A COMPARATIVE ANALYSIS OF NUMERICAL SIMULATION AND ANALYTICAL MODELING OF HORIZONTAL WELL CYCLIC STEAM INJECTION

A Thesis

by

DELMIRA CRISTINA RAVAGO BASTARDO

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2004

Major Subject: Petroleum Engineering

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Approved as to style and content by:

Daulat D. Mamora (Chair of Committee)	Akhil Datta-Gupta (Member)
Luc T. Ikelle (Member)	Stephen A. Holditch (Head of Department)

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ABSTRACT

A Comparative Analysis of Numerical Simulation and Analytical Modeling of Horizontal Well Cyclic Steam Injection. (May 2004)

Delmira Cristina Ravago Bastardo, Chemical Engineer,
Universidad de Oriente, Venezuela

Chair of Advisory Committee: Dr. Daulat Mamora

The main objective of this research is to compare the performance of cyclic steam injection using horizontal wells based on the analytical model developed by Gunadi against that based on numerical simulation. For comparison, a common reservoir model was used. The reservoir model measured 330 ft long by 330 ft wide by 120 ft thick, representing half of a 5-acre drainage area, and contained oil based on the properties of the Bachaquero-01 reservoir (Venezuela). Three steam injection cycles were assumed, consisting of a 20-day injection period at 1500 BPDCWE (half-well), followed by a 10-day soak period, and a 180-day production period. Comparisons were made for two cases of the position of the horizontal well located on one side of the reservoir model: at mid-reservoir height and at reservoir base.

The analytical model of Gunadi had to be modified before a reasonable agreement with simulation results could be obtained. Main modifications were as follows. First, the cold horizontal well productivity index was modified to that based on the Economides-Joshi model instead of that for a vertical well. Second, in calculating the growth of the steam zone, the end-point relative permeability's of steam and oil were taken into consideration, instead of assuming them to be the same (as in the original model of Gunadi).

Main results of the comparative analysis for both cases of horizontal well positions are as follows. First, the water production rates are in very close agreement with results obtained from simulation. Second, the oil production rates based on the analytical model (averaging 46,000 STB), however, are lower than values obtained from

simulation (64,000 STB). This discrepancy is most likely due to the fact that the analytical model assumes residual oil saturation in the steam zone, while there is moveable oil based on the simulation model. Nevertheless, the analytical model may be used to give a first-pass estimate of the performance of cyclic steam injection in horizontal wells, prior to conducting more detailed thermal reservoir simulation.

DEDICATION

To God, my parents, Angel, my kids, Angel, Oswaldo and Ricardo and Yolanda, for being an enduring source of light, learning, joy, inspiration, and unfailing support.

ACKNOWLEDGEMENTS

I wish to express my deep sincere gratitude to my advisor, Dr. Daulat Mamora, for his constant valuable support, encouragement and guidance offered during this study.

I wish to express my gratitude to Liao Yizhu, for his advice on reservoir simulation matters and Javier Rondon for his help using Visual Studio Program.

I thank also Dr. Akhil Datta-Gupta and Dr. Luc T. Ikelle for serving on my committee.

I would like to thank my sponsors, PDVSA for allowing me to continue my professional development.

I thank all my colleges who, in one way or another, helped with the development of this study, particularly the EOR research group class 2003-2004 and especially Jose A. Rivero.

Thank you to the professors and staff of the Department of Petroleum Engineering at Texas A&M University for their support.

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CHAPTER I

INTRODUCTION

Steam injection has been used for about five decades to improve the oil rate and recovery of heavy oil. Main mechanisms during steam injection are oil viscosity and residual oil saturation reduction by increasing the reservoir temperature. In addition, injection of fluid into the reservoirs has also the beneficial effect of enhancing oil displacement and providing reservoir pressure support.

There are two forms of steam injections, namely, steamflooding or steam drive, and cyclic steam injection also known as huff-and-puff. In steamflooding, steam is continuously injected into fixed well patterns of injection wells, while fluids are produced in designated wells. When steam is injected into a reservoir, the resulting phase distribution forms five distinct zones. The first zone -nearest to the injector-corresponds to the steam zone, where water in liquid and vapor phase and mainly residual oil are present. The light fractions of the oil are vaporized and condense ahead of the steam front creating a solvent bank, which comprises the second zone. The solvent bank is miscible with the oil, thereby reducing its interfacial tension and viscosity. The third zone consists of the hot water zone where steam and volatile oil condense upon contact with the cold matrix. As a result of oil viscosity reduction and displacement in the first three zones, an oil bank (fourth zone) is formed. The fifth zone (farthest away from the injector) is composed of original oil.

In cyclic steam injection, steam is injected and produced from the same well. This type of well stimulation is the most commonly used in thermal recovery process. This provides thermal energy in the vicinity of the wellbore, using the steam as the heat transfer medium and allowing the rock to act as a heat exchanger for temporary storage

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of the injected energy. Each cycle consists of three periods: injection, soak, and production. Usually, wet steam is injected for a short period of time during the injection stage. After that the well is closed for a short time, the soaking period, allowing the steam to heat up a larger part of the reservoir. Most of the latent heat of the steam is transferred to the formation surrounding the well, lowering the viscosity of the oil. Finally the well is put back on production for a period of time to produce the oil and the condensed injected steam. The initial production rate of the hot fluids is higher than that of the primary cold production. However the rate declines with time to near the prestimulation values, as heat is removed with produced fluids and dissipated into nonproductive formations. The main advantages of cyclic steam injection over steamflooding are faster production response, lower initial capital costs and lower pressure operations.

From a technical point of view, two main factors are necessary for the success of this kind of process: a significant effect of temperature on the viscosity of the heavy crude oil, to reduce the flow resistance around the producing well; and a natural production mechanism or a driving force present in the reservoir initially. Typically, gravity drainage and solution gas drive are the most important mechanisms in providing driving forces during the production phase. In addition, rock compaction may be a significant drive mechanism for some reservoirs.

From an operational point of view, cyclic steam injection has been accepted because the application of the process is simple: simple steam generators may service a large number of wells. In addition, if the process is successful, increased oil production happens immediately, since the oil remains hot as it flows to the well.

Oil recovery with steam injection has been enhanced with the incorporation of horizontal wells. The main advantages of horizontal wells are improved sweep efficiency, increased producible reserves, increased steam injectivity, and decreased number of wells required for field development. The use of horizontal wells for cyclic steam injection in the last years has been one of the technologies used to achieve higher production in the heavy oil fields. A horizontal well allows us to manage higher injection rates and the contact area opened to flow is larger than in vertical wells. Thus, the heat zone around the horizontal well is larger than that around the vertical well. That means a higher oil viscosity reduction and therefore typically higher oil production is reached since horizontal well access a larger volume of the reservoir compared to a vertical well.

In 1999, an analytical cyclic steam injection model was developed by Bambang Gunadi at the Petroleum Engineering Department at Texas A&M University using horizontal wells.[1-2] The analytical model was satisfactorily tested against the results of a scaled laboratory model. To verify the model, the simulation results would be compared against those based on the analytical model using the data from Bachaquero field. The reseach considers the simulation of two study cases involving two different locations of the horizontal well: horizontal well at mid-reservoir height and at reservoir base. This investigation allows corroborating the performance of the analytical model which could generate quick and sufficiently accurate estimates of the steam displacement in preliminary evaluations of cyclic steam injection using horizontal wells.

1.1 Research Objectives

The main objectives of my research are as follows:

1. Conduct a thermal numerical simulation of the discretized horizontal well using Bachaquero-01 reservoir data to model the steam advancement in and around the wellbore, and oil recovery as a function of the steam injection rate and horizontal well length.

2. Scale–up the analytical model to field conditions. Compare horizontal well cyclic steam injection performance based on analytical modeling and simulation.

CHAPTER II

LITERATURE REVIEW

Several studies have been carried out to study steam injection using horizontal wells. Numerical simulations applied to specific reservoirs, along with conceptual cases representative of non depleted, conventional heavy oil, have noted the improvement in oil recovery obtained with the application of cyclic steam injection in horizontal wells.[3-4] Some field applications of cyclic steam injection using horizontal wells have been reported in the literature.[3-12] Most of these applications have shown favorable performance.

Additionally, a few cyclic steam injection projects using horizontal wells have been conducted to evaluate the performance of the steam front and to establish a comparison between vertical and horizontal wells. [1-4,7-8,13-15] The Petroleum Engineering Department at Texas A&M University have carried out a series of studies to investigate the performance of horizontal and vertical wells under cyclic steam injection, the shape of the steam zone for an horizontal wells during cyclic steaming, the optimum injection rate and injection time for cyclic steam injection using horizontal wells, the oil production during cyclic steam injection using horizontal wells, the comparison between the performance of cyclic steam injection against that of steamflooding using horizontal wells and others. These investigations[1-4,8] have shown encouraging results; however, further analyses are required to be extended and to validate the results. A literature review covering previous experiences with the combined use of steam injection and horizontal wells will be presented.

Butler *et al.* (1981)[13] presented an analytical model for a new horizontal steamflood technique, the steam assisted gravity drainage (SAGD) method. In a SAGD pattern, two horizontal wells are utilized, namely, a horizontal injector above a horizontal producer. In this study, the growth of the steam zone is significantly affected by gravity drainage of the oil to the horizontal producer, so that the steam zone has the shape of an inverted pear in a cross sectional view. In this model oil drains down to the production well along the sides of the steam zone. The amount of oil production is calculated basically using Darcy's law and material balance equation. Fractional recovery of oil calculated by the model is in good agreement with scaled pressurized experimental results.

Toma *et al*. (1984)[14] conducted an experimental study for cyclic steam injection in a horizontal well. The experimental results showed that oil recovery of cyclic steaming in horizontal wells is affected by the axial and radial components of recovery. The growth of the steam zone along the well as a function of time and injection rate was not modeled.

Gozde *et al.* (1989)[15] developed a new analytical model for cyclic steam stimulation which incorporated some of the major recovery mechanisms which are applicable for steam stimulation (pressure drive, gravity drainage, cold oil influx and relative permeability effects). The model was validated with field data and compared with other analytical models: Gontijo & Aziz and Gozde- AOSTRA models.

Le Gallo and Latil (1993)[16] presented the coupling of steady state thermal wellbore flow models for injection and production with a thermal reservoir simulator. Wellbore hydraulics from a pipeline model and pressure drop model were modified to account for fluid fluxes between reservoir and well. The temperature profiles in the well was obtained from heat balance including the energy balance exchanges between well and reservoir.

Reis (1992)[17] presented and improved model of the SAGD process. In this model the steam zone shape is approximated by an inverted triangle with its vertex fixed at the production well. The oil drains downward along the interface of a laterally expanding steam zone. Using cumulative oil production along the horizontal well and combined with the material balance equation, the steam zone interface angle can be calculated. Oil production rate and steam zone interface angle calculated by the model are in good agreement with the experimental data of Chung and Butler.[22]

Sharma *et al*. (1994)[18] studied the use of discretized wellbore model for handling the complex wellbore dynamic that can occur in horizontal wellbores. This model was coupled to a standard blackoil simulator and its accuracy and applicability for well test analysis for horizontal well was examined.

Oballa *et al.* (1994)[19] evaluated the practical advantages and limitations of discretized wellbore modeling when coupled to full field compositional and/ thermal simulations. The guidelines for the simulation engineer on the use and possible misuse of discretized wellbore model were presented.

Fernandez and Zerpa (1995)[5] conducted a numerical simulation study to investigate the performance of cyclic steam injection using horizontal wells. The main objective of the study was to history match the horizontal well performance during cold production, and to investigate the feasibility of introducing a cyclic steam injection scheme to enhance productivity. Results showed that cyclic steam injection increase the oil production rate up to twice that under cold production. Oil recovery by cyclic steam injection with horizontal wells was 62% higher than that with vertical wells.

Oballa and Buchanan (1996)[10] examined the use of a single horizontal well using new simulation technology (hybrid grid surrounding a discretized wellbore). Two different operating strategies, SAGD and cyclic steam injection, as well as the influence of some key reservoir fluid characteristics on production were evaluated. This investigation helped to understand better the interactions between the single well configuration, the recovery process and the reservoir.

Escobar *et al.* (1997)[6] presented the experiences with surface completions and completion equipment for steam injection wells, fluid for thermal insulation, offshore equipment, steam injection with additives and the beneficial results of cyclic steam injection into two horizontal wells completed in Bachaquero reservoir.

Rodriguez (1999)[3-4] conducted a three dimensional thermal compositional simulation study to evaluate the performance of horizontal wells under cyclic steam injection and steamflooding. The results show that the oil recovery of the field can be increased by steamflooding with additional producer wells around the horizontal wells injector. The main advantages of the steamflooding are the re-pressurization and improved thermal efficiency.

Sasaki *et al.* (1999)[20] carried out SAGD experiments using 2-D scaled reservoir models, to investigate production process and performance. The results suggest that the vertical well spacing between two wells can be used as a governing factor to evaluate production rate and lead-time in the initial stage of the SAGD process. Based on these experiments results, the SAGD process was modified: the lower production well as intermittently stimulated by steam injection, in conjunction with continuous steam injection in the upper horizontal injector. Using the modified process (named SAGD-ISSSLW), the time to generate near breakthrough condition between two wells was shortened, and oil production was enhanced.

Escobar *et al.* (2000)[7] developed a new methodology for optimizing the cyclic steam injection process for vertical and horizontal wells. The procedure integrates oil production characterizations using numerical simulations, net present value maximization through a Quasi-Newton method, and model validation/tunning. The three-stage procedure provides the optimum number and/or duration of cycles, the optimal amounts of steam to be injected in each cycle and the optimal value of the overall economic indicator. The optimization algorithm was successfully validated with published results obtained from the discrete maximum principle. The methodology was applied to determine the optimal conditions of cyclic steam injection for a horizontal well located in Bachaquero field, Venezuela.

Marpriansyah (2003)[8] performed a comparative analysis of oil production using vertical and horizontal wells with cyclic steam injection. The results indicate that oil recovery for the best horizontal well case is not significantly higher than for the best vertical well case. Also for both types of well, the highest oil recovery is obtained when the completion interval is at the bottom of the reservoir. The difference between the NPV at 10 % discount rate for the best vertical well case, compared to the horizontal well case is not significant.

Vicente *et al.* (2003)[11] performed a detailed study of the parameters that affect the behavior of the flux distribution and productivity along horizontal wells, based on a fully implicit, three- dimensional numerical model coupling reservoir and horizontal well flow dynamics. The validation of the numerical model used in this study was done using production-logging data and the examples of the results of the application of the optimization protocol developed for some of the Petrobras offshore fields.

Skoreyko *et al.* (2003)[9] investigated the used of PEBI (Perpendicular Bisector) based gridding for a much more complex thermal process in a full field using commercial simulation products. The goal of this study was to evaluate both computing efficiency and accuracy by comparing results obtained by modeling a field using the more conventional corner point- based gridding with local grid refinement to those obtained using PEBI gridding approach. The results showed that the PEBI grids improve accuracy and are much more adaptable for modeling near well and in a complex geological setting. Also a three – fold run time improvement was noted for the field studied when compared to a more conventional model.

CHAPTER III

NUMERICAL SIMULATION

3.1 Simulator Description

In this study the simulator used was CMG's STARS version 2003. It is an advanced simulator that can handle a wide range of processes such as steam drive, steam cycling, in-situ combustion, polymer flooding, foam and emulsion flow, etc. In STARS two well models are available for horizontal wells. The first one is a standard sink/source approach. The second one, "Discretized Wellbore Model" is more sophisticated and attempts to overcome some deficiencies of the first model. It considers fluid and heat flow in the wellbore.

3.1.1 Sink/Source Model

In a sink /source (SS) model,[19] flow from/to a reservoir is represented by a single term in the reservoir flow equation. A steady state is assumed to be in the wellbore, i.e. there is no wellbore storativity. Only one equation per completion (layer) is solved with a bottom hole pressure as a primary variable. That means only the pressure distribution due to gravity is known in the wellbore, but not the composition and temperatures. This poses numerical difficulties when some layers in a well are producing and some injecting. Heat conduction between a wellbore and a reservoir is also neglected. Fluid flow from/to a reservoir is calculated from equation:

$$q_j = WI\lambda_M (p_w - p_{ij}) \qquad j=w,o,g \qquad (3.1)$$

WI is a well index that describes the geometry of a specified wellbore. It may be calculated based on the Peaceman model and takes into account also the reservoir heterogeneity. λ_M represents a fluid mobility and has a different meaning for an injector or a producer. When fluid is injected, λ would be the total mobility of a grid block. When fluid is produced, λ will be the mobility of each phase produced from a grid block.

3.1.2 Discretized Wellbore Model

A discretized wellbore (DW)[19] model may be used for horizontal or vertical wells as well as for undulating or deviated wells. Wells may also be regular or circulating (tubing and annulus).It models fluid and heat flow in the wellbore and between a wellbore and a reservoir/overburden. Wellbore mass and energy conservation equations are solved together with reservoir equation for each wellbore section (perforation).

A wellbore in the DW model is discretized in the same fashion as a reservoir, that is, each wellbore section is treated as a grid block and the completion to the reservoir is handled as an interblock connection. The fluid flow equation for each component as well as the energy equation is solved in each grid block the same way as equations describing flow in the reservoir. Grid fluid as well as rock fluid properties must be assigned to the wellbore. Some of the properties are read in as data and some are calculated internally (e.g. porosity, permeability). Wellbore porosity is set to one; initial permeability is calculated from Hagen-Poiseuille equation for laminar flow in a pipe as rw ^{2}/8. Annulus permeability in a circulating well, an incompressible, laminar fluid flow in a steady state in an annular region is considered.

When flow becomes turbulent (Re>2100), permeabilities are updated in such a way that the wellbore hydraulics is captured and flow equations still have the form of Darcy's law. Permeability's together with other grids dimensions are used to calculate transmissibility's for convective mass and heat flow. Transmissibility between a horizontal wellbore (or annulus) and a grid block containing a well is calculated according to Peaceman. The effective drainage radius re is evaluated as

$$r_e = \frac{\left[D_j^{\,2}\sqrt{K_k/K_j} + D_k^{\,2}\sqrt{K_j/K_k}\right]^{1/2}}{\left(K_k/K_j\right)^{(1/4)} + \left(K_j/K_k\right)^{(1/4)}} \tag{3.2}$$

Generally, rock fluid interaction in the wellbore is described by straight line relative permeability curves without capillary pressure. Specification of initial conditions in the wellbore will determine whether transient behavior will be simulated or wellbore conditions are immediately in pseudo steady state. An option to initialize the wellbore automatically to the pseudo-steady state is available. When the wellbore is initialized to conditions such that transient effects are simulated in the wellbore, the large changes of pressure, saturation, temperature and composition will require small time steps with an increase in the total number of iterations. The effect of the wellbore transients on numerical performance is larger in heavy oil or bitumen reservoirs than in convectional oil reservoir due to very low oil mobility. It also seems to be more pronounced in injectors than in producers. Simulations of the transient behavior do not affect long term physical results for most of the process used in EOR simulation.

3.1.3 Wellbore Hydraulics

Injection or production in respect of heavy oil or tar sands reservoirs may be strongly affected by wellbore hydraulics when the driving forces in a reservoir has a magnitude similar to frictional forces in a wellbore. Therefore, one of the major functions of a DW model is to describe reasonably well the frictional pressure drop in a wellbore. Frictional pressure loss is considered in both laminar and turbulent flow regime. In laminar flow, friction factor $f=64/Re$ is directly built into permeability calculation. In a turbulent flow regimen, frictional pressure drop is determined according to Dukler. The two-phase (liquid-gas) friction factor is a product of a single phase friction factor and a correlation coefficient that depends on a liquid volume fraction. Two single phase (homogeneous) friction factor is calculated from Colebrock's[19].

3.1.4 Comparison of Sink/Source and Discretized Wellbore Model

The following points may be used as guidelines in deciding which wellbore model to use in the simulation. A Sink-Source (SS) model may be adequate for the following conditions:

For reservoirs with reasonable injectivity where the effect of heat conduction between a wellbore and a reservoir is negligible. Injectivity is very low in heavy oil or tar sand reservoirs without bottom water and therefore oil may be initially mobilized only by heat heat conduction which is not possible with an SS model.

For process with small flow rate or big pipe diameter where frictional pressure drop is almost nonexistent.

For short horizontal wells with a possibility of homogeneous fluid around the wellbore.

For homogeneous reservoirs where wellbore reservoir communication is uniform.

For vertical wells where fluid segregation is minimal.

For reservoirs which have much higher pressure drawdown than the expected frictional pressure drop.

For any other case the discretized wellbore model should be used. However, one has to be aware of possible numerical difficulties due to drastic PVT behavior and increased nonlinearities. A wellbore does not contain rock to buffer the effect of temperature band when pressure and temperature condition are close to saturated values every small change in then will cause phases to appear or disappear. In a reservoir, rock will absorb the marginal fluctuation in energy and therefore transition between phases is smoother.

3.2 Overview of the Model

One model was constructed to simulate a cyclic steam injection process in a discretized horizontal well. It was decided to run simulation using thermal black-oil model, the same conditions assumed in the analytical Gunadi model. The reservoir fluids in the model therefore consist of two phases, namely, vapor and liquid. The vapor phase contains only steam, while the liquid phase contains dead oil and water.

The initial simulation model was a laboratory - scaled model - measuring 10”x10”x5” – to simulate the actual experimental data of Gunadi. However, simulation runs were very unstable and gave extremely high reservoir pressure after steam injection. It was therefore decided to verify the analytical model by comparison against simulation results using field scale. In addition since data from Bachaquero -01 was available (**Table 3.1)**; it was decided to use the oil properties of this reservoir in both the analytical and simulation models.

The two phase oil-water relative permeability data were based on empirical equations developed by Honarpour[23] in 1982. These correlations were used in both simulation and Gunadi's model. These equations were derived from oil and gas fields in the continental U.S., Alaska, Canada, Libya, Iran, Argentina and the United Arab Republic. The data set were classified according lithology (carbonate and non carbonate), and wetability (oil wet and water wet). The equations used in this study are as follows.

K_{rw} was calculated using the following equation:

$$K_{rw} = 0.035388 \frac{(S_w - S_{wi})}{(1 - S_{wi} - S_{or})} - 0.010874 \left[\frac{(S_w - S_{or})}{(1 - S_{wi} - S_{or})} \right]^{2.9} + 0.56556 (S_w)^{3.6} (S_w - S_{wi}) \tag{3.3}$$

K_{ro} was calculated using:

$$K_{ro} = 0.76067 \left\{ \frac{(S_o / 1 - S_{wi}) - S_{or}}{1 - S_{or}} \right\}^{1.8} \left(\frac{S_o - S_{or}}{1 - S_{wi} - S_{or}} \right)^{2.0} + 2.6318 \phi (1 - S_{or})(S_o - S_{or}) \tag{3.4}$$

K_{rg} was calculated using:

$$K_{rg} = 1.1072 \left(\frac{S_g - S_{gc}}{1 - S_{wi}} \right)^2 K_{rg(S_{org})} + 2.7794 \frac{S_{org}(S_g - S_{gc})}{(1 - S_{wi})} K_{rg(S_{org})} \tag{3.5}$$

Two set of relative permeability's data were used. It was assumed that the relative permeability's curves inside the wellbore are straight lines going from zero to one. That means for homogeneous fluid K_r=1.

