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GEOHERMAL RESERVOIR ENGINEERING COMPUTER
CODE COMPARISON AND VALIDATION

Prepared for

Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

Contract No. DE-AC03-80SF11452

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November 12, 1980

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1.0 INTRODUCTION

This report presents the results of computer simulations for a set of six problems typical of geothermal reservoir engineering applications. The study was conducted for the Department of Energy by GeoTrans, Inc. under contract #DE-AC03-80SF11452. These results will be compared to those obtained by others using similar geothermal reservoir simulators on the same problem set.

The purpose of this code comparison is to check the performance of participating codes on a set of typical reservoir problems. The results will provide a measure of the validity and appropriateness of the simulators in terms of major assumptions, governing equations, numerical accuracy and computational procedures.

This report contains a description of the general reservoir simulator -- its major assumptions, mathematical formulation, and numerical techniques. The code was originally developed by the U.S. Geological Survey and recently modified extensively by GeoTrans. Following the description of the model is the presentation of the results for the six problems. Included with the results for each problem is a discussion of the results; problem descriptions and result tabulations are included in appendixes.

Each of the six problems specified in the contract was successfully simulated. Only very minor changes to the

problem specification were necessary for consistency with the code. These changes were anticipated and discussed in our technical proposal. They are also discussed in the description of the problems in this report.

2.0 MODELING APPROACH

2.1 General

One basic model was used to solve each of the problems specified in the problem set. The computer program is a substantially modified version of a code developed by the U.S. Geological Survey and described by Faust and Mercer (1979b). Extensions to the former code include: an option for cylindrical geometry, specification of constant enthalpy and pressures, and free input format. No changes have been made in the basic numerical techniques. Earlier versions of the three-dimensional code are available through the U.S. Geological Survey, and a two-dimension code has been documented (Faust and Mercer, 1977).

2.2 Reservoir Simulators

To provide a rational mathematical description of fluid (liquid water and steam) flow and energy transport in permeable hydrothermal systems, one begins with the balance equations for mass, momentum, and energy in porous media. These equations are combined (invoking appropriate simplifying

assumptions) to yield two nonlinear partial differential equations posed in terms of fluid pressure and enthalpy. To complete the mathematical description, in addition to the general equations, one must specify consistent boundary and initial conditions.

The resulting mathematical model may be used to describe a large number of problems in geothermal reservoir engineering. Without a solution, however, these equations are of little value. Only a simplified subset of the general equations can be solved by analytical means, and these often describe idealized situations that are limited in application. Numerical solution of these equations using high speed digital computers offers a logical alternative. The numerical technique used in this study is based on finite-difference approximations. Computer programs are written in FORTRAN.

2.2.1 Mathematical Model

Details of the mathematical model are presented in Faust and Mercer (1979a), and only the final equations and major assumptions are included in this report. The major assumptions include the following:

- (1) Capillary pressure effects are negligible.
- (2) Thermal equilibrium exists among the steam, water, and rock.
- (3) The reservoir is single-component water consisting of either one or two phases.

- (4) Relative permeability is a function of liquid volume saturation; hysteresis is neglected.
- (5) Viscosities are considered functions of temperature.
- (6) Porosity is a linear function of pressure.
- (7) Rock density, reservoir thickness, and intrinsic permeability are functions of space.
- (8) Rock enthalpy is a linear function of temperature.

Additional expressions are needed to relate the thermodynamic properties of pure water and steam to the dependent variables pressure and enthalpy. These expressions are functional in form, were obtained by least squares regressions applied to data from steam tables (Meyer et al., 1968; Keenan et al., 1969), and are described in detail by Faust and Mercer (1977). This approach avoids the necessity of searching for and interpolating data from tables. Also, derivatives of the functions can be easily obtained by analytical methods.

The final equations are formulated in terms of the dependent variables pressure and enthalpy, because these two variables uniquely define the thermodynamic state of the system and because they are commonly obtained in a field situation. These equations are

$$\begin{aligned} \frac{\partial(\phi \rho)}{\partial t} - \bar{\nabla} \cdot \left[\frac{\bar{k} k_{rs} \rho_s}{\mu_s} \cdot (\bar{\nabla} p - \rho_s g \bar{\nabla} D) \right] \\ - \bar{\nabla} \cdot \left[\frac{\bar{k} k_{rw} \rho_w}{\mu_w} \cdot (\bar{\nabla} p - \rho_w g \bar{\nabla} D) \right] - q_m' = 0 \end{aligned} \quad (1)$$

and

$$\begin{aligned} \frac{\partial}{\partial t} [\phi \rho h + (1-\phi) \rho_r h_r] - \bar{\nabla} \cdot \left[\frac{\bar{k} k_{rs} \rho_s h_s}{\mu_s} \cdot (\bar{\nabla} p - \rho_s g \bar{\nabla} D) \right] \\ - \bar{\nabla} \cdot \left[\frac{\bar{k} k_{rw} \rho_w h_w}{\mu_w} \cdot (\bar{\nabla} p - \rho_w g \bar{\nabla} D) \right] - \bar{\nabla} \cdot \left[K_m \left(\frac{\partial T}{\partial p} \right)_h \bar{\nabla} p \right. \\ \left. + K_m \left(\frac{\partial T}{\partial h} \right)_p \bar{\nabla} h \right] - q_h' = 0 \end{aligned} \quad (2)$$

where the pressure material derivative has been neglected.

In the above equations, $\bar{\nabla}$ is the vector differential operator, ϕ is the porosity, ρ is the density, t is time, $\bar{k}$ is the intrinsic permeability tensor of the porous medium, k_r is the relative permeability of the phase, μ is the dynamic viscosity, g is the gravitational constant, D is depth, p is fluid pressure, q_m' is the mass source term, h is the specific enthalpy of the fluid or rock, K_m is a combined isotropic conduction - thermal dispersion coefficient, T is temperature, and q_h' is the energy source term. The subscripts r , w , and s refer to rock, liquid water, and steam, respectively.

These three-dimensional equations describe the two-phase flow of heat in a steam-water-rock system; however, with minor modification they also describe the flow of heat in a water-rock or a steam-rock system. When either steam or water is absent, the saturation of the absent phase is 0 and that for the existing phase is 1. Further, it is assumed that the relative permeability of the absent phase is 0 and that for the existing phase is 1. Therefore (1) and (2) reduce to the appropriate equations for either the compressed-water region or the superheated-steam region. A solution for these equations will determine whether a specified location contains compressed water, a steam-water mixture, or superheated steam.

The mass and energy source terms q_m' and q_h' , respectively, represent the amount of mass and heat lost (or gained) to source-sinks. In the two-phase region the mass rate loss to a source-sink is defined as

$$q_m' = q_s' + q_w' \quad (3)$$

and the heat rate loss to a source-sink is

$$q_h' = h_s' q_s' + h_w' q_w' \quad (4)$$

where a negative rate indicates a loss from the reservoir.

The steam production rate may be determined by the fractional flow of the steam phase as follows:

$$q_s' = \alpha_s q_m' \quad (5)$$

and

$$\alpha_s = k_{rs} / [k_{rs} + (\rho_w \mu_s / \rho_s \mu_w) k_{rw}].$$

Because h_s' and h_w' are known functions of pressure and the mass flux q_m' is specified, q_s' is calculated using (5), and q_h' is calculated using (4).

Equations (1) and (2) together comprise a pair of nonlinear second-order partial differential equations. Two conditions (one in terms of pressure and one in terms of enthalpy) are required at the boundaries. Perhaps the most common boundary condition is the specification of fluxes. Frequently, the flux is specified as zero, indicating a no-flow boundary. For specification of a mass flux the following equation must be satisfied:

$$\bar{q}_m^* = - \left(\frac{\bar{k} k_{rs} \rho_s}{\mu_s} + \frac{\bar{k} k_{rw} \rho_w}{\mu_w} \right) \cdot \frac{\partial (p - \rho q D)}{\partial n} \quad (6)$$

where $\bar{q}_m^*$ is the specified mass flux at the boundary and $\partial/\partial n$ is the outward normal derivative. If a mass flux is specified, a convective energy flux must also be specified according to an equation analogous to (4)

$$\bar{q}_h^* = \bar{q}_s^* h_s^* + \bar{q}_w^* h_w^* \quad (7)$$

where h_s^* and h_w^* are the pressure-dependent saturated water and saturated steam enthalpies and $\bar{q}_s^*$ and $\bar{q}_w^*$ are the fractional steam and water fluxes at the boundary.

The total energy flux for the general case consists of two parts,

$$\bar{q}_{th}^* = \bar{q}_h^* + \bar{q}_h^{**} \quad (8)$$

where $\bar{q}_h^{**}$ represents the conductive heat flux at the boundary, determined by

$$\bar{q}_h^{**} = -K_m \frac{\partial T}{\partial n} \quad \text{boundary} \quad (9)$$

A constant-pressure condition may also be encountered. Since this implies a mass flux at the boundary, it also implies a convective energy flux. To determine the convective energy flux, the mass flux is calculated from (6) and used in (7).

2.2.2 Numerical Model

Details of the numerical model are given in Faust and Mercer (1979b), and only a brief outline is presented in this report. The mathematical equations developed for geothermal reservoir simulation are nonlinear and are not amenable to convenient analytical solution. Additionally, the highly nonlinear thermodynamic relationships in the model render even numerical solution a difficult task. The three-dimensional model discussed here uses finite-difference approximations with fully implicit Newton-Raphson iteration and is capable of simulating one- and two-phase flow in geothermal reservoirs.

The three-dimensional model is based on a finite-difference scheme using a block-centered grid that allows variable spacing and can be used to approximate irregular reservoir geometry. The compact, implicit finite-difference representations of (1) and (2) are

$$\Delta \left[(T_w + T_s) \Delta p^{n+1} \right] - \Delta \left[(T_w \rho_w g + T_s \rho_s g) \Delta D \right] + V_b q_m' - (V_b / \Delta t) (M^{n+1} - M^n) = 0 \quad (10)$$

and

$$\Delta (T_h \Delta p^{n+1}) + \Delta (T_c \Delta h^{n+1}) - \Delta \left[(T_w h_w \rho_w g + T_s h_s \rho_s g) \Delta D \right] + V_b q_h' - (V_b / \Delta t) (E^{n+1} - E^n) = 0 \quad (11)$$

where the terms directly to the left of the equals signs in (10) and (11) are the accumulation terms for mass and energy, respectively. The transmissibility terms are defined as

$$T_w = (kA/l) \rho_w k_{rw} / \mu_w$$

$$T_s = (kA/l) \rho_s k_{rs} / \mu_s$$

$$T_h = T_w h_w + T_s h_s + (K_m A/l) (\partial T / \partial p)_h$$

$$T_c = (K_m A/l) (\partial T / \partial h)_p$$

and the mass and energy terms are

$$M = \phi \rho \quad E = [\phi \rho h + (1-\phi) \rho_r h_r]$$

where V_b , A , and l are the grid block volume, the cross-

sectional area perpendicular to the flow direction, and the length increment in the flow direction, respectively. The difference operator Δ is defined for three dimensions, but, as an example, acts as follows in the x direction:

$$\Delta_x (T_{wx} \Delta_x p^{n+1}) = T_{wx_{i+\frac{1}{2},j,k}} (p_{i+1,j,k}^{n+1} - p_{i,j,k}^{n+1}) - T_{wx_{i-\frac{1}{2},j,k}} (p_{i,j,k}^{n+1} - p_{i-1,j,k}^{n+1}) \quad (12)$$

where i, j, and k are indices in the x, y, and z direction, respectively, and n is the index for the time level. Inter-block transmissibilities (those evaluated at $i+\frac{1}{2}$, $j+\frac{1}{2}$, and $k+\frac{1}{2}$) require averaging or weighting of their various components. Density, viscosity, and the derivatives $(\partial T/\partial p)_h$ and $(\partial T/\partial h)_p$ are evaluated as arithmetic averages of the values in the adjacent blocks. Relative permeabilities and enthalpies are usually assigned the upstream value (that is, the value at the grid block having the higher fluid potential). Other terms, such as (kA/l) and $(K_m A/l)$, that are space dependent are determined as harmonic means of the values in the two adjacent blocks. For example,

$$(kA/l)_{i+\frac{1}{2}} = \frac{2k_i A_i k_{i+1} A_{i+1}}{k_i A_i l_{i+1} + k_{i+1} A_{i+1} l_i} \quad (13)$$

The difference equations (10) and (11) are nonlinear in the transmissibility, accumulation, and source terms. These terms can lead to serious numerical instabilities if not

treated properly. For isothermal, multiphase flow applications the techniques that have demonstrated the least severe stability restrictions are those that treat nonlinear terms implicitly and use upstream weighting on relative permeability terms (Blair and Weinaug, 1969; Peaceman, 1977). For many geothermal applications we have found it necessary to use the same techniques to achieve stable solutions.

Implicit treatment of nonlinear terms in (10) and (11) requires that these terms be evaluated at the new time level $(n+1)$. This leads to a system of $2N$ nonlinear equations (N being the number of grid blocks) for each time step. Each grid block is connected to, at most, six adjacent blocks (three-dimensional case), so that each equation has a maximum of seven unknown grid block values for both pressure and enthalpy, or 14 unknowns per equation. This set of equations is linearized using a residual formulation with Newton-Raphson iteration. Rewriting (10) and (11) in vector form,

$$R(X) = 0 \quad (14)$$

where R is the vector of nonlinear difference equations (10) and (11) written for each grid block and X is the vector of unknown pressure and enthalpy values at each grid block.

Application of the Newton-Raphson procedure involves approximating (14) with a Taylor's series expansion about an

assumed solution. This leads to the linearized matrix equation

$$\left[\frac{\partial R(X)^m}{\partial X} \right] \{ \delta X \} = - \{ R(X^m) \} \quad (15)$$

where m is the iteration level and $\{ \delta X \} = \{ X^{m+1} - X^m \}$. For the first iteration in each time step the values of p and h at the old time level are used as the initial solution. In general, this procedure converges very rapidly (within four iterations). Convergence is checked by calculating global mass and energy balance errors and comparing them to specified criteria.

Application of the Newton-Raphson procedure to the non-linear difference equations produces a system of linear equations in the form of (15) that require a solution for each iteration. For many problems, solving this matrix equation is the most time-consuming part of the simulation process. Hence it is essential that this operation be performed as efficiently as possible.

The three-dimensional model is severely nonlinear due to gravity terms, and hence Newton-Raphson iteration is required for spatial as well as source and accumulation terms. This fully implicit treatment yields a coefficient matrix that is nonsymmetric. To solve this linearized matrix equation, we use slice successive overrelaxation imbedded in the Newton-Raphson iteration. For a description of SSOR, see Wattenbarger and Thurnau (1976), and for a more general

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case of block successive overrelaxation, see Woo and Emanuel (1976).

This method is similar to line successive overrelaxation in two dimensions for coupled equations, except that rather than solve each row implicitly, each vertical cross section of the grid is solved implicitly. The three-dimensional equations have 14 unknowns per equation because pressure and enthalpy are solved simultaneously. SSOR blocks the matrix such that each slice has 10 unknowns per equation. Hence in this iterative scheme, 10 coefficients are treated implicitly, and only four are treated explicitly. The bandwidth of the matrix equation for each slice is approximately 4 times the number of horizontal layers rather than 4 times the number of grid blocks in a slice, as is the case for direct solution of the full three-dimensional equations. Each of these matrix equations is solved using a banded Gauss-Doolittle method with normal ordering. Since SSOR is imbedded in the Newton-Raphson iteration, only linearized equations are solved. Therefore the matrix decomposition for each slice is required only on the first SSOR iteration of each Newton-Raphson iteration. On subsequent SSOR iterations, only backsubstitution is necessary. In addition, since the SSOR is imbedded in the Newton-Raphson iteration, the convergence criterion need not be small. The convergence is checked by calculating

$$\delta p^* = \max \left\| \frac{p_{ijk}^m - p_{ijk}^{m-1}}{p_{ijk}^i - p_{ijk}^0} \right\| \quad \forall \quad ijk \quad (16)$$

$$\delta h^* = \max \left\| \frac{h_{ijk}^m - h_{ijk}^{m-1}}{h_{ijk}^1 - h_{ijk}^0} \right\| \quad \forall \quad ijk \quad (17)$$

where the superscripts m , $m-1$, 1 and 0 refer to SSOR iteration levels. The convergence criteria for δp^* and δh^* is 0.001 , which is usually reached in only six to ten iterations. Although this tolerance may seem somewhat large, subsequent Newton-Raphson iterations correct any error. Also, because of the large tolerance, selection of an over-relaxation parameter presents no difficulty (a factor between 1.0 and 1.7 is normally used).

2.2.2.1 One-and Two-Dimensional Geometry

Although the numerical model is designed for three dimensions, for many applications simpler geometry is sufficient. One-and two-dimensional models are included trivially in the three-dimensional code. This is done by specifying one slice, column, or row. For areal problems, one slice is specified and gravity is set to zero. In each case, the matrix equation can be solved directly resulting in a very stable solution algorithm.

Cylindrical geometry (r - z) is also included in the numerical model as an option. This option is not a trivial subset of the three-dimensional code. The procedure used in the model to treat terms in the radial direction was outlined by Settari and Aziz (1977). This procedure involves transforming the radial terms into r^2 . The radial space-

derivative terms in equations (1) and (2) have the form:

$$\frac{1}{r} \frac{\partial}{\partial r} \left(\lambda_r r \frac{\partial p}{\partial r} \right)$$

With $r^* = r^2$ this term is equivalent to

$$4 \frac{\partial}{\partial r^*} \left(\lambda_r r^* \frac{\partial p}{\partial r^*} \right)$$

Having made this transformation, the grid is discretized in r^* . This is accomplished by specifying the positions of the node points (r_i) and then calculating the position of the grid block boundaries by

$$r_{i+\frac{1}{2}}^* = \frac{r_{i+1}^* - r_i^*}{\ln \left(\frac{r_{i+1}^*}{r_i^*} \right)} \quad (18)$$

Hence, the block boundaries represent a logarithmic mean radius in r^2 .

An option is provided in the program to allow the user to either specify the position of the node points or to have them generated automatically. Four parameters are used in the automatic generation; namely, the number of grid blocks in the r -direction (n), the well radius (r_w), the nodal position of the first grid block (r_1), and the periphery of the reservoir ($r_{n+\frac{1}{2}}$). The spacing of the node points is based on a special solution to the steady-state flow equation that gives, for the pressure difference between two points,

$$p_{i+1} - p_i = \ln(r_{i+1}/r_i). \quad (19)$$

For uniform spacing in $\ln r$,

$$r_{i+1} = Ar_i \quad (20)$$

where

$$A = (r_{n+1/2}/r_1)^{1/(n-1/2)}$$

No matter whether node locations are user specified or automatically generated, the interior boundaries of the grid blocks are obtained by equation (18).

3.0 APPLICATION OF MODEL TO PROBLEM SET

3.1 Problem 1

3.1.1 Discussion

This problem offers little difficulty in solution. The grid spacing specified leads to numerical dispersion if upstream weighting is used. To see how significant the numerical dispersion could be, the problem was run twice -- once with upstream weighting and once with midpoint weighting (central difference).

3.1.2 Results

The results of this problem are shown in figures 1 and 2. In the model the specific heat, viscosity and density of water for 165°C and 50 bars are $.44425 \times 10^8$ ergs/g-°C, .001636 g/cm-sec, and .90893 g/cm³, respectively. Both figure 1 (temperature vs time at 37.5 m) and figure 2 (temperature vs. distance at 10³ sec) show the effects of the coarse grid spacing. The upstream-weighting results show numerical dispersion, whereas the central-difference results show an overshoot.

Figure 1. Problem 1, calculated results for node 2 at 37.5 m from injection well.

Figure 2. Problem 1, calculated results at time = 10^3 sec.

3.2 Problem 2

3.2.1 Discussion

This second problem (series) involved a set of hypothetical well tests. None of the three cases presented any computational difficulty. Rather than use a rock thermal conductivity of zero, a very small values of 10^{-5} (w/m°C) was used to avoid possible divide checks. Raising the value up to 10^{-4} didn't change the results.

3.2.2 Results

The results of the calculations for problem 2 are shown in figures 3-12.

For problem 2a the pressures show the expected straight line behavior on a t/r^2 plot (figure 3).

For problem 2b the pressures and calculations are plotted versus t/r^2 in figure 4 and 5. The discharge enthalpy is plotted in figure 6. As can be seen, there is a hint of an oscillation in the discharge enthalpy. A second part of problem 2b is a similar calculation for one node. The pressures, saturation, and discharge enthalpy are shown in figure 7, 8, and 9.

Problem 2c represents an initially liquid resevoir that undergoes a change to two-phase behavior during the well test. The pressure, saturation, and discharge results are plotted in figures 10, 11 and 12. On an expanded vertical scale, the discharge enthalpy shows oscillatory behavior, possibly the result of large time steps.

Figure 3. Problem 2a, pressure results.

Figure 4. Problem 2b, pressure results.

Figure 5. Problem 2b, saturation results.

Figure 6. Problem 2b, discharge enthalpy results.

Figure 7. Problem 2b for one node, pressure results.

Figure 8. Problem 2b for one node, saturation results.

Figure 9. Problem 2b for one node, discharge enthalpy results.

Figure 10. Problem 2c, pressure results.

Figure 11. Problem 2c, saturation results.

Figure 12. Problem 2c, discharge enthalpy results.

3.3 Problem 3

3.3.1 Discussion

Problem 3 is designed to approximate conditions in a fractured reservoir. Here the permeability is high in the fractures but the storage is high in the less permeable rock matrix. This problem presented no computational difficulties. The only deviations from the problem specification was the small value 10^{-5} (w/m°C) used for thermal conductivity and a porosity of .999 rather than 1.0 in the well block.

