH	8AH	9	10.2500E-020.5000E-020.2634E-02
AI	8AI	9	10.2500E-020.5000E-020.2634E-02
AJ	8AJ	9	10.2500E-020.5000E-020.2634E-02
AK	8AK	9	10.2500E-020.5000E-020.2634E-02
AL	8AL	9	10.2500E-020.5000E-020.2634E-02
AM	8AM	9	10.2500E-020.5000E-020.2634E-02
AN	8AN	9	10.2500E-020.5000E-020.2634E-02
AO	8AO	9	10.2500E-020.5000E-020.5268E-02
AP	8AP	9	10.2500E-020.5000E-020.5268E-02
AQ	8AQ	9	10.2500E-020.5000E-020.5268E-02
A1	9A1	10	10.5000E-020.1000E-010.1383E-01
A2	9A2	10	10.5000E-020.1000E-010.1383E-01
A3	9A3	10	10.5000E-020.1000E-010.1383E-01
A4	9A4	10	10.5000E-020.1000E-010.1383E-01
A5	9A5	10	10.5000E-020.1000E-010.7902E-02
A6	9A6	10	10.5000E-020.1000E-010.3951E-02
A7	9A7	10	10.5000E-020.1000E-010.3951E-02
A8	9A8	10	10.5000E-020.1000E-010.3951E-02
A9	9A9	10	10.5000E-020.1000E-010.3951E-02
AA	9AA	10	10.5000E-020.1000E-010.3951E-02
AB	9AB	10	10.5000E-020.1000E-010.3951E-02
AC	9AC	10	10.5000E-020.1000E-010.3951E-02
AD	9AD	10	10.5000E-020.1000E-010.3951E-02
AE	9AE	10	10.5000E-020.1000E-010.3951E-02
AF	9AF	10	10.5000E-020.1000E-010.3951E-02
AG	9AG	10	10.5000E-020.1000E-010.3951E-02
AH	9AH	10	10.5000E-020.1000E-010.3951E-02
AI	9AI	10	10.5000E-020.1000E-010.3951E-02
AJ	9AJ	10	10.5000E-020.1000E-010.3951E-02
AK	9AK	10	10.5000E-020.1000E-010.3951E-02
AL	9AL	10	10.5000E-020.1000E-010.3951E-02
AM	9AM	10	10.5000E-020.1000E-010.3951E-02
AN	9AN	10	10.5000E-020.1000E-010.3951E-02
AO	9AO	10	10.5000E-020.1000E-010.7902E-02

```
AP  9AP 10                    10.5000E-020.1000E-010.7902E-02
AQ  9AQ 10                    10.5000E-020.1000E-010.7902E-02
A1 10A1 11                    10.1000E-010.1181E-010.2305E-01
A2 10A2 11                    10.1000E-010.1181E-010.2305E-01
A3 10A3 11                    10.1000E-010.1181E-010.2305E-01
A4 10A4 11                    10.1000E-010.1181E-010.2305E-01
A5 10A5 11                    10.1000E-010.1181E-010.1317E-01
A6 10A6 11                    10.1000E-010.1181E-010.6585E-02
A7 10A7 11                    10.1000E-010.1181E-010.6585E-02
A8 10A8 11                    10.1000E-010.1181E-010.6585E-02
A9 10A9 11                    10.1000E-010.1181E-010.6585E-02
AA 10AA 11                    10.1000E-010.1181E-010.6585E-02
AB 10AB 11                    10.1000E-010.1181E-010.6585E-02
AC 10AC 11                    10.1000E-010.1181E-010.6585E-02
AD 10AD 11                    10.1000E-010.1181E-010.6585E-02
AE 10AE 11                    10.1000E-010.1181E-010.6585E-02
AF 10AF 11                    10.1000E-010.1181E-010.6585E-02
AG 10AG 11                    10.1000E-010.1181E-010.6585E-02
AH 10AH 11                    10.1000E-010.1181E-010.6585E-02
AI 10AI 11                    10.1000E-010.1181E-010.6585E-02
AJ 10AJ 11                    10.1000E-010.1181E-010.6585E-02
AK 10AK 11                    10.1000E-010.1181E-010.6585E-02
AL 10AL 11                    10.1000E-010.1181E-010.6585E-02
AM 10AM 11                    10.1000E-010.1181E-010.6585E-02
AN 10AN 11                    10.1000E-010.1181E-010.6585E-02
AO 10AO 11                    10.1000E-010.1181E-010.1317E-01
AP 10AP 11                    10.1000E-010.1181E-010.1317E-01
AQ 10AQ 11                    10.1000E-010.1181E-010.1317E-01
A1 11A1 12                    10.1181E-010.1394E-010.3393E-01
A2 11A2 12                    10.1181E-010.1394E-010.3393E-01
A3 11A3 12                    10.1181E-010.1394E-010.3393E-01
A4 11A4 12                    10.1181E-010.1394E-010.3393E-01
A5 11A5 12                    10.1181E-010.1394E-010.1939E-01
A6 11A6 12                    10.1181E-010.1394E-010.9694E-02
A7 11A7 12                    10.1181E-010.1394E-010.9694E-02
A8 11A8 12                    10.1181E-010.1394E-010.9694E-02
A9 11A9 12                    10.1181E-010.1394E-010.9694E-02
AA 11AA 12                    10.1181E-010.1394E-010.9694E-02
AB 11AB 12                    10.1181E-010.1394E-010.9694E-02
AC 11AC 12                    10.1181E-010.1394E-010.9694E-02
AD 11AD 12                    10.1181E-010.1394E-010.9694E-02
AE 11AE 12                    10.1181E-010.1394E-010.9694E-02
AF 11AF 12                    10.1181E-010.1394E-010.9694E-02
AG 11AG 12                    10.1181E-010.1394E-010.9694E-02
AH 11AH 12                    10.1181E-010.1394E-010.9694E-02
AI 11AI 12                    10.1181E-010.1394E-010.9694E-02
AJ 11AJ 12                    10.1181E-010.1394E-010.9694E-02
AK 11AK 12                    10.1181E-010.1394E-010.9694E-02
AL 11AL 12                    10.1181E-010.1394E-010.9694E-02
AM 11AM 12                    10.1181E-010.1394E-010.9694E-02
AN 11AN 12                    10.1181E-010.1394E-010.9694E-02
AO 11AO 12                    10.1181E-010.1394E-010.1939E-01
AP 11AP 12                    10.1181E-010.1394E-010.1939E-01
AQ 11AQ 12                    10.1181E-010.1394E-010.1939E-01
A1 12A1 13                    10.1394E-010.1645E-010.4678E-01
A2 12A2 13                    10.1394E-010.1645E-010.4678E-01
A3 12A3 13                    10.1394E-010.1645E-010.4678E-01
```

A4	12A4	13	10.1394E-010.1645E-010.4678E-01
A5	12A5	13	10.1394E-010.1645E-010.2673E-01
A6	12A6	13	10.1394E-010.1645E-010.1337E-01
A7	12A7	13	10.1394E-010.1645E-010.1337E-01
A8	12A8	13	10.1394E-010.1645E-010.1337E-01
A9	12A9	13	10.1394E-010.1645E-010.1337E-01
AA	12AA	13	10.1394E-010.1645E-010.1337E-01
AB	12AB	13	10.1394E-010.1645E-010.1337E-01
AC	12AC	13	10.1394E-010.1645E-010.1337E-01
AD	12AD	13	10.1394E-010.1645E-010.1337E-01
AE	12AE	13	10.1394E-010.1645E-010.1337E-01
AF	12AF	13	10.1394E-010.1645E-010.1337E-01
AG	12AG	13	10.1394E-010.1645E-010.1337E-01
AH	12AH	13	10.1394E-010.1645E-010.1337E-01
AI	12AI	13	10.1394E-010.1645E-010.1337E-01
AJ	12AJ	13	10.1394E-010.1645E-010.1337E-01
AK	12AK	13	10.1394E-010.1645E-010.1337E-01
AL	12AL	13	10.1394E-010.1645E-010.1337E-01
AM	12AM	13	10.1394E-010.1645E-010.1337E-01
AN	12AN	13	10.1394E-010.1645E-010.1337E-01
AO	12AO	13	10.1394E-010.1645E-010.2673E-01
AP	12AP	13	10.1394E-010.1645E-010.2673E-01
AQ	12AQ	13	10.1394E-010.1645E-010.2673E-01
A1	13A1	14	10.1645E-010.1942E-010.6195E-01
A2	13A2	14	10.1645E-010.1942E-010.6195E-01
A3	13A3	14	10.1645E-010.1942E-010.6195E-01
A4	13A4	14	10.1645E-010.1942E-010.6195E-01
A5	13A5	14	10.1645E-010.1942E-010.3540E-01
A6	13A6	14	10.1645E-010.1942E-010.1770E-01
A7	13A7	14	10.1645E-010.1942E-010.1770E-01
A8	13A8	14	10.1645E-010.1942E-010.1770E-01
A9	13A9	14	10.1645E-010.1942E-010.1770E-01
AA	13AA	14	10.1645E-010.1942E-010.1770E-01
AB	13AB	14	10.1645E-010.1942E-010.1770E-01
AC	13AC	14	10.1645E-010.1942E-010.1770E-01
AD	13AD	14	10.1645E-010.1942E-010.1770E-01
AE	13AE	14	10.1645E-010.1942E-010.1770E-01
AF	13AF	14	10.1645E-010.1942E-010.1770E-01
AG	13AG	14	10.1645E-010.1942E-010.1770E-01
AH	13AH	14	10.1645E-010.1942E-010.1770E-01
AI	13AI	14	10.1645E-010.1942E-010.1770E-01
AJ	13AJ	14	10.1645E-010.1942E-010.1770E-01
AK	13AK	14	10.1645E-010.1942E-010.1770E-01
AL	13AL	14	10.1645E-010.1942E-010.1770E-01
AM	13AM	14	10.1645E-010.1942E-010.1770E-01
AN	13AN	14	10.1645E-010.1942E-010.1770E-01
AO	13AO	14	10.1645E-010.1942E-010.3540E-01
AP	13AP	14	10.1645E-010.1942E-010.3540E-01
AQ	13AQ	14	10.1645E-010.1942E-010.3540E-01
A1	14A1	15	10.1942E-010.2293E-010.7985E-01
A2	14A2	15	10.1942E-010.2293E-010.7985E-01
A3	14A3	15	10.1942E-010.2293E-010.7985E-01
A4	14A4	15	10.1942E-010.2293E-010.7985E-01
A5	14A5	15	10.1942E-010.2293E-010.4563E-01
A6	14A6	15	10.1942E-010.2293E-010.2281E-01
A7	14A7	15	10.1942E-010.2293E-010.2281E-01
A8	14A8	15	10.1942E-010.2293E-010.2281E-01

```
A9 14A9 15                    10.1942E-010.2293E-010.2281E-01
AA 14AA 15                    10.1942E-010.2293E-010.2281E-01
AB 14AB 15                    10.1942E-010.2293E-010.2281E-01
AC 14AC 15                    10.1942E-010.2293E-010.2281E-01
AD 14AD 15                    10.1942E-010.2293E-010.2281E-01
AE 14AE 15                    10.1942E-010.2293E-010.2281E-01
AF 14AF 15                    10.1942E-010.2293E-010.2281E-01
AG 14AG 15                    10.1942E-010.2293E-010.2281E-01
AH 14AH 15                    10.1942E-010.2293E-010.2281E-01
AI 14AI 15                    10.1942E-010.2293E-010.2281E-01
AJ 14AJ 15                    10.1942E-010.2293E-010.2281E-01
AK 14AK 15                    10.1942E-010.2293E-010.2281E-01
AL 14AL 15                    10.1942E-010.2293E-010.2281E-01
AM 14AM 15                    10.1942E-010.2293E-010.2281E-01
AN 14AN 15                    10.1942E-010.2293E-010.2281E-01
AO 14AO 15                    10.1942E-010.2293E-010.4563E-01
AP 14AP 15                    10.1942E-010.2293E-010.4563E-01
AQ 14AQ 15                    10.1942E-010.2293E-010.4563E-01
A1 15A1 16                    10.2293E-010.5000E-050.1010E+00
A2 15A2 16                    10.2293E-010.5000E-050.1010E+00
A3 15A3 16                    10.2293E-010.5000E-050.1010E+00
A4 15A4 16                    10.2293E-010.5000E-050.1010E+00
A5 15A5 16                    10.2293E-010.5000E-050.5771E-01
A6 15A6 16                    10.2293E-010.5000E-050.2885E-01
A7 15A7 16                    10.2293E-010.5000E-050.2885E-01
A8 15A8 16                    10.2293E-010.5000E-050.2885E-01
A9 15A9 16                    10.2293E-010.5000E-050.2885E-01
AA 15AA 16                    10.2293E-010.5000E-050.2885E-01
AB 15AB 16                    10.2293E-010.5000E-050.2885E-01
AC 15AC 16                    10.2293E-010.5000E-050.2885E-01
AD 15AD 16                    10.2293E-010.5000E-050.2885E-01
AE 15AE 16                    10.2293E-010.5000E-050.2885E-01
AF 15AF 16                    10.2293E-010.5000E-050.2885E-01
AG 15AG 16                    10.2293E-010.5000E-050.2885E-01
AH 15AH 16                    10.2293E-010.5000E-050.2885E-01
AI 15AI 16                    10.2293E-010.5000E-050.2885E-01
AJ 15AJ 16                    10.2293E-010.5000E-050.2885E-01
AK 15AK 16                    10.2293E-010.5000E-050.2885E-01
AL 15AL 16                    10.2293E-010.5000E-050.2885E-01
AM 15AM 16                    10.2293E-010.5000E-050.2885E-01
AN 15AN 16                    10.2293E-010.5000E-050.2885E-01
AO 15AO 16                    10.2293E-010.5000E-050.5771E-01
AP 15AP 16                    10.2293E-010.5000E-050.5771E-01
AQ 15AQ 16                    10.2293E-010.5000E-050.5771E-01
A1  2A2  2                    30.3668E-010.3668E-010.4013E-041.
A2  2A3  2                    30.3668E-010.3668E-010.4013E-041.
A3  2A4  2                    30.3668E-010.3668E-010.4013E-041.
A4  2A5  2                    30.3668E-010.2096E-010.4013E-041.
A5  2A6  2                    30.2096E-010.1048E-010.4013E-041.
A6  2A7  2                    30.1048E-010.1048E-010.4013E-041.
A7  2A8  2                    30.1048E-010.1048E-010.4013E-041.
A8  2A9  2                    30.1048E-010.1048E-010.4013E-041.
A9  2AA  2                    30.1048E-010.1048E-010.4013E-041.
AA  2AB  2                    30.1048E-010.1048E-010.4013E-041.
AB  2AC  2                    30.1048E-010.1048E-010.4013E-041.
AC  2AD  2                    30.1048E-010.1048E-010.4013E-041.
AD  2AE  2                    30.1048E-010.1048E-010.4013E-041.
```