The fluid PVT data was obtained from a previous studies.[3,4]

Table 3.1 Bachaquero 01 Rock and Fluid Properties

Oil gravity	^{o} API	11.7
Average depth	ft	3,000
Original pressure at 3,000 ft	psia	1,370
Bubble point pressure	psia	1,319
Permeability	md	2,000
Porosity	%	33.5
Net oil sand thickness	ft	200
Initial oil viscosity	cp	635
Temperature	^{o}F	128
Gas-oil ratio	scf/STB	87
Oil saturation	%	80
Irreducible water saturation	%	20
Sand heat capacity	Btu/cu.ft-^{o}F	32.7
Sand thermal conductivity	Btu/D-ft-^{o}F	26.4
Rock compressibility	Psi^{-1}	$60x10^{-6}$
OOIP	BSTB	7.037

3.2.1 Grid Size

The Cartesian 3D- dimensional model has grid dimensions of 50x50x20. The thickness of each of the 20 layers was 6 ft. The model represents a half of 5-acres reservoir drainage area, measuring 330 ft. in length and width and 120 ft. in thickness. It contains 50,000 cells, with discretized horizontal well and local grid refinement using hybrid grids with (r,θ, z) components of 2,1,2 around the horizontal well in J direction. This cylindrical refinement provides higher resolution in areas of interest such as the wellbore region and therefore increases the accuracy in the modeling.[19] Equal spaced grids in the J-direction are used representing equal horizontal lengths of the well in the simulation. **Figs. 3.1** through **3.8** show some cross sections of the models.

In the hybrid grid approach the entire reservoir is divided into two regions – well and reservoir region. In both regions the equal flow geometry is taken into account. When the well region is considered homogeneous the flow will be radial and the fluid flow equations are formulated in cylindrical coordinates. Further away from well, in the reservoir region, linear streamlines are considered which means the Cartesian coordinate system is used to describe the fluid flow.

It was observed that the treatment of near wellbore phenomena has strong influence on reservoir simulation results. The representation of the horizontal well in field scale simulation as a line source within the coarse grid block was not adequate in this study.

The reservoir was assumed to contain 80% oil and 20% water with no initial gas saturation. Both injection and production well were assumed to be 0.292 inch diameter.

The project considered the simulation of the two study cases involving two different locations of the horizontal well: Horizontal well at mid-reservoir height and at the reservoir base. Both cases consider the well placed along the total length of the reservoir. Both models were initialized at 128 ^{o}F as reservoir temperature, and 1319 psia reservoir pressure, an oil gravity of 11.7 ^{o}API and oil viscosity of 635 cp at initial reservoir temperature. **Table 3.2** presents the crude oil viscosity for the model.

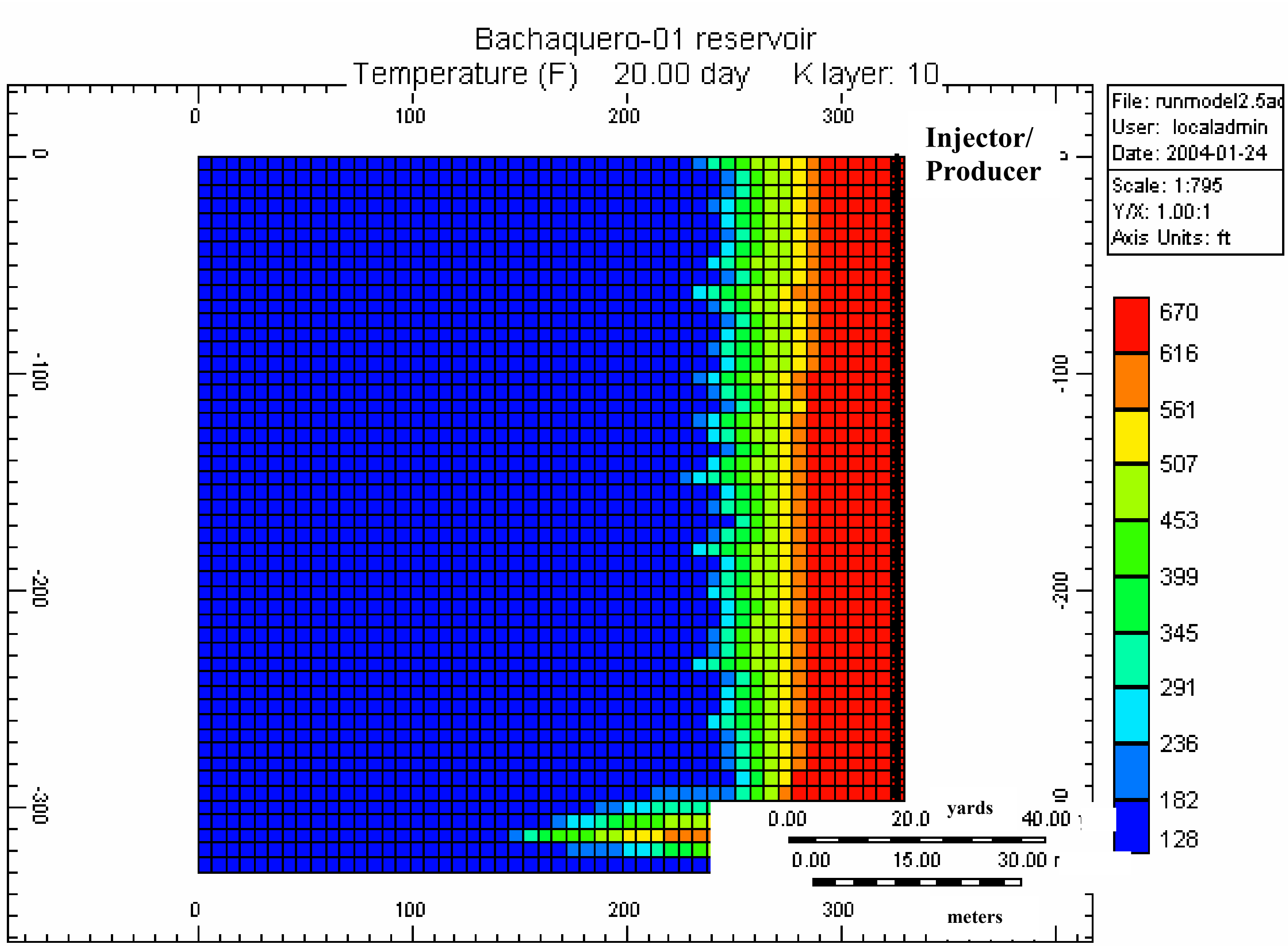

Fig. 3.1 Grid Model Temperature at 20 Days – ij Cross Section Mid-Reservoir Height

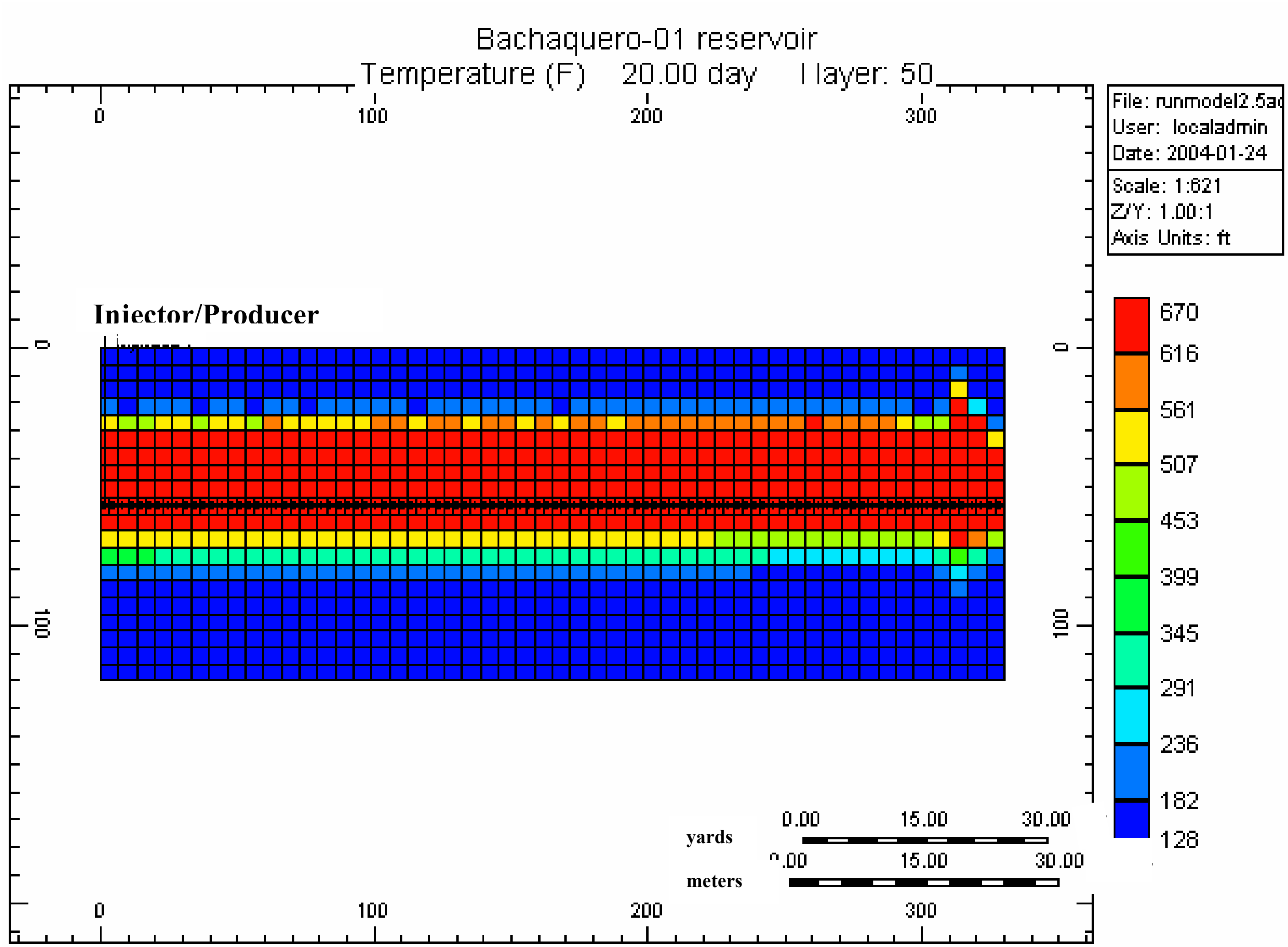

Fig. 3.2 Grid Model Temperature at 20 Days – jk Cross Section Mid-Reservoir Height

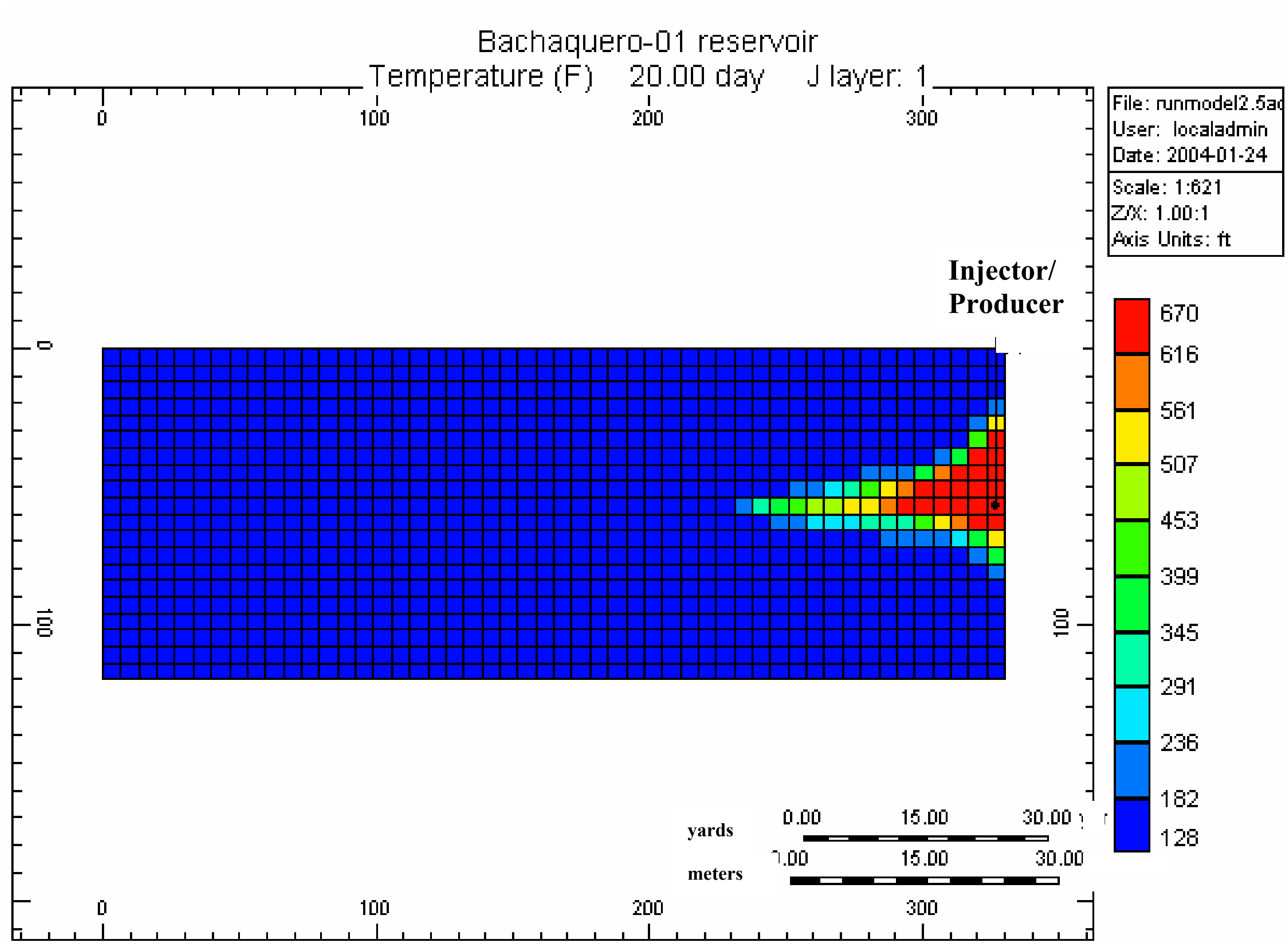

Fig. 3.3 Grid Model Temperature at 20 Days – ik Cross Section Mid-Reservoir Height

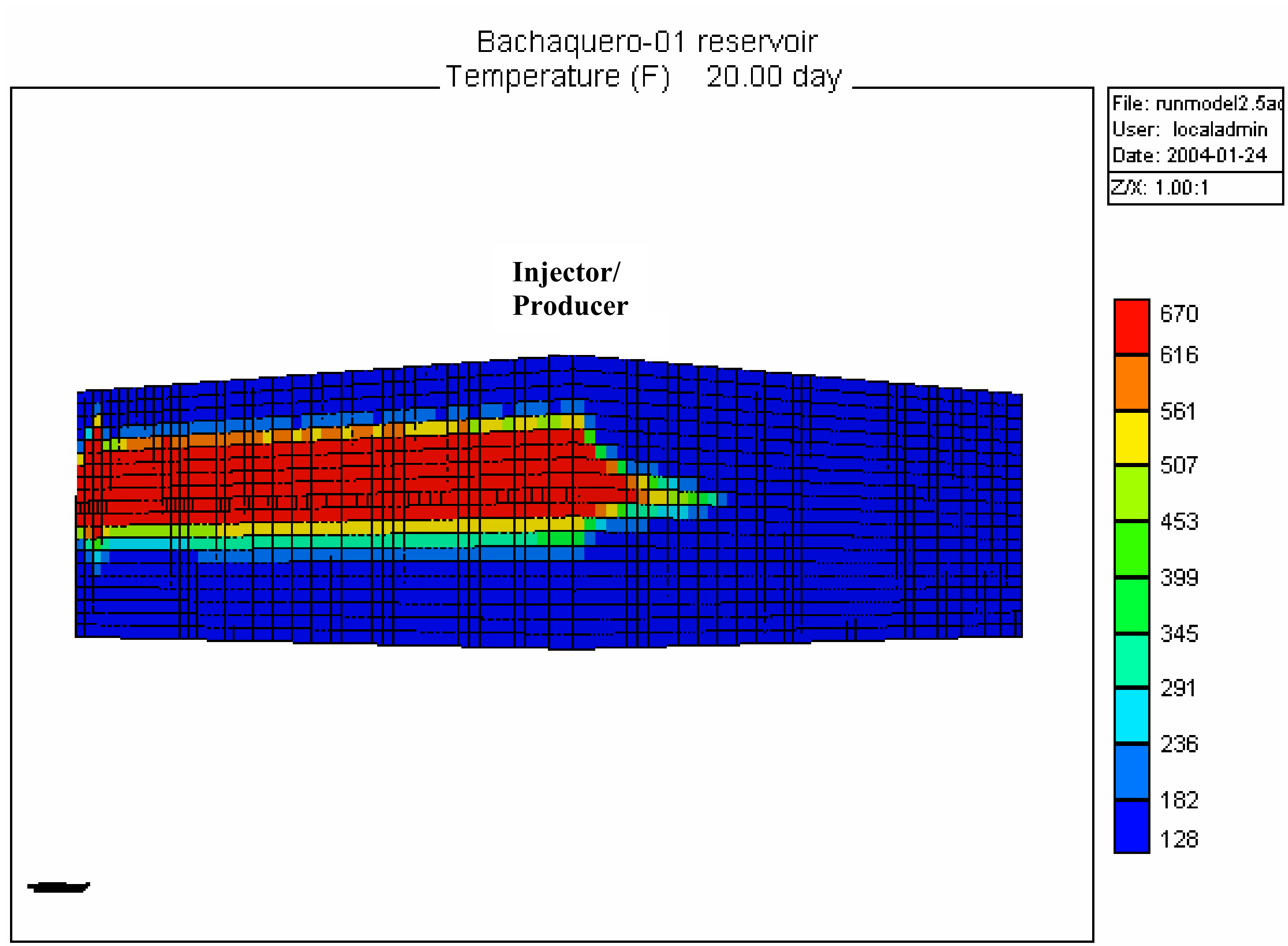

Fig. 3.4 Grid Model Temperature at 20 Days – 3D Cross Sectional View Mid-Reservoir Height