3.3.2 Results

The computed pressures for each case are shown in figures 13 and 14. In case a, the reservoir contains dry steam. In case b the reservoir contains wet steam at residual saturation, and the fracture has steam with no liquid saturation. In the plots, node 1,1,1 refers to the well block, whereas node 4,1,4 refers to the block 2.5 m from the center of the well and .25 m above the fracture.

Figure 13. Problem 3a, pressure versus time.

Figure 14. Problem 3b, pressure results.

3.4 Problem 4

3.4.1 Discussion

This problem involves 1-D vertical flow in a two layer media. The lower layer being more permeable than the one above. The pressure is maintained at the top of the column, and fluid is produced from the base of second layer. In order to run this problem with the constant pressure and temperature boundary condition, a thin block was added to the top. This block (10 m thick) was held at a constant pressure and temperature. No computational difficulties were encountered when running this problem.

3.4.2 Results

The results for this simulation are plotted in figures 15-20. In figures 15, 16, 17 the pressure, history, liquid saturation history, and temperature history are shown. In each graph the results for four blocks are shown. These blocks are centered at depths of .55 km, 1.05 km, 1.55 km and 1.95 km. In figure 18 the discharge enthalpy from the lowest layer is plotted versus time. Figures 19 and 20 show the recharge rate and cumulative recharge at the surface block.

Figure 15. Problem 4, pressure results.

Figure 16. Problem 4, liquid saturation results.

Figure 17. Problem 4, temperature results.

Figure 18. Problem 4, discharge enthalpy in production block.

Figure 19. Problem 4, recharge rate at surface block.

Figure 20. Problem 4, cumulative recharge at surface block.

3.5 Problem 5

3.5.1 Discussion

This problem represents an areal simulation of a two-phase reservoir. No difficulties were encountered in running the problem. In order to approximate the constant pressure and temperature at the right hand boundary, a thin column of blocks was added. These were held at the initial conditions specified for column 12.

3.5.2 Results

The results are presented in figures 21-28. For case a, production from the reservoir is conducted without recharge. Four graphs for case a are shown. Figure 21 is a plot of pressures in the well block and at an observation block. Figure 22 and 23 show the temperature history and discharge enthalpy in the production block. The mass of steam in place in the reservoir is plotted versus time in figure 24. Four analogous plots are contained in figures 25-28. The observation well block, however, now is the injection well block.

Figure 21. Problem 5a, pressure results.

Figure 22. Problem 5a, temperature results.

Figure 23. Problem 5a, discharge enthalpy.

Figure 24. Problem 5a, steam in place.

Figure 25. Problem 5b, pressure results.

Figure 26. Problem 5b, temperature results.

Figure 27. Problem 5b, discharge enthalpy.

Figure 28. Problem 5b, steam in place,

3.6 Problem 6

3.6.1 Discussion

The final problem involves flow in a three-dimensional reservoir. The problem is similar to problem 4. Pressures and temperatures are held constant along top, base, and one side of the volume simulated. As in problems 4 and 5 additional thin layers are added to the grid specified in the problem description to handle the constant P and T boundary conditions. For this problem computational difficulties occur at about 6.6 years into the simulation. At that time the pressure in the production block is reduced to a value outside the range of the models' thermodynamic package. This is not a problem with the code, but rather shows that the problem is not realistic. Namely the high production rate specified for after 6 years would not be attainable economically.

3.6.2 Results

The results of the simulation are shown in figures 29-32. In figures 29, 30, and 31 pressure, steam saturation and temperature for all five layers are plotted versus time. The final figure shows the discharge enthalpy in the production block.

Figure 29. Problem 6, pressure results.

Figure 30. Problem 6, saturation results.

Figure 31. Problem 6, temperature results.

Figure 32. Problem 6, discharge enthalpy.

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APPENDIX A PROBLEM SET SPECIFICATIONS

GEOTRANS, INC.

PROBLEM STATEMENT

#1. 1-D Avdonin Solution

PHYSICAL DESCRIPTION

This problem involves one-dimensional, radial, steady-state flow, and unsteady heat transport in a single-phase liquid. The purpose is to test heat conduction and convection in the single-phase compressed water region.

PROBLEM SPECIFICATIONS

Water at 160°C is injected into the fringe of a geothermal reservoir of temperature 170°C . This problem looks at one well and assumes a quasi steady-state flow field is set up very rapidly. The boundary conditions for flow are: injection rate, $q = 100\text{kg/sec}$, specified at the well face, and pressure = 50 bars at an outer radius of 1000m. For heat transport, the temperature at the well face is 160°C and at the outer radius is 170°C . Initial temperature is 170°C everywhere in the reservoir, and the initial pressure is 50 bars. Boundary conditions and initial conditions are shown below.

Properties

permeability = 10^{-12} m^2
density rock = 2500 kg/m^3
specific heat of rock = $1.0 \text{ J/g.}^\circ\text{C}$
thermal conductivity = $20 \text{ W/m.}^\circ\text{C}$
reservoir thickness = 100m
porosity = .2

Thermal properties for water

provided by modeler

specify constants: specific heat, viscosity and density of water
(165°C , 50 bars).

Numerical grid and time step data

time steps = $1.67 \times 10^7 \text{ sec}$
grid spacing = 25m

OUTPUT SPECIFICATIONS

- 1) Temperature versus radial distance at 10^9 sec
(60 time steps)
- 2) Take node at $r = 37.5\text{m}$ and give solution of temperature versus time.

COMMENTS

For constant density, viscosity, and heat capacity of water, an analytical solution is available for this problem. For example, this solution is a limiting case of the problem solved by Avdonin, 1964.

Avdonin, N.A., 1964, Some formulas for calculating the temperature field of a stratum subject to thermal injection: Meft'i Gaz, v. 3, p. 37-41.

PROBLEM STATEMENT

#2. 1-D Well Test Analysis

PHYSICAL DESCRIPTION

This problem involves a set of three constant discharge, transient well test cases. Each case has 1-D radial flow to a line sink (zero radius well) in a homogeneous porous media. In Case a the fluid is single-phase liquid; in Case b the fluid is a two-phase mixture with both water and steam mobile; and in Case c the fluid changes from compressed liquid to a two-phase mixture as a flash front propagates away from the well. For each case, either an exact analytical solution (Theis solution) or an accurate semi-analytical solution is available for comparison with numerical solutions. Solutions will consist of pressure, saturation, and flowing enthalpy changes as functions of t/r^2 (time/distance squared).

PROBLEM SPECIFICATIONS

The following initial and boundary conditions and parameter values are to be used:

Specification	Case a	Case b	Case c
Initial pressure (bars)	90	30	90
Initial liquid saturation	1	.65	1
Initial temperature ($^{\circ}\text{C}$)	260	233.8 <u>1/</u>	300
Porosity	.20	.15	.20
Permeability (10^{-12}m^2)	.01	.24	.01
Thickness (m)	100	100	100
Discharge (kg/s)	14.0	16.7	14.0
Rock heat capacity ($\text{kJ/m}^3\text{C}$)	2650	2000	2650
Rock compressibility	0	0	0
Relative permeability functions <u>2/</u>	1-ph	Corey	Corey
Rock thermal conductivity	0	0	0

1/ Saturation temperature at 30 bars

2/ $k_{rw} = [S^*]^4$, $k_{rs} = [(1-S^*)^2] \cdot [1 - (S^*)^2]$, $S^* = [(S - .3)/(.65)]$,

S = liquid saturation

GEOTRANS, INC.

NUMERICAL SOLUTIONS

Analytical results for each case indicate that solutions for pressure, saturation, and flowing enthalpy are functions of t/r . To minimize computational requirements while avoiding the significant spatial discretization errors, the following nodal arrangement should be used for each case.

$$r_n = 0.5 (\sqrt{2})^{n-1} \quad n = 1, 26$$

Total simulation time in each case should be 1 day. For the grid specification given above, an initial time step near 10^{-4} or 10^{-5} days is suggested for accurate solutions at early times.

ONE NODE TWO-PHASE PROBLEM

To facilitate evaluation of numerical solutions for two-phase flow, an additional problem under Case b conditions should be run. It involves 1 grid block with volume = 314 m^3 and constant discharge of 16.7 kg/s for .01 days. A constant time step of 10^{-4} days should be used, and the enthalpy of the discharge fluid should be weighted according to the mobility of each fluid phase (as in Cases b and c).

OUTPUT SPECIFICATIONS

Results for each case, except for the one-node problem, should consist of plots of pressure in bars, liquid saturation (Cases b and c), and flowing enthalpy in kJ/kg (Cases b and c) as functions of $\log(t/r^2)$ in days/m^2 for nodal points at 0.5 m, 0.707 m and 1.0 m from the well. The corresponding data in tabular form should also be provided. Data covering 5 log cycles for Cases a and c, and 4 log cycles

for Case b should be included in the plots and tabulations. Specification of the computational grid and time step variation utilized should also be provided. Results for the one-node problem should consist of plots of pressure, liquid saturation, and discharge enthalpy versus time, along with the corresponding data tabulations.

PROBLEM STATEMENT

#3. 2-D Flow to a Well in Fracture/Block Media

PHYSICAL DESCRIPTION

This problem represents a simplification of the general problem of well testing in fractured geothermal reservoirs. As shown in the following sketch, a well producing at constant discharge is open to a horizontal fracture of infinite lateral extent. Vertical flow in the block and radial flow in the fracture, each obeying Darcy's law,

is to be simulated. The upper boundary of the block and the lower boundary of the fracture are impermeable, and the well has a finite radius with well-bore storage.

PROBLEM SPECIFICATIONS

For application to vapor-dominated reservoirs, steam flow in the block and fracture will be simulated. Parameter specifications for two cases are listed below:

Specification	Case a	Case b
Initial pressure (bars)	30.5	30.5
Initial liquid saturation (in block) <u>1/</u>	0	.2
Initial temperature ($^{\circ}\text{C}$) <u>2/</u>	234	234
Porosity in fracture	.1	.1
Porosity in block	.1	.1
Permeability in fracture (10^{-12}m^2)	.3	.3
Permeability in block (10^{-12}m^2) <u>3/</u>	.00003	.00003
Thickness of fracture	.1	.1
Thickness of block	1.0	1.0
Well discharge (kg/s)	.028	.028
Well radius (m)	.16	.16
Rock heat capacity ($\text{kJ/m}^3\text{C}$)	2570	2570
Rock compressibility	0	0
Rock thermal conductivity	0	0

1/ Initial liquid saturation is zero in the fracture in both cases

2/ Saturation temperature at 30.5 bars

3/ Horizontal permeability in block is zero in both cases

In Case a, liquid saturation is zero everywhere (no boiling). In Case b, immobile liquid boils in the blocks but not in the fracture. Relative permeability to steam is 1.0 in both cases.

NUMERICAL SOLUTION

A computational grid consisting of 1 well block, 10 logarithmically-spaced nodes in the fracture, and 100 nodes of equal vertical thickness in the block should be used. For those codes using finite difference techniques, either block-centered or face-centered nodal

patterns could be used provided that nodal positions were approximately the same as those shown below. The porosity and permeability in the well block should be set to 1.0 and $30 \times 10^{-12} \text{ m}^2$ (or larger), respectively.

Total simulation time should be 10^4 s or more, and to define the pressure history at the well face an initial time step of 1 s should be used. Minimum simulation time of 10^4 s would be reached in about 130 time steps if a time step multiplication factor of 1.05 were used.

OUTPUT SPECIFICATIONS

Results for Cases a and b should consist of plots of pressure as a function of log (time), along with the corresponding data in tabular form. For each case, plot pressure at the well face, and pressure at a point located 2.5 m from the center line of the well and .25 m above the top of the fracture. Include a tabulation of liquid saturation versus time for this same point in the block under Case b conditions. The required data for each case should cover at least 4 log cycles in time.

PROBLEM STATEMENT

#4. Expanding 2 Phase System with Drainage

PHYSICAL DESCRIPTION

This problem involves 1-D vertical flow under both single and two phase conditions. An initially hydrostatic column of liquid is disturbed by mass withdrawal at the bottom. Boiling occurs in portions of the column, and inflow of cold water is induced at the top.

PROBLEM SPECIFICATIONS

1-D Cartesian (Vertical) Geometry

$$g = 9.8 \text{ m/s}$$

Rock Properties

	Layer "A" (0 < D < 1 km)	Layer "B" (1 km < D < 2 km)
Grain Density (g/cm ³)	2.5	2.5
Porosity	0.15	0.25
Permeability (m ²)	5×10^{-15}	100×10^{-15}
Heat Capacity (J/g-°C)	1	1
Grain Thermal Conductivity (W/m - °C)	1	1
Relative Permeability Functions: Corey (as specified in Problem #2)		

Boundary Conditions

At $D = 0$ (Surface), $P = 1.013$ Bar (~ 1 atm), $T = 10^\circ\text{C}$

At $D = 2$ km, see below.

Initial Conditions

$$T(D) = [10 + 280 (D/1 \text{ km})]^\circ\text{C} \quad 0 \leq D \leq 1 \text{ km}$$

$$T(D) = [270 + 20 (D/1 \text{ km})]^\circ\text{C} \quad 1 \text{ km} \leq D \leq 2 \text{ km}$$

$$P(D) = 1.013 \text{ Bar} + \int_0^D \rho g \, dD; \text{ hydrostatic.}$$

Production Strategy

From $t = 0$, to 40 years extract fluid from the bottom of the system ($D = 2$ km) at a rate of $100 \text{ kg/s} - \text{km}^2$.

OUTPUT SPECIFICATIONS

Plot and Tabulate: Discharge enthalpy history of the produced fluid. Recharge rate and cumulative recharge at the surface ($D = 0$).

$P(t)$, $T(t)$ and liquid saturation $S(t)$ at $D = 0.5, 1.0, 1.5$ and 2.0 km.

PROBLEM STATEMENT

#5. Flow in a 2-D Areal Reservoir

PHYSICAL DESCRIPTION

This problem involves multiphase flow in a 2-D horizontal reservoir. Mass is produced at one point in the reservoir, and recharge is induced over one of the lateral boundaries.

PROBLEM SPECIFICATIONS

2-D Areal Geometry

Region is horizontal (gravity neglected; $g_x = g_y = 0$) and of uniform thickness; extends over $0 \leq x \leq 300$ meters, $0 \leq y \leq 200$ meters

Finite - difference zoning as indicated: 12 x 8 grid (96 zones total) of uniform size $\Delta x = \Delta y = 25$ meters.

Boundary Conditions: (See Figure Below)

Impose no convection, no conduction (impermeable, insulated) along:

$$y = 0 \text{ m}; y = 200 \text{ m}; x = 0 \text{ m}$$

Maintain initial P, T along $x = 300 \text{ m}$, $0 < y < 200 \text{ m}$

($P \approx 36$ bars, $T = 160^\circ \text{C}$); see below

Initial Conditions:

Pressure initially uniform, and equal to saturation pressure at 240°C , plus 2.5 bars:

$$P(t = 0, 0 < x < 300 \text{ m}, 0 < y < 200 \text{ m}) =$$

$$P_{\text{sat}}(240^\circ \text{C}) + 2.5 \text{ bars}$$

Note that $P_{\text{sat}}(240^\circ \text{C}) \approx 33.5$ bars, so $P_0 \approx 36$ bars

Initial temperatures for each zone are provided on the table on the next page. They are given approximately by:

$$T(t=0) = 240^\circ \text{C} \text{ for } r \leq 100 \text{ m}$$

$$= \left[240 - 160 \left(\frac{r-100 \text{ m}}{200 \text{ m}} \right)^2 + 80 \left(\frac{r-100 \text{ m}}{200 \text{ m}} \right) \right]^\circ \text{C}$$

$$\text{for } 100 \text{ m} < r < 300 \text{ m}$$

$$= 160^\circ \text{C} \text{ for } r \leq 300 \text{ m}$$

$$\text{where } r = \sqrt{x^2 + y^2}$$

212.07	210.18	206.41	200.81	193.59	185.18	176.31	168.09	162.03	160.00	160.00	160.00	$j=8$
224.92	223.16	219.54	213.95	206.41	197.16	186.79	176.31	167.13	161.12	160.00	160.00	$j=7$
234.31	232.93	229.92	224.92	217.70	208.29	197.16	185.18	173.71	164.58	160.11	160.00	$j=6$
239.31	238.62	236.74	232.93	226.64	217.70	206.41	193.59	180.56	169.11	161.54	160.00	$j=5$ Y
240.00	240.00	239.77	237.76	232.93	224.92	213.95	200.81	186.79	173.71	163.85	160.00	$j=4$
240.00	240.00	WELL	239.77	236.74	229.92	219.54	206.41	191.85	177.68	166.22	160.26	$j=3$
240.00	240.00	240.00	240.00	238.62	232.93	223.16	210.18	195.36	180.56	168.09	160.77	$j=2$
240.00	240.00	240.00	240.00	239.31	234.31	224.92	212.07	197.16	182.06	169.11	161.12	$j=1$
$i=1$	$i=2$	$i=3$	$i=4$	$i=5$	$i=6$	$i=7$	$i=8$	$i=9$	$i=10$	$i=11$	$i=12$	

X

Production Strategy for Case A

A fully-penetrating production well is located at $x = 62.5\text{m}$, $y = 62.5\text{m}$ (at the center of zone $i=3$, $j=3$). Starting at $t=0$, it produces fluid at the constant rate of 0.05 kilograms/sec-meter of thickness. The well radius is 15 cm and no skin effect is present.

Production Strategy for Case B

A production well is present, identical to Case A. In addition, an injection well is located at $x = 162.5\text{m}$, $y = 137.5\text{m}$, at the center of zone $i=7$, $j=6$. The well is fully penetrating, has no skin effect,

and is of radius 15 cm. The injection well is inoperative until $t = 1$ year (3.1536×10^7 sec). Thereafter, it begins injecting water at $T = 80^\circ\text{C}$ at a rate of 0.03 kilograms/sec-meter of thickness.

OUTPUT SPECIFICATIONS

In both cases, the time domain of interest is

$$0 \leq t \leq 10 \text{ years } (3.1536 \times 10^8 \text{ sec}).$$

For cases A & B, plot and tabulate:

- (1) Pressure history in zones $i=3$, $j=3$ and $i=7$, $j=6$.
- (2) Temperature history in zones $i=3$, $j=3$.
- (3) History of discharge (flowing) enthalpy in zone $i=3$, $j=3$.
- (4) Variation with time of total mass of steam in the system per meter of thickness.

Optional (for those with subgrid well model):

- (5) What is the sandface pressure history for the production well in cases A & B?
- (6) What is the sandface pressure history for the injection well in Case B?
- (7) What is the sandface steam saturation history at the production well in cases A & B?

PROBLEM STATEMENT

#6. Flow in a 3-D Reservoir.

PHYSICAL DESCRIPTION

This problem involves flow within a 3-D system, with production from one corner grid block, and constant pressure upper and lower surfaces. The flow is initially single phase liquid, except in one layer where an immobile steam phase exists.

PROBLEM SPECIFICATIONS

3-D geometry, five layer

NOTE - VERTICAL SCALE EXAGGERATED.

$$g_x = g_y = 0$$

$$g_z = -9.8 \text{ m/s}^2$$

LAYER THICKNESSES:

LAYER 1, 0.6 km

LAYERS 2-5, 0.3 km EACH

GRID: 5 x 5 x 5

(Horizontal, uniform,
5 zones each direction)

Rock Properties

	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Grain Density (g/cm^3)	2.5	2.5	2.5	2.5	2.5
Porosity	0.2	0.25	0.25	0.25	0.2
x-Permeability (m^2)	100×10^{-15}	200×10^{-15}	200×10^{-15}	200×10^{-15}	100×10^{-15}
y-Permeability (m^2)	100×10^{-15}	200×10^{-15}	200×10^{-15}	200×10^{-15}	100×10^{-15}
z-Permeability (m^2)	2×10^{-15}	50×10^{-15}	50×10^{-15}	50×10^{-15}	2×10^{-15}
Heat Capacity ($\text{J/g-}^\circ\text{C}$)	1	1	1	1	1
Rock Therm. Cond. ($\text{w/m-}^\circ\text{C}$)	1	1	1	1	1
Relative Permeability: Corey equations as in Problem #2, except:					
S_{1r} (liquid residual)	0.3	0.3	0.3	0.3	0.3
S_{gr} (gas residual)	0.1	0.1	0.1	0.1	0.1

Initial Conditions

Temperature:

Layers 1-4, 280°C everywhereLayer 5, 160°C

Pressure:

Layer 4: $P_4^0 = P_{\text{sat}} (280^\circ\text{C}) \approx 64 \text{ Bars}$ (Steam saturation) $S_g^0 = 0.1$ (steam initially immobile)Layer 5: $P_5^0 = P_4^0 - (1470 \text{ m}^2/\text{s}^2) \times (\rho_4^0 - \text{liq} + \rho_5^0)$ Layer 3: $P_3^0 = P_4^0 + (1470 \text{ m}^2/\text{s}^2) \times (\rho_4^0 - \text{liq} + \rho_3^0)$ Layer 2: $P_2^0 = P_3^0 + (1470 \text{ m}^2/\text{s}^2) \times (\rho_3^0 + \rho_2^0)$ Layer 1: $P_1^0 = P_2^0 + (1470 \text{ m}^2/\text{s}^2) \times (\rho_2^0 + 2\rho_1^0)$ Where $\rho_4^0 - \text{liq}$ = liquid density in Layer 4

These initial conditions (P^0 , ρ^0 , S_g^0) are functions of z only.