AE	2AF	2	30.1048E-010.1048E-010.4013E-041.
AF	2AG	2	30.1048E-010.1048E-010.4013E-041.
AG	2AH	2	30.1048E-010.1048E-010.4013E-041.
AH	2AI	2	30.1048E-010.1048E-010.4013E-041.
AI	2AJ	2	30.1048E-010.1048E-010.4013E-041.
AJ	2AK	2	30.1048E-010.1048E-010.4013E-041.
AK	2AL	2	30.1048E-010.1048E-010.4013E-041.
AL	2AM	2	30.1048E-010.1048E-010.4013E-041.
AM	2AN	2	30.1048E-010.1048E-010.4013E-041.
AN	2AO	2	30.1048E-010.2096E-010.4013E-041.
AO	2AP	2	30.2096E-010.2096E-010.4013E-041.
AP	2AQ	2	30.2096E-010.2096E-010.4013E-041.
AQ	2AR	2	30.2096E-010.5000E-050.4013E-041.
A1	3A2	3	30.3668E-010.3668E-010.4278E-041.
A2	3A3	3	30.3668E-010.3668E-010.4278E-041.
A3	3A4	3	30.3668E-010.3668E-010.4278E-041.
A4	3A5	3	30.3668E-010.2096E-010.4278E-041.
A5	3A6	3	30.2096E-010.1048E-010.4278E-041.
A6	3A7	3	30.1048E-010.1048E-010.4278E-041.
A7	3A8	3	30.1048E-010.1048E-010.4278E-041.
A8	3A9	3	30.1048E-010.1048E-010.4278E-041.
A9	3AA	3	30.1048E-010.1048E-010.4278E-041.
AA	3AB	3	30.1048E-010.1048E-010.4278E-041.
AB	3AC	3	30.1048E-010.1048E-010.4278E-041.
AC	3AD	3	30.1048E-010.1048E-010.4278E-041.
AD	3AE	3	30.1048E-010.1048E-010.4278E-041.
AE	3AF	3	30.1048E-010.1048E-010.4278E-041.
AF	3AG	3	30.1048E-010.1048E-010.4278E-041.
AG	3AH	3	30.1048E-010.1048E-010.4278E-041.
AH	3AI	3	30.1048E-010.1048E-010.4278E-041.
AI	3AJ	3	30.1048E-010.1048E-010.4278E-041.
AJ	3AK	3	30.1048E-010.1048E-010.4278E-041.
AK	3AL	3	30.1048E-010.1048E-010.4278E-041.
AL	3AM	3	30.1048E-010.1048E-010.4278E-041.
AM	3AN	3	30.1048E-010.1048E-010.4278E-041.
AN	3AO	3	30.1048E-010.2096E-010.4278E-041.
AO	3AP	3	30.2096E-010.2096E-010.4278E-041.
AP	3AQ	3	30.2096E-010.2096E-010.4278E-041.
AQ	3AR	3	30.2096E-010.5000E-050.4278E-041.
A1	4A2	4	30.3668E-010.3668E-010.4544E-041.
A2	4A3	4	30.3668E-010.3668E-010.4544E-041.
A3	4A4	4	30.3668E-010.3668E-010.4544E-041.
A4	4A5	4	30.3668E-010.2096E-010.4544E-041.
A5	4A6	4	30.2096E-010.1048E-010.4544E-041.
A6	4A7	4	30.1048E-010.1048E-010.4544E-041.
A7	4A8	4	30.1048E-010.1048E-010.4544E-041.
A8	4A9	4	30.1048E-010.1048E-010.4544E-041.
A9	4AA	4	30.1048E-010.1048E-010.4544E-041.
AA	4AB	4	30.1048E-010.1048E-010.4544E-041.
AB	4AC	4	30.1048E-010.1048E-010.4544E-041.
AC	4AD	4	30.1048E-010.1048E-010.4544E-041.
AD	4AE	4	30.1048E-010.1048E-010.4544E-041.
AE	4AF	4	30.1048E-010.1048E-010.4544E-041.
AF	4AG	4	30.1048E-010.1048E-010.4544E-041.
AG	4AH	4	30.1048E-010.1048E-010.4544E-041.
AH	4AI	4	30.1048E-010.1048E-010.4544E-041.
AI	4AJ	4	30.1048E-010.1048E-010.4544E-041.

AJ	4AK	4	30.1048E-010.1048E-010.4544E-041.
AK	4AL	4	30.1048E-010.1048E-010.4544E-041.
AL	4AM	4	30.1048E-010.1048E-010.4544E-041.
AM	4AN	4	30.1048E-010.1048E-010.4544E-041.
AN	4AO	4	30.1048E-010.2096E-010.4544E-041.
AO	4AP	4	30.2096E-010.2096E-010.4544E-041.
AP	4AQ	4	30.2096E-010.2096E-010.4544E-041.
AQ	4AR	4	30.2096E-010.5000E-050.4544E-041.
A1	5A2	5	30.3668E-010.3668E-010.4809E-041.
A2	5A3	5	30.3668E-010.3668E-010.4809E-041.
A3	5A4	5	30.3668E-010.3668E-010.4809E-041.
A4	5A5	5	30.3668E-010.2096E-010.4809E-041.
A5	5A6	5	30.2096E-010.1048E-010.4809E-041.
A6	5A7	5	30.1048E-010.1048E-010.4809E-041.
A7	5A8	5	30.1048E-010.1048E-010.4809E-041.
A8	5A9	5	30.1048E-010.1048E-010.4809E-041.
A9	5AA	5	30.1048E-010.1048E-010.4809E-041.
AA	5AB	5	30.1048E-010.1048E-010.4809E-041.
AB	5AC	5	30.1048E-010.1048E-010.4809E-041.
AC	5AD	5	30.1048E-010.1048E-010.4809E-041.
AD	5AE	5	30.1048E-010.1048E-010.4809E-041.
AE	5AF	5	30.1048E-010.1048E-010.4809E-041.
AF	5AG	5	30.1048E-010.1048E-010.4809E-041.
AG	5AH	5	30.1048E-010.1048E-010.4809E-041.
AH	5AI	5	30.1048E-010.1048E-010.4809E-041.
AI	5AJ	5	30.1048E-010.1048E-010.4809E-041.
AJ	5AK	5	30.1048E-010.1048E-010.4809E-041.
AK	5AL	5	30.1048E-010.1048E-010.4809E-041.
AL	5AM	5	30.1048E-010.1048E-010.4809E-041.
AM	5AN	5	30.1048E-010.1048E-010.4809E-041.
AN	5AO	5	30.1048E-010.2096E-010.4809E-041.
AO	5AP	5	30.2096E-010.2096E-010.4809E-041.
AP	5AQ	5	30.2096E-010.2096E-010.4809E-041.
AQ	5AR	5	30.2096E-010.5000E-050.4809E-041.
A1	6A2	6	30.3668E-010.3668E-010.5074E-041.
A2	6A3	6	30.3668E-010.3668E-010.5074E-041.
A3	6A4	6	30.3668E-010.3668E-010.5074E-041.
A4	6A5	6	30.3668E-010.2096E-010.5074E-041.
A5	6A6	6	30.2096E-010.1048E-010.5074E-041.
A6	6A7	6	30.1048E-010.1048E-010.5074E-041.
A7	6A8	6	30.1048E-010.1048E-010.5074E-041.
A8	6A9	6	30.1048E-010.1048E-010.5074E-041.
A9	6AA	6	30.1048E-010.1048E-010.5074E-041.
AA	6AB	6	30.1048E-010.1048E-010.5074E-041.
AB	6AC	6	30.1048E-010.1048E-010.5074E-041.
AC	6AD	6	30.1048E-010.1048E-010.5074E-041.
AD	6AE	6	30.1048E-010.1048E-010.5074E-041.
AE	6AF	6	30.1048E-010.1048E-010.5074E-041.
AF	6AG	6	30.1048E-010.1048E-010.5074E-041.
AG	6AH	6	30.1048E-010.1048E-010.5074E-041.
AH	6AI	6	30.1048E-010.1048E-010.5074E-041.
AI	6AJ	6	30.1048E-010.1048E-010.5074E-041.
AJ	6AK	6	30.1048E-010.1048E-010.5074E-041.
AK	6AL	6	30.1048E-010.1048E-010.5074E-041.
AL	6AM	6	30.1048E-010.1048E-010.5074E-041.
AM	6AN	6	30.1048E-010.1048E-010.5074E-041.
AN	6AO	6	30.1048E-010.2096E-010.5074E-041.