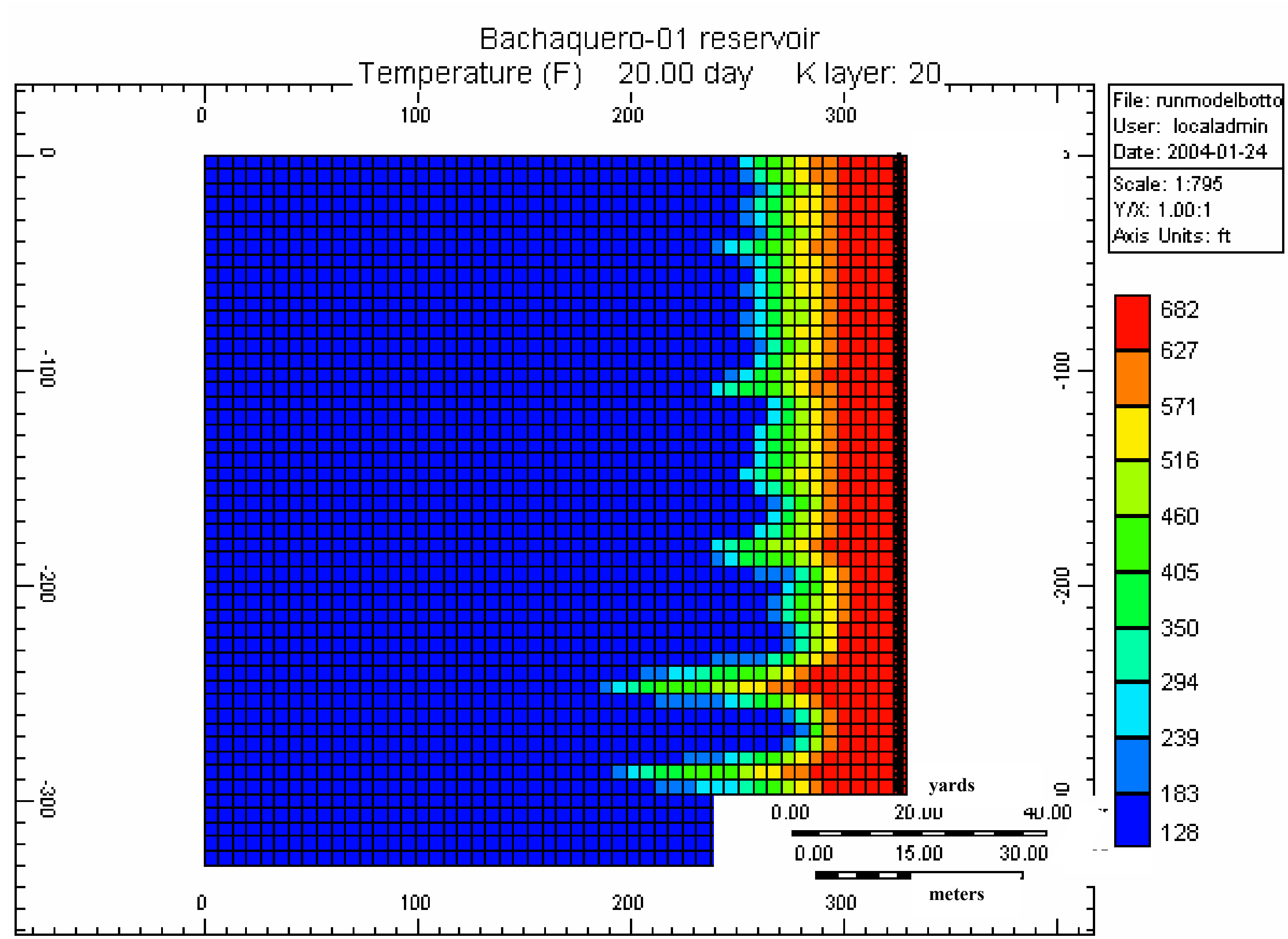

Fig. 3.5 Grid Model Temperature at 20 Days – ij Cross Section Reservoir Base

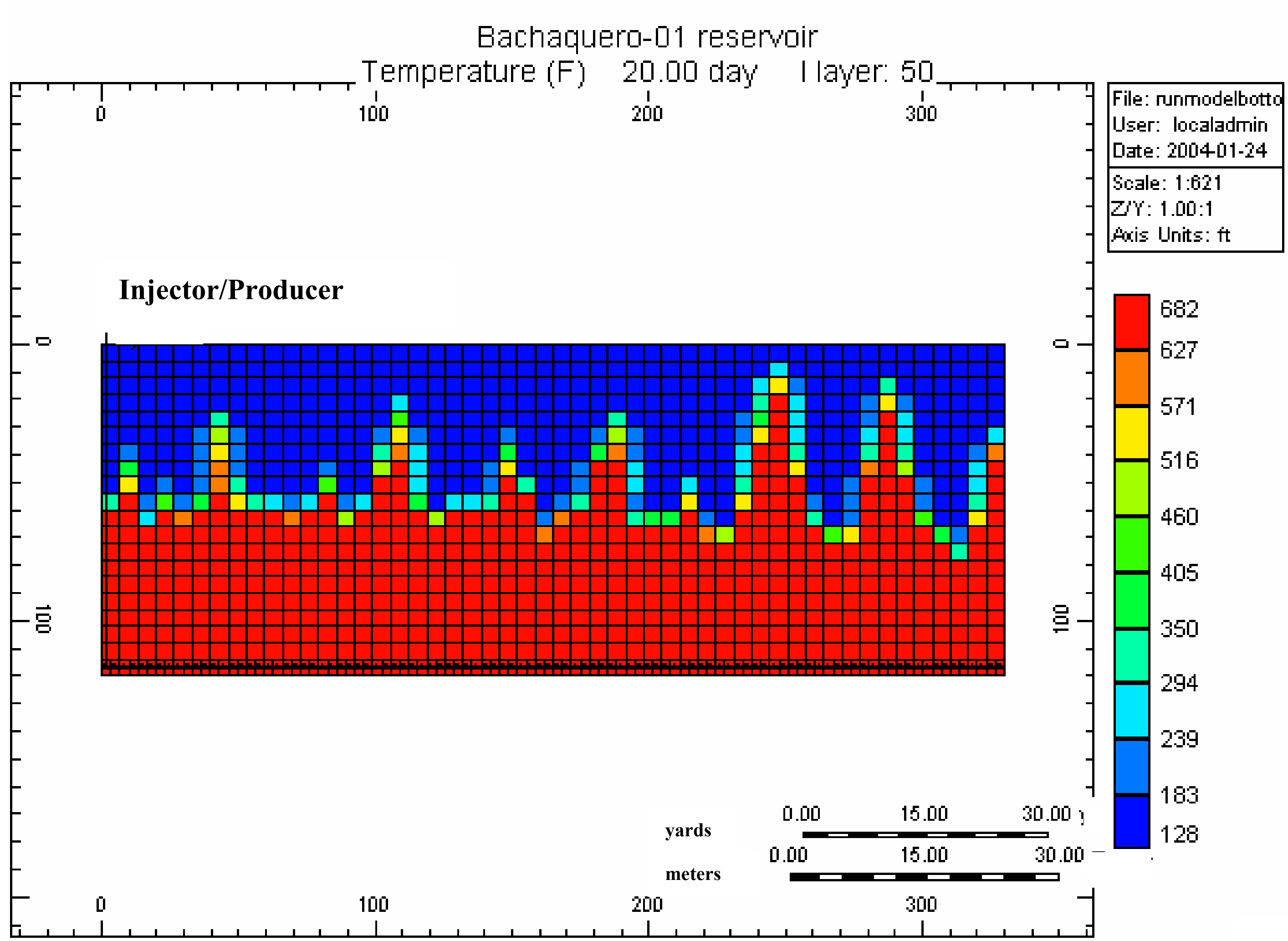

Fig. 3.6 Grid Model Temperature at 20 Days – jk Cross Section Reservoir Base

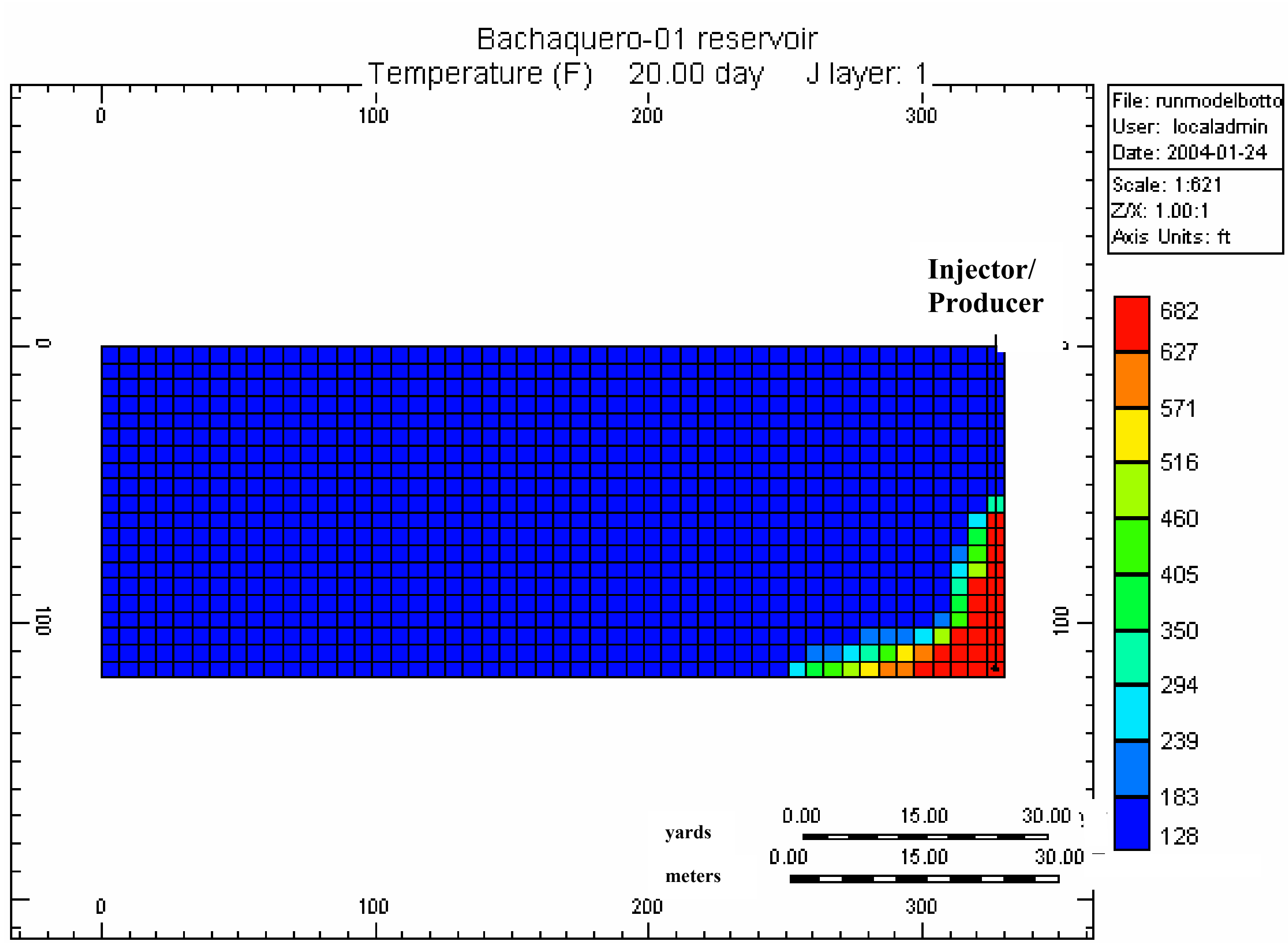

Fig. 3.7 Grid Model Temperature at 20 Days – ik Cross Section Reservoir Base

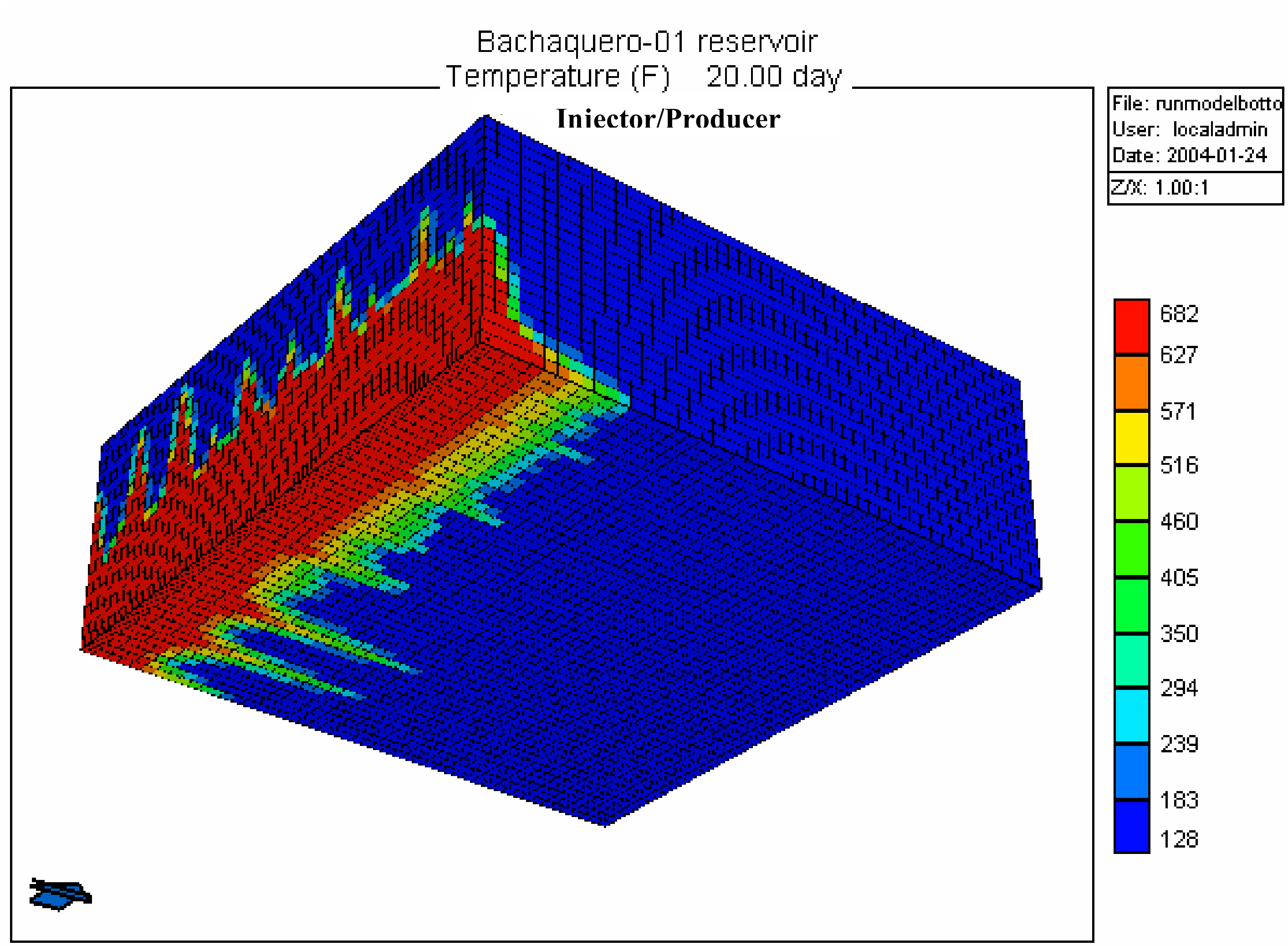

Fig. 3.8 Grid Model Temperature at 20 Days – 3D Cross Sectional View Reservoir Base

Table 3.2 Bachaquero 01 Crude Oil Viscosity

Temperature, ^{o}F	Viscosity, cp
63	7600.0
128	635.00
160	351.74
163	335.04
190	86.20
220	66.29
250	46.36
280	26.42
310	12.68
340	11.42
370	10.17
400	8.91
430	7.66
490	5.15
520	3.90
600	2.90

The well was subjected to three cycles of steam injection. **Table 3.3** shows the injector and producer condition and also the typical conditions used in every cycle.

The heat losses, temperature and pressure drops were computed in every case. STARS uses a semi – analytical model for heat transfer to or from an adjacent formation of infinitive extend. It assumes a temperature profile in the base or cap rock as a function of time and distance from the reservoir interface. The energy lost is used directly in the energy balance statistics. The only data required are the thermal conductivity and heat capacity of the base and cap rock, both of which are quite standard data.

Table 3.3 Injection Operational Parameters

Injection temperature, ^oF	640
Injector bottom hole pressure, psi	1360
Producer bottom hole pressure, psia	230
Injection steam rate, CWE	1500
Injection time, days	20
Soaking time, days	10
Production time, days	180
Steam quality, %	0.80

3.3 Simulation Results - Horizontal Well at the Mid-Reservoir Height and Reservoir Base

Initially cold production was calculated to estimate the well productivity index; considering not cyclic steam injection in the simulation file. This value corresponds to $0.8594\ Bbl/day/psi$ for horizontal well at mid- reservoir height and $0.8558\ Bbl/day/psi$ for horizontal wells at reservoir base. This results were compared with the initial cold production index estimated using the analytical model in all cases**. Fig. 3.9** shows the results for oil production rate.

Thermal numerical simulation considering discretized well using Bachaquero-01 reservoir data was used to model the performance of the steam zone around the wellbore. Many models with different dimensions and refinement levels were built during this study and due to numerical dispersion problems associated with highly unfavorable displacement and also CPU time requirements, the total area of the model was reduced to 2.5 acres.

Figs. 3.10 through **3.17** and also **Figs. 3.1** through **Fig. 3.8** show the results of the steam zone behavior using the temperature profile in different planes. Only eighteen blocks are heated from the wellbore to the reservoir in I direction which represents 36% of the total distance. For the model the steam did no reach the toe of the horizontal well ocupping only 30% and 24% of the length of the horizontal well for the well at mid-reservoir height and at reservoir base respectively. Considering the radius of the steam zone (2.5 inches, 6.35 cms) it doesn't reach the total block height during the injection period, the maximum radius obtained at the injection point cover the 65 % of the height when the well is place at mid reservoir height and 70 % when it is at reservoir base. The temperature profile along the horizontal well at different time steps during injection period does not correspond to any definite shape which has been obtained in previous research.[1,2] Any steam zone pattern can be visualized completely considering all of these charts generated from the simulation cases. However the use of discretized wellbore option is the best technique available in the STARS simulator to generate information to study the steam advancement in and around the wellbore.

As mentioned earlier, a hybrid (cylindrical/cartesian) grid was used in the well region. A gradual profile for the steam saturation was expected in the cylindrical region around the wellbore. Instead, very abrupt changes were observed in the saturation profile; therefore, this information could not be used to evaluate the growth of the steam zone. It was thought that increasing the refinement in the cylindrical grid would produce a more gradual saturation profile. However, the saturation profile remained identical after increasing the refinement level.

Based on above results one of the important aspects that need to improve in the discretization technique is the radial flux along the wellbore. The mechanisms involved are hydrodynamically complex. The detailed study of the wellbore behavior implies a challenging problem in predicting the steam zone performance in horizontal wells.

Figs.3.18 through **3.23** show a comparison of the production rates, and injector and producer bottom hole pressures corresponding to the simulations considering horizontal well at mid – reservoir height and at reservoir base. Results indicate the oil and water production in both cases are quite similar; only the cumulative water production for the case of horizontal well at reservoir base appears smaller than for horizontal well at the mid reservoir height.

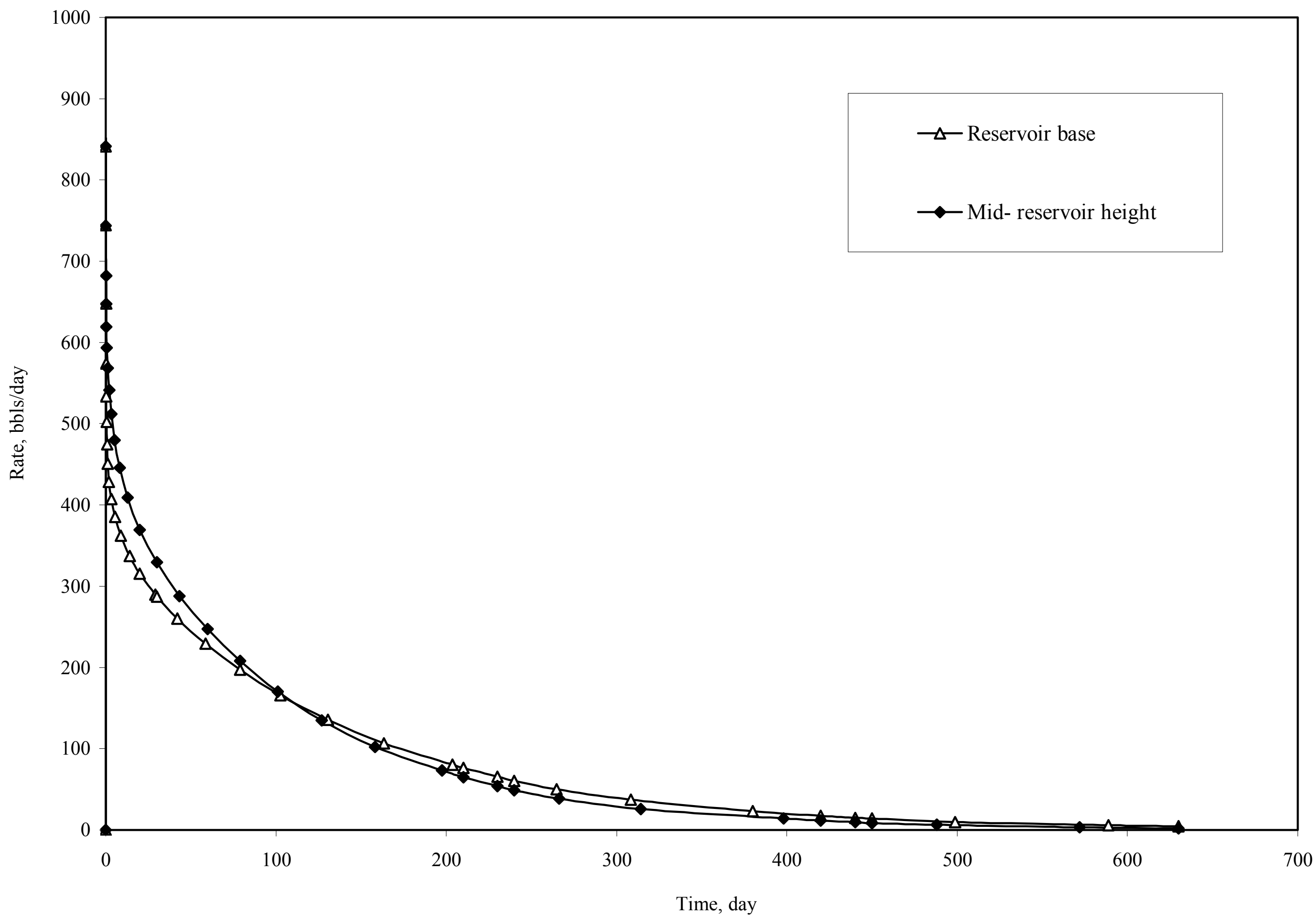

Fig. 3.9 Comparison Cold Production at Mid-Reservoir Height and Reservoir Base

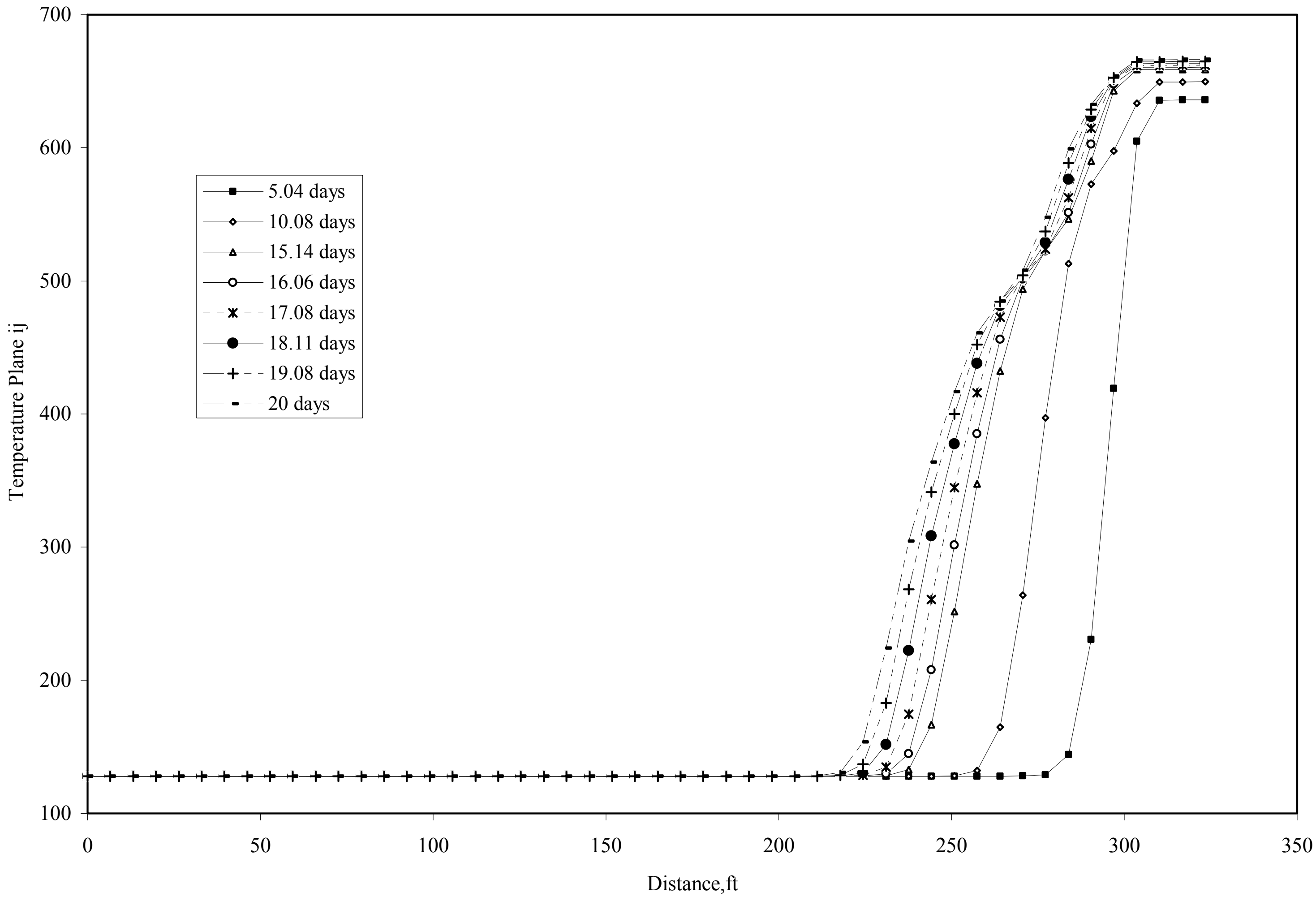

Fig. 3.10 Temperature Profile vs. Distance Plane ij Horizontal Well at Mid-Reservoir Height