Layers 1, 2, 3 and 5 are initially single-phase liquid; layer 4 is initially 2-phase with an immobile steam phase. The pressure distribution is liquid-hydrostatic throughout at zero time.

Boundary conditions

At $z = 1.5$ km (top surface), maintain $P_{\text{top}} = P_5^0 - (1470 \text{ m}^2/\text{s}^2) \times \rho_5^0$ and $T = 100^\circ\text{C}$.

At $z = 0$, maintain $P_{\text{bottom}} = P_1^0 + (2940 \text{ m}^2/\text{s}^2) \times \rho_1^0$ and $T = 280^\circ\text{C}$.

Along planes at $x = 0$ and $y = 0$, impose symmetry conditions.

Treat plane at $y = 4$ km as impermeable and insulated.

Along plane at $x = 5$ km, maintain initial distributions of P, T, S_g .

Production Strategy

All production is taken from a single corner cell ($i=1$, $j=1$, $k=2$).

$0 \leq t \leq 2$ years, $Q(t) = 1000 \text{ kg/s}$

$2 \text{ years} < t \leq 4 \text{ years}$, $Q(t) = 2500 \text{ kg/s}$

$4 \text{ years} < t \leq 6 \text{ years}$, $Q(t) = 4000 \text{ kg/s}$

$t > 6 \text{ years}$, $Q(t) = 6000 \text{ kg/s}$

OUTPUT SPECIFICATIONS

For a total production time of 10 years, plot and tabulate:

Discharge enthalpy history.

Histories of P, T, S_g at $x = y = 0$ for each layer.

APPENDIX B TABULATED RESULTS FOR PROBLEMS 1-6

Problem 1. Results for upstream weighting.

TEMPERATURE VS. TIME AT 37.5 m	TIME 107 sec	TEMP °C
	3.33	166.37
	6.67	163.96
	1.00	162.76
	13.3	162.10
	16.7	161.66
	20.0	161.35
	23.3	161.14
	26.7	160.97
	30.0	160.85
	40.0	160.60
	50.0	160.45
	60.0	160.36
	77.0	160.30
	80.0	160.25
	90.0	160.21
	100.0	160.15

TEMPERATURE VS. DISTANCE AT 10⁹ sec

DISTANCE (m)	TEMP °C
12.5	160.06
37.5	160.19
62.5	160.47
87.5	160.95
112.5	161.63
137.5	162.50
162.5	163.50
187.5	164.57
212.5	165.62
237.5	166.60
262.5	167.46
287.5	168.17
312.5	168.73
337.5	169.15
362.5	169.45

DISTANCE (m)	TEMP °C
377.5	169.65
412.5	169.79
437.5	169.98
462.5	169.93
487.5	169.96
512.5	169.98

DOE

Problem 2A

time (t) (days)	r = .5 meters		r = .707 meters		r = 1.0 meter	
	$\log(t/t_0)$	P (bars)	$\log(t/t_0)$	P (bars)	$\log(t/t_0)$	P (bars)
.116E-4	-4.33	87.98	-4.63	88.72	-4.94	89.29
.281E-4	-3.94	86.76	-4.24	87.66	-4.54	88.47
.550E-4	-3.66	85.84	-3.96	86.79	-4.26	86.70
.940E-4	-3.42	85.05	-3.73	86.03	-4.03	86.98
.153E-3	-3.21	84.34	-3.51	85.33	-3.82	86.31
.241E-3	-3.02	83.67	-3.32	84.67	-3.62	85.66
.372E-3	-2.83	83.03	-3.13	84.04	-3.43	85.03
.570E-3	-2.64	82.41	-2.94	83.42	-3.24	84.42
.867E-3	-2.46	81.79	-2.76	82.80	-3.06	83.81
.131E-2	-2.28	81.19	-2.58	82.20	-2.88	83.21
.198E-2	-2.10	80.59	-2.40	81.60	-2.70	82.61
.296E-2	-1.92	79.99	-2.22	81.00	-2.53	82.01
.448E-2	-1.75	79.39	-2.05	80.40	-2.35	81.42
.673E-2	-1.57	78.80	-1.87	79.81	-2.17	80.82
.101E-1	-1.39	78.20	-1.69	79.22	-2.00	80.23
.152E-1	-1.22	77.61	-1.52	78.62	-1.82	79.63
.228E-1	-1.04	77.01	-1.34	78.03	-1.64	79.04
.342E-1	-.864	76.42	-1.16	77.43	-1.47	78.45
.513E-1	-.688	75.83	-.989	76.84	-1.29	77.85
.770E-1	-.511	75.23	-.812	76.25	-1.11	77.26
.115	-.337	74.64	-.638	75.66	-.939	76.67
.173	-.160	74.05	-.461	75.06	-.762	76.08
.260	.017	73.46	-.284	74.47	-.585	75.48
.390	.193	72.86	-.108	73.88	-.409	74.89
.584	.369	72.27	.068	73.28	-.234	74.30
.877	.545	71.68	.244	72.69	-.057	73.70
1.0	.602	71.46	.301	72.48	0	73.49

DOE

8-5

Problem 2B

Time, t (days)	r = .5 meters				r = .707 meters				r = 1.0 meter			
	$\log(t/t_0)$	P (bars)	S	$h(t/t_0)$	$\log(t/t_0)$	P (bars)	S	$\log(t/t_0)$	P (bars)	S		
.116E-4	-4.33	29.97	.649	1.33E+3	-4.63	30.00	.650	-4.94	30.00	.650		
.289E-4	-3.94	29.97	.647	1.34E+3	-4.24	30.00	.650	-4.54	30.00	.650		
.550E-4	-3.66	29.94	.645	1.36E+3	-3.96	30.00	.650	-4.26	30.00	.650		
.940E-4	-3.42	29.89	.641	1.38E+3	-3.73	29.99	.649	-4.03	30.00	.650		
.153E-3	-3.21	29.93	.637	1.40E+3	-3.51	29.97	.648	-3.82	30.00	.650		
.241E-3	-3.02	29.73	.631	1.44E+3	-3.32	29.94	.645	-3.62	29.99	.649		
.372E-3	-2.83	29.60	.624	1.49E+3	-3.13	29.88	.640	-3.43	29.98	.649		
.570E-3	-2.64	29.40	.616	1.55E+3	-2.94	29.78	.634	-3.24	29.95	.646		
.867E-3	-2.46	29.16	.607	1.61E+3	-2.76	29.61	.626	-3.06	29.88	.641		
.131E-2	-2.28	28.80	.599	1.67E+3	-2.58	29.36	.617	-2.88	29.76	.633		
.198E-2	-2.10	28.39	.593	1.72E+3	-2.40	29.03	.609	-2.70	29.55	.624		
.298E-2	-1.92	27.92	.588	1.76E+3	-2.22	28.64	.603	-2.53	29.25	.614		
.448E-2	-1.75	27.44	.586	1.77E+3	-2.05	28.20	.597	-2.35	28.89	.607		
.673E-2	-1.57	26.96	.585	1.78E+3	-1.87	27.75	.593	-2.17	28.48	.600		
.101E-1	-1.39	26.48	.584	1.77E+3	-1.69	27.29	.590	-2.00	28.06	.596		
.152E-1	-1.22	26.00	.583	1.77E+3	-1.52	26.82	.588	-1.82	27.61	.592		
.228E-1	-1.04	25.51	.582	1.77E+3	-1.34	26.34	.586	-1.64	27.15	.590		
.342E-1	-.864	25.01	.581	1.77E+3	-1.16	25.86	.584	-1.47	26.68	.587		
.513E-1	-.688	24.50	.580	1.77E+3	-.989	25.36	.583	-1.29	26.20	.586		
.770E-1	-.511	23.98	.579	1.77E+3	-.812	24.86	.582	-1.11	25.72	.584		
.115	-.337	23.46	.578	1.77E+3	-.638	24.35	.580	-.939	25.22	.583		
.173	-.160	22.93	.577	1.77E+3	-.461	23.83	.579	-.762	24.71	.581		
.260	.017	22.38	.576	1.77E+3	-.284	23.31	.578	-.585	24.20	.580		
.390	.193	21.83	.575	1.77E+3	-.108	22.77	.577	-.409	23.68	.579		
.584	.369	21.27	.574	1.77E+3	.068	22.23	.576	-.234	23.15	.578		
.877	.545	20.70	.572	1.77E+3	.244	21.67	.575	-.057	22.61	.577		
1.0	.602	20.50	.572	1.77E+3	.301	21.47	.574	0	22.42	.576		

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Time, t, (days)	Pressure, P, (bars)	Liquid Saturation, S,	Discharge Enthalpy, h, (kJ/kg)
.100E-3	29.96	.646	1.35E+3
.200E-3	29.91	.642	1.37E+3
.300E-3	29.86	.638	1.37E+3
.400E-3	29.80	.635	1.42E+3
.500E-3	29.75	.631	1.44E+3
.600E-3	29.69	.627	1.47E+3
.700E-3	29.63	.623	1.49E+3
.800E-3	29.56	.619	1.52E+3
.900E-3	29.49	.615	1.55E+3
.100E-2	29.42	.611	1.58E+3
.110E-2	29.34	.607	1.61E+3
.120E-2	29.26	.603	1.64E+3
.130E-2	29.17	.599	1.68E+3
.140E-2	29.08	.596	1.71E+3
.150E-2	28.99	.592	1.74E+3
.160E-2	28.89	.588	1.79E+3
.170E-2	28.79	.584	1.81E+3
.180E-2	28.69	.580	1.85E+3
.190E-2	28.58	.576	1.87E+3
.200E-2	28.46	.572	1.92E+3
.210E-2	28.35	.568	1.96E+3
.220E-2	28.22	.564	2.00E+3
.230E-2	28.10	.560	2.03E+3
.240E-2	27.97	.556	2.07E+3
.250E-2	27.83	.552	2.11E+3
.260E-2	27.69	.548	2.14E+3
.270E-2	27.55	.544	2.18E+3
.280E-2	27.40	.540	2.21E+3

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Problem 2B1 (continued)

Time, t, (days)	Pressure, P, (bars)	Liquid Saturation, S,	Discharge Enthalpy, h _i (kJ/kg)
290E-2	27.25	536	2.24 E+3
300E-2	27.10	532	2.28 E+3
310E-2	26.94	528	2.31 E+3
320E-2	26.78	524	2.34 E+3
330E-2	26.62	520	2.37 E+3
340E-2	26.45	516	2.40 E+3
350E-2	26.28	512	2.43 E+3
360E-2	26.11	509	2.45 E+3
370E-2	25.94	505	2.48 E+3
380E-2	25.76	501	2.50 E+3
390E-2	25.58	497	2.53 E+3
400E-2	25.40	493	2.55 E+3
410E-2	25.22	489	2.57 E+3
420E-2	25.03	485	2.59 E+3
430E-2	24.85	481	2.61 E+3
440E-2	24.66	477	2.62 E+3
450E-2	24.47	473	2.64 E+3
460E-2	24.28	469	2.65 E+3
470E-2	24.09	465	2.67 E+3
480E-2	23.90	461	2.68 E+3
490E-2	23.71	457	2.69 E+3
500E-2	23.52	453	2.70 E+3
510E-2	23.33	449	2.71 E+3
520E-2	23.13	445	2.72 E+3
530E-2	22.94	441	2.73 E+3
540E-2	22.75	438	2.74 E+3
550E-2	22.55	434	2.75 E+3
560E-2	22.36	430	2.75 E+3

Problem 2B.2 (continued)

Time, t , (days)	Pressure, P , (bars)	Liquid Saturation, S ,	Discharge Enthalpy, h , (kJ/kg)
.570 E-2	22.17	426	2.76 E+3
.580 E-2	21.98	422	2.76 E+3
.590 E-2	21.78	418	2.77 E+3
.600 E-2	21.59	414	2.77 E+3
.610 E-2	21.40	410	2.78 E+3
.620 E-2	21.21	406	2.78 E+3
.630 E-2	21.02	403	2.78 E+3
.640 E-2	20.83	399	2.78 E+3
.650 E-2	20.64	395	2.79 E+3
.660 E-2	20.45	391	2.79 E+3
.670 E-2	20.26	387	2.79 E+3
.680 E-2	20.08	384	2.79 E+3
.690 E-2	19.89	380	2.79 E+3
.700 E-2	19.70	376	2.79 E+3
.710 E-2	19.52	372	2.80 E+3
.720 E-2	19.34	368	2.80 E+3
.730 E-2	19.15	364	2.80 E+3
.740 E-2	18.97	361	2.80 E+3
.750 E-2	18.79	357	2.80 E+3
.760 E-2	18.61	353	2.80 E+3
.770 E-2	18.43	349	2.80 E+3
.780 E-2	18.25	345	2.80 E+3
.790 E-2	18.07	342	2.80 E+3
.800 E-2	17.89	338	2.80 E+3
.810 E-2	17.72	334	2.80 E+3
.820 E-2	17.54	330	2.80 E+3
.830 E-2	17.37	327	2.80 E+3
.840 E-2	17.20	323	2.80 E+3

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Problem 2C

Time, t, (days)	r = .5 meters				r = .707 meters			r = 1.0 meter		
	log(t/h)	P (bars)	S	h (m/h)	log(t/h)	P (bars)	S	log(t/h)	P (bars)	S
.116E-4	-4.33	88.08	1.00	1.34E+3	-4.63	88.79	1.00	-4.94	89.34	1.00
.289E-4	-3.94	86.92	1.00	1.34E+3	-4.24	87.78	1.00	-4.54	88.56	1.00
.550E-4	-3.66	86.03	1.00	1.34E+3	-3.96	86.95	1.00	-4.26	87.82	1.00
.940E-4	-3.42	85.27	1.00	1.34E+3	-3.73	86.22	1.00	-4.03	87.13	1.00
.53E-3	-3.21	84.79	1.00	1.34E+3	-3.51	85.70	1.00	-3.82	86.59	1.00
.241E-3	-3.02	84.78	.998	1.34E+3	-3.32	85.57	1.00	-3.62	86.36	1.00
.372E-3	-2.93	84.77	.996	1.34E+3	-3.13	85.49	1.00	-3.43	86.21	1.00
.570E-3	-2.64	84.74	.991	1.34E+3	-2.94	85.41	1.00	-3.24	86.08	1.00
.567E-3	-2.46	84.70	.982	1.34E+3	-2.76	85.33	1.00	-3.06	85.95	1.00
.131E-2	-2.28	84.63	.968	1.34E+3	-2.58	85.22	1.00	-2.88	85.82	1.00
.198E-2	-2.10	84.52	.946	1.34E+3	-2.40	85.09	1.00	-2.70	85.67	1.00
.238E-2	-1.94	84.37	.915	1.34E+3	-2.24	84.93	1.00	-2.54	85.49	1.00
.376E-2	-1.82	84.22	.885	1.34E+3	-2.12	84.78	.999	-2.42	85.34	1.00
.465E-2	-1.73	84.09	.862	1.34E+3	-2.03	84.74	.991	-2.33	85.28	1.00
.577E-2	-1.64	83.94	.838	1.35E+3	-1.93	84.66	.974	-2.24	85.19	1.00
.7E-2	-1.54	83.74	.814	1.35E+3	-1.84	84.52	.946	-2.14	85.05	1.00
.370E-2	-1.46	83.41	.788	1.37E+3	-1.76	84.37	.916	-2.06	84.91	1.00
.102E-1	-1.39	82.98	.767	1.39E+3	-1.69	84.22	.885	-1.99	84.78	.998
.117E-1	-1.33	82.51	.753	1.41E+3	-1.63	84.08	.859	-1.93	84.74	.990
.134E-1	-1.27	81.92	.744	1.42E+3	-1.57	83.92	.835	-1.87	84.66	.974
.155E-1	-1.21	81.26	.740	1.42E+3	-1.51	83.69	.813	-1.81	84.53	.948
.179E-1	-1.15	80.52	.734	1.43E+3	-1.45	83.34	.793	-1.75	84.38	.917
.202E-1	-1.09	79.78	.727	1.44E+3	-1.39	82.92	.778	-1.69	84.23	.887
.225E-1	-1.05	79.07	.722	1.45E+3	-1.34	82.47	.769	-1.65	84.10	.862
.253E-1	-.995	78.31	.721	1.45E+3	-1.30	81.93	.763	-1.60	83.95	.838
.255E-1	-.939	77.57	.723	1.44E+3	-1.24	81.34	.760	-1.54	83.75	.817
.366E-1	-.835	76.72	.723	1.44E+3	-1.14	80.63	.754	-1.44	83.42	.797

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Fig. 2-5 (continued)

Time, t (days)	r = .5 meters				r = .707 meters				r = 1.0 meter			
	log($\frac{t}{t_0}$)	P (bars)	S	h ($\frac{1}{2}K_0$)	log($\frac{t}{t_0}$)	P (bars)	S	log($\frac{t}{t_0}$)	P (bars)	S		
.380E-1	-.818	75.91	.718	1.45E+3	-1.12	79.99	.747	-1.42	83.04	.782		
.424E-1	-.771	75.06	.713	1.46E+3	-1.07	79.34	.740	-1.37	82.63	.772		
.477E-1	-.719	74.14	.710	1.46E+3	-1.02	78.61	.736	-1.32	82.13	.766		
.542E-1	-.664	73.29	.712	1.45E+3	-.965	77.85	.735	-1.27	81.56	.761		
.636E-1	-.599	72.47	.714	1.44E+3	-.900	77.06	.734	-1.20	80.90	.757		
.718E-1	-.542	71.56	.710	1.44E+3	-.843	76.28	.729	-1.14	80.27	.750		
.808E-1	-.491	70.49	.703	1.46E+3	-.791	75.43	.723	-1.09	79.62	.743		
.905E-1	-.441	69.38	.699	1.47E+3	-.742	74.52	.718	-1.04	78.92	.737		
.102	-.389	68.38	.700	1.46E+3	-.690	73.62	.717	-.991	78.15	.735		
.118	-.326	67.70	.704	1.44E+3	-.627	72.86	.719	-.928	77.42	.735		
.136	-.264	66.77	.702	1.44E+3	-.565	72.02	.717	-.867	76.65	.732		
.154	-.210	65.40	.694	1.46E+3	-.511	70.92	.709	-.813	75.78	.725		
.172	-.162	64.00	.688	1.47E+3	-.463	69.79	.704	-.765	74.88	.719		
.194	-.110	62.81	.687	1.47E+3	-.411	68.70	.702	-.712	73.93	.717		
.222	-.052	62.12	.691	1.45E+3	-.353	67.92	.705	-.654	73.12	.718		
.260	-.017	61.25	.692	1.44E+3	-.284	67.05	.705	-.585	72.26	.718		
.296	.073	59.84	.685	1.45E+3	-.228	65.89	.699	-.529	71.30	.712		
.331	.122	58.17	.678	1.47E+3	-.179	64.53	.693	-.480	70.21	.706		
.373	.174	56.71	.676	1.47E+3	-.127	63.25	.690	-.428	69.09	.703		
.423	.228	55.85	.678	1.45E+3	-.073	62.35	.691	-.384	68.18	.704		
.491	.293	55.31	.681	1.44E+3	-.008	61.70	.694	-.309	67.45	.706		
.562	.352	53.89	.676	1.45E+3	.051	60.50	.689	-.250	66.43	.702		
.634	.404	51.76	.668	1.47E+3	.103	58.79	.682	-.198	65.05	.695		
.710	.453	49.87	.663	1.48E+3	.152	57.18	.677	-.149	63.69	.690		
.803	.507	48.74	.664	1.46E+3	.206	56.08	.677	-.095	62.62	.690		
.921	.566	48.50	.668	1.44E+3	.265	55.64	.681	-.036	62.03	.694		
1.0	.602	48.19	.668	1.43E+3	.301	55.31	.682	0	61.67	.694		

Problem 3a. Node 1,1,1 corresponds to well block, and
node 4,1,4 corresponds to point 2.5 m from
well center and .25 m above fracture.

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Time i, j, k	Pressure	Time i, j, k	Pressure
1.0000		127.91		3971.8	
1 1 1 4 1 4	.29343E+08 .30491E+08	1 1 1 4 1 4	.25078E+08 .30459E+08	1 1 1 4 1 4	.22714E+08 .28155E+08
2.1000		167.29		-5104.3	
1 1 1 4 1 4	.28620E+08 .30491E+08	1 1 1 4 1 4	.24883E+08 .30429E+08	1 1 1 4 1 4	.22542E+08 .27873E+08
3.0000		-218.47		6714.6	
1 1 1 4 1 4	.28085E+08 .30491E+08	1 1 1 4 1 4	.24690E+08 .30381E+08	1 1 1 4 1 4	.22365E+08 .27578E+08
6.1870		285.81		8730.8	
1 1 1 4 1 4	.27652E+08 .30491E+08	1 1 1 4 1 4	.24498E+08 .30306E+08	1 1 1 4 1 4	.22178E+08 .27264E+08
9.0431		371.52		-11350.	
1 1 1 4 1 4	.27284E+08 .30491E+08	1 1 1 4 1 4	.24308E+08 .30201E+08	1 1 1 4 1 4	.21976E+08 .26950E+08
12.756		481.97		14756.	
1 1 1 4 1 4	.26959E+08 .30491E+08	1 1 1 4 1 4	.24121E+08 .30082E+08	1 1 1 4 1 4	.21754E+08 .26579E+08
17.383		630.17		19184.	
1 1 1 4 1 4	.26663E+08 .30491E+08	1 1 1 4 1 4	.23937E+08 .29890E+08	1 1 1 4 1 4	.21511E+08 .26215E+08
23.858		820.22		-24940.	
1 1 1 4 1 4	.26389E+08 .30491E+08	1 1 1 4 1 4	.23756E+08 .29688E+08	1 1 1 4 1 4	.21246E+08 .25848E+08
32.815		-1067.3		32423.	
1 1 1 4 1 4	.26134E+08 .30491E+08	1 1 1 4 1 4	.23578E+08 .29462E+08	1 1 1 4 1 4	.20962E+08 .25487E+08
42.819		1388.5		42151.	
1 1 1 4 1 4	.25898E+08 .30490E+08	1 1 1 4 1 4	.23401E+08 .29218E+08	1 1 1 4 1 4	.20662E+08 .25137E+08
56.405		1806.8		-54797.	
1 1 1 4 1 4	.25679E+08 .30488E+08	1 1 1 4 1 4	.23227E+08 .28962E+08	1 1 1 4 1 4	.20349E+08 .24801E+08
74.327		2348.8		71237.	
1 1 1 4 1 4	.25473E+08 .30484E+08	1 1 1 4 1 4	.23055E+08 .28698E+08	1 1 1 4 1 4	.20027E+08 .24479E+08
97.825		3054.6		86400.	
1 1 1 4 1 4	.25274E+08 .30475E+08	1 1 1 4 1 4	.22884E+08 .28429E+08	1 1 1 4 1 4	.19780E+08 .24243E+08

Problem 3b. Same node arrangement as in 3a.