AO	6AP	6	30.2096E-010.2096E-010.5074E-041.
AP	6AQ	6	30.2096E-010.2096E-010.5074E-041.
AQ	6AR	6	30.2096E-010.5000E-050.5074E-041.
A1	7A2	7	30.3668E-010.3668E-010.1962E-031.
A2	7A3	7	30.3668E-010.3668E-010.1962E-031.
A3	7A4	7	30.3668E-010.3668E-010.1962E-031.
A4	7A5	7	30.3668E-010.2096E-010.1962E-031.
A5	7A6	7	30.2096E-010.1048E-010.1962E-031.
A6	7A7	7	30.1048E-010.1048E-010.1962E-031.
A7	7A8	7	30.1048E-010.1048E-010.1962E-031.
A8	7A9	7	30.1048E-010.1048E-010.1962E-031.
A9	7AA	7	30.1048E-010.1048E-010.1962E-031.
AA	7AB	7	30.1048E-010.1048E-010.1962E-031.
AB	7AC	7	30.1048E-010.1048E-010.1962E-031.
AC	7AD	7	30.1048E-010.1048E-010.1962E-031.
AD	7AE	7	30.1048E-010.1048E-010.1962E-031.
AE	7AF	7	30.1048E-010.1048E-010.1962E-031.
AF	7AG	7	30.1048E-010.1048E-010.1962E-031.
AG	7AH	7	30.1048E-010.1048E-010.1962E-031.
AH	7AI	7	30.1048E-010.1048E-010.1962E-031.
AI	7AJ	7	30.1048E-010.1048E-010.1962E-031.
AJ	7AK	7	30.1048E-010.1048E-010.1962E-031.
AK	7AL	7	30.1048E-010.1048E-010.1962E-031.
AL	7AM	7	30.1048E-010.1048E-010.1962E-031.
AM	7AN	7	30.1048E-010.1048E-010.1962E-031.
AN	7AO	7	30.1048E-010.2096E-010.1962E-031.
AO	7AP	7	30.2096E-010.2096E-010.1962E-031.
AP	7AQ	7	30.2096E-010.2096E-010.1962E-031.
AQ	7AR	7	30.2096E-010.5000E-050.1962E-031.
A1	8A2	8	30.3668E-010.3668E-010.5498E-031.
A2	8A3	8	30.3668E-010.3668E-010.5498E-031.
A3	8A4	8	30.3668E-010.3668E-010.5498E-031.
A4	8A5	8	30.3668E-010.2096E-010.5498E-031.
A5	8A6	8	30.2096E-010.1048E-010.5498E-031.
A6	8A7	8	30.1048E-010.1048E-010.5498E-031.
A7	8A8	8	30.1048E-010.1048E-010.5498E-031.
A8	8A9	8	30.1048E-010.1048E-010.5498E-031.
A9	8AA	8	30.1048E-010.1048E-010.5498E-031.
AA	8AB	8	30.1048E-010.1048E-010.5498E-031.
AB	8AC	8	30.1048E-010.1048E-010.5498E-031.
AC	8AD	8	30.1048E-010.1048E-010.5498E-031.
AD	8AE	8	30.1048E-010.1048E-010.5498E-031.
AE	8AF	8	30.1048E-010.1048E-010.5498E-031.
AF	8AG	8	30.1048E-010.1048E-010.5498E-031.
AG	8AH	8	30.1048E-010.1048E-010.5498E-031.
AH	8AI	8	30.1048E-010.1048E-010.5498E-031.
AI	8AJ	8	30.1048E-010.1048E-010.5498E-031.
AJ	8AK	8	30.1048E-010.1048E-010.5498E-031.
AK	8AL	8	30.1048E-010.1048E-010.5498E-031.
AL	8AM	8	30.1048E-010.1048E-010.5498E-031.
AM	8AN	8	30.1048E-010.1048E-010.5498E-031.
AN	8AO	8	30.1048E-010.2096E-010.5498E-031.
AO	8AP	8	30.2096E-010.2096E-010.5498E-031.
AP	8AQ	8	30.2096E-010.2096E-010.5498E-031.
AQ	8AR	8	30.2096E-010.5000E-050.5498E-031.
A1	9A2	9	30.3668E-010.3668E-010.1571E-021.
A2	9A3	9	30.3668E-010.3668E-010.1571E-021.

```
A3  9A4  9                    30.3668E-010.3668E-010.1571E-021.
A4  9A5  9                    30.3668E-010.2096E-010.1571E-021.
A5  9A6  9                    30.2096E-010.1048E-010.1571E-021.
A6  9A7  9                    30.1048E-010.1048E-010.1571E-021.
A7  9A8  9                    30.1048E-010.1048E-010.1571E-021.
A8  9A9  9                    30.1048E-010.1048E-010.1571E-021.
A9  9AA  9                    30.1048E-010.1048E-010.1571E-021.
AA  9AB  9                    30.1048E-010.1048E-010.1571E-021.
AB  9AC  9                    30.1048E-010.1048E-010.1571E-021.
AC  9AD  9                    30.1048E-010.1048E-010.1571E-021.
AD  9AE  9                    30.1048E-010.1048E-010.1571E-021.
AE  9AF  9                    30.1048E-010.1048E-010.1571E-021.
AF  9AG  9                    30.1048E-010.1048E-010.1571E-021.
AG  9AH  9                    30.1048E-010.1048E-010.1571E-021.
AH  9AI  9                    30.1048E-010.1048E-010.1571E-021.
AI  9AJ  9                    30.1048E-010.1048E-010.1571E-021.
AJ  9AK  9                    30.1048E-010.1048E-010.1571E-021.
AK  9AL  9                    30.1048E-010.1048E-010.1571E-021.
AL  9AM  9                    30.1048E-010.1048E-010.1571E-021.
AM  9AN  9                    30.1048E-010.1048E-010.1571E-021.
AN  9AO  9                    30.1048E-010.2096E-010.1571E-021.
AO  9AP  9                    30.2096E-010.2096E-010.1571E-021.
AP  9AQ  9                    30.2096E-010.2096E-010.1571E-021.
AQ  9AR  9                    30.2096E-010.5000E-050.1571E-021.
A1 10A2 10                    30.3668E-010.3668E-010.5027E-021.
A2 10A3 10                    30.3668E-010.3668E-010.5027E-021.
A3 10A4 10                    30.3668E-010.3668E-010.5027E-021.
A4 10A5 10                    30.3668E-010.2096E-010.5027E-021.
A5 10A6 10                    30.2096E-010.1048E-010.5027E-021.
A6 10A7 10                    30.1048E-010.1048E-010.5027E-021.
A7 10A8 10                    30.1048E-010.1048E-010.5027E-021.
A8 10A9 10                    30.1048E-010.1048E-010.5027E-021.
A9 10AA 10                    30.1048E-010.1048E-010.5027E-021.
AA 10AB 10                    30.1048E-010.1048E-010.5027E-021.
AB 10AC 10                    30.1048E-010.1048E-010.5027E-021.
AC 10AD 10                    30.1048E-010.1048E-010.5027E-021.
AD 10AE 10                    30.1048E-010.1048E-010.5027E-021.
AE 10AF 10                    30.1048E-010.1048E-010.5027E-021.
AF 10AG 10                    30.1048E-010.1048E-010.5027E-021.
AG 10AH 10                    30.1048E-010.1048E-010.5027E-021.
AH 10AI 10                    30.1048E-010.1048E-010.5027E-021.
AI 10AJ 10                    30.1048E-010.1048E-010.5027E-021.
AJ 10AK 10                    30.1048E-010.1048E-010.5027E-021.
AK 10AL 10                    30.1048E-010.1048E-010.5027E-021.
AL 10AM 10                    30.1048E-010.1048E-010.5027E-021.
AM 10AN 10                    30.1048E-010.1048E-010.5027E-021.
AN 10AO 10                    30.1048E-010.2096E-010.5027E-021.
AO 10AP 10                    30.2096E-010.2096E-010.5027E-021.
AP 10AQ 10                    30.2096E-010.2096E-010.5027E-021.
AQ 10AR 10                    30.2096E-010.5000E-050.5027E-021.
A1 11A2 11                    30.3668E-010.3668E-010.9169E-021.
A2 11A3 11                    30.3668E-010.3668E-010.9169E-021.
A3 11A4 11                    30.3668E-010.3668E-010.9169E-021.
A4 11A5 11                    30.3668E-010.2096E-010.9169E-021.
A5 11A6 11                    30.2096E-010.1048E-010.9169E-021.
A6 11A7 11                    30.1048E-010.1048E-010.9169E-021.
A7 11A8 11                    30.1048E-010.1048E-010.9169E-021.
```

```
A8 11A9 11                    30.1048E-010.1048E-010.9169E-021.
A9 11AA 11                    30.1048E-010.1048E-010.9169E-021.
AA 11AB 11                    30.1048E-010.1048E-010.9169E-021.
AB 11AC 11                    30.1048E-010.1048E-010.9169E-021.
AC 11AD 11                    30.1048E-010.1048E-010.9169E-021.
AD 11AE 11                    30.1048E-010.1048E-010.9169E-021.
AE 11AF 11                    30.1048E-010.1048E-010.9169E-021.
AF 11AG 11                    30.1048E-010.1048E-010.9169E-021.
AG 11AH 11                    30.1048E-010.1048E-010.9169E-021.
AH 11AI 11                    30.1048E-010.1048E-010.9169E-021.
AI 11AJ 11                    30.1048E-010.1048E-010.9169E-021.
AJ 11AK 11                    30.1048E-010.1048E-010.9169E-021.
AK 11AL 11                    30.1048E-010.1048E-010.9169E-021.
AL 11AM 11                    30.1048E-010.1048E-010.9169E-021.
AM 11AN 11                    30.1048E-010.1048E-010.9169E-021.
AN 11AO 11                    30.1048E-010.2096E-010.9169E-021.
AO 11AP 11                    30.2096E-010.2096E-010.9169E-021.
AP 11AQ 11                    30.2096E-010.2096E-010.9169E-021.
AQ 11AR 11                    30.2096E-010.5000E-050.9169E-021.
A1 12A2 12                    30.3668E-010.3668E-010.1533E-011.
A2 12A3 12                    30.3668E-010.3668E-010.1533E-011.
A3 12A4 12                    30.3668E-010.3668E-010.1533E-011.
A4 12A5 12                    30.3668E-010.2096E-010.1533E-011.
A5 12A6 12                    30.2096E-010.1048E-010.1533E-011.
A6 12A7 12                    30.1048E-010.1048E-010.1533E-011.
A7 12A8 12                    30.1048E-010.1048E-010.1533E-011.
A8 12A9 12                    30.1048E-010.1048E-010.1533E-011.
A9 12AA 12                    30.1048E-010.1048E-010.1533E-011.
AA 12AB 12                    30.1048E-010.1048E-010.1533E-011.
AB 12AC 12                    30.1048E-010.1048E-010.1533E-011.
AC 12AD 12                    30.1048E-010.1048E-010.1533E-011.
AD 12AE 12                    30.1048E-010.1048E-010.1533E-011.
AE 12AF 12                    30.1048E-010.1048E-010.1533E-011.
AF 12AG 12                    30.1048E-010.1048E-010.1533E-011.
AG 12AH 12                    30.1048E-010.1048E-010.1533E-011.
AH 12AI 12                    30.1048E-010.1048E-010.1533E-011.
AI 12AJ 12                    30.1048E-010.1048E-010.1533E-011.
AJ 12AK 12                    30.1048E-010.1048E-010.1533E-011.
AK 12AL 12                    30.1048E-010.1048E-010.1533E-011.
AL 12AM 12                    30.1048E-010.1048E-010.1533E-011.
AM 12AN 12                    30.1048E-010.1048E-010.1533E-011.
AN 12AO 12                    30.1048E-010.2096E-010.1533E-011.
AO 12AP 12                    30.2096E-010.2096E-010.1533E-011.
AP 12AQ 12                    30.2096E-010.2096E-010.1533E-011.
AQ 12AR 12                    30.2096E-010.5000E-050.1533E-011.
A1 13A2 13                    30.3668E-010.3668E-010.2438E-011.
A2 13A3 13                    30.3668E-010.3668E-010.2438E-011.
A3 13A4 13                    30.3668E-010.3668E-010.2438E-011.
A4 13A5 13                    30.3668E-010.2096E-010.2438E-011.
A5 13A6 13                    30.2096E-010.1048E-010.2438E-011.
A6 13A7 13                    30.1048E-010.1048E-010.2438E-011.
A7 13A8 13                    30.1048E-010.1048E-010.2438E-011.
A8 13A9 13                    30.1048E-010.1048E-010.2438E-011.
A9 13AA 13                    30.1048E-010.1048E-010.2438E-011.
AA 13AB 13                    30.1048E-010.1048E-010.2438E-011.
AB 13AC 13                    30.1048E-010.1048E-010.2438E-011.
AC 13AD 13                    30.1048E-010.1048E-010.2438E-011.
```

AD	13AE 13	30.1048E-010.1048E-010.2438E-011.
AE	13AF 13	30.1048E-010.1048E-010.2438E-011.
AF	13AG 13	30.1048E-010.1048E-010.2438E-011.
AG	13AH 13	30.1048E-010.1048E-010.2438E-011.
AH	13AI 13	30.1048E-010.1048E-010.2438E-011.
AI	13AJ 13	30.1048E-010.1048E-010.2438E-011.
AJ	13AK 13	30.1048E-010.1048E-010.2438E-011.
AK	13AL 13	30.1048E-010.1048E-010.2438E-011.
AL	13AM 13	30.1048E-010.1048E-010.2438E-011.
AM	13AN 13	30.1048E-010.1048E-010.2438E-011.
AN	13AO 13	30.1048E-010.2096E-010.2438E-011.
AO	13AP 13	30.2096E-010.2096E-010.2438E-011.
AP	13AQ 13	30.2096E-010.2096E-010.2438E-011.
AQ	13AR 13	30.2096E-010.5000E-050.2438E-011.
A1	14A2 14	30.3668E-010.3668E-010.3754E-011.
A2	14A3 14	30.3668E-010.3668E-010.3754E-011.
A3	14A4 14	30.3668E-010.3668E-010.3754E-011.
A4	14A5 14	30.3668E-010.2096E-010.3754E-011.
A5	14A6 14	30.2096E-010.1048E-010.3754E-011.
A6	14A7 14	30.1048E-010.1048E-010.3754E-011.
A7	14A8 14	30.1048E-010.1048E-010.3754E-011.
A8	14A9 14	30.1048E-010.1048E-010.3754E-011.
A9	14AA 14	30.1048E-010.1048E-010.3754E-011.
AA	14AB 14	30.1048E-010.1048E-010.3754E-011.
AB	14AC 14	30.1048E-010.1048E-010.3754E-011.
AC	14AD 14	30.1048E-010.1048E-010.3754E-011.
AD	14AE 14	30.1048E-010.1048E-010.3754E-011.
AE	14AF 14	30.1048E-010.1048E-010.3754E-011.
AF	14AG 14	30.1048E-010.1048E-010.3754E-011.
AG	14AH 14	30.1048E-010.1048E-010.3754E-011.
AH	14AI 14	30.1048E-010.1048E-010.3754E-011.
AI	14AJ 14	30.1048E-010.1048E-010.3754E-011.
AJ	14AK 14	30.1048E-010.1048E-010.3754E-011.
AK	14AL 14	30.1048E-010.1048E-010.3754E-011.
AL	14AM 14	30.1048E-010.1048E-010.3754E-011.
AM	14AN 14	30.1048E-010.1048E-010.3754E-011.
AN	14AO 14	30.1048E-010.2096E-010.3754E-011.
AO	14AP 14	30.2096E-010.2096E-010.3754E-011.
AP	14AQ 14	30.2096E-010.2096E-010.3754E-011.
AQ	14AR 14	30.2096E-010.5000E-050.3754E-011.
A1	15A2 15	30.3668E-010.3668E-010.5653E-011.
A2	15A3 15	30.3668E-010.3668E-010.5653E-011.
A3	15A4 15	30.3668E-010.3668E-010.5653E-011.
A4	15A5 15	30.3668E-010.2096E-010.5653E-011.
A5	15A6 15	30.2096E-010.1048E-010.5653E-011.
A6	15A7 15	30.1048E-010.1048E-010.5653E-011.
A7	15A8 15	30.1048E-010.1048E-010.5653E-011.
A8	15A9 15	30.1048E-010.1048E-010.5653E-011.
A9	15AA 15	30.1048E-010.1048E-010.5653E-011.
AA	15AB 15	30.1048E-010.1048E-010.5653E-011.
AB	15AC 15	30.1048E-010.1048E-010.5653E-011.
AC	15AD 15	30.1048E-010.1048E-010.5653E-011.
AD	15AE 15	30.1048E-010.1048E-010.5653E-011.
AE	15AF 15	30.1048E-010.1048E-010.5653E-011.
AF	15AG 15	30.1048E-010.1048E-010.5653E-011.
AG	15AH 15	30.1048E-010.1048E-010.5653E-011.
AH	15AI 15	30.1048E-010.1048E-010.5653E-011.

```
AI 15AJ 15                    30.1048E-010.1048E-010.5653E-011.
AJ 15AK 15                    30.1048E-010.1048E-010.5653E-011.
AK 15AL 15                    30.1048E-010.1048E-010.5653E-011.
AL 15AM 15                    30.1048E-010.1048E-010.5653E-011.
AM 15AN 15                    30.1048E-010.1048E-010.5653E-011.
AN 15AO 15                    30.1048E-010.2096E-010.5653E-011.
AO 15AP 15                    30.2096E-010.2096E-010.5653E-011.
AP 15AQ 15                    30.2096E-010.2096E-010.5653E-011.
AQ 15AR 15                    30.2096E-010.5000E-050.5653E-011.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
MESHM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RZ2D ----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RADII
   11
        0.     .0095   .010150   .010800   .011450   .012100   .012750      .015
      .020       .03       .05
LOGAR----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5          .2191
EQUID
    1          1.e-5
LAYER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
   27
    .07336                                  .04192    .02096

                                                                          .04192
                          1.e-5

ENDFI----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*val3a* ... Validation Problem No.3.
START     Heat and mass flow with phase change
START     Kruger and Ramey (1974];  Faust and Mercer [1979]
START     7-10-92: George's latest data file
START              Boundary ring included
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
CORE     2     2650.      0.36    1.E-13    1.E-13    1.E-13      2.10     1010.
        0.        0.      2.10        1.
    3           0.30      0.05
    1             0.        0.        1.
TUBES    2     2650.      0.36        0.        0.        0.      2.10     1.E+6
        0.        0.      2.10        1.
    5
    1             0.        0.        1.
BOUND    2     2650.      0.10    1.E-13    1.E-13    1.E-13        0.     1.E30
        0.        0.        0.        1.
    5             0.
    1             0.        0.        1.

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
10 19999    99990000001 0000 0 60          2.13E-5      1.80
        0.      300.     2.E-4        5.A  98          0.000        2.        1.
     1.E-6        1.        .1        1.        1.     1.E-8
             2.17 E6                192.                  0.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5
    1             0.        0.        1.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1    6                 50.
       50.
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A   0   99    1CORE  1.2098E-5
B   0   99    1TUBES     1.E30
YY  1    0    0BOUND     1.E51

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A   0A   1   98    1    1    1 2.9845E-3 2.9845E-3 2.0268E-3        0.
A  99YY  1    0    0    0    1 2.9845E-3    1.E-10 2.0268E-3        0.
A   0B   0   99    1    1    2   7.44E-3    5.0E-3 9.5261E-4        1.

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
YY  1QQQ 1    0    0    0    2     MASS
            0.          300.
   -1.35395E49   -1.35395E49
YY  1QQQ 2    0    0    0    2     AIR 1
            0.          300.
            0.   1.526036E49
        98825.        98825.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
B   0   99    1
              2.17E6              198.9                    0.
A   0
              2.17E6              191.96                   0.
A   1
              2.17E6              191.88                   0.
```