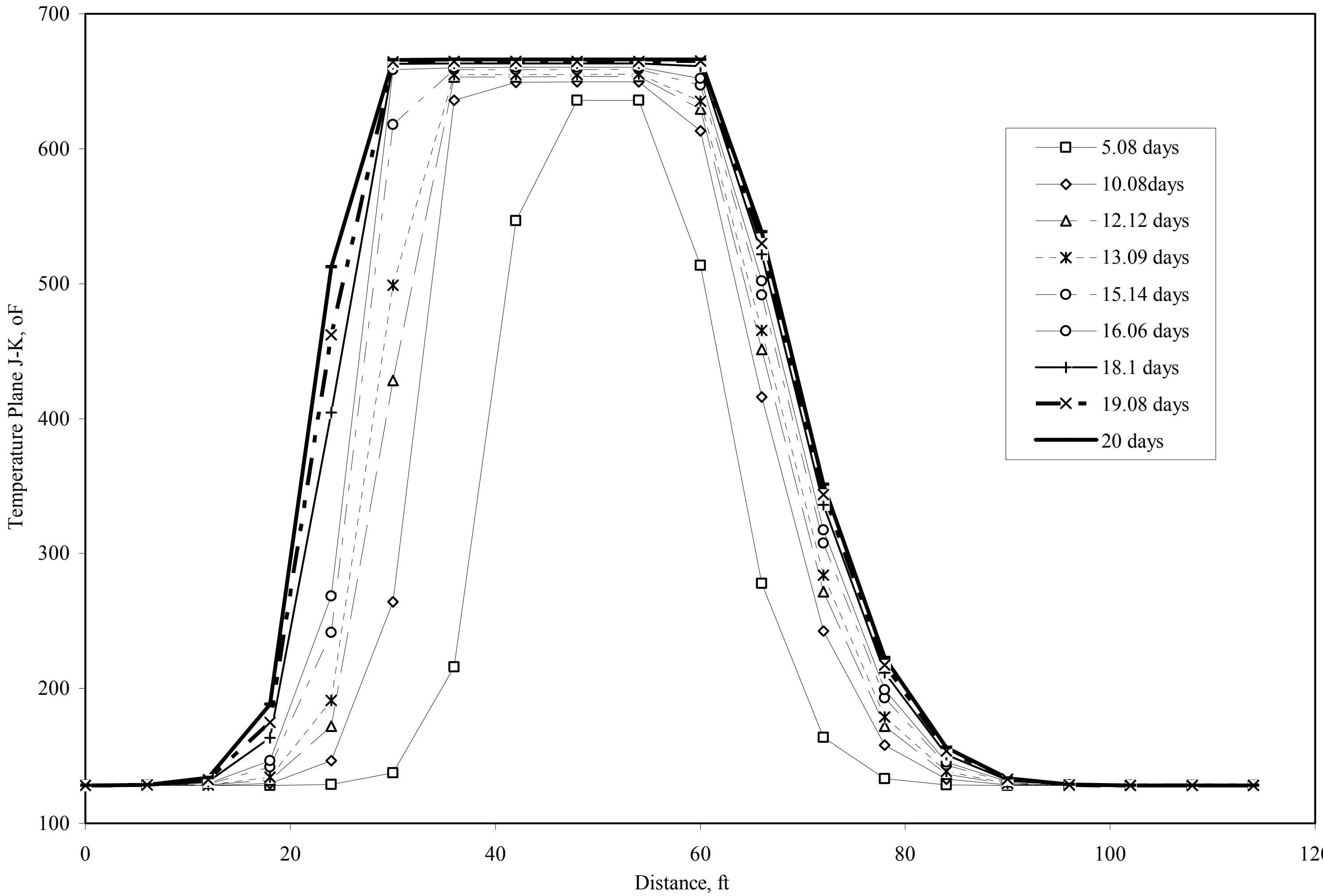

Fig. 3.11 Temperature Profile vs. Distance Plane jk Horizontal Well at Mid-Reservoir Height

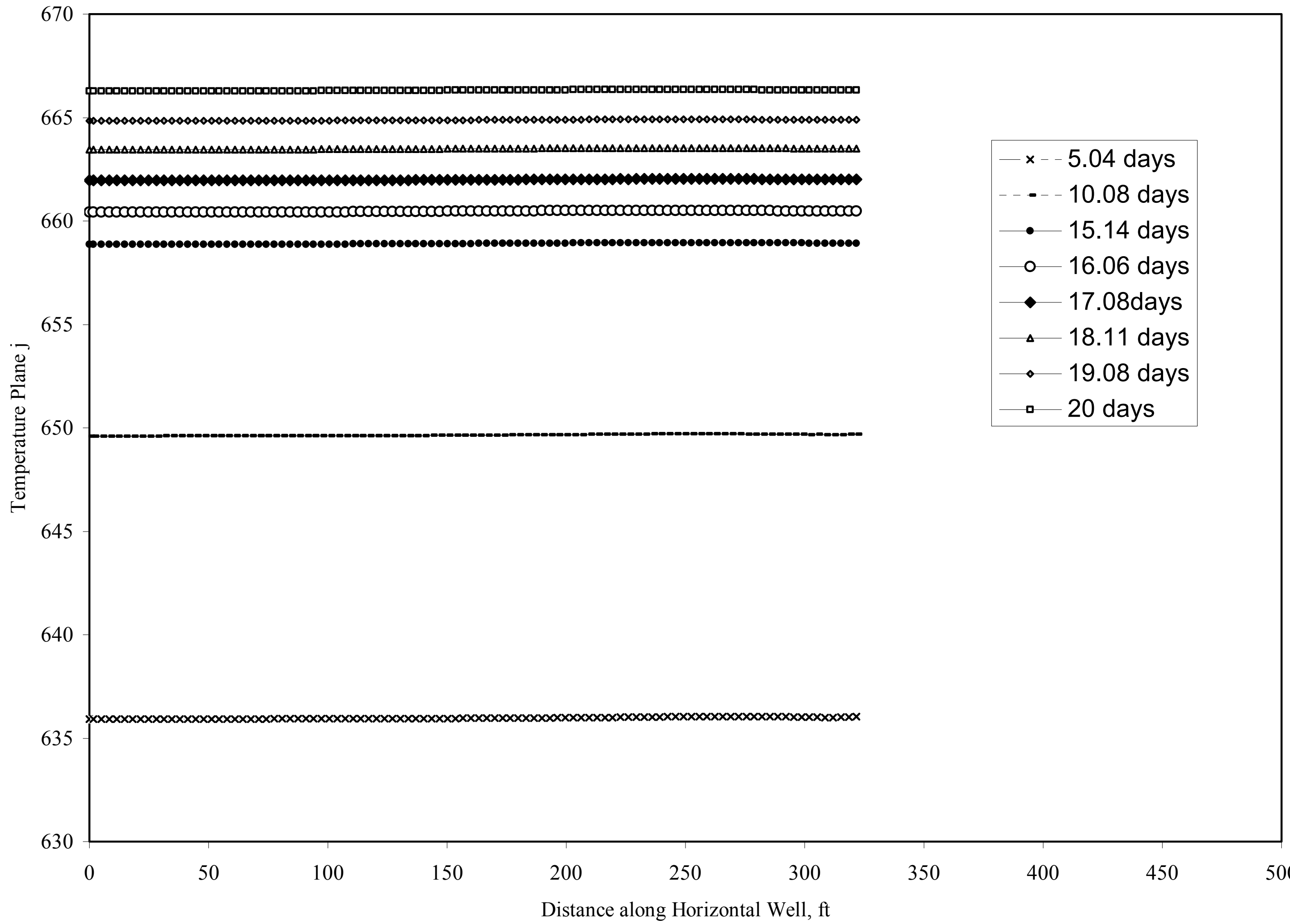

Fig. 3.12 Temperature Profile vs. Distance Plane ik Horizontal Well at Mid-Reservoir Height

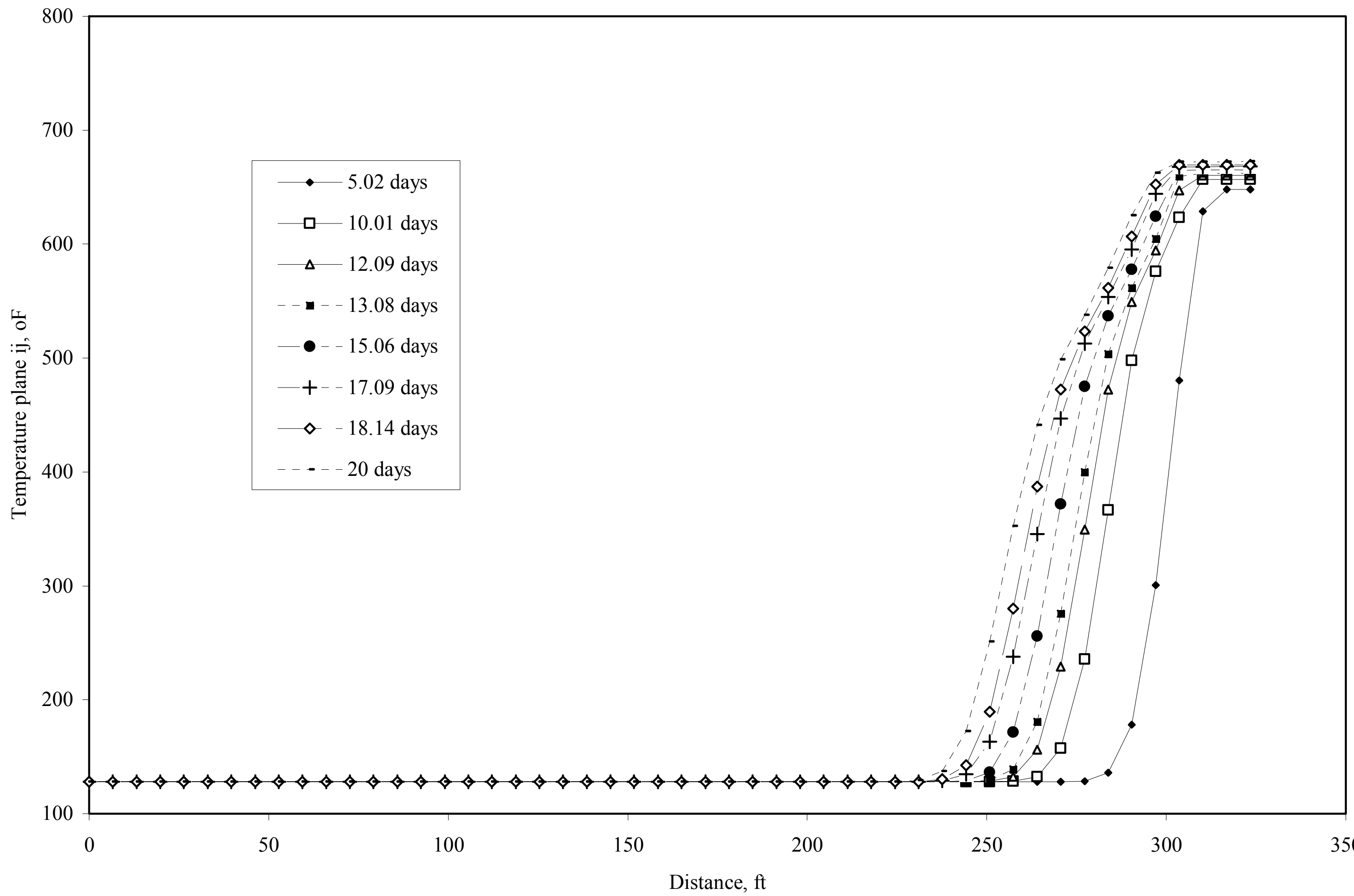

Fig. 3.13 Temperature Profile vs. Distance Plane ij Horizontal Well at Reservoir Base

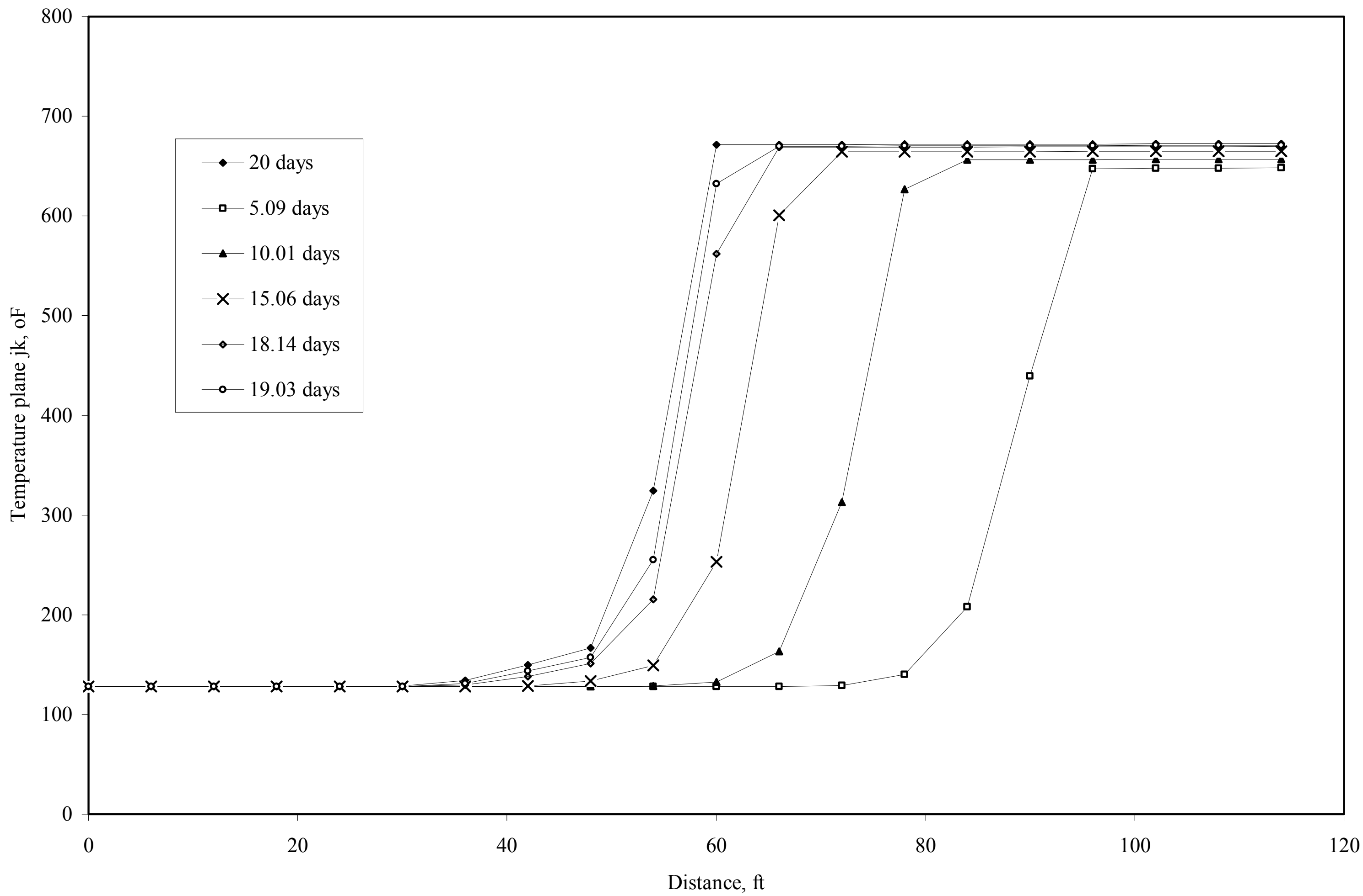

Fig. 3.14 Temperature Profile vs. Distance Plane jk Horizontal Well at Reservoir Base

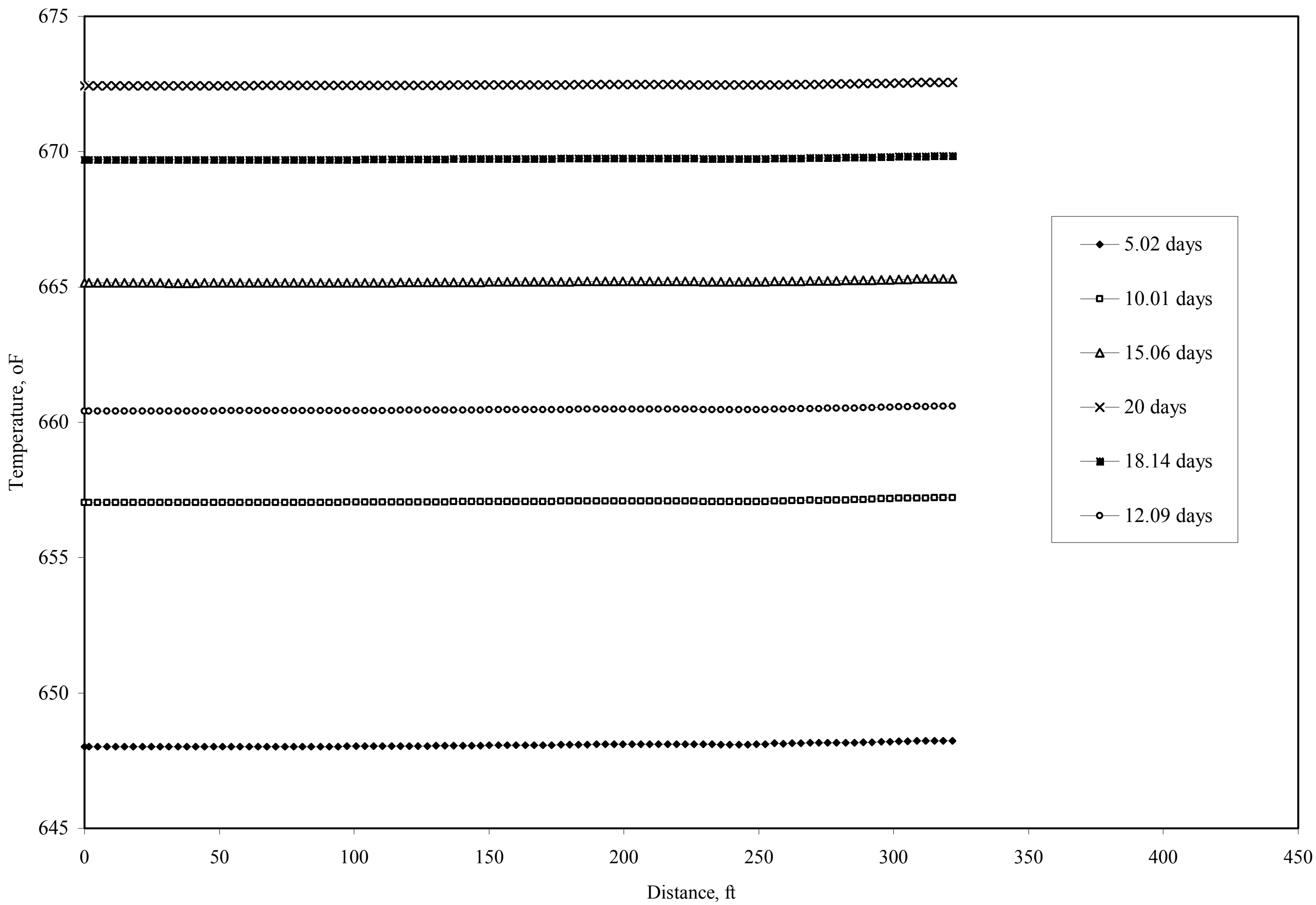

Fig. 3.15 Temperature Profile vs. Distance Plane ik Horizontal Well at Reservoir Base

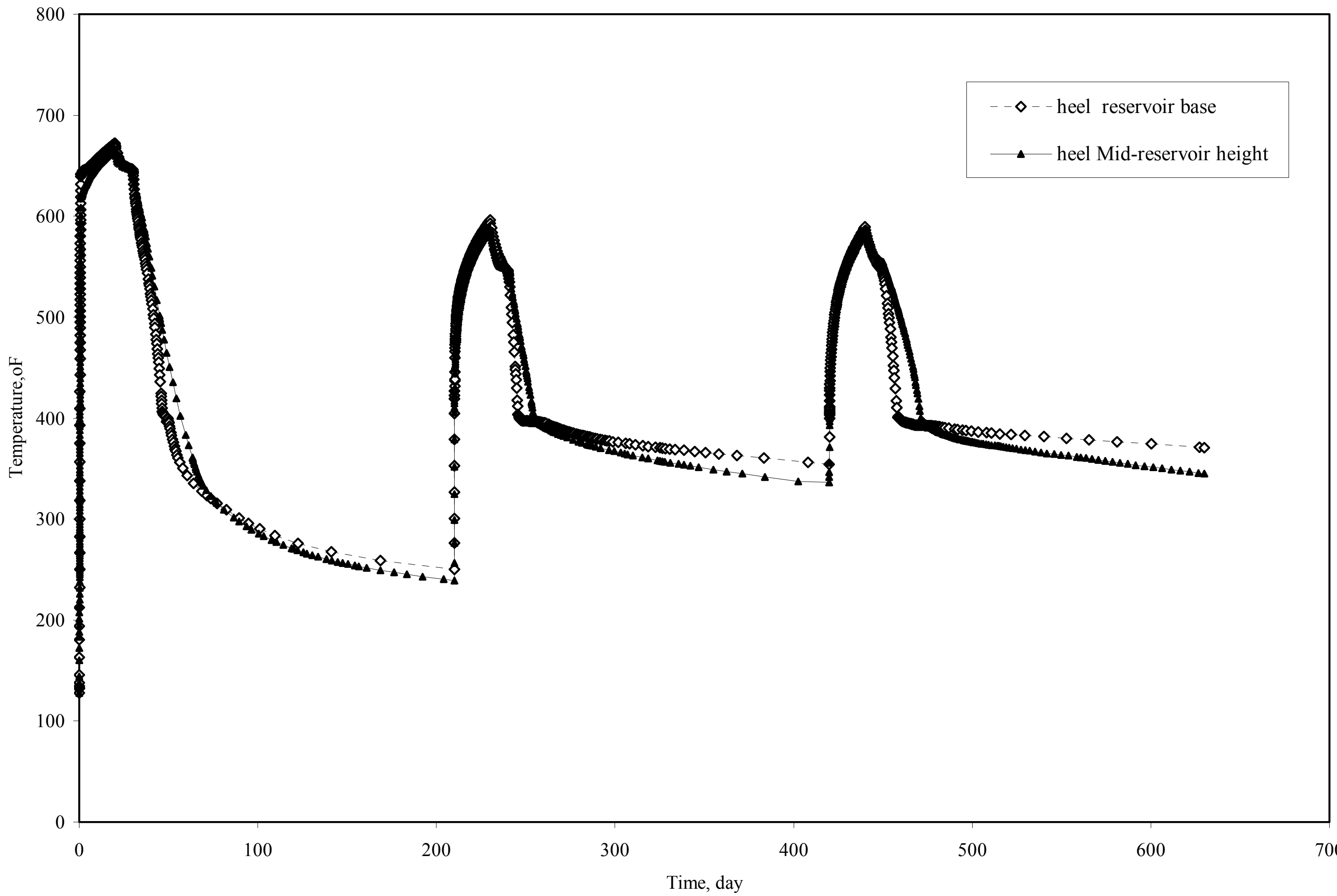

Fig. 3.16 Temperature vs. Time at the Heel, Horizontal Well at Mid-Reservoir Height and at Reservoir Base