Time (sec) L, J, K	Pressure 10 ⁻⁶ bars	saturation (liquid)	Time L, J, K	Pressure	Sat	Time L, J, K	Pressure	Sat	Time L, J, K	Pressure	Sat
1.0000			50.005			020.22			11350.		
1 1 1 4 1 4	.29434E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25000E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25078E+08 .30553E+08	0. .20005	1 1 1 4 1 4	.24140E+08 .30306E+08	0. .19347
2.3000			74.327			1007.5			14750.		
1 1 1 4 1 4	.28112E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25099E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25031E+08 .30553E+08	0. .20001	1 1 1 4 1 4	.24004E+08 .30187E+08	0. .18992
3.9900			97.025			1400.5			19100.		
1 1 1 4 1 4	.28170E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25511E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.24975E+08 .30551E+08	0. .20079	1 1 1 4 1 4	.23866E+08 .30036E+08	0. .18541
6.1070			127.91			1806.0			24940.		
1 1 1 4 1 4	.27747E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25447E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.24908E+08 .30549E+08	0. .20073	1 1 1 4 1 4	.23727E+08 .29856E+08	0. .18000
9.0431			167.29			2300.0			32423.		
1 1 1 4 1 4	.27301E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25355E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.24830E+08 .30545E+08	0. .20059	1 1 1 4 1 4	.23586E+08 .29648E+08	0. .17379
12.756			210.47			3054.4			42151.		
1 1 1 4 1 4	.27060E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25283E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.24739E+08 .30537E+08	0. .20035	1 1 1 4 1 4	.23446E+08 .29420E+08	0. .16696
17.503			285.01			3971.0			54797.		
1 1 1 4 1 4	.26770E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25230E+08 .30554E+08	0. .20016	1 1 1 4 1 4	.24636E+08 .30522E+08	0. .19991	1 1 1 4 1 4	.23304E+08 .29177E+08	0. .15966
23.050			371.92			5164.1			71257.		
1 1 1 4 1 4	.26504E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25100E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.24523E+08 .30497E+08	0. .19916	1 1 1 4 1 4	.23162E+08 .28924E+08	0. .15205
32.015			483.97			6714.6			86400.		
1 1 1 4 1 4	.26263E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25152E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.24402E+08 .30456E+08	0. .19795	1 1 1 4 1 4	.23055E+08 .28730E+08	0. .14620
47.019			630.17			8730.0					
1 1 1 4 1 4	.26048E+08 .30554E+08	0. .20000	1 1 1 4 1 4	.25117E+08 .30553E+08	0. .20005	1 1 1 4 1 4	.24273E+08 .30394E+08	0. .19610			

Problem 4.

Node	Depth
1, 1, 15	.55 km
1, 1, 10	1.05 km
1, 1, 15	1.55 km
1, 1, 1	1.95 km

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Time (sec) L, J, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time L, J, k	Pressure	Sat	Temp
100.00				3217.2			
-1 1 1	.15629E+04	1.0000	309.00	1 1 1	.15621E+04	1.0000	309.00
-1 1 5	.12860E+09	1.0000	301.00	1 1 5	.12859E+09	1.0000	301.00
-1 1 6	.12159E+09	1.0000	299.00	1 1 6	.12157E+09	1.0000	299.00
-1 1 10	.93140E+08	1.0000	291.00	1 1 10	.93138E+08	1.0000	291.00
-1 1 11	.85840E+08	1.0000	276.00	1 1 11	.85837E+08	1.0000	276.00
-1 1 15	.52910E+08	1.0000	164.00	1 1 15	.52908E+08	1.0000	164.00
-1 1 16	.43880E+08	1.0000	136.00	1 1 16	.43877E+08	1.0000	136.00
250.00				4925.8			
1 1 1	.15629E+04	1.0000	309.00	1 1 1	.15618E+04	1.0000	309.00
1 1 5	.12860E+09	1.0000	301.00	1 1 5	.12859E+09	1.0000	301.00
1 1 6	.12159E+09	1.0000	299.00	1 1 6	.12157E+09	1.0000	299.00
1 1 10	.93140E+08	1.0000	291.00	1 1 10	.93137E+08	1.0000	291.00
1 1 11	.85840E+08	1.0000	276.00	1 1 11	.85835E+08	1.0000	276.00
1 1 15	.52910E+08	1.0000	164.00	1 1 15	.52905E+08	1.0000	164.00
1 1 16	.43880E+08	1.0000	136.00	1 1 16	.43876E+08	1.0000	136.00
475.00				7488.7			
1 1 1	.15628E+04	1.0000	309.00	1 1 1	.15614E+04	1.0000	309.00
1 1 5	.12860E+09	1.0000	301.00	1 1 5	.12858E+09	1.0000	301.00
1 1 6	.12159E+09	1.0000	299.00	1 1 6	.12156E+09	1.0000	299.00
1 1 10	.93140E+08	1.0000	291.00	1 1 10	.93135E+08	1.0000	291.00
1 1 11	.85839E+08	1.0000	276.00	1 1 11	.85832E+08	1.0000	276.00
1 1 15	.52909E+08	1.0000	164.00	1 1 15	.52902E+08	1.0000	164.00
1 1 16	.43880E+08	1.0000	136.00	1 1 16	.43874E+08	1.0000	136.00
812.50				11155.			
1 1 1	.15627E+04	1.0000	309.00	1 1 1	.15610E+04	1.0000	309.00
1 1 5	.12860E+09	1.0000	301.00	1 1 5	.12856E+09	1.0000	301.00
1 1 6	.12159E+09	1.0000	299.00	1 1 6	.12155E+09	1.0000	299.00
1 1 10	.93140E+08	1.0000	291.00	1 1 10	.93133E+08	1.0000	291.00
1 1 11	.85839E+08	1.0000	276.00	1 1 11	.85828E+08	1.0000	276.00
1 1 15	.52909E+08	1.0000	164.00	1 1 15	.52898E+08	1.0000	164.00
1 1 16	.43879E+08	1.0000	136.00	1 1 16	.43870E+08	1.0000	136.00
1318.8				17100.			
1 1 1	.15625E+04	1.0000	309.00	1 1 1	.15604E+04	1.0000	309.00
1 1 5	.12860E+09	1.0000	301.00	1 1 5	.12853E+09	1.0000	301.00
1 1 6	.12158E+09	1.0000	299.00	1 1 6	.12153E+09	1.0000	299.00
1 1 10	.93119E+08	1.0000	291.00	1 1 10	.93128E+08	1.0000	291.00
1 1 11	.85839E+08	1.0000	276.00	1 1 11	.85823E+08	1.0000	276.00
1 1 15	.52909E+08	1.0000	164.00	1 1 15	.52891E+08	1.0000	164.00
1 1 16	.43879E+08	1.0000	136.00	1 1 16	.43865E+08	1.0000	136.00
2078.1				25749.			
1 1 1	.15623E+04	1.0000	309.00	1 1 1	.15597E+04	1.0000	309.00
1 1 5	.12860E+09	1.0000	301.00	1 1 5	.12849E+09	1.0000	301.00
1 1 6	.12158E+09	1.0000	299.00	1 1 6	.12150E+09	1.0000	299.00
1 1 10	.93138E+08	1.0000	291.00	1 1 10	.93114E+08	1.0000	291.00
1 1 11	.85838E+08	1.0000	276.00	1 1 11	.85812E+08	1.0000	276.00
1 1 15	.52908E+08	1.0000	164.00	1 1 15	.52882E+08	1.0000	164.00
1 1 16	.43878E+08	1.0000	136.00	1 1 16	.43857E+08	1.0000	136.00

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Time (sec) <i>i, j, k</i>	Pressure 10^{-6} bars	Saturation (liquid)	Temp °C	Time <i>i, j, k</i>	Pressure	Sat	Temp
.58724.				.44317E+06			
1 1 1	.15589E+09	1.0000	309.00	1 1 1	.15415E+09	1.0000	309.02
1 1 5	.12843E+09	1.0000	301.00	1 1 5	.12676E+09	1.0000	301.01
1 1 6	.12144E+09	1.0000	299.00	1 1 6	.11980E+09	1.0000	299.01
1 1 10	.93085E+08	1.0000	291.00	1 1 10	.91533E+08	1.0000	291.01
1 1 11	.85790E+08	1.0000	276.00	1 1 11	.84394E+08	1.0000	276.00
1 1 15	.52868E+08	1.0000	164.00	1 1 15	.52201E+08	1.0000	164.00
1 1 16	.43845E+08	1.0000	136.00	1 1 16	.43296E+08	1.0000	136.00
.50186.				.66485E+06			
1 1 1	.15577E+09	1.0000	309.00	1 1 1	.15330E+09	1.0000	309.03
1 1 5	.12834E+09	1.0000	301.00	1 1 5	.12592E+09	1.0000	301.02
1 1 6	.12136E+09	1.0000	299.00	1 1 6	.11896E+09	1.0000	299.02
1 1 10	.93022E+08	1.0000	291.00	1 1 10	.90704E+08	1.0000	291.01
1 1 11	.85746E+08	1.0000	276.00	1 1 11	.83598E+08	1.0000	276.00
1 1 15	.52868E+08	1.0000	164.00	1 1 15	.51688E+08	1.0000	164.00
1 1 16	.43827E+08	1.0000	136.00	1 1 16	.42856E+08	1.0000	136.00
.67379.				.99738E+06			
1 1 1	.15563E+09	1.0000	309.01	1 1 1	.15208E+09	1.0000	309.04
1 1 5	.12820E+09	1.0000	301.00	1 1 5	.12478E+09	1.0000	301.03
1 1 6	.12123E+09	1.0000	299.00	1 1 6	.11774E+09	1.0000	299.03
1 1 10	.92917E+08	1.0000	291.00	1 1 10	.89501E+08	1.0000	291.01
1 1 11	.85663E+08	1.0000	276.00	1 1 11	.82430E+08	1.0000	276.00
1 1 15	.52814E+08	1.0000	164.00	1 1 15	.50843E+08	1.0000	164.00
1 1 16	.43798E+08	1.0000	136.00	1 1 16	.42106E+08	1.0000	136.00
.13117E+06				.14962E+07			
1 1 1	.15543E+09	1.0000	309.01	1 1 1	.15031E+09	1.0000	309.05
1 1 5	.12801E+09	1.0000	301.00	1 1 5	.12294E+09	1.0000	301.04
1 1 6	.12105E+09	1.0000	299.00	1 1 6	.11599E+09	1.0000	299.04
1 1 10	.92748E+08	1.0000	291.00	1 1 10	.87766E+08	1.0000	291.02
1 1 11	.85520E+08	1.0000	276.00	1 1 11	.80732E+08	1.0000	276.00
1 1 15	.52760E+08	1.0000	164.00	1 1 15	.49512E+08	1.0000	164.00
1 1 16	.43754E+08	1.0000	136.00	1 1 16	.40895E+08	1.0000	136.00
.19685E+06				.22443E+07			
1 1 1	.15515E+09	1.0000	309.01	1 1 1	.14780E+09	1.0000	309.07
1 1 5	.12774E+09	1.0000	301.01	1 1 5	.12043E+09	1.0000	301.06
1 1 6	.12078E+09	1.0000	299.01	1 1 6	.11349E+09	1.0000	299.05
1 1 10	.92488E+08	1.0000	291.00	1 1 10	.85281E+08	1.0000	291.03
1 1 11	.85288E+08	1.0000	276.00	1 1 11	.78294E+08	1.0000	276.00
1 1 15	.52667E+08	1.0000	164.00	1 1 15	.47505E+08	1.0000	164.00
1 1 16	.43678E+08	1.0000	136.00	1 1 16	.39043E+08	1.0000	136.00
.29538E+06				.33066E+07			
1 1 1	.15474E+09	1.0000	309.01	1 1 1	.14425E+09	1.0000	309.10
1 1 5	.12734E+09	1.0000	301.01	1 1 5	.11690E+09	1.0000	301.08
1 1 6	.12038E+09	1.0000	299.01	1 1 6	.10996E+09	1.0000	299.07
1 1 10	.92101E+08	1.0000	291.00	1 1 10	.81781E+08	1.0000	291.03
1 1 11	.84931E+08	1.0000	276.00	1 1 11	.74845E+08	1.0000	276.00
1 1 15	.52499E+08	1.0000	164.00	1 1 15	.44605E+08	1.0000	164.00
1 1 16	.43543E+08	1.0000	136.00	1 1 16	.36347E+08	1.0000	135.99

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Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.50500E+07				.45740E+08			
1 1 1	.15938E+09	1.0000	309.13	1 1 1	.13579E+09	1.0000	309.00
1 1 5	.11205E+09	1.0000	301.11	1 1 5	.10854E+09	1.0000	300.98
1 1 6	.10511E+09	1.0000	299.10	1 1 6	.10104E+09	1.0000	298.97
1 1 10	.76968E+08	1.0000	291.04	1 1 10	.73850E+08	.83322	289.79
1 1 11	.78102E+08	1.0000	275.97	1 1 11	.66807E+08	1.0000	275.51
1 1 15	.40578E+08	1.0000	163.98	1 1 15	.36588E+08	1.0000	163.51
1 1 16	.32596E+08	1.0000	135.98	1 1 16	.28655E+08	1.0000	135.52
.75752E+07				.52941E+08			
1 1 1	.13722E+09	1.0000	309.14	1 1 1	.13526E+09	1.0000	308.97
1 1 5	.10995E+09	1.0000	301.11	1 1 5	.10800E+09	1.0000	300.95
1 1 6	.10304E+09	1.0000	299.11	1 1 6	.10110E+09	1.0000	298.94
1 1 10	.75063E+08	.99216	290.98	1 1 10	.73405E+08	.79371	289.35
1 1 11	.68073E+08	1.0000	275.93	1 1 11	.66397E+08	1.0000	275.54
1 1 15	.38152E+08	1.0000	163.95	1 1 15	.36245E+08	1.0000	163.39
1 1 16	.30213E+08	1.0000	135.95	1 1 16	.28336E+08	1.0000	135.40
.11363E+08				.62254E+08			
1 1 1	.13701E+09	1.0000	309.13	1 1 1	.13453E+09	1.0000	308.98
1 1 5	.10974E+09	1.0000	301.10	1 1 5	.10727E+09	1.0000	300.92
1 1 6	.10286E+09	1.0000	299.09	1 1 6	.10037E+09	1.0000	298.91
1 1 10	.74946E+08	.97548	290.87	1 1 10	.72816E+08	.75639	288.77
1 1 11	.67879E+08	1.0000	275.86	1 1 11	.65863E+08	1.0000	275.70
1 1 15	.37563E+08	1.0000	163.91	1 1 15	.35798E+08	1.0000	163.27
1 1 16	.29582E+08	1.0000	135.91	1 1 16	.27928E+08	1.0000	135.28
.17044E+08				.71729E+08			
1 1 1	.15684E+09	1.0000	309.10	1 1 1	.13353E+09	1.0000	308.91
1 1 5	.10959E+09	1.0000	301.08	1 1 5	.10627E+09	1.0000	300.88
1 1 6	.10264E+09	1.0000	299.07	1 1 6	.99372E+08	1.0000	298.88
1 1 10	.74749E+08	.95023	290.70	1 1 10	.72027E+08	.71536	287.98
1 1 11	.67695E+08	1.0000	275.80	1 1 11	.65149E+08	1.0000	276.05
1 1 15	.37344E+08	1.0000	163.84	1 1 15	.35207E+08	1.0000	163.14
1 1 16	.29362E+08	1.0000	135.84	1 1 16	.27376E+08	1.0000	135.16
.25567E+08				.81439E+08			
1 1 1	.15655E+09	1.0000	309.07	1 1 1	.13215E+09	1.0000	308.88
1 1 5	.10929E+09	1.0000	301.05	1 1 5	.10489E+09	1.0000	300.86
1 1 6	.10240E+09	1.0000	299.04	1 1 6	.97988E+08	1.0000	298.85
1 1 10	.74503E+08	.91259	290.43	1 1 10	.70982E+08	.67678	286.92
1 1 11	.67432E+08	1.0000	275.86	1 1 11	.64202E+08	1.0000	276.84
1 1 15	.37115E+08	1.0000	163.74	1 1 15	.34424E+08	1.0000	163.80
1 1 16	.29146E+08	1.0000	135.74	1 1 16	.26650E+08	1.0000	135.02
.14622E+08				.91487E+08			
1 1 1	.13620E+09	1.0000	309.08	1 1 1	.13158E+09	1.0000	308.84
1 1 5	.10995E+09	1.0000	301.02	1 1 5	.10433E+09	1.0000	300.82
1 1 6	.10205E+09	1.0000	299.01	1 1 6	.97426E+08	1.0000	298.81
1 1 10	.74202E+08	.87286	290.14	1 1 10	.69971E+08	.66415	285.89
1 1 11	.67139E+08	1.0000	275.58	1 1 11	.64243E+08	1.0000	277.32
1 1 15	.36865E+08	1.0000	163.62	1 1 15	.33620E+08	1.0000	162.86
1 1 16	.28915E+08	1.0000	135.63	1 1 16	.25903E+08	1.0000	134.88

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Time (sec) i, j, k	Pressure 10^{-6} bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.26976E+09							
1 1 1	.12253E+09	1.0000	308.19	.36080E+09			
1 1 5	.95247E+08	1.0000	308.17	1 1 1	.11835E+09	1.0100	307.85
1 1 8	.88543E+08	1.0000	298.14	1 1 5	.91855E+08	1.0100	299.82
1 1 10	.86310E+08	.12079	282.86	1 1 8	.88144E+08	1.0100	297.59
1 1 11	.84112E+08	.78099	279.67	1 1 10	.85721E+08	.9969	281.42
1 1 15	.84388E+08	1.0000	180.29	1 1 11	.84983E+08	.9681	279.51
1 1 16	.26588E+08	1.0000	132.37	1 1 15	.34247E+08	1.0100	159.84
.28365E+09				1 1 16	.26447E+08	1.0100	131.14
1 1 1	.12161E+09	1.0000	308.14	.38207E+09			
1 1 5	.94324E+08	1.0000	308.12	1 1 1	.11682E+09	1.0100	307.77
1 1 8	.87418E+08	1.0000	298.08	1 1 5	.89520E+08	1.0100	299.73
1 1 10	.86345E+08	.11234	282.09	1 1 8	.82805E+08	1.0100	297.37
1 1 11	.84232E+08	.57666	279.81	1 1 10	.86022E+08	.9956	281.75
1 1 15	.84467E+08	1.0000	180.18	1 1 11	.84095E+08	.96737	279.66
1 1 16	.26658E+08	1.0000	132.18	1 1 15	.34344E+08	1.0000	158.75
.29648E+09				1 1 16	.26534E+08	1.0000	130.85
1 1 1	.12092E+09	1.0000	308.09	.39798E+09			
1 1 5	.93841E+08	1.0000	308.08	1 1 1	.11581E+09	1.0000	307.72
1 1 8	.86735E+08	1.0000	298.02	1 1 5	.88511E+08	1.0000	299.66
1 1 10	.86258E+08	.50619	282.00	1 1 8	.81542E+08	.98869	297.14
1 1 11	.84288E+08	.67434	279.87	1 1 10	.86178E+08	.99577	281.91
1 1 15	.84516E+08	1.0000	159.93	1 1 11	.84224E+08	.96875	279.80
1 1 16	.26702E+08	1.0000	132.08	1 1 15	.34448E+08	1.0000	158.53
.31109E+09				1 1 16	.26625E+08	1.0000	130.64
1 1 1	.12057E+09	1.0000	308.03	.41350E+09			
1 1 5	.93284E+08	1.0000	308.02	1 1 1	.11540E+09	1.0000	307.66
1 1 8	.86377E+08	1.0100	297.95	1 1 5	.88183E+08	1.0000	299.58
1 1 10	.86030E+08	.50182	281.75	1 1 8	.81188E+08	.99866	296.77
1 1 11	.84247E+08	.67158	279.82	1 1 10	.86148E+08	.99442	281.88
1 1 15	.84487E+08	1.0100	159.73	1 1 11	.84287E+08	.96818	279.87
1 1 16	.26675E+08	1.0100	131.81	1 1 15	.34493E+08	1.0010	158.32
.32444E+09				1 1 16	.26671E+08	1.0010	130.43
1 1 1	.12017E+09	1.0100	307.98	.42596E+09			
1 1 5	.92842E+08	1.0100	299.97	1 1 1	.11501E+09	1.0010	307.61
1 1 8	.85974E+08	1.0100	297.87	1 1 5	.87706E+08	1.0010	299.51
1 1 10	.85804E+08	.69731	281.51	1 1 8	.80818E+08	.99878	296.43
1 1 11	.84144E+08	.66716	279.71	1 1 10	.86045E+08	.99315	281.77
1 1 15	.84405E+08	1.0000	159.54	1 1 11	.84283E+08	.96817	279.86
1 1 16	.26548E+08	1.0000	131.83	1 1 15	.34493E+08	1.0010	158.16
.33898E+09				1 1 16	.26668E+08	1.0010	130.27
1 1 1	.11960E+09	1.0000	307.93	.44059E+09			
1 1 5	.92312E+08	1.0000	299.91	1 1 1	.11445E+09	1.0010	307.55
1 1 8	.85403E+08	1.0000	297.77	1 1 5	.87144E+08	1.0010	299.41
1 1 10	.85641E+08	.69199	281.36	1 1 8	.80275E+08	.98266	295.93
1 1 11	.84914E+08	.66666	279.57	1 1 10	.85926E+08	.99266	281.64
1 1 15	.84298E+08	1.0100	159.34	1 1 11	.84238E+08	.96441	279.81
1 1 16	.26697E+08	1.0100	131.43	1 1 15	.34453E+08	1.0010	157.96
.35308E+09				1 1 16	.26629E+08	1.0010	130.07