A	2	2.17E6	191.80	0.
A	3	2.17E6	191.72	0.
A	4	2.17E6	191.64	0.
A	5	2.17E6	191.56	0.
A	6	2.17E6	191.48	0.
A	7	2.17E6	191.40	0.
A	8	2.17E6	191.32	0.
A	9	2.17E6	191.24	0.
A	10	2.17E6	191.16	0.
A	11	2.17E6	191.08	0.
A	12	2.17E6	191.00	0.
A	13	2.17E6	190.92	0.
A	14	2.17E6	190.84	0.
A	15	2.17E6	190.76	0.
A	16	2.17E6	190.68	0.
A	17	2.17E6	190.60	0.
A	18	2.17E6	190.52	0.
A	19	2.17E6	190.44	0.
A	20	2.17E6	190.36	0.
A	21	2.17E6	190.28	0.
A	22	2.17E6	190.20	0.
A	23	2.17E6	190.12	0.
A	24	2.17E6	190.04	0.
A	25	2.17E6	189.96	0.
A	26	2.17E6	189.88	0.
A	27	2.17E6	189.80	0.
A	28	2.17E6	189.72	0.
A	29	2.17E6	189.64	0.
A	30			

A	31	2.17E6	189.56	0.
A	32	2.17E6	189.48	0.
A	33	2.17E6	189.40	0.
A	34	2.17E6	189.32	0.
A	35	2.17E6	189.24	0.
A	36	2.17E6	189.16	0.
A	37	2.17E6	189.08	0.
A	38	2.17E6	189.00	0.
A	39	2.17E6	188.92	0.
A	40	2.17E6	188.84	0.
A	41	2.17E6	188.76	0.
A	42	2.17E6	188.68	0.
A	43	2.17E6	188.60	0.
A	44	2.17E6	188.52	0.
A	45	2.17E6	188.44	0.
A	46	2.17E6	188.36	0.
A	47	2.17E6	188.28	0.
A	48	2.17E6	188.20	0.
A	49	2.17E6	188.12	0.
A	50	2.17E6	188.04	0.
A	51	2.17E6	187.96	0.
A	52	2.17E6	187.88	0.
A	53	2.17E6	187.80	0.
A	54	2.17E6	187.72	0.
A	55	2.17E6	187.64	0.
A	56	2.17E6	187.56	0.
A	57	2.17E6	187.48	0.
A	58	2.17E6	187.40	0.
		2.17E6	187.32	0.

A	58		
		2.17E6	187.24	0.
A	60		
		2.17E6	187.16	0.
A	61		
		2.17E6	187.08	0.
A	62		
		2.17E6	187.00	0.
A	63		
		2.17E6	186.92	0.
A	64		
		2.17E6	186.84	0.
A	65		
		2.17E6	186.76	0.
A	66		
		2.17E6	186.68	0.
A	67		
		2.17E6	186.60	0.
A	68		
		2.17E6	186.52	0.
A	69		
		2.17E6	186.44	0.
A	70		
		2.17E6	186.36	0.
A	71		
		2.17E6	186.28	0.
A	72		
		2.17E6	186.20	0.
A	73		
		2.17E6	186.12	0.
A	74		
		2.17E6	186.04	0.
A	75		
		2.17E6	185.96	0.
A	76		
		2.17E6	185.88	0.
A	77		
		2.17E6	185.80	0.
A	78		
		2.17E6	185.72	0.
A	79		
		2.17E6	185.64	0.
A	80		
		2.17E6	185.56	0.
A	81		
		2.17E6	185.48	0.
A	82		
		2.17E6	185.40	0.
A	83		
		2.17E6	185.32	0.
A	84		
		2.17E6	185.24	0.
A	85		
		2.17E6	185.16	0.
A	86		
		2.17E6	185.08	0.
A	87		

```
                2.17E6              185.00                  0.
A  88
                2.17E6              184.92                  0.
A  89
                2.17E6              184.84                  0.
A  90
                2.17E6              184.76                  0.
A  91
                2.17E6              184.68                  0.
A  92
                2.17E6              184.60                  0.
A  93
                2.17E6              184.52                  0.
A  94
                2.17E6              184.44                  0.
A  95
                2.17E6              184.36                  0.
A  96
                2.17E6              184.28                  0.
A  97
                2.17E6              184.20                  0.
A  98
                2.17E6              184.12                  0.
A  99
                2.17E6              184.04                  0.
YY  1
            1.840965E6                 20.                  1.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*val3b* ... Validation Problem No.3.
START     Heat and mass flow with phase change
START     Kruger and Ramey (1974];  Faust and Mercer [1979]
START     7-10-92: George's latest data file
START              Boundary ring omitted
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
CORE     2     2650.      0.36    1.E-13    1.E-13    1.E-13      2.10     1010.
        0.        0.      2.10        1.
    3           0.30      0.05
    1             0.        0.        1.
BOUND    2     2650.      0.10    1.E-13    1.E-13    1.E-13        0.     1.E30
        0.        0.        0.        1.
    5             0.
    1             0.        0.        1.

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
10 19999    99990000001 0000 0 60          2.13E-5      1.80
        0.      300.     2.E-4        5.A  98          0.000        2.        1.
     1.E-6        1.        .1        1.        1.     1.E-8
             2.17 E6                192.                  0.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5
    1             0.        0.        1.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1    6                 50.
       50.
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A   0   99    1CORE  1.2098E-5
YY  1    0    0BOUND     1.E51

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A   0A   1   98    1    1    1 2.9845E-3 2.9845E-3 2.0268E-3        0.
A  99YY  1    0    0    0    1 2.9845E-3    1.E-10 2.0268E-3        0.

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
YY  1QQQ 1    0    0    0    2     MASS
            0.          300.
   -1.35395E49   -1.35395E49
YY  1QQQ 2    0    0    0    2     AIR 1
            0.          300.
            0.   1.526036E49
        98825.        98825.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A   0
             2.17E6              191.96                  0.
A   1
             2.17E6              191.88                  0.
A   2
             2.17E6              191.80                  0.
A   3
             2.17E6              191.72                  0.
A   4
             2.17E6              191.64                  0.
A   5
             2.17E6              191.56                  0.
```

A	6		
		2.17E6	191.48	0.
A	7		
		2.17E6	191.40	0.
A	8		
		2.17E6	191.32	0.
A	9		
		2.17E6	191.24	0.
A	10		
		2.17E6	191.16	0.
A	11		
		2.17E6	191.08	0.
A	12		
		2.17E6	191.00	0.
A	13		
		2.17E6	190.92	0.
A	14		
		2.17E6	190.84	0.
A	15		
		2.17E6	190.76	0.
A	16		
		2.17E6	190.68	0.
A	17		
		2.17E6	190.60	0.
A	18		
		2.17E6	190.52	0.
A	19		
		2.17E6	190.44	0.
A	20		
		2.17E6	190.36	0.
A	21		
		2.17E6	190.28	0.
A	22		
		2.17E6	190.20	0.
A	23		
		2.17E6	190.12	0.
A	24		
		2.17E6	190.04	0.
A	25		
		2.17E6	189.96	0.
A	26		
		2.17E6	189.88	0.
A	27		
		2.17E6	189.80	0.
A	28		
		2.17E6	189.72	0.
A	29		
		2.17E6	189.64	0.
A	30		
		2.17E6	189.56	0.
A	31		
		2.17E6	189.48	0.
A	32		
		2.17E6	189.40	0.
A	33		
		2.17E6	189.32	0.
A	34		

	2.17E6	189.24	0.
A 35			
	2.17E6	189.16	0.
A 36			
	2.17E6	189.08	0.
A 37			
	2.17E6	189.00	0.
A 38			
	2.17E6	188.92	0.
A 39			
	2.17E6	188.84	0.
A 40			
	2.17E6	188.76	0.
A 41			
	2.17E6	188.68	0.
A 42			
	2.17E6	188.60	0.
A 43			
	2.17E6	188.52	0.
A 44			
	2.17E6	188.44	0.
A 45			
	2.17E6	188.36	0.
A 46			
	2.17E6	188.28	0.
A 47			
	2.17E6	188.20	0.
A 48			
	2.17E6	188.12	0.
A 49			
	2.17E6	188.04	0.
A 50			
	2.17E6	187.96	0.
A 51			
	2.17E6	187.88	0.
A 52			
	2.17E6	187.80	0.
A 53			
	2.17E6	187.72	0.
A 54			
	2.17E6	187.64	0.
A 55			
	2.17E6	187.56	0.
A 56			
	2.17E6	187.48	0.
A 57			
	2.17E6	187.40	0.
A 58			
	2.17E6	187.32	0.
A 58			
	2.17E6	187.24	0.
A 60			
	2.17E6	187.16	0.
A 61			
	2.17E6	187.08	0.
A 62			
	2.17E6	187.00	0.