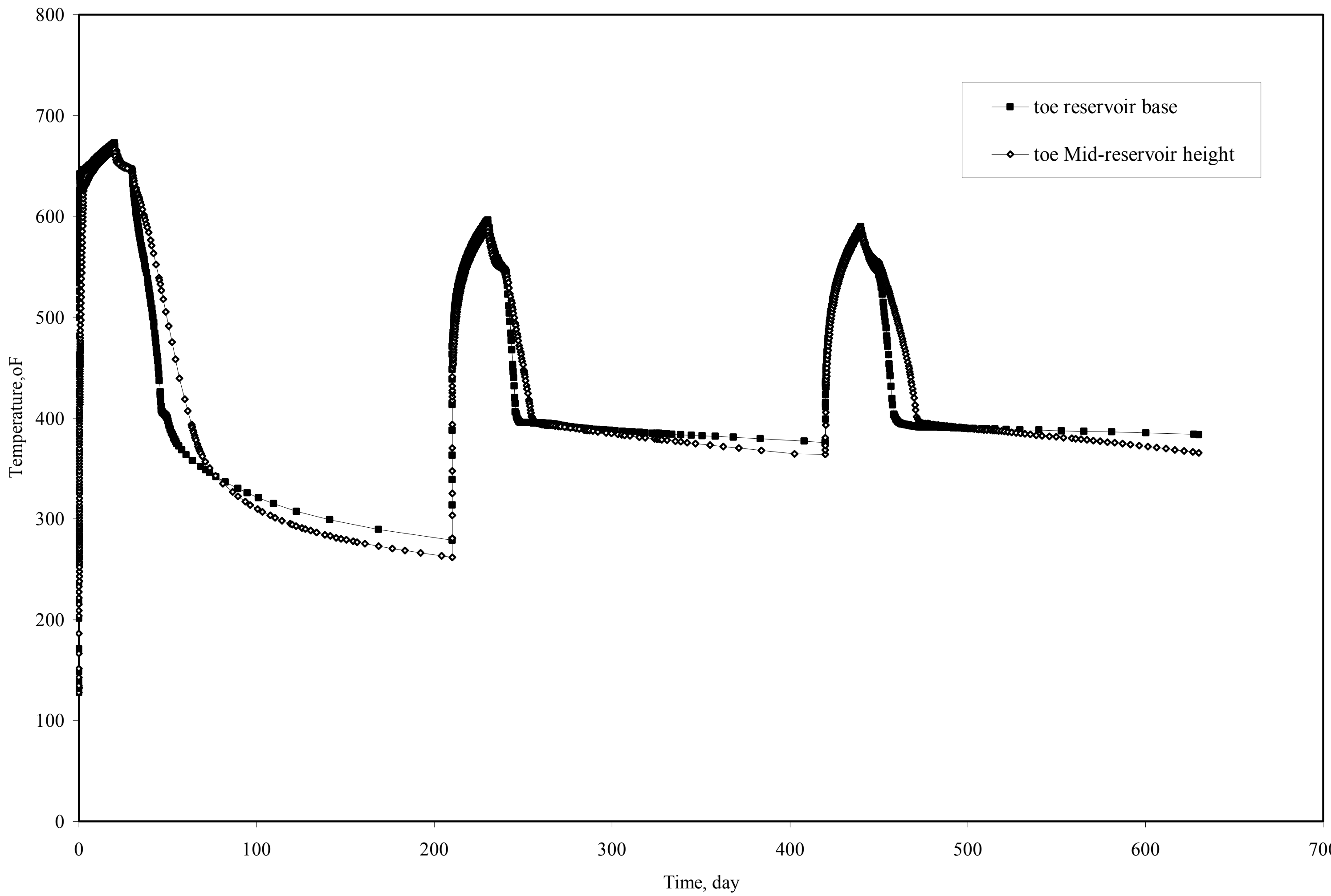

Fig. 3.17 Temperature vs. Time at the Toe, Horizontal Well at Mid-Reservoir Height and at Reservoir Base

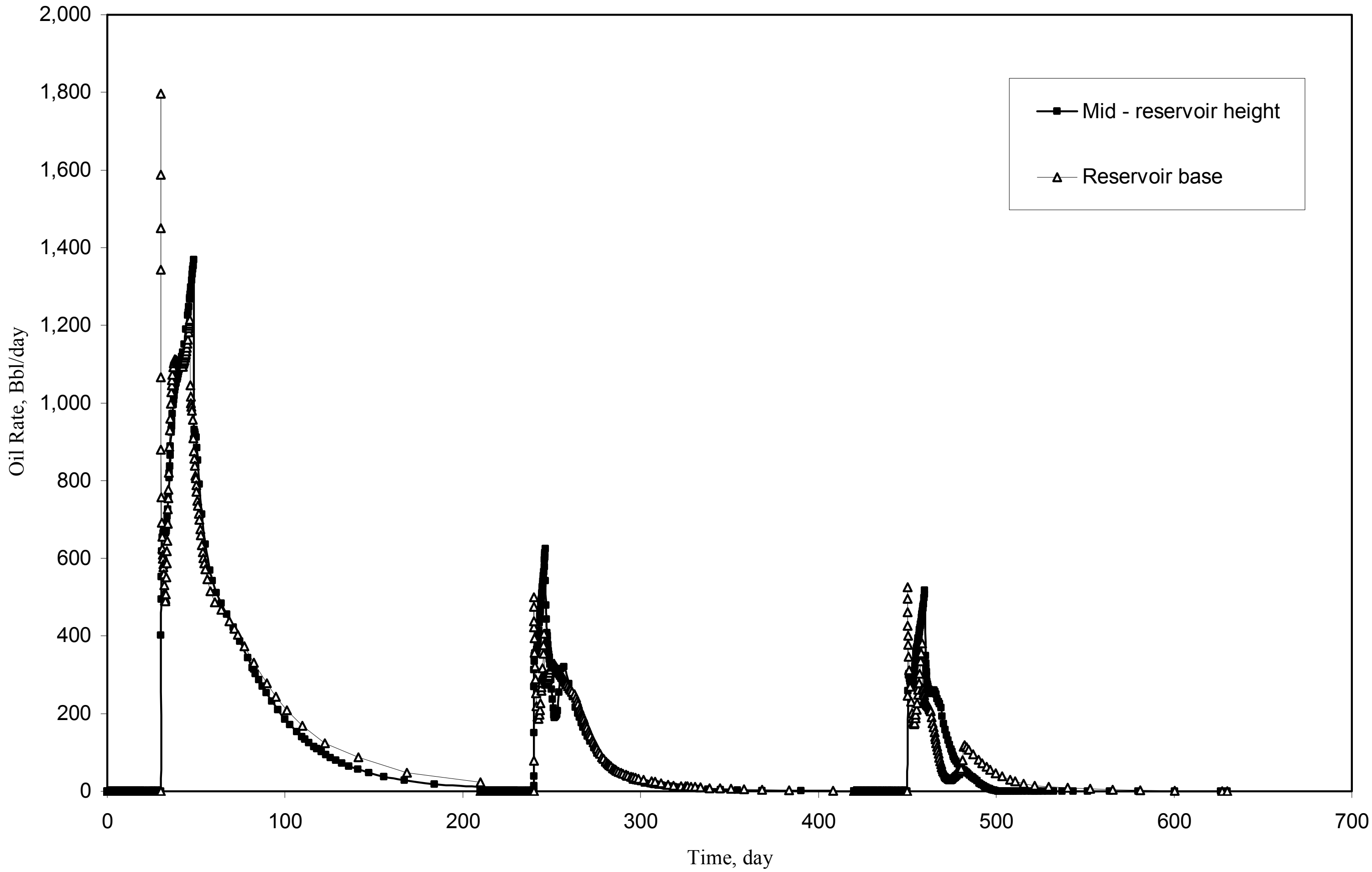

Fig. 3.18 Comparison of Oil Production Rate at Mid-Reservoir Height and Reservoir Base

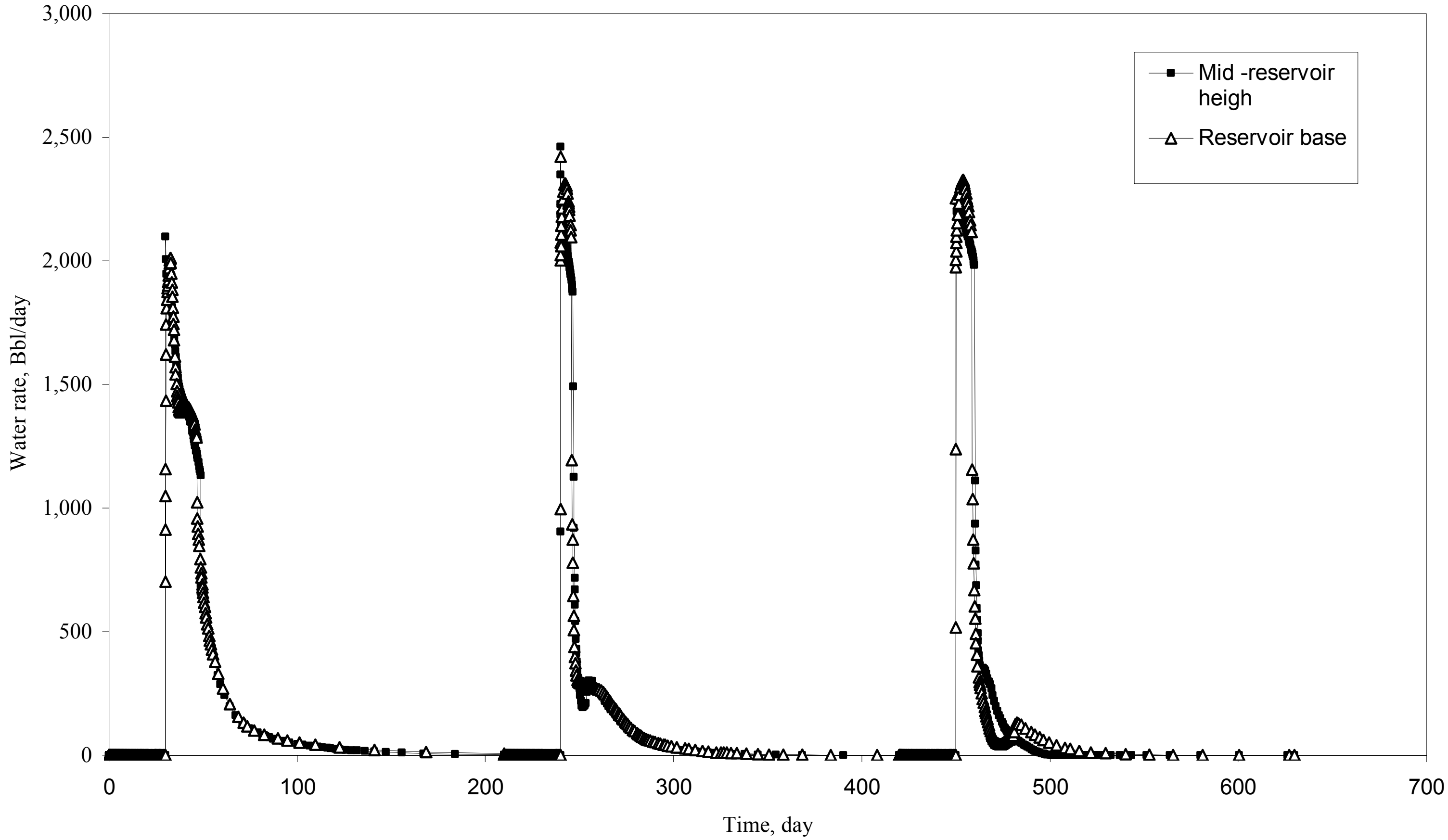

Fig. 3.19 Comparison of Water Production Rate at Mid-Reservoir Height and Reservoir Base

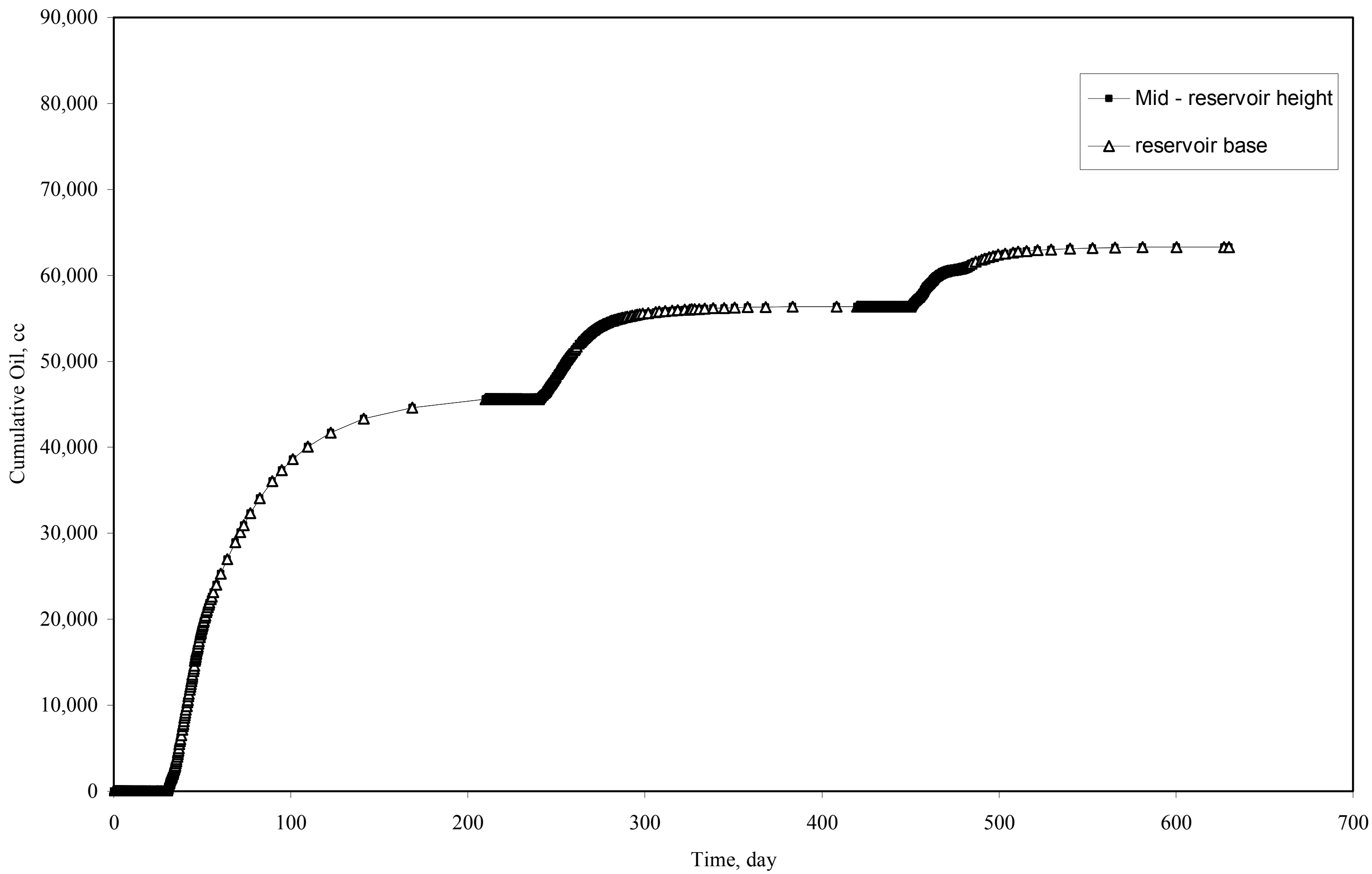

Fig. 3.20 Comparison of Cumulative Oil at Mid-Reservoir Height and Reservoir Base

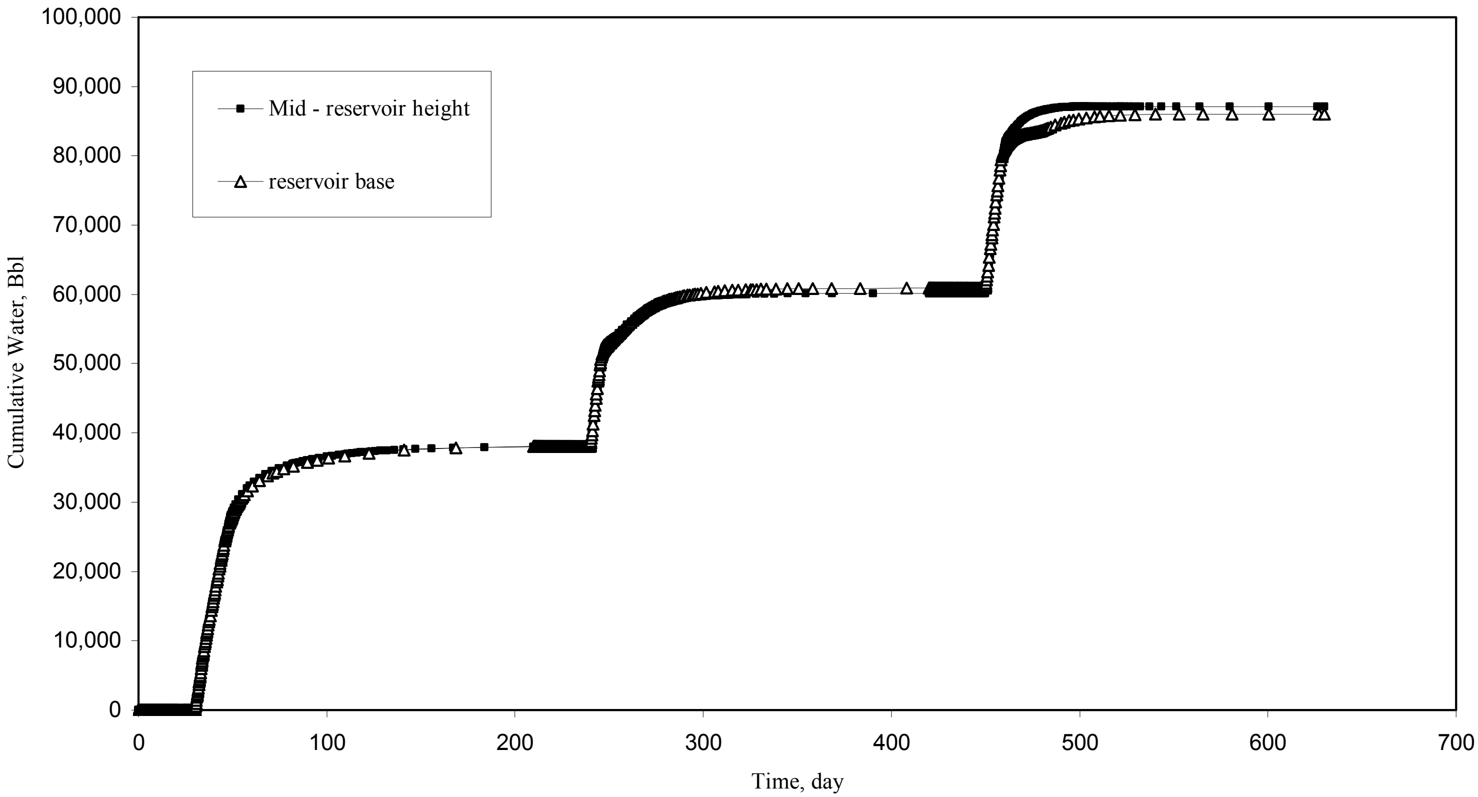

Fig. 3.21 Comparison of Cumulative Water at Mid-Reservoir Height and Reservoir Base

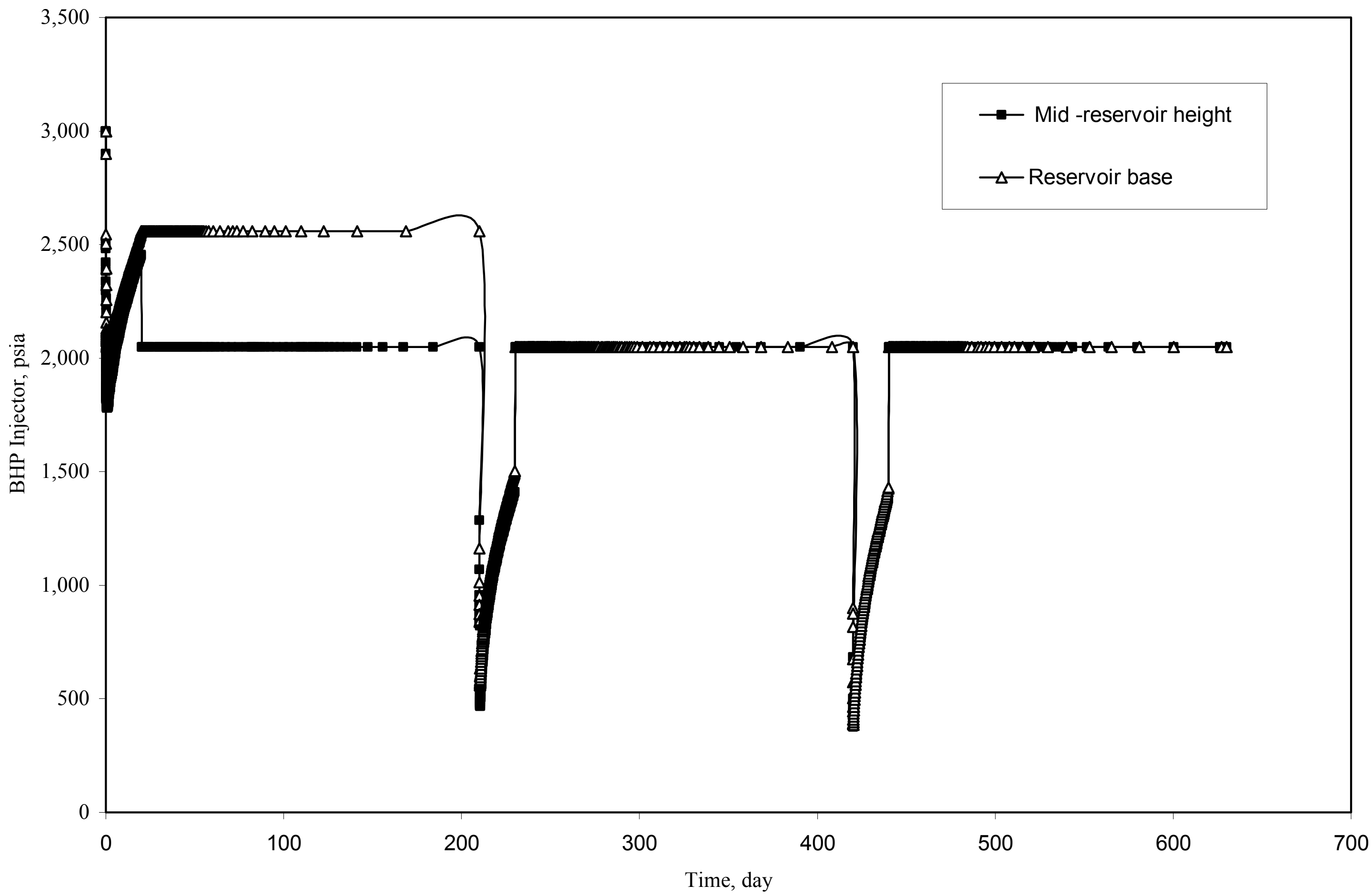

Fig. 3.22 Comparison of BHP Injector at Mid-Reservoir Height and Reservoir Base

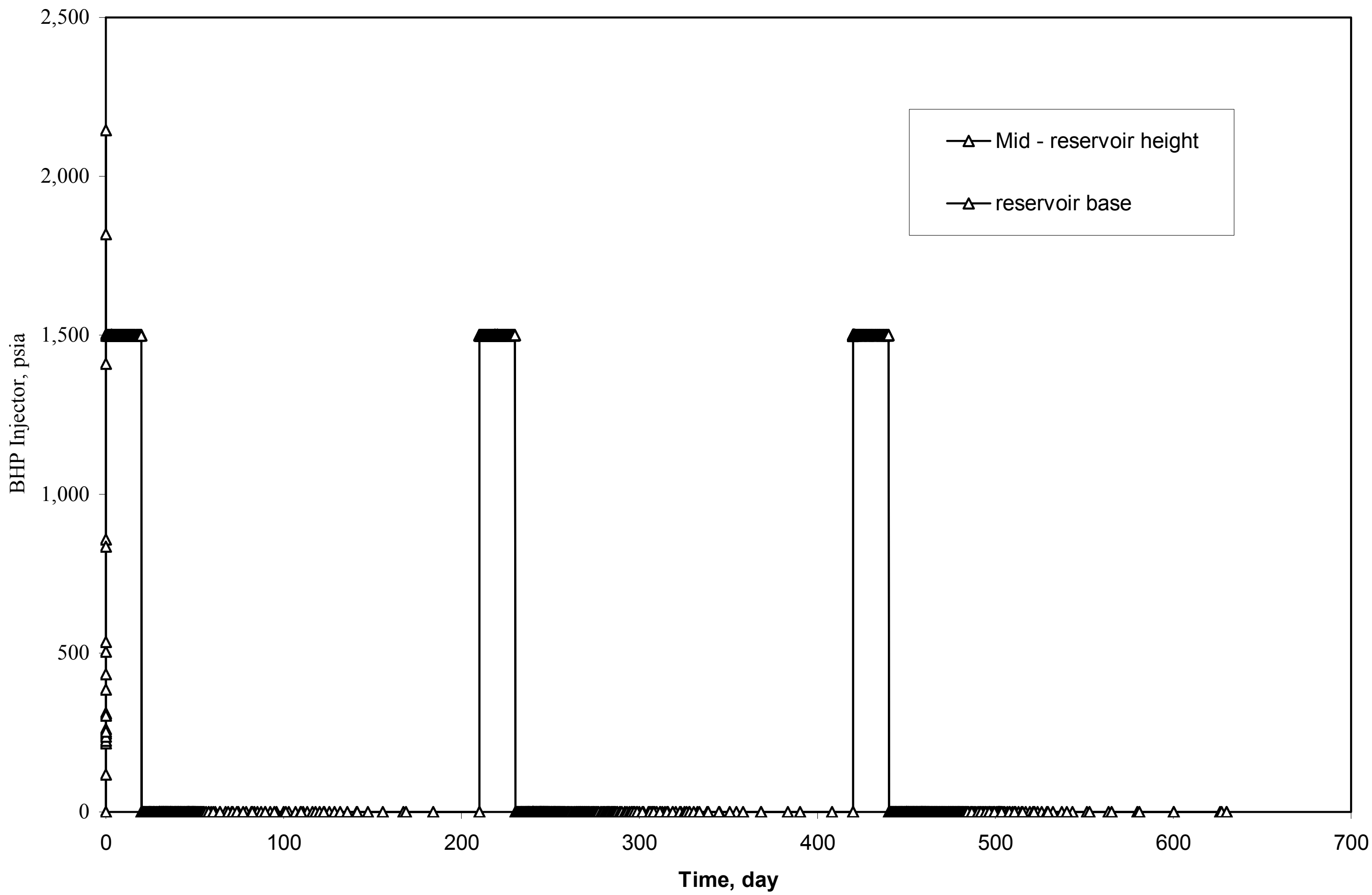

Fig. 3.23 Comparison of Water Injection Rate at Mid-Reservoir Height and Reservoir Base

CHAPTER IV

ANALYTICAL MODEL

4.1 Overview of the Analytical Model

The proposed research is aimed at validating the analytical model of cyclic steam injection using horizontal wells model developed by Bambang Gunadi.[1-2] The analytical model consists of the following two sub-models: sub- model for injection period and sub-model for soaking and production period.