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Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.46234E+09				.57338E+09			
1 1 1	.11334E+09	1.0010	307.47	1 1 1	.10774E+09	1.0000	307.07
1 1 5	.86032E+08	1.0010	299.24	1 1 5	.86050E+08	.86259	296.09
1 1 6	.79169E+08	.86510	294.90	1 1 6	.73500E+08	.82717	289.51
1 1 10	.65882E+08	.49213	281.00	1 1 10	.66234E+08	.49266	281.98
1 1 11	.64177E+08	.64371	279.75	1 1 11	.64494E+08	.66335	280.09
1 1 15	.34402E+08	1.0000	157.88	1 1 15	.34038E+08	1.0000	156.18
1 1 16	.26580E+08	1.0000	129.78	1 1 16	.26789E+08	1.0000	128.33
.46204E+09				.58862E+09			
1 1 1	.11203E+09	1.0000	307.40	1 1 1	.10681E+09	1.0000	307.61
1 1 5	.84711E+08	1.0000	299.04	1 1 5	.79519E+08	.85550	295.23
1 1 6	.77644E+08	.85181	293.86	1 1 6	.72670E+08	.10820	288.62
1 1 10	.66007E+08	.49323	281.73	1 1 10	.66285E+08	.49269	282.03
1 1 11	.64214E+08	.64136	279.79	1 1 11	.64523E+08	.66316	280.12
1 1 15	.34425E+08	1.0000	157.39	1 1 15	.34059E+08	1.0000	155.98
1 1 16	.26599E+08	1.0000	129.51	1 1 16	.26800E+08	1.0000	128.13
.50187E+09				.60501E+09			
1 1 1	.11066E+09	1.0000	307.33	1 1 1	.10571E+09	1.0000	306.96
1 1 5	.83339E+08	.98244	290.73	1 1 5	.78393E+08	.84886	294.17
1 1 6	.76426E+08	.84717	292.30	1 1 6	.71601E+08	.71161	287.55
1 1 10	.66208E+08	.49399	281.95	1 1 10	.66391E+08	.49300	282.14
1 1 11	.64338E+08	.64573	279.92	1 1 11	.64588E+08	.66348	280.28
1 1 15	.34519E+08	1.0000	157.11	1 1 15	.34708E+08	1.0000	155.77
1 1 16	.26644E+08	1.0000	129.24	1 1 16	.26850E+08	1.0000	127.92
.52876E+09				.62496E+09			
1 1 1	.11001E+09	1.0000	307.25	1 1 1	.10510E+09	1.0000	306.68
1 1 5	.82706E+08	.91259	298.15	1 1 5	.77631E+08	.84184	293.46
1 1 6	.75666E+08	.84147	291.57	1 1 6	.70664E+08	.71403	286.60
1 1 10	.66255E+08	.49368	282.00	1 1 10	.66452E+08	.49288	282.21
1 1 11	.64428E+08	.64563	280.02	1 1 11	.64662E+08	.66339	280.28
1 1 15	.34589E+08	1.0000	156.83	1 1 15	.34766E+08	1.0000	155.51
1 1 16	.26747E+08	1.0000	128.96	1 1 16	.26902E+08	1.0000	127.67
.53671E+09				.63611E+09			
1 1 1	.10955E+09	1.0000	307.20	1 1 1	.10465E+09	1.0000	306.88
1 1 5	.82209E+08	.88602	297.74	1 1 5	.77248E+08	.86077	293.09
1 1 6	.75254E+08	.85770	291.17	1 1 6	.70272E+08	.71513	286.20
1 1 10	.66246E+08	.49333	281.99	1 1 10	.66486E+08	.49263	282.22
1 1 11	.64459E+08	.64511	280.05	1 1 11	.64695E+08	.66310	280.31
1 1 15	.34614E+08	1.0000	156.67	1 1 15	.34792E+08	1.0000	155.36
1 1 16	.26769E+08	1.0000	128.81	1 1 16	.26925E+08	1.0000	127.53
.55467E+09				.65035E+09			
1 1 1	.10871E+09	1.0000	307.14	1 1 1	.10394E+09	1.0000	306.79
1 1 5	.81434E+08	.87883	297.80	1 1 5	.76609E+08	.84951	292.53
1 1 6	.74509E+08	.84393	290.44	1 1 6	.69831E+08	.75878	285.75
1 1 10	.66229E+08	.49290	281.97	1 1 10	.66485E+08	.49263	282.24
1 1 11	.64477E+08	.64409	280.07	1 1 11	.64729E+08	.66264	280.35
1 1 15	.34627E+08	1.0000	156.43	1 1 15	.34818E+08	1.0000	155.18
1 1 16	.26780E+08	1.0000	128.57	1 1 16	.26948E+08	1.0000	127.58

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Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.67171E+09				.76511E+09			
1 1 1	.10289E+09	1.0000	306.71	1 1 1	.98552E+08	1.0000	306.36
1 1 5	.75805E+08	.83515	291.51	1 1 5	.71295E+08	.70842	287.24
1 1 6	.69239E+08	.69661	285.14	1 1 6	.68822E+08	.52995	284.70
1 1 10	.66555E+08	.69231	282.32	1 1 10	.66788E+08	.49150	282.56
1 1 11	.64792E+08	.66226	280.42	1 1 11	.65059E+08	.66030	280.71
1 1 15	.34860E+08	1.0000	154.90	1 1 15	.35074E+08	1.0000	153.74
1 1 16	.26991E+08	1.0000	127.07	1 1 16	.27176E+08	1.0000	125.93
.66642E+09				.78586E+09			
1 1 1	.10206E+09	1.0000	306.65	1 1 1	.97243E+08	1.0000	306.26
1 1 5	.74793E+08	.82439	290.72	1 1 5	.70453E+08	.70457	286.38
1 1 6	.68990E+08	.65359	284.88	1 1 6	.69010E+08	.51625	284.90
1 1 10	.66606E+08	.69133	282.37	1 1 10	.66410E+08	.49168	282.69
1 1 11	.64840E+08	.66208	280.47	1 1 11	.65150E+08	.66036	280.81
1 1 15	.34903E+08	1.0000	154.71	1 1 15	.35145E+08	1.0000	153.45
1 1 16	.27026E+08	1.0000	126.89	1 1 16	.27240E+08	1.0000	125.65
.70809E+09				.80012E+09			
1 1 1	.10121E+09	1.0000	306.60	1 1 1	.96367E+08	1.0000	306.20
1 1 5	.74959E+08	.81017	289.90	1 1 5	.70118E+08	.66146	286.04
1 1 6	.68920E+08	.65168	284.80	1 1 6	.69088E+08	.50966	284.98
1 1 10	.66606E+08	.69210	282.43	1 1 10	.66491E+08	.49176	282.78
1 1 11	.64889E+08	.66196	280.52	1 1 11	.65218E+08	.66046	280.88
1 1 15	.34942E+08	1.0000	154.54	1 1 15	.35199E+08	1.0000	153.27
1 1 16	.27059E+08	1.0000	126.72	1 1 16	.27289E+08	1.0000	125.47
.71466E+09				.81334E+09			
1 1 1	.10055E+09	1.0000	306.55	1 1 1	.95721E+08	1.0000	306.16
1 1 5	.73141E+08	.83331	289.09	1 1 5	.69419E+08	.62597	285.84
1 1 6	.68870E+08	.65332	284.75	1 1 6	.69119E+08	.50504	284.81
1 1 10	.66712E+08	.64222	282.40	1 1 10	.67054E+08	.49172	282.85
1 1 11	.64945E+08	.64174	280.58	1 1 11	.65283E+08	.66043	280.95
1 1 15	.34984E+08	1.0000	154.35	1 1 15	.35250E+08	1.0000	153.11
1 1 16	.27097E+08	1.0000	126.53	1 1 16	.27336E+08	1.0000	125.31
.73502E+09				.82025E+09			
1 1 1	.99951E+08	1.0000	306.48	1 1 1	.95280E+08	1.0000	306.06
1 1 5	.72587E+08	.80580	288.34	1 1 5	.69723E+08	.59658	285.04
1 1 6	.68768E+08	.65574	284.65	1 1 6	.69083E+08	.50097	284.97
1 1 10	.66737E+08	.64188	282.51	1 1 10	.67089E+08	.49145	282.80
1 1 11	.64943E+08	.64122	280.60	1 1 11	.65341E+08	.66003	281.01
1 1 15	.35020E+08	1.0000	154.12	1 1 15	.35297E+08	1.0000	152.92
1 1 16	.27132E+08	1.0000	126.30	1 1 16	.27378E+08	1.0000	125.13
.74518E+09				.84056E+09			
1 1 1	.99450E+08	1.0000	306.43	1 1 1	.94853E+08	1.0000	305.99
1 1 5	.71969E+08	.80012	287.92	1 1 5	.69612E+08	.57826	285.52
1 1 6	.68734E+08	.64441	284.61	1 1 6	.69040E+08	.49840	284.93
1 1 10	.66784E+08	.64163	282.52	1 1 10	.67095E+08	.49112	282.89
1 1 11	.64918E+08	.66078	280.66	1 1 11	.65374E+08	.65947	281.05
1 1 15	.35042E+08	1.0000	153.97	1 1 15	.35340E+08	1.0000	152.77
1 1 16	.27149E+08	1.0000	126.15	1 1 16	.27403E+08	1.0000	124.98

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Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.85523E+09				.95246E+09			
1 1 1	.94200E+08	1.0000	305.89	1 1 1	.89509E+08	.88591	304.13
1 1 5	.84591E+08	.56114	285.50	1 1 5	.89951E+08	.49973	285.47
1 1 6	.89033E+08	.49660	284.42	1 1 6	.89456E+08	.49447	285.36
1 1 10	.87098E+08	.49076	282.19	1 1 10	.87502E+08	.49032	283.12
1 1 11	.85400E+08	.45872	281.18	1 1 11	.85796E+08	.45756	281.50
1 1 15	.85345E+08	1.0000	151.39	1 1 15	.85861E+08	1.0000	151.41
1 1 16	.27420E+08	1.0000	124.60	1 1 16	.27707E+08	1.0000	123.68
.87724E+09				.97324E+09			
1 1 1	.92996E+08	1.0000	305.71	1 1 1	.88462E+08	.87006	303.24
1 1 5	.89785E+08	.53953	285.78	1 1 5	.70030E+08	.49780	285.95
1 1 6	.89189E+08	.49627	285.88	1 1 6	.84513E+08	.49418	285.82
1 1 10	.87170E+08	.49068	282.97	1 1 10	.87537E+08	.48997	283.36
1 1 11	.85457E+08	.45826	281.14	1 1 11	.85880E+08	.45672	281.56
1 1 15	.85489E+08	1.0000	152.31	1 1 15	.85701E+08	1.0000	151.16
1 1 16	.27400E+08	1.0000	124.34	1 1 16	.27745E+08	1.0000	123.40
.89758E+09				.10021E+10			
1 1 1	.91789E+08	1.0000	305.31	1 1 1	.88558E+08	.85699	301.58
1 1 5	.78008E+08	.52354	285.73	1 1 5	.70358E+08	.49820	286.29
1 1 6	.89594E+08	.49677	285.10	1 1 6	.89785E+08	.49539	285.70
1 1 10	.87296E+08	.49090	283.18	1 1 10	.87701E+08	.49011	283.53
1 1 11	.85548E+08	.45443	281.24	1 1 11	.85973E+08	.45662	281.69
1 1 15	.85461E+08	1.0000	152.87	1 1 15	.85803E+08	1.0000	150.82
1 1 16	.27525E+08	1.0000	124.39	1 1 16	.27835E+08	1.0000	123.86
.91199E+09				.10108E+10			
1 1 1	.90883E+08	.98929	185.31	1 1 1	.85374E+08	.85267	300.54
1 1 5	.78090E+08	.51460	286.01	1 1 5	.70517E+08	.49833	286.45
1 1 6	.89496E+08	.49601	285.40	1 1 6	.89934E+08	.49546	285.85
1 1 10	.87391E+08	.49181	283.20	1 1 10	.87816E+08	.49025	283.65
1 1 11	.85627E+08	.45862	281.32	1 1 11	.86067E+08	.45678	281.79
1 1 15	.85523E+08	1.0000	151.94	1 1 15	.85878E+08	1.0000	150.62
1 1 16	.27582E+08	1.0000	114.17	1 1 16	.27903E+08	1.0000	122.87
.92596E+09				.10323E+10			
1 1 1	.90471E+08	.94509	304.92	1 1 1	.84378E+08	.85008	299.66
1 1 5	.78061E+08	.50775	285.44	1 1 5	.70607E+08	.49818	286.54
1 1 6	.89513E+08	.49618	285.42	1 1 6	.70030E+08	.49617	285.95
1 1 10	.87858E+08	.49093	283.27	1 1 10	.87910E+08	.49032	283.75
1 1 11	.85700E+08	.45857	281.40	1 1 11	.86151E+08	.45689	281.88
1 1 15	.85583E+08	1.0000	151.73	1 1 15	.85946E+08	1.0000	150.86
1 1 16	.27636E+08	1.0000	123.96	1 1 16	.27966E+08	1.0000	122.72
.93868E+09				.10454E+10			
1 1 1	.90854E+08	.90859	304.80	1 1 1	.83348E+08	.84688	298.73
1 1 5	.89997E+08	.50307	295.42	1 1 5	.70684E+08	.49804	286.62
1 1 6	.89485E+08	.49531	285.39	1 1 6	.70112E+08	.49628	286.03
1 1 10	.87890E+08	.49069	283.31	1 1 10	.87997E+08	.49033	283.84
1 1 11	.85755E+08	.45822	281.46	1 1 11	.86236E+08	.45690	281.97
1 1 15	.85627E+08	1.0000	151.18	1 1 15	.86010E+08	1.0000	150.31
1 1 16	.27676E+08	1.0000	123.61	1 1 16	.28029E+08	1.0000	122.57

Problem 4
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Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.10597E+10				.11520E+10			
1 1 1	.6212E+08	.84282	297.63	1 1 1	.74010E+08	.76261	289.95
1 1 5	.7078E+08	.49809	286.72	1 1 5	.70859E+08	.49422	286.80
1 1 6	.7020E+08	.49684	286.15	1 1 6	.70307E+08	.49321	286.30
1 1 10	.68042E+08	.49031	283.94	1 1 10	.68419E+08	.48844	284.20
1 1 11	.6630E+08	.45481	282.04	1 1 11	.66761E+08	.45326	282.53
1 1 15	.56043E+08	1.0000	150.14	1 1 15	.36451E+08	1.0000	149.09
1 1 16	.28100E+08	1.0000	122.40	1 1 16	.28427E+08	1.0000	121.37
.10772E+10				.11710E+10			
1 1 1	.8030E+08	.83814	296.22	1 1 1	.72498E+08	.71663	288.45
1 1 5	.70898E+08	.49817	286.84	1 1 5	.70715E+08	.49217	286.65
1 1 6	.70374E+08	.49659	286.25	1 1 6	.70257E+08	.49141	286.10
1 1 10	.63206E+08	.49025	284.04	1 1 10	.68380E+08	.48767	284.24
1 1 11	.63486E+08	.45650	282.20	1 1 11	.66762E+08	.45202	282.54
1 1 15	.36188E+08	1.0000	149.94	1 1 15	.36453E+08	1.0000	148.88
1 1 16	.28107E+08	1.0000	122.21	1 1 16	.28427E+08	1.0000	121.16
.10933E+10				.11676E+10			
1 1 1	.79230E+08	.83569	296.96	1 1 1	.71385E+08	.67768	287.33
1 1 5	.70950E+08	.49776	286.89	1 1 5	.70856E+08	.48933	286.39
1 1 6	.70392E+08	.49635	286.32	1 1 6	.70053E+08	.48899	285.97
1 1 10	.68298E+08	.49008	284.16	1 1 10	.68283E+08	.48675	284.14
1 1 11	.66547E+08	.45622	282.31	1 1 11	.66720E+08	.45065	282.49
1 1 15	.36272E+08	1.0000	149.76	1 1 15	.36419E+08	1.0000	148.69
1 1 16	.28263E+08	1.0000	122.02	1 1 16	.28395E+08	1.0000	120.98
.11067E+10				.12045E+10			
1 1 1	.78130E+08	.83115	293.92	1 1 1	.78670E+08	.64392	286.60
1 1 5	.78947E+08	.49705	286.49	1 1 5	.69991E+08	.48444	285.91
1 1 6	.70410E+08	.49581	286.34	1 1 6	.69672E+08	.48517	285.58
1 1 10	.68355E+08	.48982	284.22	1 1 10	.68070E+08	.48537	283.92
1 1 11	.68621E+08	.45576	282.39	1 1 11	.68602E+08	.44868	282.37
1 1 15	.36131E+08	1.0000	149.60	1 1 15	.36324E+08	1.0000	148.50
1 1 16	.28320E+08	1.0000	121.87	1 1 16	.28306E+08	1.0000	120.79
.11200E+10				.12247E+10			
1 1 1	.36998E+08	.82045	292.85	1 1 1	.69434E+08	.60920	285.34
1 1 5	.70923E+08	.49620	286.86	1 1 5	.69258E+08	.47826	285.16
1 1 6	.70485E+08	.49504	286.33	1 1 6	.69037E+08	.47934	284.93
1 1 10	.68391E+08	.48946	284.25	1 1 10	.67664E+08	.48319	283.49
1 1 11	.68680E+08	.45510	282.45	1 1 11	.68328E+08	.46559	282.07
1 1 15	.36383E+08	1.0000	149.45	1 1 15	.36099E+08	1.0000	148.27
1 1 16	.28365E+08	1.0000	121.73	1 1 16	.28097E+08	1.0000	120.56
.11346E+10				.12478E+10			
1 1 1	.75647E+08	.79927	291.55	1 1 1	.67883E+08	.57787	283.72
1 1 5	.70900E+08	.49513	286.84	1 1 5	.68213E+08	.46925	284.87
1 1 6	.70394E+08	.49427	286.32	1 1 6	.68093E+08	.47121	283.94
1 1 10	.68413E+08	.48901	284.28	1 1 10	.66475E+08	.48019	282.76
1 1 11	.66727E+08	.45428	282.50	1 1 11	.65816E+08	.46149	281.52
1 1 15	.36422E+08	1.0000	149.29	1 1 15	.35675E+08	1.0000	148.00
1 1 16	.28401E+08	1.0000	121.56	1 1 16	.27703E+08	1.0000	120.30

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Time (sec) t, s, R	Pressure 10^{-6} bars	Saturation (liquid)	Temp °C
.12774E+10			
1 1 1	.05903E+08	.58882	281.62
1 1 5	.06671E+08	.45633	282.44
1 1 6	.06650E+08	.45940	282.42
1 1 10	.05809E+08	.47617	281.52
1 1 11	.04869E+08	.63641	260.50
1 1 15	.34885E+08	1.0000	147.84
1 1 16	.26968E+08	1.0000	119.95
.13155E+10			
1 1 1	.05437E+08	.51416	278.93
1 1 5	.04512E+08	.43843	280.11
1 1 6	.04571E+08	.44306	280.18
1 1 10	.03990E+08	.47169	279.54
1 1 11	.05290E+08	.63145	278.77
1 1 15	.33558E+08	1.0000	147.15
1 1 16	.15734E+08	1.0000	119.46