A	63		
		2.17E6	186.92	0.
A	64		
		2.17E6	186.84	0.
A	65		
		2.17E6	186.76	0.
A	66		
		2.17E6	186.68	0.
A	67		
		2.17E6	186.60	0.
A	68		
		2.17E6	186.52	0.
A	69		
		2.17E6	186.44	0.
A	70		
		2.17E6	186.36	0.
A	71		
		2.17E6	186.28	0.
A	72		
		2.17E6	186.20	0.
A	73		
		2.17E6	186.12	0.
A	74		
		2.17E6	186.04	0.
A	75		
		2.17E6	185.96	0.
A	76		
		2.17E6	185.88	0.
A	77		
		2.17E6	185.80	0.
A	78		
		2.17E6	185.72	0.
A	79		
		2.17E6	185.64	0.
A	80		
		2.17E6	185.56	0.
A	81		
		2.17E6	185.48	0.
A	82		
		2.17E6	185.40	0.
A	83		
		2.17E6	185.32	0.
A	84		
		2.17E6	185.24	0.
A	85		
		2.17E6	185.16	0.
A	86		
		2.17E6	185.08	0.
A	87		
		2.17E6	185.00	0.
A	88		
		2.17E6	184.92	0.
A	89		
		2.17E6	184.84	0.
A	90		
		2.17E6	184.76	0.
A	91		

```
                2.17E6              184.68                  0.
A  92
                2.17E6              184.60                  0.
A  93
                2.17E6              184.52                  0.
A  94
                2.17E6              184.44                  0.
A  95
                2.17E6              184.36                  0.
A  96
                2.17E6              184.28                  0.
A  97
                2.17E6              184.20                  0.
A  98
                2.17E6              184.12                  0.
A  99
                2.17E6              184.04                  0.
YY  1
           1.840965E6                 20.                  1.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver1a* ... Verification Problem No.1.
START     1-d infiltration after Philip (1955) - Ross et al. (1982)
START     Original data file supplied by S. Webb
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
TUBES     2385.     .45          1.2e-14                        1.045  1030.
BOUND     2650.     .45          1.2e-14                        1.045  10000.
RING     2     2650.       .45   1.2e-14                        1.045      1.e4

    1           .333       -.1        1.        0.
    1             0.      .333        1.

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 2 200 600  1000000010000000 4
            9504.0        -1.       5.e2f   1
      1.e0
     1.e-5     1.e-5                                  1.e-7
                1.e5         .5555555556 20.
START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1           .333       -.1        1.        0.
    1      9.79020e3      .333        1.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    3    3      5.e2
    8.64e2   5.184e3   9.504e3
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0          BOUND     1.e50
f   1   39    1TUBES     5.e-3
r   1   39    1RING      1.e50

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0f   1                   1    1.e-10   .0025       1.      0.
f   1f   2   38    1    1    1    .0025    .0025       1.      0.
f   1r   1   39    1    1    1    .0025    .0         10.      0.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0
                1.e5                 20.
r   1   39    1
                1.e5                 20.                  1.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver1b* ... Verification Problem No.1.
START     1-d infiltration after Philip (1955) - Ross et al. (1982)
START     Removal of second row of cells; upstream weighing (MOP(11)=0)
START     7-10-92: George's latest
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
TUBES     2385.     .45          1.2e-14                        1.045  1030.
BOUND     2650.     .45          1.2e-14                        1.045  10000.

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 2 200 600  1000000010001000 4
            9504.0        -1.       5.e2f   1
     1.e0
    1.e-5     1.e-5                                  1.e-7
               1.e5         .5555555556 20.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1           .333       -.1        1.        0.
    1      9.79020e3      .333        1.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    3    3      5.e2
    8.64e2   5.184e3   9.504e3
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0          BOUND     1.e50
f   1   39    1TUBES     5.e-3

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0f   1                   1    1.e-10   .0025       1.      0.
f   1f   2   38    1    1    1    .0025    .0025       1.      0.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0
               1.e5                 20.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver1c* ... Verification Problem No.1.
START     1-d infiltration after Philip (1955) - Ross et al. (1982)
START     Removal of second row of cells;midpoint weighing (MOP(11)=1)
START     7-10-92: George's latest
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
TUBES     2385.     .45          1.2e-14                        1.045  1030.
BOUND     2650.     .45          1.2e-14                        1.045  10000.

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 2 200 600  1000000010001000 4
            9504.0        -1.       5.e2f   1
      1.e0
     1.e-5     1.e-5                                  1.e-7
                1.e5         .5555555556 20.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1           .333       -.1        1.        0.
    1      9.79020e3      .333        1.
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    3    3      5.e2
    8.64e2   5.184e3   9.504e3
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0          BOUND     1.e50
f   1   39    1TUBES     5.e-3

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0f   1                   1    1.e-10   .0025       1.      0.
f   1f   2   38    1    1    1    .0025    .0025       1.      0.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
lb  0
                1.e5                 20.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver2a* ... Verification Problem No.2.
START     1-d heat transport - Avdonin (1964), Ross (1984)
START     1st modification; upstream weighting + injection
START     6-10-92: modified from George's latest
START              increase V(u   0)
START              fix GENER, simplify INCON
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
aquif    0    2898.7       0.2   1.8e-11        0.        0.      20.0    739.35
left     0    2898.7       0.2   1.8e-11        0.        0.      20.0     1.e40
right    0    2898.7       0.2   1.8e-11        0.        0.      20.0      1.e6

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 11300    130010000010000000 30          2.13e-5      1.80
        0.   130000.       -1.      100.a   0          9.807        2.       1.0
      100.
     1.e-5       1.0       0.1        1.        1.     1.e-8
                5.e6                170.                  0.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5
    1            0.0       0.0       1.0
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0    0    0left         1.
a   0   99    1aquif       10.
b   0   99    1aquif       10.
c   0   99    1aquif       10.
d   0   99    1aquif       10.
rb  1    0    0right     1.e50

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0a   0    0    0    0    1     5.E-5      0.05      100.        0.
a   0a   1   98    1    1    1      0.05      0.05      100.        0.
a  99b   0    0    0    0    1      0.05      0.05      100.        0.
b   0b   1   98    1    1    1      0.05      0.05      100.        0.
b  99c   0    0    0    0    1      0.05      0.05      100.        0.
c   0c   1   98    1    1    1      0.05      0.05      100.        0.
c  99d   0    0    0    0    1      0.05      0.05      100.        0.
d   0d   1   98    1    1    1      0.05      0.05      100.        0.
d  99rb  1    0    0    0    1      0.05    1.e-10      100.        0.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0    0    0
                5.e6              160.00                  0.0

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0 S  1 0    0    0    0        WATE        10.   6.782e5

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver2b* ... Verification Problem No.2.
START     1-d heat transport - Avdonin (1964), Ross (1984)
START     1st modification; midpoint weighting + injection
START     6-10-92: modified from George's latest
START              increase V(u   0)
START              fix GENER, simplify INCON
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
aquif    0    2898.7       0.2   1.8e-11        0.        0.      20.0    739.35
left     0    2898.7       0.2   1.8e-11        0.        0.      20.0     1.e40
right    0    2898.7       0.2   1.8e-11        0.        0.      20.0      1.e6

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 11300    130010000010001000 30          2.13e-5      1.80
        0.   130000.       -1.      100.a   0          9.807        2.       1.0
      100.
     1.e-5       1.0       0.1        1.        1.     1.e-8
                5.e6                170.                  0.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5
    1            0.0       0.0       1.0
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0    0    0left         1.
a   0   99    1aquif       10.
b   0   99    1aquif       10.
c   0   99    1aquif       10.
d   0   99    1aquif       10.
rb  1    0    0right     1.e50

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0a   0    0    0    0    1     5.E-5      0.05      100.        0.
a   0a   1   98    1    1    1      0.05      0.05      100.        0.
a  99b   0    0    0    0    1      0.05      0.05      100.        0.
b   0b   1   98    1    1    1      0.05      0.05      100.        0.
b  99c   0    0    0    0    1      0.05      0.05      100.        0.
c   0c   1   98    1    1    1      0.05      0.05      100.        0.
c  99d   0    0    0    0    1      0.05      0.05      100.        0.
d   0d   1   98    1    1    1      0.05      0.05      100.        0.
d  99rb  1    0    0    0    1      0.05    1.e-10      100.        0.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0    0    0
                5.e6               160.00                  0.0

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
u   0 S  1 0    0    0    0        WATE        10.   6.782e5

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver3a* ... Verification Problem No.3.
START     1-d radial heat transport - Avdonin (1964), Ross (1984)
START     upstream weighting + injection
START     7-10-92: George's latest
START              grid generation using MESHMAKER from TOUGH2
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
WELL     0   2898.68       0.26.6646E-13                          20.0    1.0E50
AQUIF    0   2898.68       0.26.6646E-13                          20.0  7.3935E2
BOUND    0   2898.68       0.26.6646E-13                          20.0     1.0E6

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 13000357510000000001 0000 0 40          2.13E-5      1.80
        0.      1.E9       -1.      1.E6A   0          9.807        2.       1.0
        1.
     1.E-5       1.0       0.1        1.        1.     1.E-8
                5.E6                170.                  0.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5
    1            0.0       0.0       1.0
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    9    9      1.E6
      1.E1      1.E2      1.E3      1.E4      1.E5      1.E6      1.E7      1.E8
      1.E9
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A1  1         0WELL  .6252E-03 .1250E-04           .9950E-02          -.5000E+02
A1  2         0AQUIF .1036E+00 .2072E-02           .1537E-01          -.5000E+02
A1  3         0AQUIF .1917E+00 .3834E-02           .2649E-01          -.5000E+02
A1  4         0AQUIF .2984E+00 .5969E-02           .3843E-01          -.5000E+02
A1  5         0AQUIF .4270E+00 .8541E-02           .5124E-01          -.5000E+02
A1  6         0AQUIF .5813E+00 .1163E-01           .6499E-01          -.5000E+02
A1  7         0AQUIF .7654E+00 .1531E-01           .7975E-01          -.5000E+02
A1  8         0AQUIF .9846E+00 .1969E-01           .9558E-01          -.5000E+02
A1  9         0AQUIF .1244E+01 .2489E-01           .1126E+00          -.5000E+02
A1 10         0AQUIF .1552E+01 .3104E-01           .1308E+00          -.5000E+02
A1 11         0AQUIF .1915E+01 .3829E-01           .1504E+00          -.5000E+02
A1 12         0AQUIF .2342E+01 .4683E-01           .1714E+00          -.5000E+02
A1 13         0AQUIF .2844E+01 .5687E-01           .1939E+00          -.5000E+02
A1 14         0AQUIF .3432E+01 .6865E-01           .2181E+00          -.5000E+02
A1 15         0AQUIF .4122E+01 .8244E-01           .2441E+00          -.5000E+02
A1 16         0AQUIF .4928E+01 .9857E-01           .2719E+00          -.5000E+02
A1 17         0AQUIF .5871E+01 .1174E+00           .3018E+00          -.5000E+02
A1 18         0AQUIF .6970E+01 .1394E+00           .3339E+00          -.5000E+02
A1 19         0AQUIF .8251E+01 .1650E+00           .3684E+00          -.5000E+02
A1 20         0AQUIF .9743E+01 .1949E+00           .4053E+00          -.5000E+02
A1 21         0AQUIF .1148E+02 .2296E+00           .4450E+00          -.5000E+02
A1 22         0AQUIF .1350E+02 .2700E+00           .4875E+00          -.5000E+02
A1 23         0AQUIF .1584E+02 .3168E+00           .5332E+00          -.5000E+02
A1 24         0AQUIF .1856E+02 .3713E+00           .5822E+00          -.5000E+02
A1 25         0AQUIF .2172E+02 .4345E+00           .6348E+00          -.5000E+02
A1 26         0AQUIF .2539E+02 .5077E+00           .6913E+00          -.5000E+02
A1 27         0AQUIF .2963E+02 .5926E+00           .7519E+00          -.5000E+02
A1 28         0AQUIF .3455E+02 .6910E+00           .8169E+00          -.5000E+02
A1 29         0AQUIF .4024E+02 .8049E+00           .8867E+00          -.5000E+02
A1 30         0AQUIF .4684E+02 .9367E+00           .9615E+00          -.5000E+02
A1 31         0AQUIF .5446E+02 .1089E+01           .1042E+01          -.5000E+02
A1 32         0AQUIF .6329E+02 .1266E+01           .1128E+01          -.5000E+02
```

A1	33	0AQUIF	.7349E+02	.1470E+01	.1221E+01	-.5000E+02
A1	34	0AQUIF	.8528E+02	.1706E+01	.1320E+01	-.5000E+02
A1	35	0AQUIF	.9891E+02	.1978E+01	.1427E+01	-.5000E+02
A1	36	0AQUIF	.1147E+03	.2293E+01	.1541E+01	-.5000E+02
A1	37	0AQUIF	.1329E+03	.2657E+01	.1664E+01	-.5000E+02
A1	38	0AQUIF	.1539E+03	.3077E+01	.1795E+01	-.5000E+02
A1	39	0AQUIF	.1781E+03	.3563E+01	.1937E+01	-.5000E+02
A1	40	0AQUIF	.2061E+03	.4123E+01	.2089E+01	-.5000E+02
A1	41	0AQUIF	.2385E+03	.4769E+01	.2251E+01	-.5000E+02
A1	42	0AQUIF	.2758E+03	.5516E+01	.2426E+01	-.5000E+02
A1	43	0AQUIF	.3188E+03	.6377E+01	.2614E+01	-.5000E+02
A1	44	0AQUIF	.3685E+03	.7370E+01	.2815E+01	-.5000E+02
A1	45	0AQUIF	.4258E+03	.8517E+01	.3031E+01	-.5000E+02
A1	46	0AQUIF	.4919E+03	.9839E+01	.3263E+01	-.5000E+02
A1	47	0AQUIF	.5682E+03	.1136E+02	.3511E+01	-.5000E+02
A1	48	0AQUIF	.6561E+03	.1312E+02	.3778E+01	-.5000E+02
A1	49	0AQUIF	.7575E+03	.1515E+02	.4065E+01	-.5000E+02
A1	50	0AQUIF	.8744E+03	.1749E+02	.4372E+01	-.5000E+02
A1	51	0AQUIF	.1009E+04	.2018E+02	.4702E+01	-.5000E+02
A1	52	0AQUIF	.1165E+04	.2329E+02	.5056E+01	-.5000E+02
A1	53	0AQUIF	.1344E+04	.2688E+02	.5436E+01	-.5000E+02
A1	54	0AQUIF	.1550E+04	.3101E+02	.5844E+01	-.5000E+02
A1	55	0AQUIF	.1788E+04	.3577E+02	.6282E+01	-.5000E+02
A1	56	0AQUIF	.2063E+04	.4125E+02	.6751E+01	-.5000E+02
A1	57	0AQUIF	.2379E+04	.4758E+02	.7255E+01	-.5000E+02
A1	58	0AQUIF	.2743E+04	.5486E+02	.7796E+01	-.5000E+02
A1	59	0AQUIF	.3163E+04	.6326E+02	.8377E+01	-.5000E+02
A1	60	0AQUIF	.3647E+04	.7294E+02	.9000E+01	-.5000E+02
A1	61	0AQUIF	.4205E+04	.8409E+02	.9668E+01	-.5000E+02
A1	62	0AQUIF	.4847E+04	.9694E+02	.1039E+02	-.5000E+02
A1	63	0AQUIF	.5587E+04	.1117E+03	.1116E+02	-.5000E+02
A1	64	0AQUIF	.6440E+04	.1288E+03	.1198E+02	-.5000E+02
A1	65	0AQUIF	.7423E+04	.1485E+03	.1287E+02	-.5000E+02
A1	66	0AQUIF	.8556E+04	.1711E+03	.1382E+02	-.5000E+02
A1	67	0AQUIF	.9860E+04	.1972E+03	.1484E+02	-.5000E+02
A1	68	0AQUIF	.1136E+05	.2273E+03	.1594E+02	-.5000E+02
A1	69	0AQUIF	.1309E+05	.2619E+03	.1711E+02	-.5000E+02
A1	70	0AQUIF	.1509E+05	.3018E+03	.1838E+02	-.5000E+02
A1	71	0AQUIF	.1739E+05	.3477E+03	.1973E+02	-.5000E+02
A1	72	0AQUIF	.2003E+05	.4007E+03	.2118E+02	-.5000E+02
A1	73	0AQUIF	.2308E+05	.4617E+03	.2275E+02	-.5000E+02
A1	74	0AQUIF	.2660E+05	.5319E+03	.2442E+02	-.5000E+02
A1	75	0AQUIF	.3064E+05	.6129E+03	.2622E+02	-.5000E+02
A1	76	0AQUIF	.3530E+05	.7061E+03	.2814E+02	-.5000E+02
A1	77	0AQUIF	.4067E+05	.8135E+03	.3021E+02	-.5000E+02
A1	78	0AQUIF	.4686E+05	.9371E+03	.3243E+02	-.5000E+02
A1	79	0AQUIF	.5398E+05	.1080E+04	.3482E+02	-.5000E+02
A1	80	0AQUIF	.6219E+05	.1244E+04	.3738E+02	-.5000E+02
A1	81	0AQUIF	.7164E+05	.1433E+04	.4012E+02	-.5000E+02
A1	82	0AQUIF	.8253E+05	.1651E+04	.4307E+02	-.5000E+02
A1	83	0AQUIF	.9507E+05	.1901E+04	.4623E+02	-.5000E+02
A1	84	0AQUIF	.1095E+06	.2190E+04	.4962E+02	-.5000E+02
A1	85	0AQUIF	.1261E+06	.2523E+04	.5326E+02	-.5000E+02
A1	86	0AQUIF	.1453E+06	.2906E+04	.5717E+02	-.5000E+02
A1	87	0AQUIF	.1674E+06	.3348E+04	.6136E+02	-.5000E+02
A1	88	0AQUIF	.1928E+06	.3856E+04	.6586E+02	-.5000E+02
A1	89	0AQUIF	.2221E+06	.4442E+04	.7069E+02	-.5000E+02

```
A1 90          0AQUIF .2558E+06 .5116E+04            .7587E+02          -.5000E+02
A1 91          0AQUIF .2946E+06 .5893E+04            .8144E+02          -.5000E+02
A1 92          0AQUIF .3394E+06 .6788E+04            .8741E+02          -.5000E+02
A1 93          0AQUIF .3909E+06 .7818E+04            .9381E+02          -.5000E+02
A1 94          0AQUIF .4502E+06 .9005E+04            .1007E+03          -.5000E+02
A1 95          0AQUIF .5186E+06 .1037E+05            .1081E+03          -.5000E+02
A1 96          0AQUIF .5973E+06 .1195E+05            .1160E+03          -.5000E+02
A1 97          0AQUIF .6880E+06 .1376E+05            .1245E+03          -.5000E+02
A1 98          0AQUIF .7924E+06 .1585E+05            .1336E+03          -.5000E+02
A1 99          0AQUIF .9127E+06 .1825E+05            .1434E+03          -.5000E+02
A11 0          0AQUIF .1051E+07 .2102E+05            .1539E+03          -.5000E+02
A11 1          0AQUIF .1211E+07 .2422E+05            .1652E+03          -.5000E+02
A11 2          0AQUIF .1395E+07 .2789E+05            .1772E+03          -.5000E+02
A11 3          0AQUIF .1606E+07 .3212E+05            .1902E+03          -.5000E+02
A11 4          0AQUIF .1850E+07 .3700E+05            .2042E+03          -.5000E+02
A11 5          0AQUIF .2131E+07 .4261E+05            .2191E+03          -.5000E+02
A11 6          0AQUIF .2454E+07 .4908E+05            .2351E+03          -.5000E+02
A11 7          0AQUIF .2826E+07 .5653E+05            .2524E+03          -.5000E+02
A11 8          0AQUIF .3255E+07 .6510E+05            .2708E+03          -.5000E+02
A11 9          0AQUIF .3749E+07 .7498E+05            .2907E+03          -.5000E+02
A1110          0AQUIF .4318E+07 .8636E+05            .3120E+03          -.5000E+02
A1111          0AQUIF .4973E+07 .9947E+05            .3348E+03          -.5000E+02
A1112          0AQUIF .5728E+07 .1146E+06            .3593E+03          -.5000E+02
A1113          0AQUIF .6597E+07 .1319E+06            .3856E+03          -.5000E+02
A1114          0AQUIF .7598E+07 .1520E+06            .4138E+03          -.5000E+02
A1115          0AQUIF .8751E+07 .1750E+06            .4441E+03          -.5000E+02
A1116          0AQUIF .1008E+08 .2016E+06            .4766E+03          -.5000E+02
A1117          0AQUIF .1161E+08 .2322E+06            .5115E+03          -.5000E+02
A1118          0AQUIF .1337E+08 .2674E+06            .5489E+03          -.5000E+02
A1119          0AQUIF .1540E+08 .3079E+06            .5891E+03          -.5000E+02
A1120          0AQUIF .1773E+08 .3547E+06            .6322E+03          -.5000E+02
A1121          0AQUIF .2042E+08 .4085E+06            .6785E+03          -.5000E+02
A1122          0AQUIF .2352E+08 .4704E+06            .7282E+03          -.5000E+02
A1123          0AQUIF .2709E+08 .5418E+06            .7815E+03          -.5000E+02
A1124          0AQUIF .3120E+08 .6240E+06            .8387E+03          -.5000E+02
A1125          0AQUIF .3593E+08 .7187E+06            .9000E+03          -.5000E+02
A1126          0AQUIF .4139E+08 .8277E+06            .9659E+03          -.5000E+02
A1127          0BOUND .1000E+39 .1257E+05            .1000E+04          -.5000E+02

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A1  1A1  2                  1 .5000E-04 .5366E-02 .6283E+01
A1  2A1  3                  1 .5366E-02 .5759E-02 .1303E+02
A1  3A1  4                  1 .5759E-02 .6180E-02 .2026E+02
A1  4A1  5                  1 .6180E-02 .6632E-02 .2803E+02
A1  5A1  6                  1 .6632E-02 .7117E-02 .3636E+02
A1  6A1  7                  1 .7117E-02 .7638E-02 .4531E+02
A1  7A1  8                  1 .7638E-02 .8197E-02 .5490E+02
A1  8A1  9                  1 .8197E-02 .8797E-02 .6521E+02
A1  9A1 10                  1 .8797E-02 .9441E-02 .7626E+02
A1 10A1 11                  1 .9441E-02 .1013E-01 .8812E+02
A1 11A1 12                  1 .1013E-01 .1087E-01 .1009E+03
A1 12A1 13                  1 .1087E-01 .1167E-01 .1145E+03
A1 13A1 14                  1 .1167E-01 .1252E-01 .1292E+03
A1 14A1 15                  1 .1252E-01 .1344E-01 .1449E+03
A1 15A1 16                  1 .1344E-01 .1442E-01 .1618E+03
A1 16A1 17                  1 .1442E-01 .1548E-01 .1799E+03
A1 17A1 18                  1 .1548E-01 .1661E-01 .1994E+03
```