The first sub-model involves the estimation of the length and radius of the steam zone during the injection period. This sub-model follows the Marx and Langenheim model for steam injection. The steam zone is approximated to be cylindrical in shape in every segment of the horizontal length. With increasing injection time the steam zone grows around each segment and displaces more oil around the wellbore. **Fig. 4.1** shows the growth of the steam zone assumes by model. The growth in radius and length of the steam zone is calculated using a material balance, Darcy's law, and heat balance, and are as follows.

For a general case corresponds to segment i at time step j, the material balance equation is expressed by the **Eq. 4.1**:

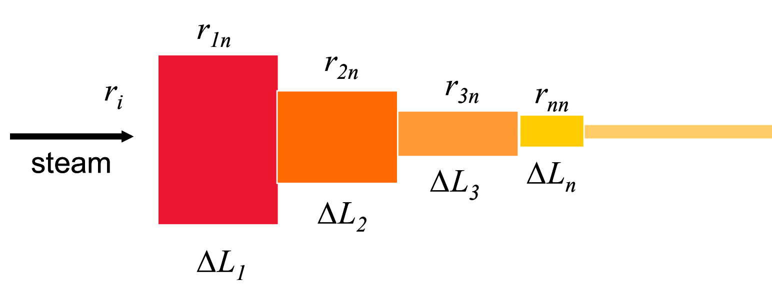

Fig. 4.1 Growth of the Steam Zone Radius and Length

$$\frac{i_w}{\rho_s} = q_{s(1,j)} + q_{s(i,j)} + q_{o(i,j)} + \frac{\pi r_t^2 \Delta L_i}{\Delta t_j}$$

(4.1)

Where i_w is the mass of the steam injected, ρ_s is the density of steam, $q_{s(i,j})$ is the volumetric rate of steam entering the formation, $q_{o(i,j)}$ is the volumetric rate of oil displaced to the formation, r_t is the internal radius of the tubing, ΔL_i is the length of the segment i swept by steam, and Δt_j is the time step j.

Assuming the same pressure gradient and relative permeability, the volumetric rate of oil displaced in the original model is given by:

$$q_{o_{ij}} = q_{s_{ij}} \frac{\mu_s}{\mu_o} \tag{4.2}$$

Also for every segment applying Darcy's law you can use the following relation:

$$q_{s_{ij}} = \frac{\Delta L_j}{\sum_{k=1}^{j} \Delta L_k} q_{s(i-1 j-1)} \tag{4.3}$$

The heat balance 1 during time j can be written as follows

$$I_w H_s \Delta t_j \Delta L_i = q_{s(i-1,j-1)} \rho_s H_s \Delta t_j + \pi r_t^2 \left(\rho_s H_s + C_o \left(T_s - T_r\right)\right) \tag{4.4}$$

where H_s is the steam enthalpy, and C_o is the volumetric heat capacity of oil.These relation establishes that the heat injected equals the amount of heat injected into the reservoir plus the amount of heat required to increase the temperature of oil in the well plus the amount of heat store in the well (steam). Substituting $q_{o_{ij}}$ in **Eq. 4.1** and q_{sij} in the heat balance 1, the growth of length of the steam zone is calculated by

$$\Delta L_i = \frac{I_w H_s \Delta t_2 - q_{s(i-1,j-1)} \rho_s H_s \Delta t_j}{\pi r_t^2 (\rho_s H_s + C_o (T_s - T_r))} \tag{4.5}$$

Also in the heat balance 2 the amount of heat injected into the reservoir equals the amount of heat contained in the steam zone plus the amount of heat lost by conduction. **Fig. 4.2** shows an squematic corresponding to the heat balance 2. That is,

$$q_{sij}\, \rho_s\, H_s\, \Delta t_j = \pi\left(r_{ij}^2 - r_t^2\right) C_{RF} \left(T_s - T_R\right) \Delta L_i + \lambda_{F\,ij} + \lambda_{B\,ij} \tag{4.6}$$

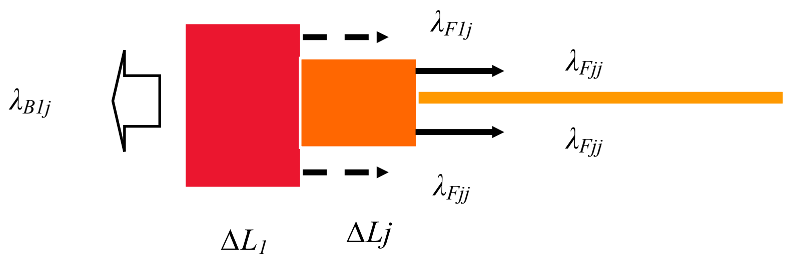

Fig. 4.2 Steam Zone at Time Step j

Where r_{ij} is the steam zone radius for segment i at the end of Δt_j, C_{RF} is the volumetric heat capacity of the reservoir, λ_{Fij} and λ_{Bij} are the conduction heat losses (parallel to the wellbore direction) across the front and back of the steam zone, respectively. Those heat losses are calculated by the **Eq. 4.7** and **Eq. 4.8**.

$$\chi_{Fij} = \frac{2\pi\left(r_{1-1,j}^{\ 2} - r_{ij}^{\ 2}\right)\lambda_R\left(T_s - T_R\right)}{\sqrt{\pi\alpha/\Delta t_j}} \tag{4.7}$$

$$\chi_{B1j} = \frac{2\pi r_{1j}^{\ 2}\lambda_R\left(T_s - T_R\right)}{\sqrt{\pi\alpha/\Delta t_j}} \tag{4.8}$$

From the **Eq. 4.6** the radius of the steam zone is solved from a quadratic equation after substitution of ΔL_i and q_{sij}

$$r_{ij} = \frac{\sqrt{-4de}}{2d} \tag{4.9}$$

where d and e

$$d = \pi\Delta L_i C_{RF}\left(T_s - T_R\right) + \left(\frac{2\pi\lambda_R\left(T_s - T_R\right)\sqrt{\Delta t_j}}{\sqrt{\pi\alpha_R}}\right) \tag{4.10}$$

$$e = -r_t^{\ 2}\pi\Delta L_i C_{RF}\left(T_s - T_R\right) - \left(\frac{2\pi r_t^{\ 2}\lambda_R\left(T_s - T_R\right)}{\sqrt{\pi\alpha_R/\Delta tj}}\right) - q_{sij}\rho_s H_s \Delta t_j \tag{4.11}$$

The second sub-model enables the calculation of the average temperature and fluid production during the soak and production periods. The sub model for soaking periods is based on a Boberg and Lantz method. The method was modified to include the effect of relative permeability in the calculation of oil and water production. The average temperature in the steam zone at the end of the soaking period is given by:

$$T_{av} = T_R + (T_s - T_R)(v_R v_z) \tag{4.12}$$

and the average radius R_{av} is calculated by

$$R_{av} = \frac{\sum_{1}^{n} r_1^{\,2} \Delta L_i}{L_{sz}} \tag{4.13}$$

In the production time, the temperature T_x at distance x ahead of the hot zone-warm zone interface can be shown to be:

$$T_x = (T_{avh} - T_{cz})\left[1 - erf\,\frac{x}{\sqrt{4\alpha t}}\right] + T_{cz} \tag{4.14}$$

The new reservoir pressure resulting from steam injected Pr_1 is based on fluid compressibility as follows

$$P_{r1} = P_r + \Delta P = P_r + \Delta V / VC_t \tag{4.15}$$

Oil and water production rates from the hot zone are given by the following equations:

$$q_{oh} = \frac{kk_{roh} L_{sz} (P_{r1} - P_{wf})}{\mu_{oh} \ln(r_e / r_w)} \tag{4.16}$$

$$q_{wh} = \frac{kk_{rwh} L_{sz} (P_{r1} - P_{wf})}{\mu_{wh} \ln(r_e / r_w)} \tag{4.17}$$

Oil and water production from the warm zone are given by the following equations:

$$q_{owarm} = \frac{kk_{row} (L - L_{sz})(P_{r\,1} - P_{wf})}{\mu_{ow} \ln(r_e / r_w)} \tag{4.18}$$

$$q_{wwarm} = \frac{kk_{rww} (L - L_{sz})(P_{r1} - P_{wf})}{\mu_{ww} Ln(r_e / r_w)} \tag{4.19}$$

The model could not be evaluated in field unit scale due to the structure used in its developmentAll the equations were made to simulate a process in an isolated block which dimensions and vacuum conditions allow to reproduce the field condition. In other way to keep the field condition the model has to be changed dramatically in its dimensions and all properties of this sand pack. However this model can be used for any type of crude oil, scaling all the field conditions to laboratory condition.

4.2 Physical Model Scaling

The physical model was scaled following the Stegeimeier *et al.* method[26] in the same way than Gunadi's research did. The model represents half of five-acre reservoir drainage for a horizontal well. The scaled model consists of a 10-inch long by 10-inch wide by 5-inch high parallelepiped aluminum container, which represents a reservoir volume measuring 330 ft long by 330 ft wide by 120 ft thick (**Fig. 4.3**). The horizontal well is located in one plane of the parallelepiped and consists of a 0.125 inch OD tubing.

Pressure scaling can be calculated using the following relationship.

$$P_M - P_{pM} = (P_R - P_{pR})/(L_R/L_M) \tag{4.20}$$

where the subscripts M and R represent the model and the reservoir, P_M is pressure in the model, P_R is pressure in the reservoir, P_{pM} is flowing pressure in the model, P_{PR} is flowing pressure in the reservoir. L_R and L_M are the reservoir and model lengths, so that L_R/L_M equals 396. Using initial pressure $P_{M\,i}$ of 5 psia in the model to

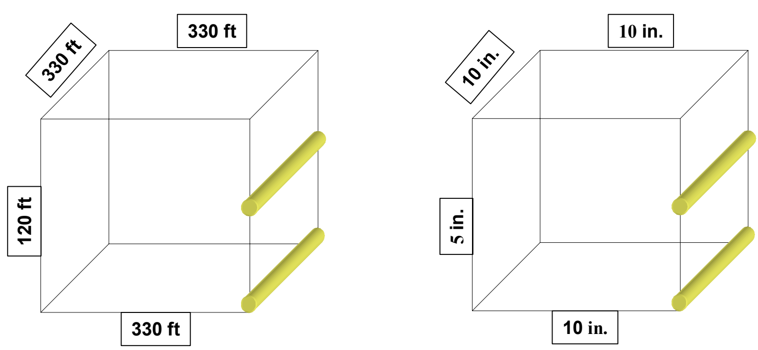

Fig. 4.3 Model Scaling

represent an initial pressure P_{Ri} of 1319 psia in the reservoir, we obtain from **Eq. 4.14** the following

$$P_M = 0.00253 P_R + 1.66919 \tag{4.21}$$

Temperature scaling is based on the ratio of saturated steam temperature in the reservoir and in the model. The calculation involves finding the ratio of temperature difference in the reservoir to the corresponding difference in the model, X, given by:

$$X = \frac{(T_R - T_{Ri})}{(T_M - T_{Mi})} \tag{4.22}$$

where T_R is the steam temperature in the reservoir, T_{Ri} is the initial temperature reservoir, T_M is the steam temperature in the model, and T_{Mi} is the initial model temperature. By substituting values of X, T_{Ri}, T_{Mi} into **Eq. 4.22** we obtain the relation ship between temperature in the model and temperature in the reservoir. The temperature scaling relationship is given by

$$T_M = (1/X)T_R + (T_{Mi} - (1/X)T_{Ri}) \tag{4.23}$$

The initial reservoir temperature considered was 128 ^oF and the initial model temperature 63 ^oF. Substituting these values in **Eq. 4.23** gives:

$$T_M = 0.25428 T_R + 30.4525 \tag{4.24}$$

The required steam quality in the model is calculated using **Eq.4.25**

$$f_{sM} = \left(\frac{Cw\Delta T}{Lv}\right)_M \left\{\left(\frac{fsLv}{Cw\Delta T} + 1\right)_R \left[\left(\frac{\phi_R \Delta S_R}{\phi_M \Delta S_M}\right)\left(\frac{\rho_R C_R}{\rho_M C_M}\right)\left(\frac{\rho_{CM} C_{CM}}{\rho_{CR} C_{CR}}\right)\right] - 1\right\} \tag{4.25}$$

where $Cw\Delta T$ is the difference between water enthalpies at steam temperature, and at initial temperature corresponding (130.13– 33.09) Btu/Lbm in the model and (588.9 - 91.68) Btu/Lbm in the reservoir, φ is the porosity 33.5 % in the model and also in the reservoir, ρC is the volumetric heat capacity, and $\rho_C C_C$ is the volumetric heat capacity of the rock. At initial reservoir pressure of 1319 psia, and initial model pressure 5 psia, the saturated steam temperatures are 580 ^oF in the reservoir and 162.21 ^oF in the model. Using these values and considering steam quality in the reservoir 80%, ΔS_R=0.6,

ΔS_M=0.115, $\left(\frac{\rho_R C_R}{\rho_M C_M}\right)=1$ and $\left(\frac{\rho_{CM} C_{CM}}{\rho_{CR} C_{CR}}\right)=1$, then the steam quality in the model is given by

$$f_{sM}=\left(\frac{130.117-33.09}{1000.9}\right)_M\left\{\left(\frac{(0.8)(588.1)}{588.9-91.68}+1\right)_R\left[\left(\frac{(0.335)(0.70)_R}{(0.335)(0.115)_M}\right)(1)(1)\right]-1\right\}=0.80$$

The time scale ratio is calculated according to the following expression

$$\frac{t_M}{t_R}=\left(\frac{K_{hR}}{K_{hM}}\right)\left(\frac{\rho_{CM} C_{CM}}{\rho_{CR} C_{CR}}\right)\left(\frac{L_M}{L_R}\right)^2$$

(4.26)

where K_h is the heat conductivity cap rock. Using in the reservoir K_{hR}= 1.36 and in the model K_{hM}=0.388 Btu/hr ft ^oF, the time scaling relation is calculated by

$$\frac{t_M}{t_R}=\left(\frac{1.36}{0.3888}\right)(1)\left(\frac{1}{396}\right)^2\frac{\min}{yr}$$

$\frac{t_M}{t_R}=11.7536\frac{\min}{yr}$, that means that one minute in the model represents 31 days in the reservoir.

Injection and production rate are scaled using the same relation, where the volumetric rates are at standard conditions. In assigning values on a per well basis, the use of half a well in the model was taken account. The **Eq. 4.27** shows the relationship used

$$\frac{q_M}{q_R}=\left(\frac{\rho_{oM}}{\rho_{oR}}\right)\left(\frac{L_M}{L_R}\right)^3\left(\frac{\phi_M \Delta S_M}{\phi_R \Delta S_R}\right)\left(\frac{t_R}{t_M}\right) \quad (4.27)$$

where ρ_o is the oil density. Using ρ_{oM}= ρ_{oR} and time scale equation

$$\frac{q_M}{q_R}=(1)\left(\frac{1}{396}\right)^3\left(\frac{(0.335)(0.115)}{(0.335)(0.6)}\right)\left(\frac{1}{11.7536}\right)(525{,}960)(110.4)\frac{\text{cc/min}}{\text{bbl/D}}$$

$\frac{q_M}{q_R} = 0.015 \frac{\text{cc/min}}{\text{bbl/D}}$, which means that one cc/min in the model represents 65.6 bbl/D in the reservoir.

4.3 Verification of the Model Considering Bachaquero- 01 Data

Two analytical models were evaluated in this research using different fluid properties, sand pack properties and cyclic operating conditions. Based on the original Gunadi's models developed in Visual Basic 6 the evaluation was done. A new version of for Visual Basic 6 for Visual Studio program was used.

In both models the subroutine used to generate the oil properties were changed for Bachaquero 01 crude oil data. In future any crude oil can be evaluated knowing its corresponding viscosity table. A minimum of two points is required because linear interpolation is used to calculate the viscosity at the average temperature during the injection, soaking and production time.

The Honarpour relative permeability correlations were kept, adjusting the end points used in Bachaquero field. Basically the sub model for injection period was not modified. In the main subroutine "steamzone" which involves the calculation of the length and radius of the steam zone, only the effect of the oil and steam relative permeability's was included into the length equation at time step 1. Original model assumed according Darcy's law that the volumetric rate of oil displaced is equal to the volumetric rate of steam multiplied by the viscosity ratio of steam and oil, considering the same pressure gradients and relative permeability's for oil and steam. This approach tested not to be adequate when the viscosity relation between steam and oil are smaller at steam temperature. The new ΔL_1 equation is given by

$$\Delta L_1 = \frac{I_w H_s \Delta t_1 - \dfrac{I_w H_s \Delta t_1}{1 + \dfrac{\mu_s}{\mu_o}\dfrac{K_{ro}}{K_{rs}}}}{\pi r_1^2 \left\{ \rho_s H_s + C_o (T_s - T_R) - \dfrac{\rho_s H_s}{1 + \dfrac{\mu_s}{\mu_o}\dfrac{K_{ro}}{K_{rs}}} \right\}} \tag{4.28}$$

This modification has impact in the average radius equation calculated in the soaking period module. The sub-models for soaking and production periods which follow Boberg and Lantz method were adjusted trying to be close from the numerical simulation assumption. The main changes basically involved the following aspects:

The modification of the total fluid compressibility equation which has a huge impact in the equation for the new reservoir pressure resulting from steam injected. Actually the total compressibility considers all the fluids involved. It was assumed the same compressibility for oil and water and the compressibility of the steam as 1/PR in the original model. This change improves the pressure estimates by time step per cycle and therefore the oil and water production rates values.

$$C_T = S_{wi} * C_w + S_{oi} * C_o + S_{gi} * C_g \tag{4.29}$$

The revision of well index corresponding to cold production (cold index), which was really sub-estimated using the original approach. The initial equation considered the total length of the steam zone. For the cases whose has small steam zone length this equation generated low values which affect the oil production rates. The cold production index was adjusted according simulation results based on Economides - Joshi equation.

The adjustment in the oil and water production rate equations realized due to the low values generated in special for the water production rate. In the hot oil rate equation (q_{oh}+q_{oc}) was introduced the effect of the relative permeability of the oil and in the cold oil rate the viscosity variation and also the fraction of the steam zone corresponding to this values. In the water rate (q_w) was incorporated the mobility relation and also the fraction of the steam zone affected for this expressions. All of these revisions tried to reduce the impact generated from the assumptions considered in Boberg and Lanz method.

$$q_{oh} = \frac{J_{hz} J_{CSZ} K_{ro} (P_R - P_{Wf})}{14.7} \tag{4.30}$$

Where:

$$J_{hz} = \frac{1}{\left(\frac{\mu_{oh}}{\mu_{oc}}\right) C_1 + C_2}$$, according to Boberg and Lanz

J_{csz} is estimated using Joshi and Economides production index[27].

$$J_{CSZ} = \frac{K_h h}{141.2 B\mu \left[Ln\left(\left(a_e + \sqrt{a_e^{\,2} - (L/2)^2} \right) \Big/ (L/2) \right) + ((\beta h/L) Ln((\beta h / r_w(\beta + 1)))) \right]}$$

where K_h is the horizontal permeability, h is the reservoir thickness, B is the formation volume factor, μ is the viscosity, L is the length of well horizontal section, r_w is the wellbore radius, β is the index of horizontal to vertical permeability anisotropy defined as $\beta = \sqrt{K_h / K_v}$ and a_e is the large half-axis of the drainage ellipse formed by a horizontal well equals $a = (L/2)\sqrt{0.5 + \left[0.25 + (r_{eh}/(L/2))^4\right]^{0.5}}$, where r_{eh} si the drainage radius of the horizontal wellbore.

$$q_{oc} = J_{CSZ} \left(\frac{L - L_{TOTAL}}{L_{TOTAL}} \right) \left(\frac{\mu_{oc}}{\mu_{ow}} \right) \left(\frac{(P_R - P_{Wf})}{14.7} \right) \tag{4.31}$$

$$q_w = 0.5 J_{CW} \left(\frac{L_{TOT}}{L} \right) \left(\frac{(P_R - P_{Wf})}{14.7} \right) \tag{4.32}$$

where $J_{CW} = J_{CSZ} \left(\frac{K_{rwM}}{K_{roM}} \right) \left(\frac{\mu_{oc}}{\mu_w} \right)$

4.4 Length and Radius of the Steam Zone

Figs. 4.4 and **4.5** show the results for the steam zone radius in terms of the length of the steam zone. Maximum radius of the steam zone for the case at mid reservoir height never reaches the top of the scaled model (2.5 inches/6.35 cm). The predicted value represents the 65 % of the total available radius. In the case of the well at reservoir base this values was 98 % of the half of the model height. The calculated results agree with the Bambang's research for the well at middle of the wellbore but different performance was obtained for the reservoir base.