DOE

Problem 4

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Time (sec)	Discharge Entropy (J/gm)	Recharge Rate (gm/sec)	Cumulative Entropy (J/gm)
100	1.396 E+3	781.89	78.22
250	1.396 E+3	781.14	1.954 E+5
475	1.396 E+3	780.03	3.709 E+5
812.5	1.396 E+3	778.39	6.336 E+5
1318.8	1.396 E+3	775.94	1.026 E+6
2078.1	1.396 E+3	772.34	1.613 E+6
3217.2	1.396 E+3	767.07	2.487 E+6
4925.8	1.396 E+3	759.45	3.784 E+6
7488.7	1.396 E+3	748.64	5.703 E+6
11333	1.396 E+3	733.73	9.524 E+6
17100	1.396 E+3	713.99	1.264 E+7
25749	1.396 E+3	689.48	1.866 E+7
38724	1.396 E+3	661.99	2.719 E+7
58186	1.396 E+3	636.32	3.959 E+7
87379	1.396 E+3	621.44	5.772 E+7
1.312 E+5	1.396 E+3	631.15	8.536 E+7
1.969 E+5	1.396 E+3	685.62	1.304 E+8
2.954 E+5	1.396 E+3	819.42	2.111 E+8
4.432 E+5	1.396 E+3	1105.7	3.745 E+8
6.649 E+5	1.396 E+3	1695.2	7.504 E+8
9.974 E+5	1.395 E+3	2841.0	1.695 E+9
1.496 E+6	1.395 E+3	4878.8	4.129 E+9
2.244 E+6	1.395 E+3	8178.0	1.025 E+10
3.367 E+6	1.395 E+3	13110.	2.496 E+10
5.050 E+6	1.394 E+3	20042	5.870 E+10
7.575 E+6	1.394 E+3	25075	1.220 E+11
1.136 E+7	1.394 E+3	26702	2.232 E+11
1.704 E+7	1.394 E+3	27188	3.776 E+11

DOE

Problem 4

3.5.4

Time (sec)	Discharge Enthalpy	Recharge Rate	Cumulative Recharge
2.56 E+7	1.394 E+3	27571	6.126 E+11
3.462 E+7	1.393 E+3	27968	8.659 E+11
4.374 E+7	1.393 E+3	28414	1.125 E+12
5.294 E+7	1.393 E+3	28963	1.391 E+12
6.225 E+7	1.393 E+3	29677	1.668 E+12
7.173 E+7	1.392 E+3	30632	1.958 E+12
8.144 E+7	1.392 E+3	31903	2.268 E+12
9.149 E+7	1.392 E+3	33215	2.602 E+12
1.052 E+8	1.391 E+3	34215	3.090 E+12
1.146 E+8	1.391 E+3	34661	3.391 E+12
1.238 E+8	1.391 E+3	33857	3.704 E+12
1.333 E+8	1.391 E+3	33626	4.021 E+12
1.435 E+8	1.390 E+3	33339	4.363 E+12
1.550 E+8	1.390 E+3	32995	4.741 E+12
1.684 E+8	1.390 E+3	32590	5.178 E+12
1.853 E+8	1.389 E+3	32101	5.721 E+12
2.052 E+8	1.389 E+3	31843	6.354 E+12
2.190 E+8	1.388 E+3	31818	6.795 E+12
2.324 E+8	1.388 E+3	31844	7.220 E+12
2.524 E+8	1.388 E+3	31695	7.854 E+12
2.698 E+8	1.387 E+3	31435	8.400 E+12
2.837 E+8	1.387 E+3	31230	8.834 E+12
2.965 E+8	1.387 E+3	31109	9.233 E+12
3.111 E+8	1.386 E+3	31106	9.687 E+12
3.244 E+8	1.386 E+3	31196	1.010 E+13
3.390 E+8	1.385 E+3	31325	1.056 E+13
3.608 E+8	1.385 E+3	31344	1.124 E+13

DOE

Problem 4

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Time (seconds)	Discharge Entalpy (J/gm)	Recharge Rate	Cumulative Recharge
3.821E+8	1.384E+3	31127	1.191E+13
3.980E+8	1.384E+3	30918	1.240E+13
4.135E+8	1.384E+3	30788	1.287E+13
4.260E+8	1.383E+3	30751	1.326E+13
4.406E+8	1.383E+3	30772	1.371E+13
4.625E+8	1.382E+3	30789	1.438E+13
4.826E+8	1.382E+3	30696	1.500E+13
5.039E+8	1.381E+3	30486	1.565E+13
5.248E+8	1.381E+3	30313	1.628E+13
5.367E+8	1.381E+3	30240	1.664E+13
5.547E+8	1.380E+3	30167	1.718E+13
5.734E+8	1.380E+3	30097	1.775E+13
5.886E+8	1.379E+3	30023	1.821E+13
6.050E+8	1.379E+3	29901	1.870E+13
6.250E+8	1.379E+3	29756	1.929E+13
6.361E+8	1.378E+3	29685	1.962E+13
6.503E+8	1.378E+3	29605	2.004E+13
6.717E+8	1.377E+3	29473	2.067E+13
6.864E+8	1.377E+3	29377	2.110E+13
7.001E+8	1.377E+3	29281	2.150E+13
7.147E+8	1.376E+3	29178	2.193E+13
7.330E+8	1.376E+3	29069	2.246E+13
7.451E+8	1.376E+3	29008	2.281E+13
7.621E+8	1.375E+3	28914	2.333E+13
7.859E+8	1.375E+3	28748	2.399E+13
8.001E+8	1.374E+3	28630	2.440E+13
8.133E+8	1.374E+3	28519	2.477E+13

DOE

Problem 4

4014

Time	Discharge Enthalpy	Recharge Rate	Cumulative Recharge
8.283E+8	1.373E+3	28410	2.520E+13
8.406E+8	1.373E+3	28338	2.555E+13
8.552E+8	1.372E+3	28271	2.596E+13
8.772E+8	1.371E+3	28152	2.658E+13
8.976E+8	1.370E+3	27995	2.715E+13
9.120E+8	1.369E+3	27867	2.755E+13
9.260E+8	1.367E+3	27744	2.794E+13
9.386E+8	1.366E+3	27647	2.829E+13
9.525E+8	1.364E+3	27563	2.867E+13
9.732E+8	1.361E+3	27456	2.924E+13
1.002E+9	1.354E+3	27240	3.003E+13
1.019E+9	1.349E+3	27091	3.048E+13
1.032E+9	1.345E+3	26960	3.084E+13
1.045E+9	1.341E+3	26828	3.119E+13
1.060E+9	1.336E+3	26681	3.158E+13
1.077E+9	1.329E+3	26502	3.204E+13
1.093E+9	1.323E+3	26344	3.246E+13
1.107E+9	1.319E+3	26225	3.282E+13
1.120E+9	1.317E+3	26124	3.316E+13
1.135E+9	1.321E+3	26035	3.354E+13
1.152E+9	1.346E+3	25957	3.400E+13
1.171E+9	1.429E+3	25917	3.449E+13
1.188E+9	1.572E+3	25935	3.492E+13
1.205E+9	1.762E+3	26042	3.534E+13
1.225E+9	2.010E+3	26333	3.589E+13
1.248E+9	2.241E+3	26910	3.651E+13
1.277E+9	2.490E+3	28010	3.734E+13
1.316E+9	2.594E+3	29870	3.842E+13

Problem 5. Node 3,1,3 pumping well
Case A Node 7,1,6 injection well

1 of 4

Time (sec) i, j, k	Pressure 10^{-6} bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat.	Temp
000000				.12017E+08			
3 1 3	.34438E+08	.97118	239.90	3 1 3	.32929E+08	.76239	237.35
7 1 6	.35073E+08	1.0000	197.15	7 1 6	.34775E+08	1.0000	198.13
.25077E+06				.15084E+08			
3 1 3	.34381E+08	.94488	239.81	3 1 3	.32676E+08	.75528	236.91
7 1 6	.35244E+08	1.0000	197.15	7 1 6	.34697E+08	1.0000	195.82
.44693E+06				.18401E+08			
3 1 3	.34306E+08	.91631	239.68	3 1 3	.32401E+08	.74880	236.44
7 1 6	.35240E+08	1.0000	197.13	7 1 6	.34612E+08	1.0000	195.46
.60778E+06				.22015E+08			
3 1 3	.34230E+08	.87453	239.55	3 1 3	.32115E+08	.74269	235.98
7 1 6	.35165E+08	1.0000	197.12	7 1 6	.34524E+08	1.0000	195.84
.95702E+06				.25909E+08			
3 1 3	.34146E+08	.83663	239.41	3 1 3	.31814E+08	.73609	235.41
7 1 6	.35118E+08	1.0000	197.10	7 1 6	.34424E+08	1.0000	194.57
.12397E+07				.28867E+08			
3 1 3	.34060E+08	.80278	239.27	3 1 3	.31583E+08	.73084	235.01
7 1 6	.35093E+08	1.0000	197.08	7 1 6	.34343E+08	1.0000	194.19
.15754E+07				.31705E+08			
3 1 3	.33947E+08	.77290	239.08	3 1 3	.31359E+08	.72584	234.61
7 1 6	.35066E+08	1.0000	197.05	7 1 6	.34260E+08	1.0000	193.81
.20252E+07				.34402E+08			
3 1 3	.33786E+08	.75260	238.81	3 1 3	.31130E+08	.72099	234.21
7 1 6	.35034E+08	1.0000	197.02	7 1 6	.34176E+08	1.0000	193.40
.27000E+07				.37513E+08			
3 1 3	.33630E+08	.75205	238.58	3 1 3	.30921E+08	.71761	233.83
7 1 6	.35013E+08	1.0000	196.97	7 1 6	.34086E+08	1.0000	192.98
.37122E+07				.41181E+08			
3 1 3	.33536E+08	.76451	238.38	3 1 3	.30680E+08	.71450	233.40
7 1 6	.34986E+08	1.0000	196.89	7 1 6	.33975E+08	1.0000	192.42
.49826E+07				.45518E+08			
3 1 3	.33436E+08	.76914	238.21	3 1 3	.30623E+08	.71724	233.30
7 1 6	.34953E+08	1.0000	196.78	7 1 6	.33928E+08	1.0000	192.86
.60881E+07				.48674E+08			
3 1 3	.33298E+08	.76965	237.98	3 1 3	.30548E+08	.71781	233.16
7 1 6	.34905E+08	1.0000	196.62	7 1 6	.33868E+08	1.0000	191.66
.92214E+07				.48876E+08			
3 1 3	.33137E+08	.76759	237.79	3 1 3	.30462E+08	.71857	233.01
7 1 6	.34846E+08	1.0000	196.40	7 1 6	.33803E+08	1.0000	191.21

Case A
Problem 5
2 of 4

Time (sec) i, j, k	Pressure 10^{-6} bars	Saturation (liquid)	Temp $^{\circ}\text{C}$	Time i, j, k	Pressure	Sat	Temp
.52097E+08 3 1 3 7 1 6	.30374E+08 .33729E+08	.72017 1.0000	232.85 190.67	.98136E+08 3 1 3 7 1 6	.29682E+08 .33030E+08	.86664 1.0000	231.59 182.48
.56232E+08 3 1 3 7 1 6	.30278E+08 .33631E+08	.72305 1.0000	232.68 189.97	.10074E+09 3 1 3 7 1 6	.29598E+08 .33002E+08	.93245 1.0000	231.44 182.02
.62324E+08 3 1 3 7 1 6	.30221E+08 .33488E+08	.73061 1.0000	232.58 188.90	.10233E+09 3 1 3 7 1 6	.29542E+08 .32981E+08	.98112 1.0000	231.33 181.75
.67711E+08 3 1 3 7 1 6	.30092E+08 .33356E+08	.73339 1.0000	232.34 187.93	.10363E+09 3 1 3 7 1 6	.29649E+08 .32990E+08	1.0000 1.0000	231.15 181.52
.70005E+08 3 1 3 7 1 6	.30045E+08 .33319E+08	.73595 1.0000	232.26 187.51	.10554E+09 3 1 3 7 1 6	.29803E+08 .33030E+08	1.0000 1.0000	230.76 181.20
.73439E+08 3 1 3 7 1 6	.30041E+08 .33293E+08	.74482 1.0000	232.25 186.89	.10841E+09 3 1 3 7 1 6	.29874E+08 .33050E+08	1.0000 1.0000	230.15 180.73
.78594E+08 3 1 3 7 1 6	.29977E+08 .33227E+08	.75426 1.0000	232.13 185.96	.11272E+09 3 1 3 7 1 6	.29945E+08 .33059E+08	1.0000 1.0000	229.32 180.64
.82145E+08 3 1 3 7 1 6	.29902E+08 .33176E+08	.75940 1.0000	231.99 185.32	.11708E+09 3 1 3 7 1 6	.29989E+08 .33059E+08	1.0000 1.0000	228.55 179.36
.84290E+08 3 1 3 7 1 6	.29852E+08 .33145E+08	.76304 1.0000	231.90 184.93	.12100E+09 3 1 3 7 1 6	.29966E+08 .33046E+08	1.0000 1.0000	227.88 178.76
.87522E+08 3 1 3 7 1 6	.29847E+08 .33134E+08	.78126 1.0000	231.89 184.35	.12353E+09 3 1 3 7 1 6	.29984E+08 .33049E+08	1.0000 1.0000	227.46 178.38
.91200E+08 3 1 3 7 1 6	.29820E+08 .33100E+08	.80128 1.0000	231.84 183.78	.12732E+09 3 1 3 7 1 6	.30018E+08 .33056E+08	1.0000 1.0000	226.87 177.82
.94170E+08 3 1 3 7 1 6	.29778E+08 .33067E+08	.82071 1.0000	231.76 183.18	.12962E+09 3 1 3 7 1 6	.30020E+08 .33059E+08	1.0000 1.0000	226.50 177.49
.96329E+08 3 1 3 7 1 6	.29727E+08 .33040E+08	.83893 1.0000	231.62 182.79	.13161E+09 3 1 3 7 1 6	.30057E+08 .33082E+08	1.0000 1.0000	226.19 177.21

Case A
Problem 5
3 of 4

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.13449E+09 3 1 3 7 1 6	.30091E+08 .33100E+08	1.0000 1.0000	225.74 176.81	.18867E+09 3 1 3 7 1 6	.30484E+08 .33316E+08	1.0000 1.0000	218.28 170.86
.13671E+09 3 1 3 7 1 6	.30125E+08 .33120E+08	1.0000 1.0000	225.39 176.51	.19291E+09 3 1 3 7 1 6	.30500E+08 .33338E+08	1.0000 1.0000	217.69 176.49
.14003E+09 3 1 3 7 1 6	.30182E+08 .33152E+08	1.0000 1.0000	224.88 176.07	.19925E+09 3 1 3 7 1 6	.30528E+08 .33359E+08	1.0000 1.0000	216.81 169.97
.14502E+09 3 1 3 7 1 6	.30232E+08 .33177E+08	1.0000 1.0000	224.15 175.44	.20659E+09 3 1 3 7 1 6	.30543E+08 .33373E+08	1.0000 1.0000	215.77 169.40
.15111E+09 3 1 3 7 1 6	.30279E+08 .33199E+08	1.0000 1.0000	223.30 174.71	.21760E+09 3 1 3 7 1 6	.30589E+08 .33408E+08	1.0000 1.0000	214.25 168.62
.15673E+09 3 1 3 7 1 6	.30313E+08 .33215E+08	1.0000 1.0000	222.56 174.06	.22687E+09 3 1 3 7 1 6	.30602E+08 .33422E+08	1.0000 1.0000	213.08 168.02
.16153E+09 3 1 3 7 1 6	.30338E+08 .33225E+08	1.0000 1.0000	221.95 173.53	.23684E+09 3 1 3 7 1 6	.30607E+08 .33433E+08	1.0000 1.0000	211.59 167.40
.16581E+09 3 1 3 7 1 6	.30346E+08 .33231E+08	1.0000 1.0000	221.39 173.07	.24831E+09 3 1 3 7 1 6	.30610E+08 .33443E+08	1.0000 1.0000	210.83 166.75
.17202E+09 3 1 3 7 1 6	.30361E+08 .33248E+08	1.0000 1.0000	220.52 172.43	.26552E+09 3 1 3 7 1 6	.30621E+08 .33462E+08	1.0000 1.0000	207.76 165.96
.17567E+09 3 1 3 7 1 6	.30408E+08 .33275E+08	1.0000 1.0000	220.07 172.08	.29077E+09 3 1 3 7 1 6	.30601E+08 .33469E+08	1.0000 1.0000	204.47 164.86
.18014E+09 3 1 3 7 1 6	.30439E+08 .33295E+08	1.0000 1.0000	219.44 171.64	.31536E+09 3 1 3 7 1 6	.30573E+08 .33478E+08	1.0000 1.0000	201.38 164.02
.18443E+09 3 1 3 7 1 6	.30454E+08 .33307E+08	1.0000 1.0000	218.87 171.24				

Case A
Problem 5
4 of 4

Time (sec) i, j, k	Pressure 10^{-6} bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.10576E+09				.10641E+09			
1 1 1	.13109E+09	1.0000	308.79	1 1 1	.12771E+09	1.0000	308.56
1 1 5	.10383E+09	1.0000	300.77	1 1 5	.10044E+09	1.0000	300.54
1 1 6	.96933E+08	1.0000	298.76	1 1 6	.93537E+08	1.0000	298.53
1 1 10	.64007E+08	.68483	284.96	1 1 10	.67355E+08	.62915	283.16
1 1 11	.62541E+08	.97660	277.94	1 1 11	.63602E+08	.79668	279.11
1 1 15	.33006E+08	1.0000	162.64	1 1 15	.33872E+08	1.0000	161.72
1 1 16	.25326E+08	1.0000	134.67	1 1 16	.26117E+08	1.0000	133.76
.11460E+09				.10931E+09			
1 1 1	.13066E+09	1.0000	308.75	1 1 1	.12647E+09	1.0000	308.50
1 1 5	.10340E+09	1.0000	300.73	1 1 5	.99202E+08	1.0000	300.48
1 1 6	.96501E+08	1.0000	298.73	1 1 6	.92300E+08	1.0000	298.47
1 1 10	.66795E+08	.70301	284.67	1 1 10	.67049E+08	.39514	282.64
1 1 11	.62699E+08	.93834	278.11	1 1 11	.63889E+08	.73198	279.43
1 1 15	.33101E+08	1.0000	162.51	1 1 15	.34132E+08	1.0000	161.48
1 1 16	.25410E+08	1.0000	134.56	1 1 16	.26357E+08	1.0000	133.53
.12384E+09				.20518E+09			
1 1 1	.13017E+09	1.0000	308.72	1 1 1	.12584E+09	1.0000	308.42
1 1 5	.10240E+09	1.0000	300.70	1 1 5	.98567E+08	1.0000	300.41
1 1 6	.96008E+08	1.0000	298.69	1 1 6	.91665E+08	1.0000	298.40
1 1 10	.66591E+08	.70478	284.46	1 1 10	.66495E+08	.57030	282.25
1 1 11	.62829E+08	.89915	278.26	1 1 11	.63989E+08	.70617	279.54
1 1 15	.33203E+08	1.0000	162.37	1 1 15	.34245E+08	1.0000	161.20
1 1 16	.25503E+08	1.0000	134.40	1 1 16	.26461E+08	1.0000	133.25
.13327E+09				.21904E+09			
1 1 1	.12967E+09	1.0000	308.69	1 1 1	.12539E+09	1.0000	308.37
1 1 5	.10241E+09	1.0000	300.67	1 1 5	.98115E+08	1.0000	300.36
1 1 6	.95510E+08	1.0000	298.66	1 1 6	.91210E+08	1.0000	298.34
1 1 10	.66153E+08	.69433	284.21	1 1 10	.66141E+08	.51623	281.67
1 1 11	.62975E+08	.86232	278.42	1 1 11	.63949E+08	.61277	279.50
1 1 15	.33321E+08	1.0000	162.23	1 1 15	.34230E+08	1.0000	161.60
1 1 16	.25612E+08	1.0000	134.26	1 1 16	.26446E+08	1.0000	133.66
.14352E+09				.23238E+09			
1 1 1	.12915E+09	1.0000	308.65	1 1 1	.12482E+09	1.0000	308.32
1 1 5	.10188E+09	1.0000	300.63	1 1 5	.97538E+08	1.0000	300.31
1 1 6	.94981E+08	1.0000	298.62	1 1 6	.90635E+08	1.0000	298.29
1 1 10	.66055E+08	.67729	283.90	1 1 10	.65976E+08	.58451	281.70
1 1 11	.63153E+08	.82655	278.62	1 1 11	.63886E+08	.68403	279.43
1 1 15	.33472E+08	1.0000	162.08	1 1 15	.34187E+08	1.0000	160.62
1 1 16	.25750E+08	1.0000	134.11	1 1 16	.26405E+08	1.0000	132.88
.15497E+09				.25241E+09			
1 1 1	.12853E+09	1.0000	308.61	1 1 1	.12366E+09	1.0000	308.25
1 1 5	.10126E+09	1.0000	300.59	1 1 5	.96376E+08	1.0000	300.24
1 1 6	.94358E+08	1.0000	298.58	1 1 6	.89472E+08	1.0000	298.21
1 1 10	.67712E+08	.65583	283.54	1 1 10	.66135E+08	.53326	281.67
1 1 11	.63362E+08	.79285	278.85	1 1 11	.63953E+08	.67940	279.50
1 1 15	.33656E+08	1.0000	161.91	1 1 15	.34241E+08	1.0000	160.54
1 1 16	.25919E+08	1.0000	133.95	1 1 16	.26452E+08	1.0000	132.60