A1	18A1	19	1	.1661E-01	.1782E-01	.2202E+03
A1	19A1	20	1	.1782E-01	.1913E-01	.2426E+03
A1	20A1	21	1	.1913E-01	.2053E-01	.2667E+03
A1	21A1	22	1	.2053E-01	.2203E-01	.2925E+03
A1	22A1	23	1	.2203E-01	.2364E-01	.3202E+03
A1	23A1	24	1	.2364E-01	.2537E-01	.3499E+03
A1	24A1	25	1	.2537E-01	.2723E-01	.3818E+03
A1	25A1	26	1	.2723E-01	.2922E-01	.4160E+03
A1	26A1	27	1	.2922E-01	.3136E-01	.4527E+03
A1	27A1	28	1	.3136E-01	.3366E-01	.4921E+03
A1	28A1	29	1	.3366E-01	.3612E-01	.5344E+03
A1	29A1	30	1	.3612E-01	.3876E-01	.5798E+03
A1	30A1	31	1	.3876E-01	.4160E-01	.6285E+03
A1	31A1	32	1	.4160E-01	.4464E-01	.6808E+03
A1	32A1	33	1	.4464E-01	.4791E-01	.7369E+03
A1	33A1	34	1	.4791E-01	.5141E-01	.7971E+03
A1	34A1	35	1	.5141E-01	.5518E-01	.8617E+03
A1	35A1	36	1	.5518E-01	.5921E-01	.9310E+03
A1	36A1	37	1	.5921E-01	.6355E-01	.1005E+04
A1	37A1	38	1	.6355E-01	.6820E-01	.1085E+04
A1	38A1	39	1	.6820E-01	.7319E-01	.1171E+04
A1	39A1	40	1	.7319E-01	.7854E-01	.1263E+04
A1	40A1	41	1	.7854E-01	.8429E-01	.1362E+04
A1	41A1	42	1	.8429E-01	.9046E-01	.1468E+04
A1	42A1	43	1	.9046E-01	.9708E-01	.1581E+04
A1	43A1	44	1	.9708E-01	.1042E+00	.1703E+04
A1	44A1	45	1	.1042E+00	.1118E+00	.1834E+04
A1	45A1	46	1	.1118E+00	.1200E+00	.1975E+04
A1	46A1	47	1	.1200E+00	.1288E+00	.2125E+04
A1	47A1	48	1	.1288E+00	.1382E+00	.2287E+04
A1	48A1	49	1	.1382E+00	.1483E+00	.2461E+04
A1	49A1	50	1	.1483E+00	.1591E+00	.2647E+04
A1	50A1	51	1	.1591E+00	.1708E+00	.2847E+04
A1	51A1	52	1	.1708E+00	.1833E+00	.3062E+04
A1	52A1	53	1	.1833E+00	.1967E+00	.3292E+04
A1	53A1	54	1	.1967E+00	.2111E+00	.3539E+04
A1	54A1	55	1	.2111E+00	.2265E+00	.3805E+04
A1	55A1	56	1	.2265E+00	.2431E+00	.4089E+04
A1	56A1	57	1	.2431E+00	.2609E+00	.4395E+04
A1	57A1	58	1	.2609E+00	.2800E+00	.4723E+04
A1	58A1	59	1	.2800E+00	.3005E+00	.5075E+04
A1	59A1	60	1	.3005E+00	.3225E+00	.5452E+04
A1	60A1	61	1	.3225E+00	.3461E+00	.5857E+04
A1	61A1	62	1	.3461E+00	.3714E+00	.6292E+04
A1	62A1	63	1	.3714E+00	.3986E+00	.6759E+04
A1	63A1	64	1	.3986E+00	.4277E+00	.7260E+04
A1	64A1	65	1	.4277E+00	.4590E+00	.7797E+04
A1	65A1	66	1	.4590E+00	.4926E+00	.8374E+04
A1	66A1	67	1	.4926E+00	.5287E+00	.8993E+04
A1	67A1	68	1	.5287E+00	.5674E+00	.9658E+04
A1	68A1	69	1	.5674E+00	.6089E+00	.1037E+05
A1	69A1	70	1	.6089E+00	.6534E+00	.1114E+05
A1	70A1	71	1	.6534E+00	.7012E+00	.1196E+05
A1	71A1	72	1	.7012E+00	.7526E+00	.1284E+05
A1	72A1	73	1	.7526E+00	.8076E+00	.1378E+05
A1	73A1	74	1	.8076E+00	.8667E+00	.1480E+05
A1	74A1	75	1	.8667E+00	.9301E+00	.1589E+05

```
A1 75A1 76                    1 .9301E+00 .9982E+00 .1706E+05
A1 76A1 77                    1 .9982E+00 .1071E+01 .1831E+05
A1 77A1 78                    1 .1071E+01 .1150E+01 .1966E+05
A1 78A1 79                    1 .1150E+01 .1234E+01 .2110E+05
A1 79A1 80                    1 .1234E+01 .1324E+01 .2265E+05
A1 80A1 81                    1 .1324E+01 .1421E+01 .2432E+05
A1 81A1 82                    1 .1421E+01 .1525E+01 .2610E+05
A1 82A1 83                    1 .1525E+01 .1636E+01 .2802E+05
A1 83A1 84                    1 .1636E+01 .1756E+01 .3007E+05
A1 84A1 85                    1 .1756E+01 .1885E+01 .3228E+05
A1 85A1 86                    1 .1885E+01 .2023E+01 .3465E+05
A1 86A1 87                    1 .2023E+01 .2171E+01 .3719E+05
A1 87A1 88                    1 .2171E+01 .2329E+01 .3992E+05
A1 88A1 89                    1 .2329E+01 .2500E+01 .4285E+05
A1 89A1 90                    1 .2500E+01 .2683E+01 .4599E+05
A1 90A1 91                    1 .2683E+01 .2879E+01 .4936E+05
A1 91A1 92                    1 .2879E+01 .3090E+01 .5298E+05
A1 92A1 93                    1 .3090E+01 .3316E+01 .5686E+05
A1 93A1 94                    1 .3316E+01 .3559E+01 .6103E+05
A1 94A1 95                    1 .3559E+01 .3819E+01 .6550E+05
A1 95A1 96                    1 .3819E+01 .4098E+01 .7030E+05
A1 96A1 97                    1 .4098E+01 .4398E+01 .7545E+05
A1 97A1 98                    1 .4398E+01 .4720E+01 .8097E+05
A1 98A1 99                    1 .4720E+01 .5066E+01 .8691E+05
A1 99A11 0                    1 .5066E+01 .5436E+01 .9327E+05
A11 0A11 1                    1 .5436E+01 .5834E+01 .1001E+06
A11 1A11 2                    1 .5834E+01 .6261E+01 .1074E+06
A11 2A11 3                    1 .6261E+01 .6719E+01 .1153E+06
A11 3A11 4                    1 .6719E+01 .7211E+01 .1237E+06
A11 4A11 5                    1 .7211E+01 .7738E+01 .1328E+06
A11 5A11 6                    1 .7738E+01 .8305E+01 .1425E+06
A11 6A11 7                    1 .8305E+01 .8912E+01 .1530E+06
A11 7A11 8                    1 .8912E+01 .9564E+01 .1642E+06
A11 8A11 9                    1 .9564E+01 .1026E+02 .1762E+06
A11 9A1110                    1 .1026E+02 .1102E+02 .1891E+06
A1110A1111                    1 .1102E+02 .1182E+02 .2029E+06
A1111A1112                    1 .1182E+02 .1269E+02 .2178E+06
A1112A1113                    1 .1269E+02 .1361E+02 .2337E+06
A1113A1114                    1 .1361E+02 .1461E+02 .2508E+06
A1114A1115                    1 .1461E+02 .1568E+02 .2692E+06
A1115A1116                    1 .1568E+02 .1683E+02 .2889E+06
A1116A1117                    1 .1683E+02 .1806E+02 .3100E+06
A1117A1118                    1 .1806E+02 .1938E+02 .3327E+06
A1118A1119                    1 .1938E+02 .2080E+02 .3571E+06
A1119A1120                    1 .2080E+02 .2232E+02 .3832E+06
A1120A1121                    1 .2232E+02 .2395E+02 .4113E+06
A1121A1122                    1 .2395E+02 .2571E+02 .4414E+06
A1122A1123                    1 .2571E+02 .2759E+02 .4737E+06
A1123A1124                    1 .2759E+02 .2961E+02 .5083E+06
A1124A1125                    1 .2961E+02 .3177E+02 .5455E+06
A1125A1126                    1 .3177E+02 .3410E+02 .5855E+06
A1126A1127                    1 .3410E+02 .5000E+00 .6283E+06

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A1  1S   1    0    0    0    0     WATE        10.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
A1  1    0    0            0.2
              5.05E6                1.6E2
A1  2   97    1            0.2
              5.05E6                1.7E2
A11 0   27    1            0.2
              5.05E6                1.7E2

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
MESHM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RZ2D ----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RADII
    1
    1.0E-4
LOGAR----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
  125          1000.    1.0E-2
RADII
    1
      1.E0
LAYER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1
       100

ENDFI----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver3b* ... Verification Problem No.3.
START     1-d radial heat transport - Avdonin (1964), Ross (1984)
START     Midpoint weighting + injection
START     7-10-92: George's latest
START              grid generation using MESHMAKER from TOUGH2
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
WELL     0   2898.68       0.26.6646E-13                          20.0    1.0E50
AQUIF    0   2898.68       0.26.6646E-13                          20.0  7.3935E2
BOUND    0   2898.68       0.26.6646E-13                          20.0     1.0E6

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 13000357510000000001 0010 0 40          2.13E-5      1.80
        0.      1.E9       -1.      1.E6A   0          9.807        2.       1.0
        1.
     1.E-5       1.0       0.1        1.        1.     1.E-8
                5.E6                170.                  0.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    5
    1            0.0       0.0       1.0
TIMES----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    9    9      1.E6
      1.E1      1.E2      1.E3      1.E4      1.E5      1.E6      1.E7      1.E8
      1.E9
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A1  1         0WELL  .6252E-03 .1250E-04           .9950E-02          -.5000E+02
A1  2         0AQUIF .1036E+00 .2072E-02           .1537E-01          -.5000E+02
A1  3         0AQUIF .1917E+00 .3834E-02           .2649E-01          -.5000E+02
A1  4         0AQUIF .2984E+00 .5969E-02           .3843E-01          -.5000E+02
A1  5         0AQUIF .4270E+00 .8541E-02           .5124E-01          -.5000E+02
A1  6         0AQUIF .5813E+00 .1163E-01           .6499E-01          -.5000E+02
A1  7         0AQUIF .7654E+00 .1531E-01           .7975E-01          -.5000E+02
A1  8         0AQUIF .9846E+00 .1969E-01           .9558E-01          -.5000E+02
A1  9         0AQUIF .1244E+01 .2489E-01           .1126E+00          -.5000E+02
A1 10         0AQUIF .1552E+01 .3104E-01           .1308E+00          -.5000E+02
A1 11         0AQUIF .1915E+01 .3829E-01           .1504E+00          -.5000E+02
A1 12         0AQUIF .2342E+01 .4683E-01           .1714E+00          -.5000E+02
A1 13         0AQUIF .2844E+01 .5687E-01           .1939E+00          -.5000E+02
A1 14         0AQUIF .3432E+01 .6865E-01           .2181E+00          -.5000E+02
A1 15         0AQUIF .4122E+01 .8244E-01           .2441E+00          -.5000E+02
A1 16         0AQUIF .4928E+01 .9857E-01           .2719E+00          -.5000E+02
A1 17         0AQUIF .5871E+01 .1174E+00           .3018E+00          -.5000E+02
A1 18         0AQUIF .6970E+01 .1394E+00           .3339E+00          -.5000E+02
A1 19         0AQUIF .8251E+01 .1650E+00           .3684E+00          -.5000E+02
A1 20         0AQUIF .9743E+01 .1949E+00           .4053E+00          -.5000E+02
A1 21         0AQUIF .1148E+02 .2296E+00           .4450E+00          -.5000E+02
A1 22         0AQUIF .1350E+02 .2700E+00           .4875E+00          -.5000E+02
A1 23         0AQUIF .1584E+02 .3168E+00           .5332E+00          -.5000E+02
A1 24         0AQUIF .1856E+02 .3713E+00           .5822E+00          -.5000E+02
A1 25         0AQUIF .2172E+02 .4345E+00           .6348E+00          -.5000E+02
A1 26         0AQUIF .2539E+02 .5077E+00           .6913E+00          -.5000E+02
A1 27         0AQUIF .2963E+02 .5926E+00           .7519E+00          -.5000E+02
A1 28         0AQUIF .3455E+02 .6910E+00           .8169E+00          -.5000E+02
A1 29         0AQUIF .4024E+02 .8049E+00           .8867E+00          -.5000E+02
A1 30         0AQUIF .4684E+02 .9367E+00           .9615E+00          -.5000E+02
A1 31         0AQUIF .5446E+02 .1089E+01           .1042E+01          -.5000E+02
A1 32         0AQUIF .6329E+02 .1266E+01           .1128E+01          -.5000E+02
```