The main difference was found in the model results for the length of the steam zone in both cases. The calculated values in all cycles in both study cases are not really significant. For the well at mid reservoir height the length of the steam zone represents the 3 % of the total horizontal length and for the reservoir at the base the 1%. The performance is quite different from that obtained using Duri oil (22 ^{o}API).

According these results the length of the steam zone is really affected by the quality of the oil and the injection operational parameters. In this study the average temperature ranges calculated are nearer to the steam injection temperature and higher from Gunadi results. This situation allows estimating a higher steam zone radius but lower lengths. **Fig. 4.8** shows the general flow diagram used in this research.

Sensitivity analysis considering the same Gunadi's operational conditions improved the length of the steam to 12 % of the total horizontal length but never the results reached the 40 % of the total horizontal length with Bachaquero-01 fluid properties. This means that the oil viscosity is an important factor in the reduction of the length of the steam.

Fig. 4.6 shows the average temperature profile corresponding to both evaluated cases. The temperatures values at Mid-Reservoir Base always were smaller than at Reservoir Base which is expected because the heat losses are higher when the well is placed at Mid-Reservoir Height (half a well) in comparisson when the well is at Reservoir Base (a quarter of well). **Fig. 4.7** shows the same performance for pressure.

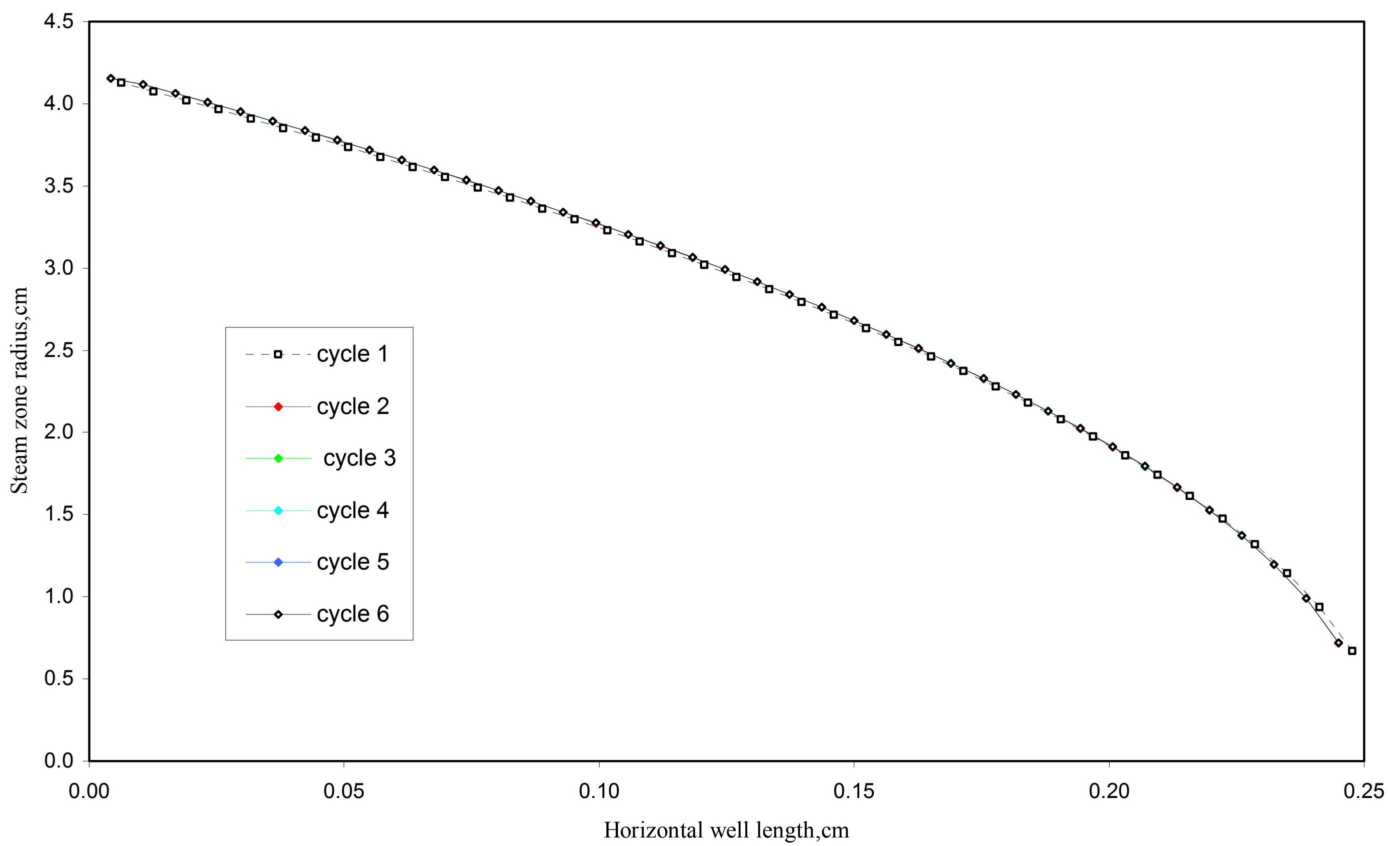

Fig. 4.4 Model Steam Zone Profile Horizontal Well at Mid-Reservoir Height

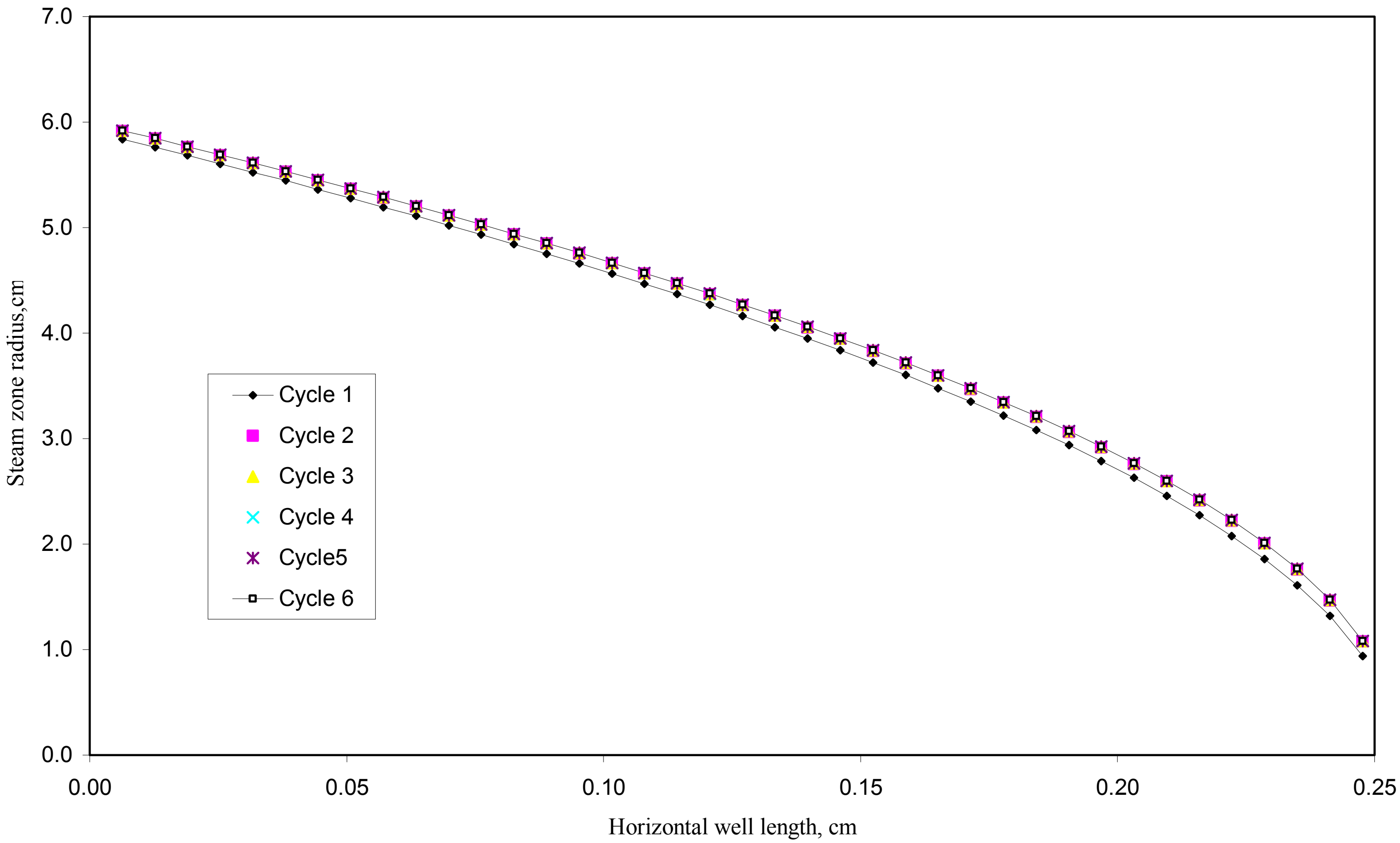

Fig. 4.5 Model Steam Zone Profile Horizontal Well at Reservoir Base

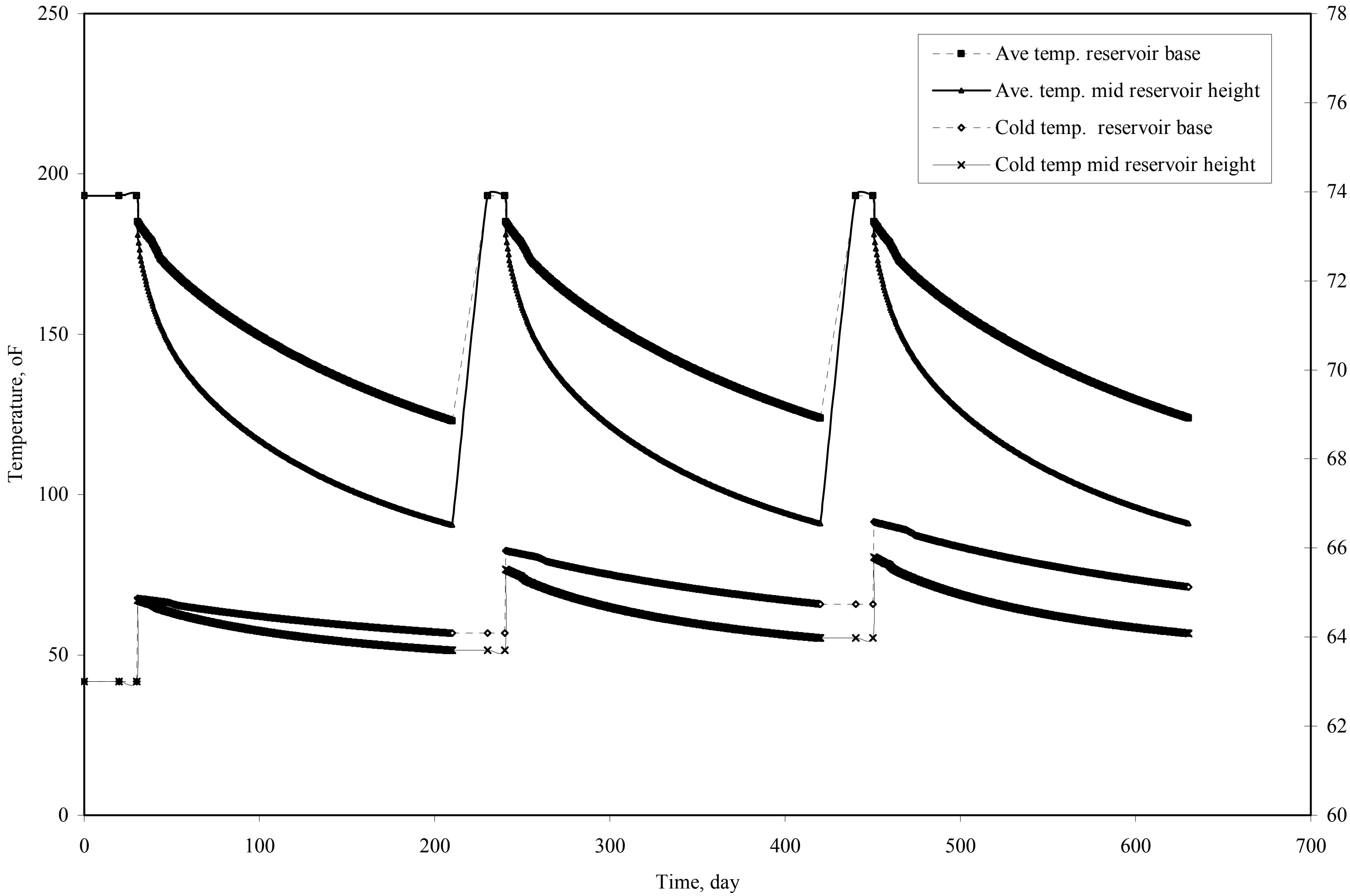

Fig. 4.6 Model Average Temperatures Horizontal Well at Mid-Reservoir Height and at Reservoir Base

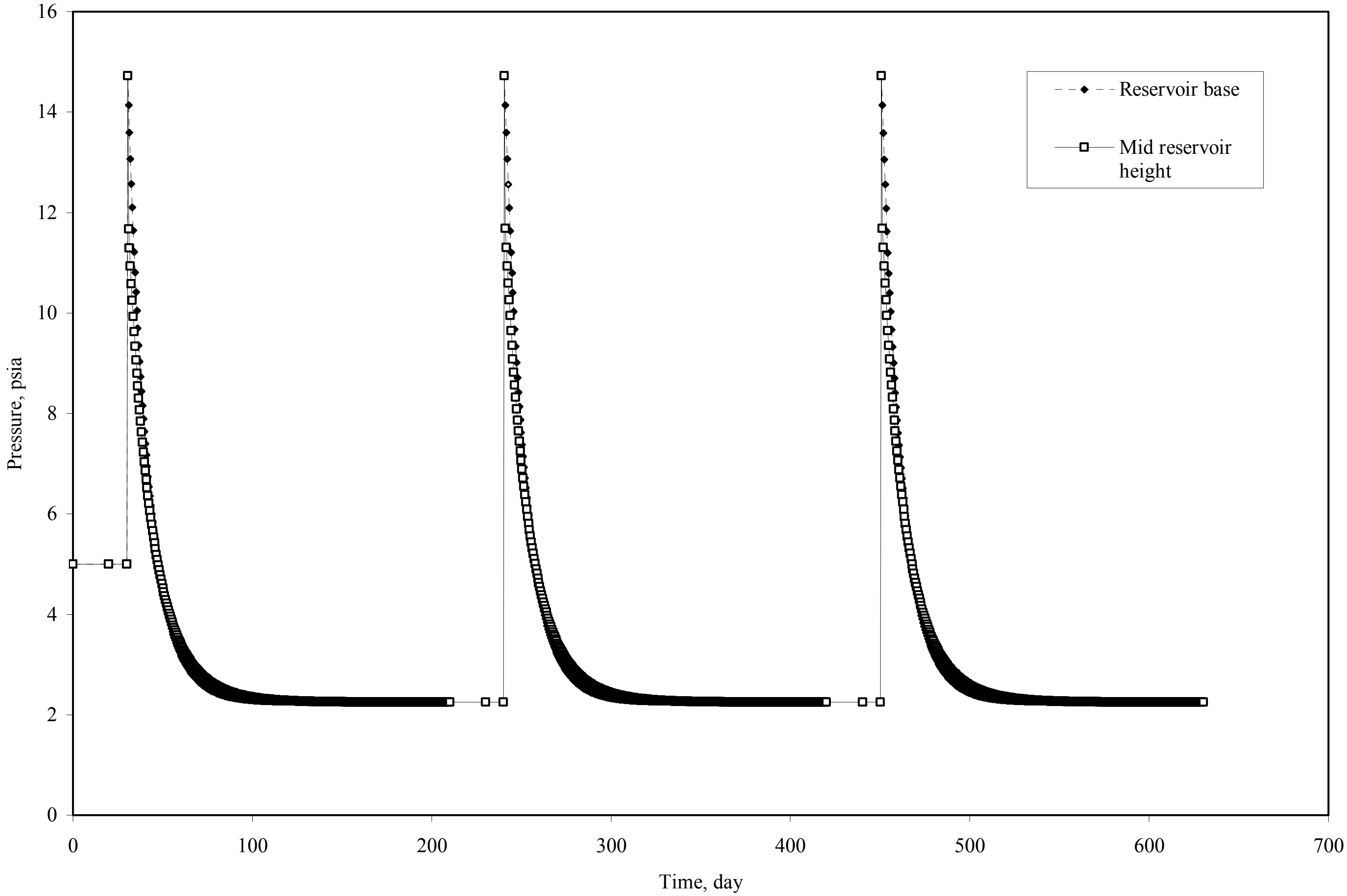

Fig. 4.7 Model Average Pressure Horizontal Well at Mid-Reservoir Height and at Reservoir Base

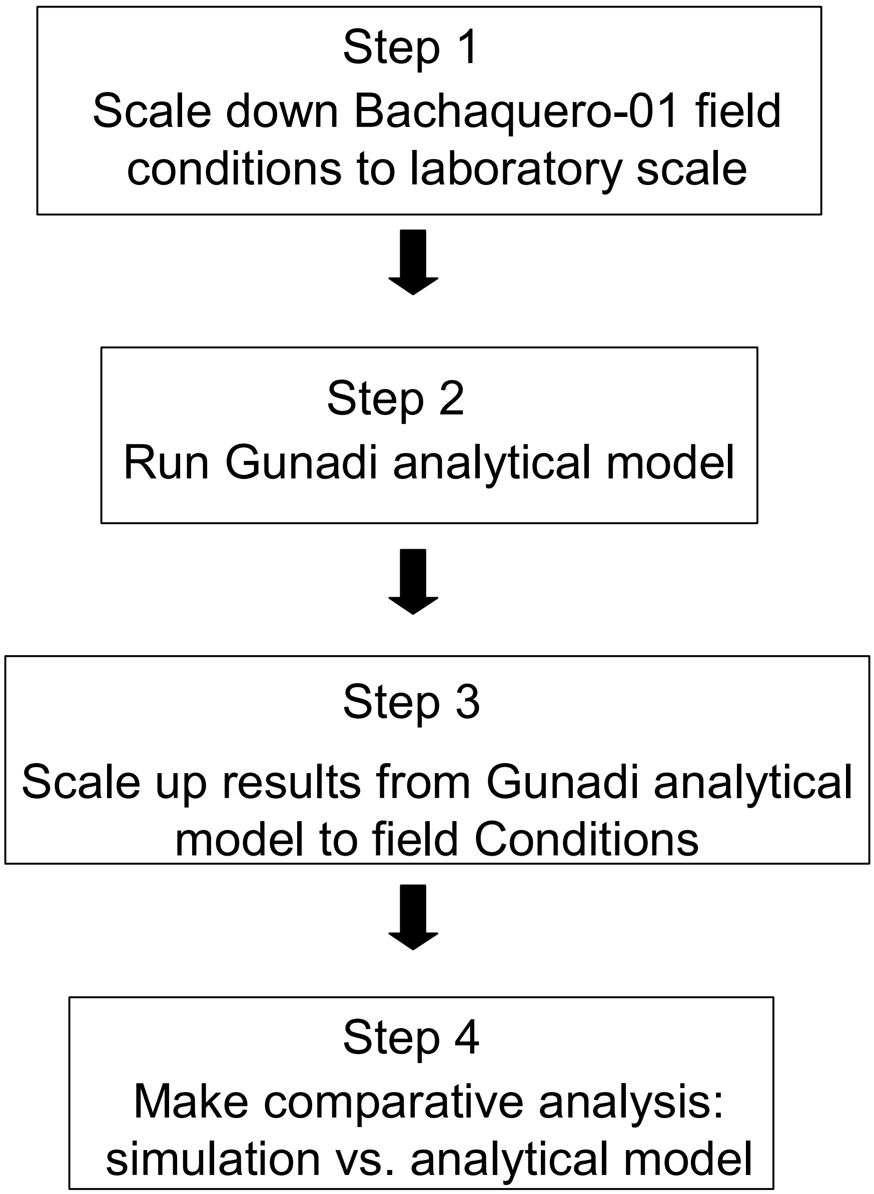

Fig. 4.8 Applied Flow Diagram in the Evaluation Process

CHAPTER V
COMPARATIVE ANALYSIS OF SIMULATION AND ANALYTICAL MODEL

As described in Chapter III, during this research a thermal numerical simulation of the discretized well using Bachaquero-01 data was conducted for two cases: reservoir at mid reservoir height and at reservoir base. The steam zone advancement in and around the wellbore was studied together in both cases. Also the oil recovery was evaluated for each case. Additionally, the field Bachaquero-01 operational conditions were scaled to laboratory conditions and the Gunadi's models for horizontal well were tested for different fluid properties and conditions. Some modifications were introduced into the model to compare all of these results from simulations in similar conditions.

Figs. 5.1 through **5.16** shows a comparison between simulation and analytical model for both cases: reservoir at mid reservoir height and at reservoir base. The results in general demonstrated that Gunadi's analytical model can adequately represent a good approach in comparison with numerical simulation.

Oil model production rates for the second and third cycles are higher than the simulation estimates (**Figs. 5.1 and 5.9**). The simulations present better performance (typical performance observed in field) for the oil production rate. The reduction in the oil production, during the second and third cycles, due to declination of the reservoir pressure can be observed. The analytical model has a limitation in the initial reservoir pressure estimate because the pressure decline is not considered in additional cycles. For this reason in every cycle almost the same pressure is reached in the first time step and therefore the maximum fluid production is reached. The difference between the cumulative oil production calculated by the model and simulation was 23 % for reservoir at mid reservoir height and 33 % at the reservoir base case.

An excellent mach was predicted by the model for the water production rate in both study cases during the three cycles (**Figs. 5.2 and 5.10**). The cumulative water production by the model is 9 % smaller than the estimated using simulation, considering the reservoir at mid reservoir height. For the reservoir at the base the difference was 10 %.

A significant difference in the reservoir pressure was found (**Figs. 5.15 and 5.16**). A direct comparison between numerical solution and the analytical model cannot be made due to the differences in the calculation of the pressure drop. The simulation considers that the maximum bottom hole pressure expected in the reservoir after injection is 2070 psia but the model estimate is 5168 psia for all study cases. This was believed to have been caused by incomplete representation of the model of the complex wellbore dynamic with the same accuracy than simulation. The model basically represents a simplified approach based in Boberg and Lanz method. This method generates adequate predictions for steam stimulation response for most conventional heavy oil well and the many references recommend its use to make preliminary field studies. For the other side in the simulation the discretized wellbore approach allow variable flow regimes along the length of the wellbore and also can manage multiphase flow such the pressure drop can be calculated more exactly.