DDE

Problem 5A

1.07

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (J/gm)
1.000 E+5	85950	1.042 E+3
2.388 E+5	4.066 E+5	1.041 E+3
4.469 E+5	8.584 E+5	1.041 E+3
6.878 E+5	1.348 E+6	1.040 E+3
9.570 E+5	1.877 E+6	1.040 E+3
1.240 E+6	2.426 E+6	1.042 E+3
1.575 E+6	3.066 E+6	1.048 E+3
2.025 E+6	3.905 E+6	1.055 E+3
2.700 E+6	5.159 E+6	1.054 E+3
3.712 E+6	7.015 E+6	1.048 E+3
4.983 E+6	9.289 E+6	1.045 E+3
6.888 E+6	1.258 E+7	1.044 E+3
9.221 E+6	1.643 E+7	1.043 E+3
1.202 E+7	2.077 E+7	1.043 E+3
1.508 E+7	2.520 E+7	1.044 E+3
1.840 E+7	2.962 E+7	1.045 E+3
2.202 E+7	3.400 E+7	1.046 E+3
2.591 E+7	3.820 E+7	1.048 E+3
2.887 E+7	4.105 E+7	1.050 E+3
3.171 E+7	4.346 E+7	1.052 E+3
3.460 E+7	4.558 E+7	1.055 E+3
3.751 E+7	4.737 E+7	1.057 E+3
4.118 E+7	4.910 E+7	1.058 E+3
4.352 E+7	5.007 E+7	1.054 E+3
4.607 E+7	5.094 E+7	1.053 E+3
4.888 E+7	5.167 E+7	1.051 E+3

DOE
Problem 5.1

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (Joules/gram)
5.210 E+7	5.223 E+7	1.049 E+3
5.623 E+7	5.249 E+7	1.045 E+3
6.232 E+7	5.197 E+7	1.038 E+3
6.771 E+7	5.075 E+7	1.034 E+3
7.000 E+7	5.014 E+7	1.033 E+3
7.344 E+7	4.916 E+7	1.027 E+3
7.859 E+7	4.731 E+7	1.021 E+3
8.215 E+7	4.583 E+7	1.018 E+3
8.430 E+7	4.486 E+7	1.016 E+3
8.752 E+7	4.343 E+7	1.011 E+3
9.120 E+7	4.166 E+7	1.001 E+3
9.417 E+7	4.014 E+7	1.005 E+3
9.633 E+7	3.897 E+7	1.003 E+3
9.814 E+7	3.800 E+7	1.002 E+3
1.007 E+8	3.655 E+7	1.001 E+3
1.028 E+8	3.564 E+7	1.001 E+3
1.036 E+8	3.491 E+7	9.999 E+2
1.055 E+8	3.392 E+7	9.981 E+2
1.084 E+8	3.250 E+7	9.951 E+2
1.127 E+8	3.041 E+7	9.911 E+2
1.171 E+8	2.830 E+7	9.876 E+2
1.210 E+8	2.635 E+7	9.845 E+2
1.235 E+8	2.510 E+7	9.825 E+2
1.273 E+8	2.328 E+7	9.797 E+2
1.296 E+8	2.218 E+7	9.780 E+2
1.316 E+8	2.131 E+7	9.765 E+2

DOE
Problem 5A

Tab:

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (Joules/gram)
1.345E+8	2.000E+7	9.744E+2
1.367E+8	1.922E+7	9.728E+2
1.400E+8	1.802E+7	9.703E+2
1.450E+8	1.636E+7	9.668E+2
1.511E+8	1.448E+7	9.628E+2
1.567E+8	1.285E+7	9.594E+2
1.615E+8	1.152E+7	9.565E+2
1.658E+8	1.037E+7	9.541E+2
1.720E+8	8.821E+6	9.499E+2
1.755E+8	8.064E+6	9.478E+2
1.801E+8	7.142E+6	9.449E+2
1.844E+8	6.347E+6	9.421E+2
1.887E+8	5.605E+6	9.394E+2
1.929E+8	4.973E+6	9.366E+2
1.993E+8	4.169E+6	9.324E+2
2.066E+8	3.352E+6	9.276E+2
2.176E+8	2.546E+6	9.204E+2
2.267E+8	2.023E+6	9.147E+2
2.368E+8	1.549E+6	9.081E+2
2.483E+8	1.145E+6	9.010E+2
2.655E+8	8.770E+5	8.901E+2
2.908E+8	6.287E+5	8.752E+2
3.154E+8	3.579E+5	8.610E+2

Problem 5
Case B

1 of 3

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
100000				.12017E+08			
3 1 3 7 1 6	.34438E+08 .35073E+08	.97118 1.0000	239.90 197.15	3 1 3 7 1 6	.32929E+08 .34775E+08	.76239 1.0000	237.35 196.13
.23877E+06				.15084E+08			
3 1 3 7 1 6	.34381E+08 .35244E+08	.94488 1.0000	239.41 197.15	3 1 3 7 1 6	.32676E+08 .34697E+08	.75526 1.0000	236.91 195.82
.44693E+06				.14401E+08			
3 1 3 7 1 6	.34306E+08 .35240E+08	.91031 1.0000	239.46 197.13	3 1 3 7 1 6	.32401E+08 .34612E+08	.74880 1.0000	236.44 195.46
.68278E+06				.22015E+08			
3 1 3 7 1 6	.34240E+08 .35165E+08	.87453 1.0000	239.55 197.12	3 1 3 7 1 6	.32115E+08 .34526E+08	.74269 1.0000	235.94 195.04
.95702E+06				.25909E+08			
3 1 3 7 1 6	.34140E+08 .35118E+08	.83643 1.0000	239.41 197.10	3 1 3 7 1 6	.31814E+08 .34424E+08	.73609 1.0000	235.41 194.57
.12397E+07				.28867E+08			
3 1 3 7 1 6	.34060E+08 .35093E+08	.80274 1.0000	239.27 197.08	3 1 3 7 1 6	.31583E+08 .34343E+08	.73084 1.0000	235.01 194.19
.15754E+07				.31536E+08			
3 1 3 7 1 6	.33947E+08 .35066E+08	.77290 1.0000	239.08 197.05	3 1 3 7 1 6	.31373E+08 .34266E+08	.72612 1.0000	234.64 193.83
.20252E+07				.31640E+08			
3 1 3 7 1 6	.33786E+08 .35034E+08	.75260 1.0000	238.81 197.02	3 1 3 7 1 6	.31365E+08 .34269E+08	.72612 1.0000	234.62 193.80
.27000E+07				.31807E+08			
3 1 3 7 1 6	.33630E+08 .35013E+08	.75205 1.0000	238.54 196.97	3 1 3 7 1 6	.31355E+08 .34215E+08	.72648 1.0000	234.61 191.75
.37122E+07				.32051E+08			
3 1 3 7 1 6	.33530E+08 .34986E+08	.76451 1.0000	238.38 196.89	3 1 3 7 1 6	.31127E+08 .3420E+08	.72754 1.0000	234.59 189.91
.49826E+07				.32416E+08			
3 1 3 7 1 6	.33430E+08 .34953E+08	.76914 1.0000	238.21 196.78	3 1 3 7 1 6	.31343E+08 .3422E+08	.72943 1.0000	234.58 187.21
.68861E+07				.32965E+08			
3 1 3 7 1 6	.33298E+08 .34905E+08	.76965 1.0000	237.98 196.62	3 1 3 7 1 6	.31349E+08 .3424E+08	.73163 1.0000	234.59 183.33
.92214E+07				.33787E+08			
3 1 3 7 1 6	.33137E+08 .34846E+08	.76759 1.0000	237.70 196.40	3 1 3 7 1 6	.31357E+08 .3426E+08	.73362 1.0000	234.61 177.64

Problem 5
Case B

2 of 3

Time (sec) i, j, k	Pressure 10^{-6} bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.35021E+08 3 1 3 7 1 6	.31474E+08 .35472E+08	.74423 1.0000	234.82 170.29	-.74079E+08 3 1 3 7 1 6	.31243E+08 .35744E+08	.98635 1.0000	234.41 89.617
-.34472E+08 3 1 3 7 1 6	.31403E+08 .35496E+08	.75065 1.0000	235.04 160.31	.77886E+08 3 1 3 7 1 6	.31323E+08 .35761E+08	1.0000 1.0000	234.16 88.797
.39133E+08 3 1 3 7 1 6	.31658E+08 .35514E+08	.75137 1.0000	235.14 169.83	.80301E+08 3 1 3 7 1 6	.31415E+08 .35801E+08	1.0000 1.0000	233.78 87.848
.40944E+08 3 1 3 7 1 6	.31622E+08 .35524E+08	.74772 1.0000	235.08 162.40	.83922E+08 3 1 3 7 1 6	.31441E+08 .35820E+08	1.0000 1.0000	233.16 86.888
-.42330E+08 3 1 3 7 1 6	.31623E+08 .35552E+08	.75060 1.0000	235.08 137.22	.89155E+08 3 1 3 7 1 6	.31501E+08 .35865E+08	1.0000 1.0000	232.23 85.381
.44410E+08 3 1 3 7 1 6	.31665E+08 .35601E+08	.75821 1.0000	235.15 130.44	.94140E+08 3 1 3 7 1 6	.31536E+08 .35887E+08	1.0000 1.0000	231.43 84.458
.47529E+08 3 1 3 7 1 6	.31668E+08 .35640E+08	.76311 1.0000	235.16 122.87	.98547E+08 3 1 3 7 1 6	.31549E+08 .35899E+08	1.0000 1.0000	230.79 83.832
-.52208E+08 3 1 3 7 1 6	.31635E+08 .35680E+08	.77163 1.0000	235.10 112.57	.10170E+09 3 1 3 7 1 6	.31558E+08 .35907E+08	1.0000 1.0000	230.31 83.435
.57849E+08 3 1 3 7 1 6	.31572E+08 .35706E+08	.78054 1.0000	234.99 105.16	.10643E+09 3 1 3 7 1 6	.31598E+08 .35936E+08	1.0000 1.0000	229.64 82.963
.60070E+08 3 1 3 7 1 6	.31524E+08 .35717E+08	.78660 1.0000	234.90 101.32	.11013E+09 3 1 3 7 1 6	.31581E+08 .35940E+08	1.0000 1.0000	229.09 82.655
-.64602E+08 3 1 3 7 1 6	.31501E+08 .35752E+08	.81380 1.0000	234.86 96.881	.11280E+09 3 1 3 7 1 6	.31614E+08 .35960E+08	1.0000 1.0000	228.70 82.460
.69652E+08 3 1 3 7 1 6	.31425E+08 .35762E+08	.86742 1.0000	234.73 93.059	.11668E+09 3 1 3 7 1 6	.31632E+08 .35977E+08	1.0000 1.0000	228.13 82.223
.73788E+08 3 1 3 7 1 6	.31318E+08 .35753E+08	.93522 1.0000	234.54 90.785	.11919E+09 3 1 3 7 1 6	.31628E+08 .35981E+08	1.0000 1.0000	227.71 82.077

Problem 5
Case B

3 of 3

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.12185E+09 3 1 3 7 1 6	.31661E+08 .36006E+08	1.0000 1.0000	227.34 81.958	.19490E+09 3 1 3 7 1 6	.31733E+08 .36222E+08	1.0000 1.0000	213.96 80.789
.12555E+09 3 1 3 7 1 6	.31685E+08 .36027E+08	1.0000 1.0000	226.76 81.804	.20267E+09 3 1 3 7 1 6	.31714E+08 .36232E+08	1.0000 1.0000	212.31 80.658
.13111E+09 3 1 3 7 1 6	.31696E+08 .36046E+08	1.0000 1.0000	225.87 81.618	.21622E+09 3 1 3 7 1 6	.31723E+08 .36255E+08	1.0000 1.0000	210.72 80.613
.13756E+09 3 1 3 7 1 6	.31702E+08 .36063E+08	1.0000 1.0000	224.80 81.444	.22154E+09 3 1 3 7 1 6	.31708E+08 .36275E+08	1.0000 1.0000	208.32 80.554
.14288E+09 3 1 3 7 1 6	.31714E+08 .36081E+08	1.0000 1.0000	223.92 81.324	.23853E+09 3 1 3 7 1 6	.31665E+08 .36292E+08	1.0000 1.0000	204.76 80.482
.15045E+09 3 1 3 7 1 6	.31732E+08 .36107E+08	1.0000 1.0000	222.57 81.179	.25350E+09 3 1 3 7 1 6	.31586E+08 .36285E+08	1.0000 1.0000	201.44 80.429
.15610E+09 3 1 3 7 1 6	.31708E+08 .36111E+08	1.0000 1.0000	221.61 81.097	.27546E+09 3 1 3 7 1 6	.31567E+08 .36321E+08	1.0000 1.0000	196.83 80.366
.16002E+09 3 1 3 7 1 6	.31727E+08 .36129E+08	1.0000 1.0000	220.90 81.041	.29642E+09 3 1 3 7 1 6	.31509E+08 .36333E+08	1.0000 1.0000	192.62 80.317
.16588E+09 3 1 3 7 1 6	.31745E+08 .36153E+08	1.0000 1.0000	219.82 80.968	.31516E+09 3 1 3 7 1 6	.31444E+08 .36336E+08	1.0000 1.0000	188.98 80.282
.17235E+09 3 1 3 7 1 6	.31737E+08 .36167E+08	1.0000 1.0000	218.56 80.898				
.17771E+09 3 1 3 7 1 6	.31726E+08 .36175E+08	1.0000 1.0000	217.48 80.845				
.18576E+09 3 1 3 7 1 6	.31751E+08 .36208E+08	1.0000 1.0000	219.86 80.777				

DOE
Problem 5310⁻⁷

Time (seconds)	Steam Mass (grams)	Conversion Efficiency (Joules/gram)
1.000E+5	8.595E+4	1.042E+3
2.388E+5	4.066E+5	1.041E+3
4.469E+5	8.584E+5	1.041E+3
6.878E+5	1.348E+6	1.040E+3
9.570E+5	1.977E+6	1.040E+3
1.240E+6	2.426E+6	1.042E+3
1.575E+6	3.066E+6	1.048E+3
2.025E+6	3.905E+6	1.055E+3
2.700E+6	5.159E+6	1.054E+3
3.712E+6	7.015E+6	1.048E+3
4.983E+6	9.289E+6	1.045E+3
6.888E+6	1.258E+7	1.044E+3
9.221E+6	1.643E+7	1.043E+3
1.202E+7	2.077E+7	1.043E+3
1.508E+7	2.520E+7	1.044E+3
1.840E+7	2.962E+7	1.045E+3
2.202E+7	3.400E+7	1.046E+3
2.591E+7	3.820E+7	1.048E+3
2.887E+7	4.105E+7	1.050E+3
3.154E+7	4.334E+7	1.052E+3
3.164E+7	4.334E+7	2.133E+3
3.181E+7	4.332E+7	2.132E+3
3.205E+7	4.328E+7	2.130E+3
3.242E+7	4.324E+7	2.126E+3
3.297E+7	4.316E+7	2.121E+3
3.379E+7	4.303E+7	2.119E+3

DOE

Problem 5B

= 3² 3

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (joules/gram)
3.502 E+7	4.289 E+7	2.102 E+3
3.687 E+7	4.266 E+7	2.096 E+3
3.913 E+7	4.230 E+7	2.093 E+3
4.094 E+7	4.197 E+7	2.100 E+3
4.233 E+7	4.173 E+7	2.097 E+3
4.441 E+7	4.140 E+7	2.058 E+3
4.753 E+7	4.086 E+7	2.083 E+3
5.221 E+7	3.991 E+7	2.075 E+3
5.705 E+7	3.871 E+7	2.063 E+3
6.007 E+7	3.787 E+7	2.063 E+3
6.460 E+7	3.661 E+7	2.053 E+3
6.985 E+7	3.494 E+7	2.045 E+3
7.377 E+7	3.354 E+7	2.043 E+3
7.608 E+7	3.265 E+7	2.041 E+3
7.789 E+7	3.196 E+7	2.039 E+3
8.030 E+7	3.114 E+7	2.034 E+3
8.392 E+7	2.993 E+7	2.027 E+3
8.936 E+7	2.826 E+7	2.015 E+3
9.434 E+7	2.675 E+7	2.006 E+3
9.855 E+7	2.547 E+7	2.006 E+3
1.017 E+8	2.450 E+7	1.993 E+3
1.064 E+8	2.313 E+7	1.985 E+3
1.101 E+8	2.203 E+7	1.978 E+3
1.128 E+8	2.129 E+7	1.974 E+3
1.167 E+8	2.026 E+7	1.967 E+3
1.194 E+8	1.954 E+7	1.962 E+3

Problem 6.

Nucle	Layer
1,1,2	1
1,1,3	2
1,1,4	3
1,1,5	4
1,1,6	5

1 of 4

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.10000E+07							
1 1 2	.14081E+09	1.0000	280.00	1 1 2	.13990E+09	1.0000	280.01
1 1 3	.14148E+09	1.0000	280.05	1 1 3	.98529E+08	1.0000	280.04
1 1 4	.83725E+08	1.0000	280.02	1 1 4	.88028E+08	1.0000	279.96
1 1 5	.84384E+08	.89355	279.97	1 1 5	.82907E+08	.70270	278.34
1 1 6	.39577E+08	1.0000	159.99	1 1 6	.38810E+08	1.0000	160.03
.25000E+07							
1 1 2	.14054E+09	1.0000	280.01	1 1 2	.13986E+09	1.0000	280.01
1 1 3	.10088E+09	1.0000	280.05	1 1 3	.98194E+08	1.0000	280.04
1 1 4	.83270E+08	1.0000	280.02	1 1 4	.79888E+08	1.0000	279.96
1 1 5	.84333E+08	.88373	279.92	1 1 5	.82809E+08	.89559	278.24
1 1 6	.39318E+08	1.0000	159.99	1 1 6	.38782E+08	1.0000	160.05
.47500E+07							
1 1 2	.14044E+09	1.0000	280.01	1 1 2	.13815E+09	1.0000	280.02
1 1 3	.10870E+09	1.0000	280.05	1 1 3	.85773E+08	1.0000	280.12
1 1 4	.83048E+08	1.0000	280.02	1 1 4	.71011E+08	1.0000	279.99
1 1 5	.84259E+08	.86987	279.84	1 1 5	.82641E+08	.88897	278.10
1 1 6	.39240E+08	1.0000	159.98	1 1 6	.38764E+08	1.0000	160.07
.81250E+07							
1 1 2	.14038E+09	1.0000	280.01	1 1 2	.13772E+09	1.0000	280.03
1 1 3	.10049E+09	1.0000	280.05	1 1 3	.82584E+08	1.0000	280.13
1 1 4	.82784E+08	1.0000	280.02	1 1 4	.84719E+08	1.0000	279.99
1 1 5	.84155E+08	.85101	279.72	1 1 5	.82517E+08	.86183	277.91
1 1 6	.39203E+08	1.0000	159.97	1 1 6	.38738E+08	1.0000	160.12
.13188E+08							
1 1 2	.14032E+09	1.0000	280.01	1 1 2	.13748E+09	1.0000	280.03
1 1 3	.10020E+09	1.0000	280.05	1 1 3	.81544E+08	1.0000	280.14
1 1 4	.82377E+08	1.0000	280.01	1 1 4	.86578E+08	1.0000	279.98
1 1 5	.84012E+08	.82038	279.57	1 1 5	.82280E+08	.83885	277.82
1 1 6	.39152E+08	1.0000	159.96	1 1 6	.38647E+08	1.0000	160.20
.20781E+08							
1 1 2	.14028E+09	1.0000	280.01	1 1 2	.13714E+09	1.0000	280.03
1 1 3	.99811E+08	1.0000	280.05	1 1 3	.80340E+08	1.0000	280.14
1 1 4	.81885E+08	1.0000	280.01	1 1 4	.87201E+08	1.0000	279.96
1 1 5	.83815E+08	.79567	279.35	1 1 5	.81677E+08	.81299	277.19
1 1 6	.39086E+08	1.0000	159.94	1 1 6	.38625E+08	1.0000	160.30
.38088E+08							
1 1 2	.14014E+09	1.0000	280.01	1 1 2	.13677E+09	1.0000	280.03
1 1 3	.99360E+08	1.0000	280.05	1 1 3	.79071E+08	1.0000	280.15
1 1 4	.81289E+08	1.0000	280.00	1 1 4	.85718E+08	1.0000	279.94
1 1 5	.83575E+08	.76364	279.48	1 1 5	.81355E+08	.58806	278.80
1 1 6	.39004E+08	1.0000	159.94	1 1 6	.38505E+08	1.0000	160.27
.43055E+08							
1 1 2	.14003E+09	1.0000	280.01	1 1 2	.13638E+09	1.0000	280.04
1 1 3	.98870E+08	1.0000	280.04	1 1 3	.77788E+08	1.0000	280.16
1 1 4	.80879E+08	1.0000	279.98	1 1 4	.84329E+08	.99805	279.91
1 1 5	.83284E+08	.73255	278.78	1 1 5	.80707E+08	.58673	278.87
1 1 6	.38921E+08	1.0000	159.96	1 1 6	.38320E+08	1.0000	161.09