A1	33	0AQUIF	.7349E+02	.1470E+01	.1221E+01	-.5000E+02
A1	34	0AQUIF	.8528E+02	.1706E+01	.1320E+01	-.5000E+02
A1	35	0AQUIF	.9891E+02	.1978E+01	.1427E+01	-.5000E+02
A1	36	0AQUIF	.1147E+03	.2293E+01	.1541E+01	-.5000E+02
A1	37	0AQUIF	.1329E+03	.2657E+01	.1664E+01	-.5000E+02
A1	38	0AQUIF	.1539E+03	.3077E+01	.1795E+01	-.5000E+02
A1	39	0AQUIF	.1781E+03	.3563E+01	.1937E+01	-.5000E+02
A1	40	0AQUIF	.2061E+03	.4123E+01	.2089E+01	-.5000E+02
A1	41	0AQUIF	.2385E+03	.4769E+01	.2251E+01	-.5000E+02
A1	42	0AQUIF	.2758E+03	.5516E+01	.2426E+01	-.5000E+02
A1	43	0AQUIF	.3188E+03	.6377E+01	.2614E+01	-.5000E+02
A1	44	0AQUIF	.3685E+03	.7370E+01	.2815E+01	-.5000E+02
A1	45	0AQUIF	.4258E+03	.8517E+01	.3031E+01	-.5000E+02
A1	46	0AQUIF	.4919E+03	.9839E+01	.3263E+01	-.5000E+02
A1	47	0AQUIF	.5682E+03	.1136E+02	.3511E+01	-.5000E+02
A1	48	0AQUIF	.6561E+03	.1312E+02	.3778E+01	-.5000E+02
A1	49	0AQUIF	.7575E+03	.1515E+02	.4065E+01	-.5000E+02
A1	50	0AQUIF	.8744E+03	.1749E+02	.4372E+01	-.5000E+02
A1	51	0AQUIF	.1009E+04	.2018E+02	.4702E+01	-.5000E+02
A1	52	0AQUIF	.1165E+04	.2329E+02	.5056E+01	-.5000E+02
A1	53	0AQUIF	.1344E+04	.2688E+02	.5436E+01	-.5000E+02
A1	54	0AQUIF	.1550E+04	.3101E+02	.5844E+01	-.5000E+02
A1	55	0AQUIF	.1788E+04	.3577E+02	.6282E+01	-.5000E+02
A1	56	0AQUIF	.2063E+04	.4125E+02	.6751E+01	-.5000E+02
A1	57	0AQUIF	.2379E+04	.4758E+02	.7255E+01	-.5000E+02
A1	58	0AQUIF	.2743E+04	.5486E+02	.7796E+01	-.5000E+02
A1	59	0AQUIF	.3163E+04	.6326E+02	.8377E+01	-.5000E+02
A1	60	0AQUIF	.3647E+04	.7294E+02	.9000E+01	-.5000E+02
A1	61	0AQUIF	.4205E+04	.8409E+02	.9668E+01	-.5000E+02
A1	62	0AQUIF	.4847E+04	.9694E+02	.1039E+02	-.5000E+02
A1	63	0AQUIF	.5587E+04	.1117E+03	.1116E+02	-.5000E+02
A1	64	0AQUIF	.6440E+04	.1288E+03	.1198E+02	-.5000E+02
A1	65	0AQUIF	.7423E+04	.1485E+03	.1287E+02	-.5000E+02
A1	66	0AQUIF	.8556E+04	.1711E+03	.1382E+02	-.5000E+02
A1	67	0AQUIF	.9860E+04	.1972E+03	.1484E+02	-.5000E+02
A1	68	0AQUIF	.1136E+05	.2273E+03	.1594E+02	-.5000E+02
A1	69	0AQUIF	.1309E+05	.2619E+03	.1711E+02	-.5000E+02
A1	70	0AQUIF	.1509E+05	.3018E+03	.1838E+02	-.5000E+02
A1	71	0AQUIF	.1739E+05	.3477E+03	.1973E+02	-.5000E+02
A1	72	0AQUIF	.2003E+05	.4007E+03	.2118E+02	-.5000E+02
A1	73	0AQUIF	.2308E+05	.4617E+03	.2275E+02	-.5000E+02
A1	74	0AQUIF	.2660E+05	.5319E+03	.2442E+02	-.5000E+02
A1	75	0AQUIF	.3064E+05	.6129E+03	.2622E+02	-.5000E+02
A1	76	0AQUIF	.3530E+05	.7061E+03	.2814E+02	-.5000E+02
A1	77	0AQUIF	.4067E+05	.8135E+03	.3021E+02	-.5000E+02
A1	78	0AQUIF	.4686E+05	.9371E+03	.3243E+02	-.5000E+02
A1	79	0AQUIF	.5398E+05	.1080E+04	.3482E+02	-.5000E+02
A1	80	0AQUIF	.6219E+05	.1244E+04	.3738E+02	-.5000E+02
A1	81	0AQUIF	.7164E+05	.1433E+04	.4012E+02	-.5000E+02
A1	82	0AQUIF	.8253E+05	.1651E+04	.4307E+02	-.5000E+02
A1	83	0AQUIF	.9507E+05	.1901E+04	.4623E+02	-.5000E+02
A1	84	0AQUIF	.1095E+06	.2190E+04	.4962E+02	-.5000E+02
A1	85	0AQUIF	.1261E+06	.2523E+04	.5326E+02	-.5000E+02
A1	86	0AQUIF	.1453E+06	.2906E+04	.5717E+02	-.5000E+02
A1	87	0AQUIF	.1674E+06	.3348E+04	.6136E+02	-.5000E+02
A1	88	0AQUIF	.1928E+06	.3856E+04	.6586E+02	-.5000E+02
A1	89	0AQUIF	.2221E+06	.4442E+04	.7069E+02	-.5000E+02

A1 90	0AQUIF	.2558E+06	.5116E+04	.7587E+02	-.5000E+02
A1 91	0AQUIF	.2946E+06	.5893E+04	.8144E+02	-.5000E+02
A1 92	0AQUIF	.3394E+06	.6788E+04	.8741E+02	-.5000E+02
A1 93	0AQUIF	.3909E+06	.7818E+04	.9381E+02	-.5000E+02
A1 94	0AQUIF	.4502E+06	.9005E+04	.1007E+03	-.5000E+02
A1 95	0AQUIF	.5186E+06	.1037E+05	.1081E+03	-.5000E+02
A1 96	0AQUIF	.5973E+06	.1195E+05	.1160E+03	-.5000E+02
A1 97	0AQUIF	.6880E+06	.1376E+05	.1245E+03	-.5000E+02
A1 98	0AQUIF	.7924E+06	.1585E+05	.1336E+03	-.5000E+02
A1 99	0AQUIF	.9127E+06	.1825E+05	.1434E+03	-.5000E+02
A11 0	0AQUIF	.1051E+07	.2102E+05	.1539E+03	-.5000E+02
A11 1	0AQUIF	.1211E+07	.2422E+05	.1652E+03	-.5000E+02
A11 2	0AQUIF	.1395E+07	.2789E+05	.1772E+03	-.5000E+02
A11 3	0AQUIF	.1606E+07	.3212E+05	.1902E+03	-.5000E+02
A11 4	0AQUIF	.1850E+07	.3700E+05	.2042E+03	-.5000E+02
A11 5	0AQUIF	.2131E+07	.4261E+05	.2191E+03	-.5000E+02
A11 6	0AQUIF	.2454E+07	.4908E+05	.2351E+03	-.5000E+02
A11 7	0AQUIF	.2826E+07	.5653E+05	.2524E+03	-.5000E+02
A11 8	0AQUIF	.3255E+07	.6510E+05	.2708E+03	-.5000E+02
A11 9	0AQUIF	.3749E+07	.7498E+05	.2907E+03	-.5000E+02
A1110	0AQUIF	.4318E+07	.8636E+05	.3120E+03	-.5000E+02
A1111	0AQUIF	.4973E+07	.9947E+05	.3348E+03	-.5000E+02
A1112	0AQUIF	.5728E+07	.1146E+06	.3593E+03	-.5000E+02
A1113	0AQUIF	.6597E+07	.1319E+06	.3856E+03	-.5000E+02
A1114	0AQUIF	.7598E+07	.1520E+06	.4138E+03	-.5000E+02
A1115	0AQUIF	.8751E+07	.1750E+06	.4441E+03	-.5000E+02
A1116	0AQUIF	.1008E+08	.2016E+06	.4766E+03	-.5000E+02
A1117	0AQUIF	.1161E+08	.2322E+06	.5115E+03	-.5000E+02
A1118	0AQUIF	.1337E+08	.2674E+06	.5489E+03	-.5000E+02
A1119	0AQUIF	.1540E+08	.3079E+06	.5891E+03	-.5000E+02
A1120	0AQUIF	.1773E+08	.3547E+06	.6322E+03	-.5000E+02
A1121	0AQUIF	.2042E+08	.4085E+06	.6785E+03	-.5000E+02
A1122	0AQUIF	.2352E+08	.4704E+06	.7282E+03	-.5000E+02
A1123	0AQUIF	.2709E+08	.5418E+06	.7815E+03	-.5000E+02
A1124	0AQUIF	.3120E+08	.6240E+06	.8387E+03	-.5000E+02
A1125	0AQUIF	.3593E+08	.7187E+06	.9000E+03	-.5000E+02
A1126	0AQUIF	.4139E+08	.8277E+06	.9659E+03	-.5000E+02
A1127	0BOUND	.1000E+39	.1257E+05	.1000E+04	-.5000E+02

```
CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A1  1A1  2                  1 .5000E-04 .5366E-02 .6283E+01
A1  2A1  3                  1 .5366E-02 .5759E-02 .1303E+02
A1  3A1  4                  1 .5759E-02 .6180E-02 .2026E+02
A1  4A1  5                  1 .6180E-02 .6632E-02 .2803E+02
A1  5A1  6                  1 .6632E-02 .7117E-02 .3636E+02
A1  6A1  7                  1 .7117E-02 .7638E-02 .4531E+02
A1  7A1  8                  1 .7638E-02 .8197E-02 .5490E+02
A1  8A1  9                  1 .8197E-02 .8797E-02 .6521E+02
A1  9A1 10                  1 .8797E-02 .9441E-02 .7626E+02
A1 10A1 11                  1 .9441E-02 .1013E-01 .8812E+02
A1 11A1 12                  1 .1013E-01 .1087E-01 .1009E+03
A1 12A1 13                  1 .1087E-01 .1167E-01 .1145E+03
A1 13A1 14                  1 .1167E-01 .1252E-01 .1292E+03
A1 14A1 15                  1 .1252E-01 .1344E-01 .1449E+03
A1 15A1 16                  1 .1344E-01 .1442E-01 .1618E+03
A1 16A1 17                  1 .1442E-01 .1548E-01 .1799E+03
A1 17A1 18                  1 .1548E-01 .1661E-01 .1994E+03
```

A1	18A1	19	1	.1661E-01	.1782E-01	.2202E+03
A1	19A1	20	1	.1782E-01	.1913E-01	.2426E+03
A1	20A1	21	1	.1913E-01	.2053E-01	.2667E+03
A1	21A1	22	1	.2053E-01	.2203E-01	.2925E+03
A1	22A1	23	1	.2203E-01	.2364E-01	.3202E+03
A1	23A1	24	1	.2364E-01	.2537E-01	.3499E+03
A1	24A1	25	1	.2537E-01	.2723E-01	.3818E+03
A1	25A1	26	1	.2723E-01	.2922E-01	.4160E+03
A1	26A1	27	1	.2922E-01	.3136E-01	.4527E+03
A1	27A1	28	1	.3136E-01	.3366E-01	.4921E+03
A1	28A1	29	1	.3366E-01	.3612E-01	.5344E+03
A1	29A1	30	1	.3612E-01	.3876E-01	.5798E+03
A1	30A1	31	1	.3876E-01	.4160E-01	.6285E+03
A1	31A1	32	1	.4160E-01	.4464E-01	.6808E+03
A1	32A1	33	1	.4464E-01	.4791E-01	.7369E+03
A1	33A1	34	1	.4791E-01	.5141E-01	.7971E+03
A1	34A1	35	1	.5141E-01	.5518E-01	.8617E+03
A1	35A1	36	1	.5518E-01	.5921E-01	.9310E+03
A1	36A1	37	1	.5921E-01	.6355E-01	.1005E+04
A1	37A1	38	1	.6355E-01	.6820E-01	.1085E+04
A1	38A1	39	1	.6820E-01	.7319E-01	.1171E+04
A1	39A1	40	1	.7319E-01	.7854E-01	.1263E+04
A1	40A1	41	1	.7854E-01	.8429E-01	.1362E+04
A1	41A1	42	1	.8429E-01	.9046E-01	.1468E+04
A1	42A1	43	1	.9046E-01	.9708E-01	.1581E+04
A1	43A1	44	1	.9708E-01	.1042E+00	.1703E+04
A1	44A1	45	1	.1042E+00	.1118E+00	.1834E+04
A1	45A1	46	1	.1118E+00	.1200E+00	.1975E+04
A1	46A1	47	1	.1200E+00	.1288E+00	.2125E+04
A1	47A1	48	1	.1288E+00	.1382E+00	.2287E+04
A1	48A1	49	1	.1382E+00	.1483E+00	.2461E+04
A1	49A1	50	1	.1483E+00	.1591E+00	.2647E+04
A1	50A1	51	1	.1591E+00	.1708E+00	.2847E+04
A1	51A1	52	1	.1708E+00	.1833E+00	.3062E+04
A1	52A1	53	1	.1833E+00	.1967E+00	.3292E+04
A1	53A1	54	1	.1967E+00	.2111E+00	.3539E+04
A1	54A1	55	1	.2111E+00	.2265E+00	.3805E+04
A1	55A1	56	1	.2265E+00	.2431E+00	.4089E+04
A1	56A1	57	1	.2431E+00	.2609E+00	.4395E+04
A1	57A1	58	1	.2609E+00	.2800E+00	.4723E+04
A1	58A1	59	1	.2800E+00	.3005E+00	.5075E+04
A1	59A1	60	1	.3005E+00	.3225E+00	.5452E+04
A1	60A1	61	1	.3225E+00	.3461E+00	.5857E+04
A1	61A1	62	1	.3461E+00	.3714E+00	.6292E+04
A1	62A1	63	1	.3714E+00	.3986E+00	.6759E+04
A1	63A1	64	1	.3986E+00	.4277E+00	.7260E+04
A1	64A1	65	1	.4277E+00	.4590E+00	.7797E+04
A1	65A1	66	1	.4590E+00	.4926E+00	.8374E+04
A1	66A1	67	1	.4926E+00	.5287E+00	.8993E+04
A1	67A1	68	1	.5287E+00	.5674E+00	.9658E+04
A1	68A1	69	1	.5674E+00	.6089E+00	.1037E+05
A1	69A1	70	1	.6089E+00	.6534E+00	.1114E+05
A1	70A1	71	1	.6534E+00	.7012E+00	.1196E+05
A1	71A1	72	1	.7012E+00	.7526E+00	.1284E+05
A1	72A1	73	1	.7526E+00	.8076E+00	.1378E+05
A1	73A1	74	1	.8076E+00	.8667E+00	.1480E+05
A1	74A1	75	1	.8667E+00	.9301E+00	.1589E+05

```
A1 75A1 76                    1 .9301E+00 .9982E+00 .1706E+05
A1 76A1 77                    1 .9982E+00 .1071E+01 .1831E+05
A1 77A1 78                    1 .1071E+01 .1150E+01 .1966E+05
A1 78A1 79                    1 .1150E+01 .1234E+01 .2110E+05
A1 79A1 80                    1 .1234E+01 .1324E+01 .2265E+05
A1 80A1 81                    1 .1324E+01 .1421E+01 .2432E+05
A1 81A1 82                    1 .1421E+01 .1525E+01 .2610E+05
A1 82A1 83                    1 .1525E+01 .1636E+01 .2802E+05
A1 83A1 84                    1 .1636E+01 .1756E+01 .3007E+05
A1 84A1 85                    1 .1756E+01 .1885E+01 .3228E+05
A1 85A1 86                    1 .1885E+01 .2023E+01 .3465E+05
A1 86A1 87                    1 .2023E+01 .2171E+01 .3719E+05
A1 87A1 88                    1 .2171E+01 .2329E+01 .3992E+05
A1 88A1 89                    1 .2329E+01 .2500E+01 .4285E+05
A1 89A1 90                    1 .2500E+01 .2683E+01 .4599E+05
A1 90A1 91                    1 .2683E+01 .2879E+01 .4936E+05
A1 91A1 92                    1 .2879E+01 .3090E+01 .5298E+05
A1 92A1 93                    1 .3090E+01 .3316E+01 .5686E+05
A1 93A1 94                    1 .3316E+01 .3559E+01 .6103E+05
A1 94A1 95                    1 .3559E+01 .3819E+01 .6550E+05
A1 95A1 96                    1 .3819E+01 .4098E+01 .7030E+05
A1 96A1 97                    1 .4098E+01 .4398E+01 .7545E+05
A1 97A1 98                    1 .4398E+01 .4720E+01 .8097E+05
A1 98A1 99                    1 .4720E+01 .5066E+01 .8691E+05
A1 99A11 0                    1 .5066E+01 .5436E+01 .9327E+05
A11 0A11 1                    1 .5436E+01 .5834E+01 .1001E+06
A11 1A11 2                    1 .5834E+01 .6261E+01 .1074E+06
A11 2A11 3                    1 .6261E+01 .6719E+01 .1153E+06
A11 3A11 4                    1 .6719E+01 .7211E+01 .1237E+06
A11 4A11 5                    1 .7211E+01 .7738E+01 .1328E+06
A11 5A11 6                    1 .7738E+01 .8305E+01 .1425E+06
A11 6A11 7                    1 .8305E+01 .8912E+01 .1530E+06
A11 7A11 8                    1 .8912E+01 .9564E+01 .1642E+06
A11 8A11 9                    1 .9564E+01 .1026E+02 .1762E+06
A11 9A1110                    1 .1026E+02 .1102E+02 .1891E+06
A1110A1111                    1 .1102E+02 .1182E+02 .2029E+06
A1111A1112                    1 .1182E+02 .1269E+02 .2178E+06
A1112A1113                    1 .1269E+02 .1361E+02 .2337E+06
A1113A1114                    1 .1361E+02 .1461E+02 .2508E+06
A1114A1115                    1 .1461E+02 .1568E+02 .2692E+06
A1115A1116                    1 .1568E+02 .1683E+02 .2889E+06
A1116A1117                    1 .1683E+02 .1806E+02 .3100E+06
A1117A1118                    1 .1806E+02 .1938E+02 .3327E+06
A1118A1119                    1 .1938E+02 .2080E+02 .3571E+06
A1119A1120                    1 .2080E+02 .2232E+02 .3832E+06
A1120A1121                    1 .2232E+02 .2395E+02 .4113E+06
A1121A1122                    1 .2395E+02 .2571E+02 .4414E+06
A1122A1123                    1 .2571E+02 .2759E+02 .4737E+06
A1123A1124                    1 .2759E+02 .2961E+02 .5083E+06
A1124A1125                    1 .2961E+02 .3177E+02 .5455E+06
A1125A1126                    1 .3177E+02 .3410E+02 .5855E+06
A1126A1127                    1 .3410E+02 .5000E+00 .6283E+06

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
A1  1S   1    0    0    0    0     WATE        10.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
A1  1    0    0            0.2
              5.05E6               1.6E2
A1  2   97    1            0.2
              5.05E6               1.7E2
A11 0   27    1            0.2
              5.05E6               1.7E2

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
MESHM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RZ2D ----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
RADII
    1
    1.0E-4
LOGAR----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
  125          1000.    1.0E-2
RADII
    1
      1.E0
LAYER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    1
       100

ENDFI----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver4* ... Verification Problem No.4.
START     Flow to a geothermal well - Garg (1980) in paper SPE 7479
START     Data file as in the TOUGH User's Guide (Pruess, 1987)
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
LAY 1     2650.     .20           1.E-14                    4.20      1000.

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
   1  50       500003000000000030
                    -1.                 AA  1
        2.

                 9.E6                300.
RPCAP----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
    3     .30       .05
    1               1.
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
AA  1          LAY 1 3.142E+02
AA  2          LAY 1 9.425E+02
AA  3          LAY 1 1.571E+03
AA  4          LAY 1 2.199E+03
AA  5          LAY 1 2.827E+03
AA  6          LAY 1 3.456E+03
AA  7          LAY 1 4.084E+03
AA  8          LAY 1 4.712E+03
AA  9          LAY 1 5.341E+03
AA 10          LAY 1 5.969E+03
AA 11          LAY 1 7.634E+03
AA 12          LAY 1 9.797E+03
AA 13          LAY 1 1.261E+04
AA 14          LAY 1 1.627E+04
AA 15          LAY 1 2.106E+04
AA 16          LAY 1 2.731E+04
AA 17          LAY 1 3.549E+04
AA 18          LAY 1 4.620E+04
AA 19          LAY 1 6.025E+04
AA 20          LAY 1 7.869E+04
AA 21          LAY 1 1.029E+05
AA 22          LAY 1 1.347E+05
AA 23          LAY 1 1.766E+05
AA 24          LAY 1 2.316E+05
AA 25          LAY 1 3.041E+05
AA 26          LAY 1 3.996E+05
AA 27          LAY 1 5.253E+05
AA 28          LAY 1 6.909E+05
AA 29          LAY 1 9.092E+05
AA 30          LAY 1 1.197E+06
AA 31          LAY 1 1.576E+06
AA 32          LAY 1 2.077E+06
AA 33          LAY 1 2.737E+06
AA 34          LAY 1 3.607E+06
AA 35          LAY 1 4.756E+06
AA 36          LAY 1 6.271E+06
AA 37          LAY 1 8.271E+06
AA 38          LAY 1 1.091E+07
AA 39          LAY 1 1.439E+07
AA 40          LAY 1 1.899E+07
```

```
AA 41          LAY 1 2.505E+07
AA 42          LAY 1 3.306E+07
AA 43          LAY 1 4.363E+07
AA 44          LAY 1 5.758E+07
AA 45          LAY 1 7.600E+07
AA 46          LAY 1 1.003E+08
AA 47          LAY 1 1.324E+08
AA 48          LAY 1 1.748E+08
AA 49          LAY 1 2.307E+08
AA 50          LAY 1 3.045E+08

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
AA  1AA  2                  1 5.000E-01 5.000E-01 6.283E+02
AA  2AA  3                  1 5.000E-01 5.000E-01 1.257E+03
AA  3AA  4                  1 5.000E-01 5.000E-01 1.885E+03
AA  4AA  5                  1 5.000E-01 5.000E-01 2.513E+03
AA  5AA  6                  1 5.000E-01 5.000E-01 3.142E+03
AA  6AA  7                  1 5.000E-01 5.000E-01 3.770E+03
AA  7AA  8                  1 5.000E-01 5.000E-01 4.398E+03
AA  8AA  9                  1 5.000E-01 5.000E-01 5.027E+03
AA  9AA 10                  1 5.000E-01 5.000E-01 5.655E+03
AA 10AA 11                  1 5.000E-01 5.745E-01 6.283E+03
AA 11AA 12                  1 5.745E-01 6.602E-01 7.005E+03
AA 12AA 13                  1 6.602E-01 7.585E-01 7.835E+03
AA 13AA 14                  1 7.585E-01 8.716E-01 8.788E+03
AA 14AA 15                  1 8.716E-01 1.002E+00 9.883E+03
AA 15AA 16                  1 1.002E+00 1.151E+00 1.114E+04
AA 16AA 17                  1 1.151E+00 1.322E+00 1.259E+04
AA 17AA 18                  1 1.322E+00 1.519E+00 1.425E+04
AA 18AA 19                  1 1.519E+00 1.746E+00 1.616E+04
AA 19AA 20                  1 1.746E+00 2.006E+00 1.835E+04
AA 20AA 21                  1 2.006E+00 2.305E+00 2.087E+04
AA 21AA 22                  1 2.305E+00 2.649E+00 2.377E+04
AA 22AA 23                  1 2.649E+00 3.043E+00 2.710E+04
AA 23AA 24                  1 3.043E+00 3.497E+00 3.092E+04
AA 24AA 25                  1 3.497E+00 4.018E+00 3.532E+04
AA 25AA 26                  1 4.018E+00 4.617E+00 4.037E+04
AA 26AA 27                  1 4.617E+00 5.305E+00 4.617E+04
AA 27AA 28                  1 5.305E+00 6.096E+00 5.284E+04
AA 28AA 29                  1 6.096E+00 7.005E+00 6.050E+04
AA 29AA 30                  1 7.005E+00 8.049E+00 6.930E+04
AA 30AA 31                  1 8.049E+00 9.248E+00 7.941E+04
AA 31AA 32                  1 9.248E+00 1.063E+01 9.104E+04
AA 32AA 33                  1 1.063E+01 1.221E+01 1.044E+05
AA 33AA 34                  1 1.221E+01 1.403E+01 1.197E+05
AA 34AA 35                  1 1.403E+01 1.612E+01 1.374E+05
AA 35AA 36                  1 1.612E+01 1.852E+01 1.576E+05
AA 36AA 37                  1 1.852E+01 2.129E+01 1.809E+05
AA 37AA 38                  1 2.129E+01 2.446E+01 2.077E+05
AA 38AA 39                  1 2.446E+01 2.810E+01 2.384E+05
AA 39AA 40                  1 2.810E+01 3.229E+01 2.737E+05
AA 40AA 41                  1 3.229E+01 3.711E+01 3.143E+05
AA 41AA 42                  1 3.711E+01 4.264E+01 3.609E+05
AA 42AA 43                  1 4.264E+01 4.899E+01 4.145E+05
AA 43AA 44                  1 4.899E+01 5.629E+01 4.761E+05
AA 44AA 45                  1 5.629E+01 6.468E+01 5.468E+05
AA 45AA 46                  1 6.468E+01 7.433E+01 6.281E+05
```

```
AA 46AA 47                    1 7.433E+01 8.540E+01 7.215E+05
AA 47AA 48                    1 8.540E+01 9.813E+01 8.288E+05
AA 48AA 49                    1 9.813E+01 1.128E+02 9.521E+05
AA 49AA 50                    1 1.128E+02 1.296E+02 1.094E+06

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
AA  1PRO 1                          MASS       -14.

INCON----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```

```
*ver5* ... Verification Problem No.5.
START     Heat pipe problem - Udell and Fitch (1985)
START     Data file as in the TOUGH User's Guide (Pruess, 1987)
ROCKS----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
SAMPL    2     2600.       0.4    1.E-12    1.E-12    1.E-12 1.13     700.
                    0.582     0.5
    6     0.150
    6     632455.53 0.150
LBND     2     2600.       0.4    1.E-12    1.E-12    1.E-12 1.13     700.    E4
                    0.582     0.5
    1     0.1       0.8       0.2       0.9
    1     0.        0.1       0.9

START----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
PARAM----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
 8 2 1003600  2000000010000000400000000 2.6   E-5 1.   E-10
0.                  1.000               SAM 1     9.817     5.

101330.             0.5                 70.
ELEME----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
LBD00          LBND 1.     E30
SAM00   89    1SAMPL 0.025

CONNE----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
LBD00SAM00                  1 1.   E-10 .0125    1.        0.
SAM00SAM01   88    1    1    1 .0125    .0125     1.        0.

GENER----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
SAM89Q   1                        HEAT 100.

ENDCY----1----*----2----*----3----*----4----*----5----*----6----*----7----*----8
```