Problem 6
 2 of 4

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.12614E+09				.14657E+09			
1 1 2	.13626E+09	1.0000	280.04	1 1 2	.13409E+09	1.0000	280.06
1 1 3	.77610E+08	1.0000	280.16	1 1 3	.63450E+08	.76481	278.95
1 1 4	.66272E+08	.98664	279.85	1 1 4	.63259E+08	.74641	278.74
1 1 5	.60306E+08	.55782	275.48	1 1 5	.54563E+08	.54181	274.58
1 1 6	.56213E+08	1.0000	161.32	1 1 6	.37439E+08	1.0000	161.90
.13064E+09				.14656E+09			
1 1 2	.13492E+09	1.0000	280.05	1 1 2	.13394E+09	1.0000	280.06
1 1 3	.66412E+08	1.0000	280.16	1 1 3	.62780E+08	.72520	278.18
1 1 4	.63624E+08	.87772	279.36	1 1 4	.63222E+08	.73978	278.69
1 1 5	.60187E+08	.55355	275.27	1 1 5	.54512E+08	.54022	274.49
1 1 6	.56150E+08	1.0000	161.44	1 1 6	.37911E+08	1.0000	162.95
.13230E+09				.15050E+09			
1 1 2	.13455E+09	1.0000	280.05	1 1 2	.13378E+09	1.0000	280.06
1 1 3	.64505E+08	.99734	280.17	1 1 3	.61537E+08	.68789	276.58
1 1 4	.63083E+08	.84404	279.20	1 1 4	.63172E+08	.73192	278.64
1 1 5	.60121E+08	.55203	275.20	1 1 5	.54441E+08	.53908	274.41
1 1 6	.56135E+08	1.0000	161.49	1 1 6	.37881E+08	1.0000	162.01
.13626E+09				.15271E+09			
1 1 2	.13443E+09	1.0000	280.05	1 1 2	.13342E+09	1.0000	280.06
1 1 3	.64491E+08	.98054	280.09	1 1 3	.63662E+08	.65493	273.51
1 1 4	.63087E+08	.81861	279.08	1 1 4	.63088E+08	.72060	278.55
1 1 5	.60064E+08	.55031	275.11	1 1 5	.54387E+08	.53793	274.33
1 1 6	.56109E+08	1.0000	161.54	1 1 6	.37850E+08	1.0000	162.08
.13712E+09				.15532E+09			
1 1 2	.13435E+09	1.0000	280.05	1 1 2	.13281E+09	1.0000	280.07
1 1 3	.64335E+08	.94693	279.92	1 1 3	.64214E+08	.62971	268.16
1 1 4	.63454E+08	.79077	278.96	1 1 4	.62927E+08	.70231	278.57
1 1 5	.64454E+08	.54799	274.98	1 1 5	.54282E+08	.53663	274.23
1 1 6	.56071E+08	1.0000	161.62	1 1 6	.37812E+08	1.0000	162.15
.14001E+09				.15924E+09			
1 1 2	.13428E+09	1.0000	280.05	1 1 2	.13198E+09	1.0000	280.07
1 1 3	.64152E+08	.89205	279.72	1 1 3	.64352E+08	.62215	260.62
1 1 4	.63362E+08	.77280	278.87	1 1 4	.62533E+08	.67433	277.43
1 1 5	.64582E+08	.54581	274.86	1 1 5	.54918E+08	.53486	274.09
1 1 6	.56032E+08	1.0000	161.71	1 1 6	.37756E+08	1.0000	162.27
.14238E+09				.16485E+09			
1 1 2	.13422E+09	1.0000	280.05	1 1 2	.13147E+09	1.0000	280.08
1 1 3	.64507E+08	.84411	279.54	1 1 3	.64493E+08	.63805	255.31
1 1 4	.63332E+08	.76158	278.82	1 1 4	.61790E+08	.64807	277.09
1 1 5	.64730E+08	.54418	274.75	1 1 5	.54888E+08	.53236	273.88
1 1 6	.57999E+08	1.0000	161.77	1 1 6	.37872E+08	1.0000	162.44
.14455E+09				.16999E+09			
1 1 2	.13410E+09	1.0000	280.06	1 1 2	.13111E+09	1.0000	280.08
1 1 3	.64388E+08	.80568	279.32	1 1 3	.63373E+08	.65562	253.72
1 1 4	.63293E+08	.75329	278.77	1 1 4	.61878E+08	.63429	276.29
1 1 5	.64657E+08	.54278	274.66	1 1 5	.54810E+08	.53008	273.68
1 1 6	.57969E+08	1.0000	161.84	1 1 6	.37588E+08	1.0000	162.54

Problem 6
3 of 4

Time (sec) i, j, k	Pressure lb./sq. in.	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.17422E+09				.13275E+07			
1 1 2	.13093E+09	1.0000	280.08	1 1 2	.13023E+09	1.0000	280.09
1 1 3	.43057E+08	.66353	253.26	1 1 3	.39528E+08	.60153	248.82
1 1 4	.60494E+08	.62611	275.62	1 1 4	.58454E+08	.61570	273.26
1 1 5	.58654E+08	.52810	273.50	1 1 5	.57934E+08	.52066	272.65
1 1 6	.37516E+08	1.0000	162.72	1 1 6	.37194E+08	1.0000	163.21
.17937E+09				.16741E+07			
1 1 2	.13075E+09	1.0000	280.08	1 1 2	.13011E+09	1.0000	280.09
1 1 3	.42780E+08	.66497	252.86	1 1 3	.38377E+08	.58694	246.25
1 1 4	.59806E+08	.61983	274.83	1 1 4	.58406E+08	.61540	273.21
1 1 5	.58444E+08	.52572	273.25	1 1 5	.57916E+08	.52050	272.63
1 1 6	.37421E+08	1.0000	162.88	1 1 6	.37186E+08	1.0000	163.22
.18589E+09				.20506E+07			
1 1 2	.13055E+09	1.0000	280.08	1 1 2	.12997E+09	1.0000	280.09
1 1 3	.42221E+08	.66194	252.05	1 1 3	.36954E+08	.57255	244.00
1 1 4	.59006E+08	.61685	273.91	1 1 4	.58352E+08	.61493	273.14
1 1 5	.58153E+08	.52276	272.91	1 1 5	.57898E+08	.52037	272.61
1 1 6	.37291E+08	1.0000	163.07	1 1 6	.37178E+08	1.0000	163.24
.18922E+09				.24421E+07			
1 1 2	.13044E+09	1.0000	280.08	1 1 2	.12978E+09	1.0000	280.09
1 1 3	.41873E+08	.66004	251.54	1 1 3	.35239E+08	.55839	241.23
1 1 4	.58617E+08	.61622	273.45	1 1 4	.58291E+08	.61439	273.07
1 1 5	.57994E+08	.52129	272.73	1 1 5	.57878E+08	.52015	272.59
1 1 6	.37222E+08	1.0000	163.17	1 1 6	.37170E+08	1.0000	163.25
*.15800E+09				.27958E+07			
1 1 2	.13043E+09	1.0000	280.08	1 1 2	.12956E+09	1.0000	280.09
1 1 3	.41747E+08	.65300	251.35	1 1 3	.33212E+08	.54453	237.83
1 1 4	.58598E+08	.61620	273.43	1 1 4	.58219E+08	.61361	272.99
1 1 5	.57992E+08	.52121	272.72	1 1 5	.57858E+08	.51946	272.56
1 1 6	.37219E+08	1.0000	163.18	1 1 6	.37162E+08	1.0000	163.26
.36866E+09				.32219E+07			
1 1 2	.13042E+09	1.0000	280.08	1 1 2	.12930E+09	1.0000	280.09
1 1 3	.41524E+08	.64361	251.02	1 1 3	.30852E+08	.53164	233.71
1 1 4	.58574E+08	.61615	273.40	1 1 4	.58134E+08	.61255	272.89
1 1 5	.57981E+08	.52111	272.71	1 1 5	.57835E+08	.51975	272.53
1 1 6	.37214E+08	1.0000	163.18	1 1 6	.37152E+08	1.0000	163.27
.64954E+09				.36957E+07			
1 1 2	.13038E+09	1.0000	280.08	1 1 2	.12897E+09	1.0000	280.09
1 1 3	.41113E+08	.63112	250.41	1 1 3	.28131E+08	.51804	228.70
1 1 4	.58540E+08	.61607	273.36	1 1 4	.58028E+08	.61114	272.76
1 1 5	.57967E+08	.52096	272.69	1 1 5	.57409E+08	.51951	272.50
1 1 6	.37208E+08	1.0000	163.19	1 1 6	.37141E+08	1.0000	163.29
.98689E+09				.42428E+07			
1 1 2	.13031E+09	1.0000	280.08	1 1 2	.12859E+09	1.0000	280.10
1 1 3	.40431E+08	.61626	249.39	1 1 3	.25001E+08	.50572	222.53
1 1 4	.58494E+08	.61592	273.31	1 1 4	.57490E+08	.60920	272.60
1 1 5	.57951E+08	.52082	272.67	1 1 5	.57778E+08	.51922	272.47
1 1 6	.37201E+08	1.0000	163.20	1 1 6	.37129E+08	1.0000	163.30

* Starting here add 6 years (1.5922×10^8 sec)
to all times.

Problem 6
4 of 4

Time (sec) i, j, k	Pressure 10 ⁻⁶ bars	Saturation (liquid)	Temp °C	Time i, j, k	Pressure	Sat	Temp
.49079E+07				.10502E+08			
1 1 2	.12812E+09	1.0000	280.10	1 1 2	.12622E+09	1.0000	280.11
1 1 3	.21385E+08	.49445	214.71	1 1 3	.71775E+07	.50578	166.25
1 1 4	.57702E+08	.60648	272.38	1 1 4	.55605E+08	.57783	269.86
1 1 5	.57738E+08	.51886	272.42	1 1 5	.57337E+08	.51520	271.94
1 1 6	.37113E+08	1.0000	163.32	1 1 6	.36972E+08	1.0000	163.49
.57932E+07				.10949E+08			
1 1 2	.12758E+09	1.0000	280.10	1 1 2	.12613E+09	1.0000	280.11
1 1 3	.17194E+08	.48599	204.37	1 1 3	.67567E+07	.51246	163.70
1 1 4	.57617E+08	.60248	272.04	1 1 4	.55315E+08	.57421	269.51
1 1 5	.57682E+08	.51835	272.35	1 1 5	.57279E+08	.51867	271.87
1 1 6	.37092E+08	1.0000	163.35	1 1 6	.36953E+08	1.0000	163.50
.65808E+07				.11568E+08			
1 1 2	.12721E+09	1.0000	280.11	1 1 2	.12606E+09	1.0000	280.11
1 1 3	.14161E+08	.48344	195.59	1 1 3	.64369E+07	.51681	161.66
1 1 4	.57141E+08	.59867	271.71	1 1 4	.55034E+08	.57081	269.17
1 1 5	.57630E+08	.51787	272.29	1 1 5	.57220E+08	.51414	271.80
1 1 6	.37073E+08	1.0000	163.37	1 1 6	.36934E+08	1.0000	163.52
.73130E+07				.12299E+08			
1 1 2	.12693E+09	1.0000	280.11	1 1 2	.12598E+09	1.0000	280.11
1 1 3	.11919E+08	.44419	186.00	1 1 3	.61120E+07	.51943	159.50
1 1 4	.56665E+08	.59480	271.38	1 1 4	.54694E+08	.56694	268.76
1 1 5	.57578E+08	.51740	272.23	1 1 5	.57149E+08	.51350	271.72
1 1 6	.37054E+08	1.0000	163.39	1 1 6	.36912E+08	1.0000	163.55
.80652E+07				.13252E+08			
1 1 2	.12670E+09	1.0000	280.11	1 1 2	.12590E+09	1.0000	280.11
1 1 3	.10143E+08	.48742	181.02	1 1 3	.57062E+07	.51814	156.66
1 1 4	.56565E+08	.59061	271.02	1 1 4	.54256E+08	.56201	268.21
1 1 5	.57522E+08	.51689	272.16	1 1 5	.57049E+08	.51262	271.60
1 1 6	.37034E+08	1.0000	163.42	1 1 6	.36881E+08	1.0000	163.57
.88471E+07				.14452E+08			
1 1 2	.12650E+09	1.0000	280.11	1 1 2	.12579E+09	1.0000	280.11
1 1 3	.87747E+07	.49271	174.80	1 1 3	.51456E+07	.51225	152.47
1 1 4	.56239E+08	.58615	270.43	1 1 4	.53691E+08	.55607	267.51
1 1 5	.57461E+08	.51633	272.09	1 1 5	.56916E+08	.51145	271.44
1 1 6	.37013E+08	1.0000	163.44	1 1 6	.36841E+08	1.0000	163.61
.96113E+07				.15803E+08			
1 1 2	.12634E+09	1.0000	280.11	1 1 2	.12568E+09	1.0000	280.11
1 1 3	.78083E+07	.49917	169.82	1 1 3	.44116E+07	.50170	146.50
1 1 4	.55910E+08	.58176	270.23	1 1 4	.53046E+08	.54971	266.70
1 1 5	.57397E+08	.51575	272.02	1 1 5	.56756E+08	.51686	271.25
1 1 6	.36992E+08	1.0000	163.46	1 1 6	.36793E+08	1.0000	163.65
				.17333E+08			
				1 1 2	.12555E+09	1.0000	280.11
				1 1 3	.34253E+07	.48609	137.90
				1 1 4	.52305E+08	.54286	265.77
				1 1 5	.56561E+08	.50880	271.02
				1 1 6	.36737E+08	1.0000	163.70

DOE

Problem 6

1-17

Time (seconds)	Discharge Enthalpy (Joules/gram)	Time (seconds)	Discharge Enthalpy
1.000 E+6	1.242 E+3	1.506 E+8	1.349 E+3
2.500 E+6	1.242 E+3	1.527 E+8	1.447 E+3
4.750 E+6	1.242 E+3	1.553 E+8	1.547 E+3
8.125 E+6	1.242 E+3	1.592 E+8	1.542 E+3
1.319 E+7	1.242 E+3	1.648 E+8	1.408 E+3
2.078 E+7	1.242 E+3	1.700 E+8	1.315 E+3
3.069 E+7	1.242 E+3	1.742 E+8	1.282 E+3
4.306 E+7	1.242 E+3	1.794 E+8	1.274 E+3
5.897 E+7	1.242 E+3	1.859 E+8	1.280 E+3
6.307 E+7	1.242 E+3	1.892 E+8	1.233 E+3
6.607 E+7	1.241 E+3	1.894 E+8	1.310 E+3
7.057 E+7	1.241 E+3	1.896 E+8	1.350 E+3
7.732 E+7	1.241 E+3	1.899 E+8	1.412 E+3
8.745 E+7	1.241 E+3	1.902 E+8	1.499 E+3
1.010 E+8	1.241 E+3	1.905 E+8	1.598 E+3
1.175 E+8	1.241 E+3	1.909 E+8	1.709 E+3
1.261 E+8	1.241 E+3	1.913 E+8	1.825 E+3
1.306 E+8	1.240 E+3	1.916 E+8	1.944 E+3
1.323 E+8	1.240 E+3	1.920 E+8	2.059 E+3
1.343 E+8	1.239 E+3	1.924 E+8	2.164 E+3
1.371 E+8	1.239 E+3	1.929 E+8	2.256 E+3
1.400 E+8	1.238 E+3	1.935 E+8	2.331 E+3
✓ 1.424 E+8	1.237 E+3	1.941 E+8	2.384 E+3
1.445 E+8	1.240 E+3	1.950 E+8	2.399 E+3
1.466 E+8	1.252 E+3	1.958 E+8	2.367 E+3
1.486 E+8	1.283 E+3	1.965 E+8	2.309 E+3

DOE
Problem 6

2 of 2

Time (seconds)	Discharge Enthalpy (Joules/gram)
1.973 E+8	2.227 E+3
1.981 E+8	2.114 E+3
1.988 E+8	1.975 E+3
1.993 E+8	1.851 E+3
2.002 E+8	1.736 E+3
2.008 E+8	1.657 E+3
2.015 E+8	1.596 E+3
2.025 E+8	1.586 E+3
2.037 E+8	1.617 E+3
2.050 E+8	1.702 E+3
2.066 E+8	1.816 E+3

CORRECTIONS TO REPORT 10-00K

GEOHERMAL RESERVOIR ENGINEERING COMPUTER
CODE COMPARISON AND VALIDATION

Prepared for

Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

Contract No. DE-AC03-80SF11452

By

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November 21, 1980

Replacements for pages 40, 45, 48, and 49
and also B-29, B-30, B-31, B-35, B-36, and B-37

GEOTRANS, INC.

Figure 20. Problem 4, cumulative recharge at surface block.

Figure 24. Problem 5a, steam in place.

Figure 27. Problem 5b, discharge enthalpy.

Figure 28. Problem 5b, steam in place.

DOE

Problem 5d

1, 2, 3

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (J/gm)
1.000 E+5	3.008 E+4	1.042 E+3
2.388 E+5	1.423 E+5	1.041 E+3
4.469 E+5	3.004 E+5	1.041 E+3
6.878 E+5	4.718 E+5	1.040 E+3
9.570 E+5	6.570 E+5	1.040 E+3
1.240 E+6	8.491 E+5	1.042 E+3
1.575 E+6	1.073 E+6	1.048 E+3
2.025 E+6	1.367 E+6	1.055 E+3
2.700 E+6	1.806 E+6	1.054 E+3
3.712 E+6	2.455 E+6	1.048 E+3
4.983 E+6	3.251 E+6	1.045 E+3
6.888 E+6	4.403 E+6	1.044 E+3
9.221 E+6	5.751 E+6	1.043 E+3
1.202 E+7	7.270 E+6	1.043 E+3
1.508 E+7	8.820 E+6	1.044 E+3
1.840 E+7	1.037 E+7	1.045 E+3
2.202 E+7	1.190 E+7	1.046 E+3
2.591 E+7	1.337 E+7	1.048 E+3
2.887 E+7	1.437 E+7	1.050 E+3
3.171 E+7	1.521 E+7	1.052 E+3
3.460 E+7	1.595 E+7	1.055 E+3
3.751 E+7	1.658 E+7	1.057 E+3
4.118 E+7	1.719 E+7	1.058 E+3
4.352 E+7	1.752 E+7	1.054 E+3
4.607 E+7	1.783 E+7	1.053 E+3
4.888 E+7	1.808 E+7	1.051 E+3

DOE
Problem 5A

7-1-7

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (Joules/gram)
5.210E+7	1.828E+7	1.049E+3
5.623E+7	1.837E+7	1.045E+3
6.232E+7	1.819E+7	1.038E+3
6.771E+7	1.776E+7	1.034E+3
7.000E+7	1.755E+7	1.033E+3
7.344E+7	1.721E+7	1.027E+3
7.859E+7	1.656E+7	1.021E+3
8.215E+7	1.604E+7	1.018E+3
8.430E+7	1.570E+7	1.016E+3
8.752E+7	1.520E+7	1.011E+3
9.120E+7	1.458E+7	1.001E+3
9.417E+7	1.405E+7	1.005E+3
9.633E+7	1.364E+7	1.003E+3
9.814E+7	1.330E+7	1.002E+3
1.007E+8	1.279E+7	1.001E+3
1.023E+8	1.247E+7	1.001E+3
1.036E+8	1.222E+7	9.999E+2
1.055E+8	1.187E+7	9.981E+2
1.084E+8	1.138E+7	9.951E+2
1.127E+8	1.064E+7	9.911E+2
1.171E+8	9.905E+6	9.876E+2
1.210E+8	9.223E+6	9.845E+2
1.235E+8	8.785E+6	9.825E+2
1.273E+8	8.148E+6	9.797E+2
1.296E+8	7.763E+6	9.780E+2
1.316E+8	7.459E+6	9.765E+2

DOE
Problem 5B10⁻⁷

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (Joules/gram)
1.000E+5	3.008E+4	1.042E+3
2.389E+5	1.423E+5	1.041E+3
4.469E+5	3.004E+5	1.041E+3
6.878E+5	4.718E+5	1.040E+3
9.570E+5	6.570E+5	1.040E+3
1.240E+6	8.491E+5	1.042E+3
1.575E+6	1.073E+6	1.048E+3
2.025E+6	1.367E+6	1.055E+3
2.700E+6	1.806E+6	1.054E+3
3.712E+6	2.455E+6	1.048E+3
4.983E+6	3.251E+6	1.045E+3
6.888E+6	4.403E+6	1.044E+3
9.221E+6	5.751E+6	1.043E+3
1.202E+7	7.270E+6	1.043E+3
1.508E+7	8.820E+6	1.044E+3
1.840E+7	1.037E+7	1.045E+3
2.202E+7	1.190E+7	1.046E+3
2.591E+7	1.337E+7	1.048E+3
2.887E+7	1.437E+7	1.050E+3
3.154E+7	1.517E+7	1.052E+3
3.164E+7	1.517E+7	1.052E+3
3.181E+7	1.516E+7	1.052E+3
3.205E+7	1.515E+7	1.051E+3
3.242E+7	1.513E+7	1.049E+3
3.297E+7	1.511E+7	1.048E+3
3.379E+7	1.506E+7	1.046E+3

DOE

Problem 5B

2 of 3

Time (seconds)	Steam Mass (grams)	Discharge Enthalpy (Boules/gram)
3.502E+7	1.501E+7	1.040E+3
3.687E+7	1.493E+7	1.037E+3
3.913E+7	1.481E+7	1.036E+3
4.094E+7	1.469E+7	1.039E+3
4.233E+7	1.461E+7	1.038E+3
4.441E+7	1.449E+7	1.035E+3
4.753E+7	1.430E+7	1.032E+3
5.221E+7	1.397E+7	1.029E+3
5.705E+7	1.355E+7	1.026E+3
6.007E+7	1.325E+7	1.024E+3
6.460E+7	1.281E+7	1.020E+3
6.985E+7	1.223E+7	1.017E+3
7.377E+7	1.174E+7	1.016E+3
7.608E+7	1.143E+7	1.016E+3
7.789E+7	1.119E+7	1.014E+3
8.030E+7	1.090E+7	1.013E+3
8.392E+7	1.048E+7	1.010E+3
8.936E+7	9.891E+6	1.005E+3
9.434E+7	9.363E+6	1.001E+3
9.855E+7	8.915E+6	9.983E+2
1.017E+8	8.575E+6	9.962E+2
1.064E+8	8.096E+6	9.929E+2
1.101E+8	7.711E+6	9.903E+2
1.128E+8	7.452E+6	9.885E+2
1.167E+8	7.091E+6	9.858E+2
1.194E+8	6.839E+6	9.838E+2