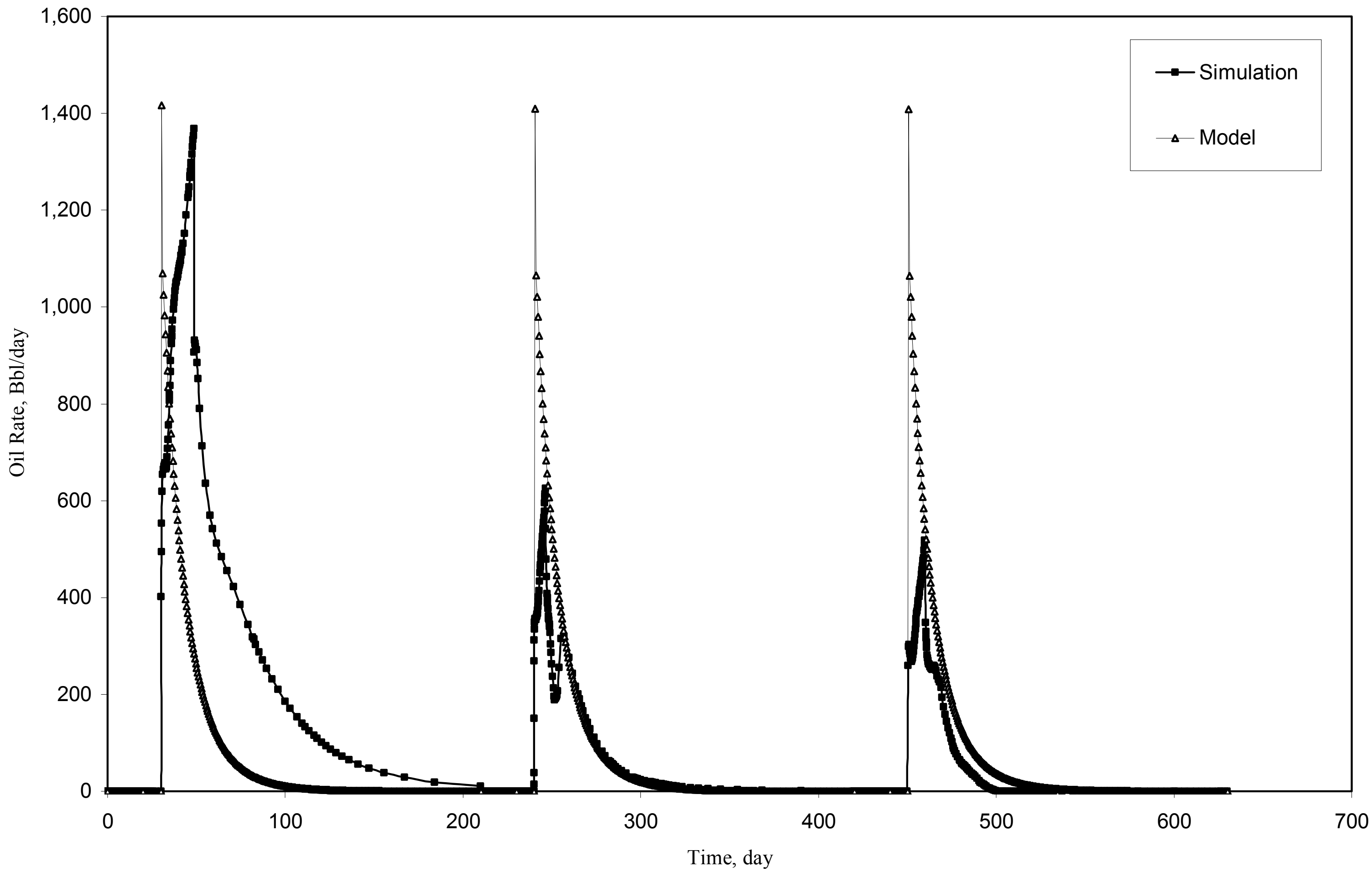

Fig. 5.1 Oil Rate Simulation vs. Analytical Model at Mid-Reservoir Height

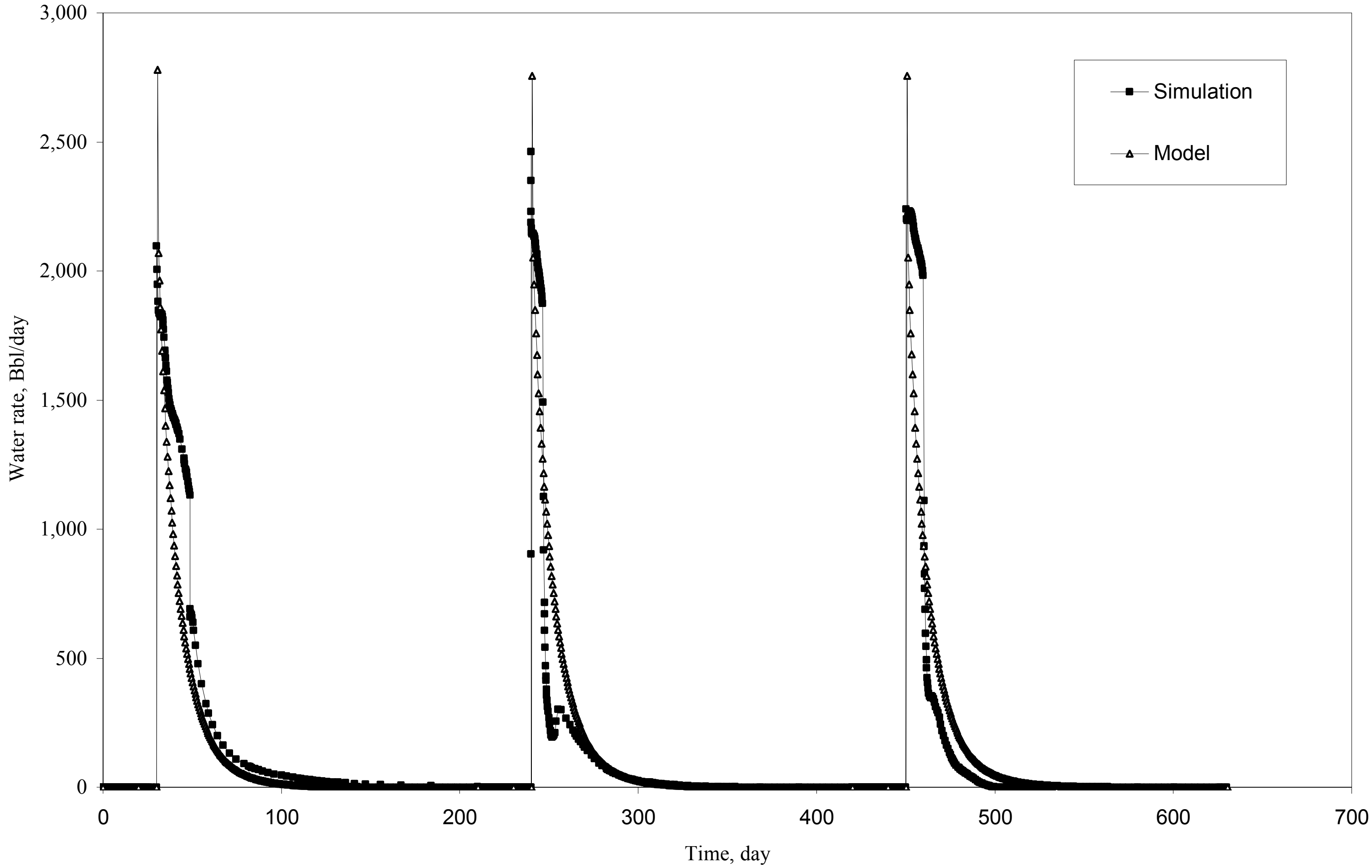

Fig. 5.2 Water Rate Simulation vs. Analytical Model at Mid-Reservoir Height

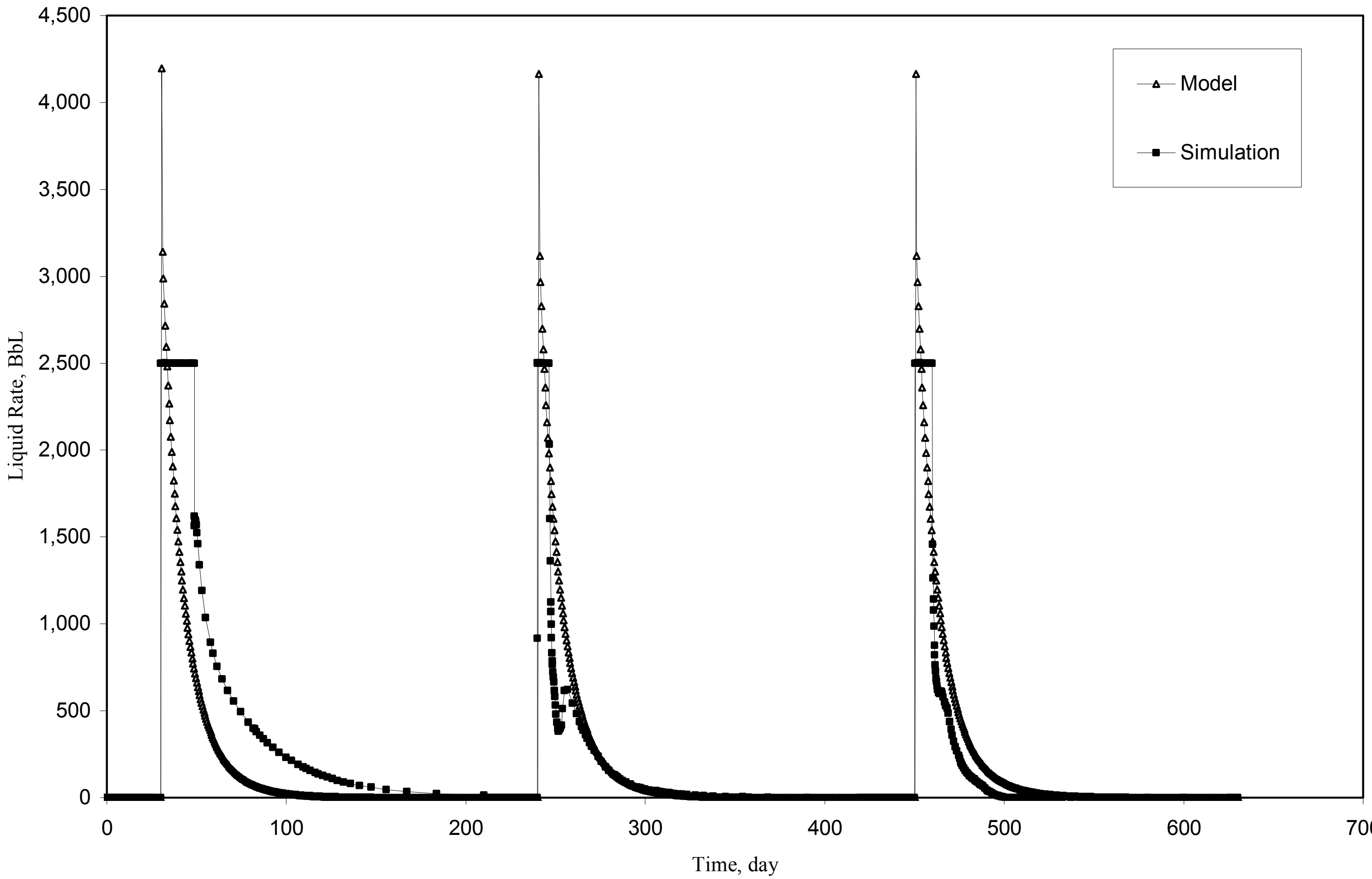

Fig. 5.3 Liquid Rate Simulation vs. Analytical Model at Mid-Reservoir Height

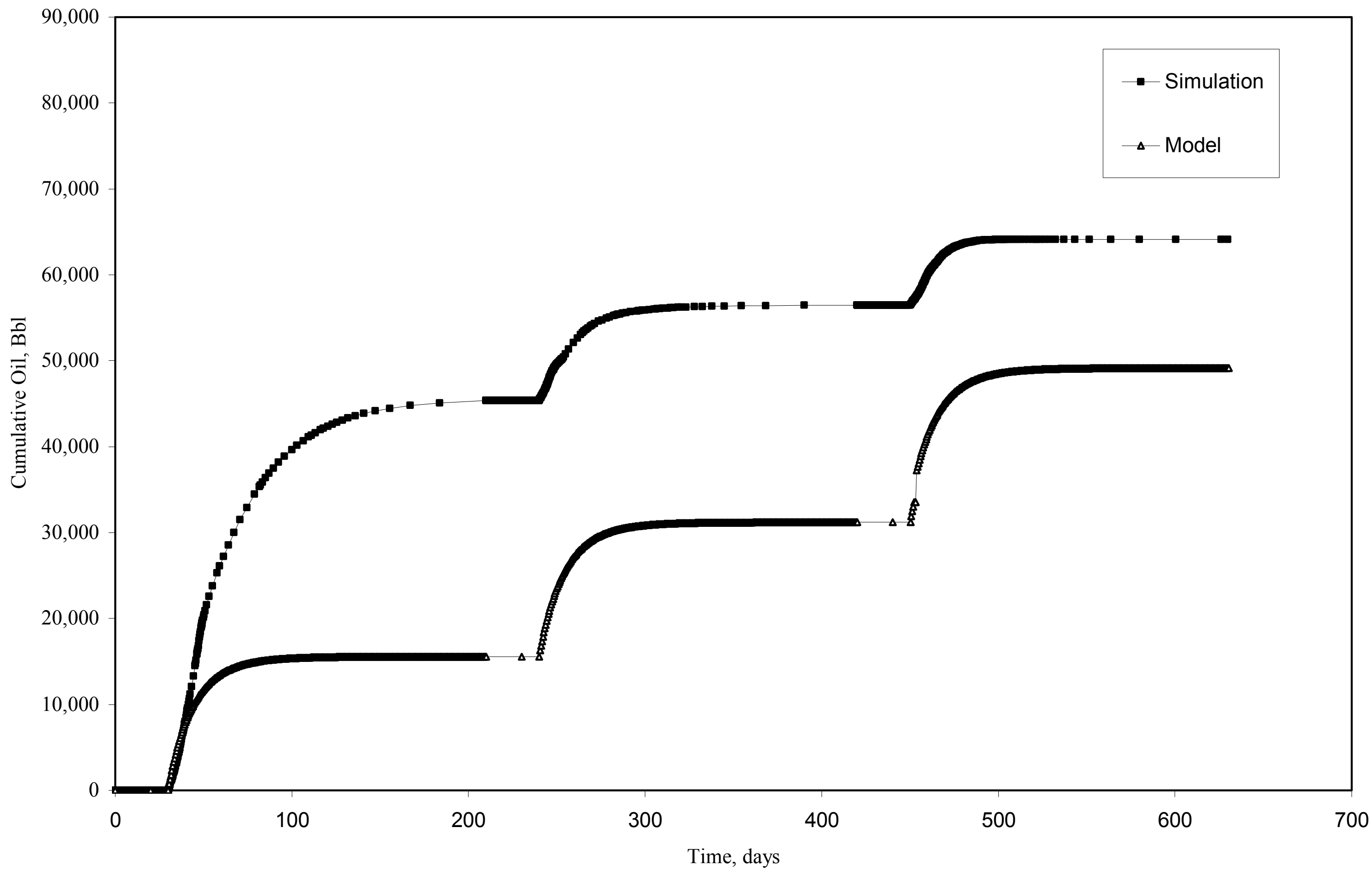

Fig. 5.4 Cumulative Oil Simulation vs. Analytical Model at Mid-Reservoir Height

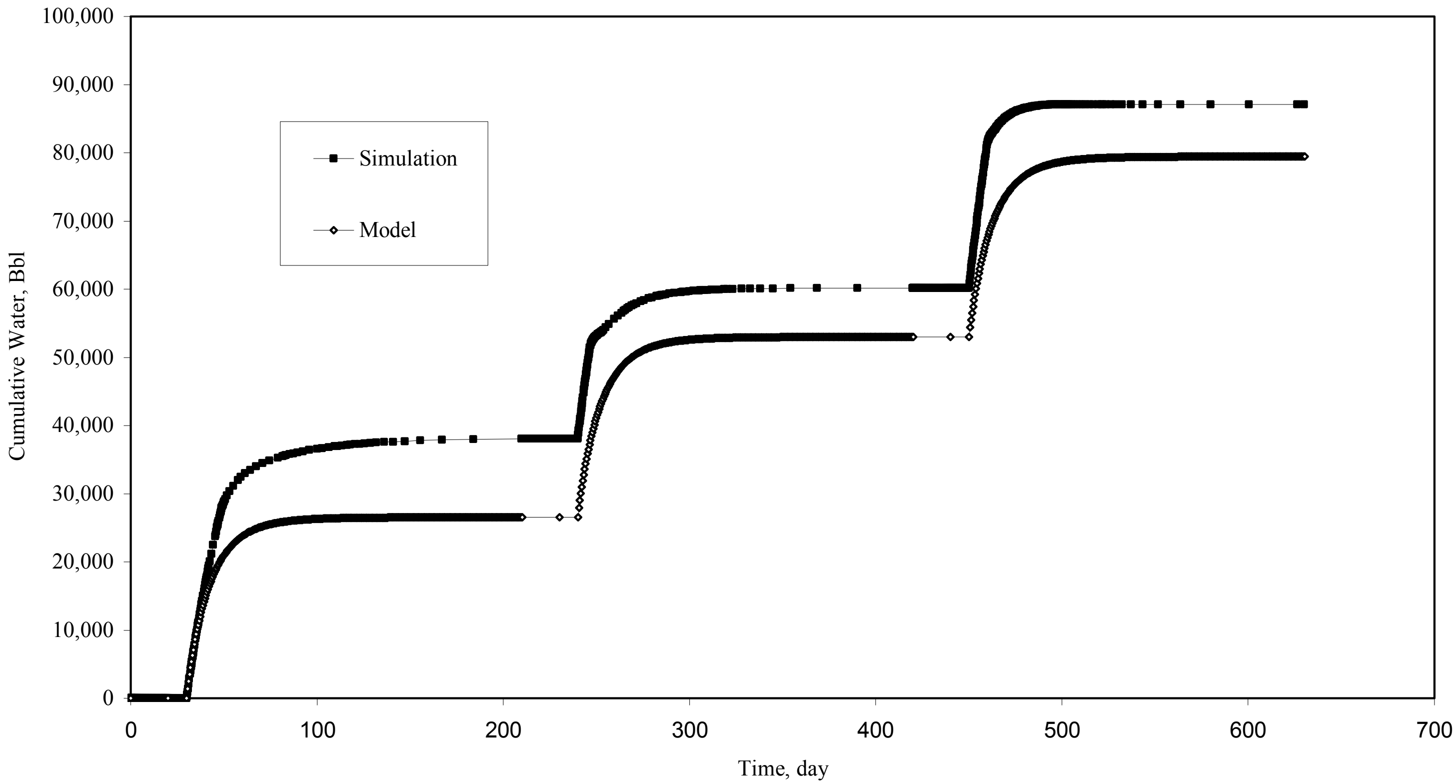

Fig. 5.5 Cumulative Water Simulation vs. Analytical Model at Mid-Reservoir Height

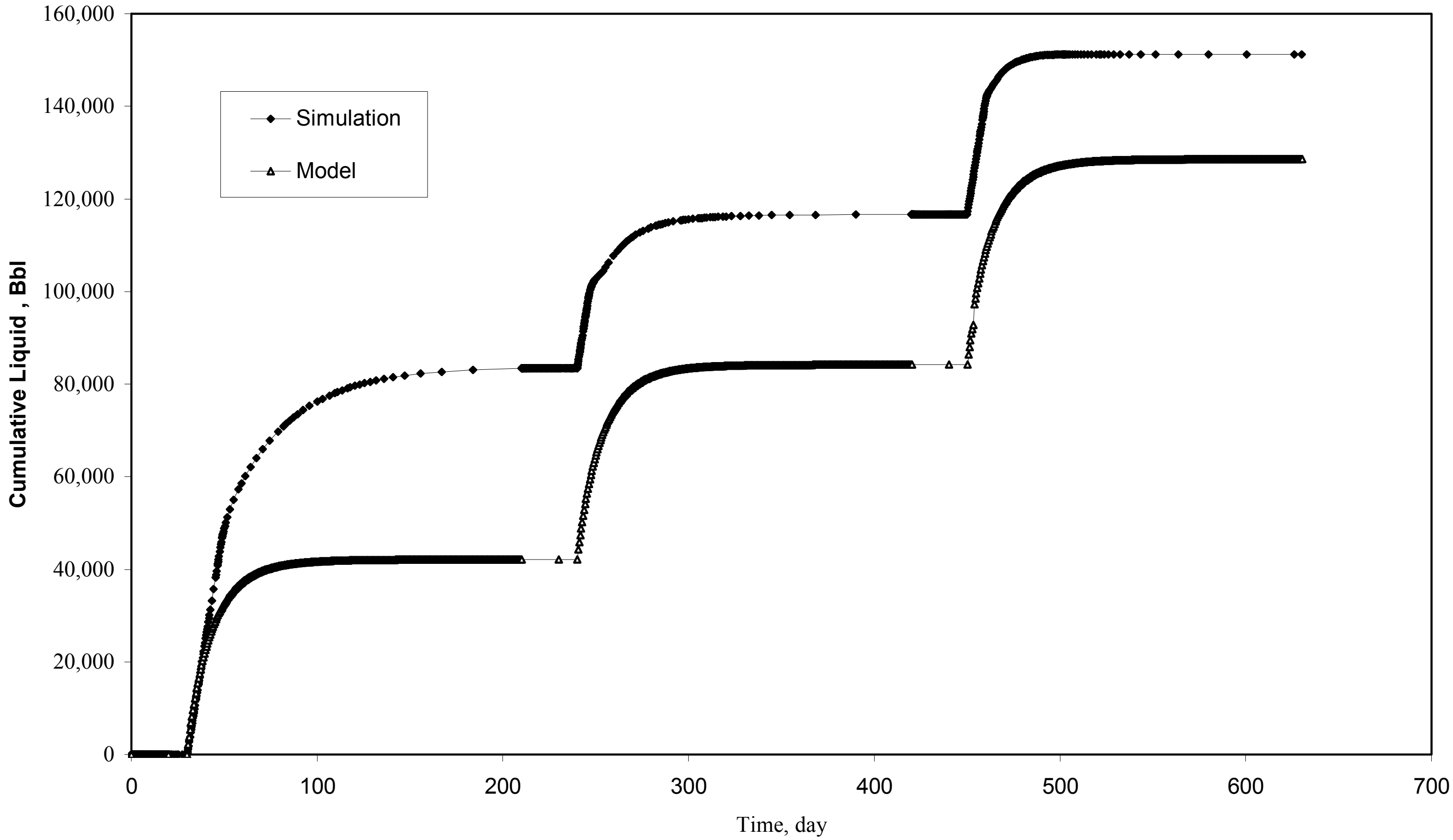

Fig. 5.6 Cumulative Liquid Simulation vs. Analytical Model at Mid-Reservoir Height

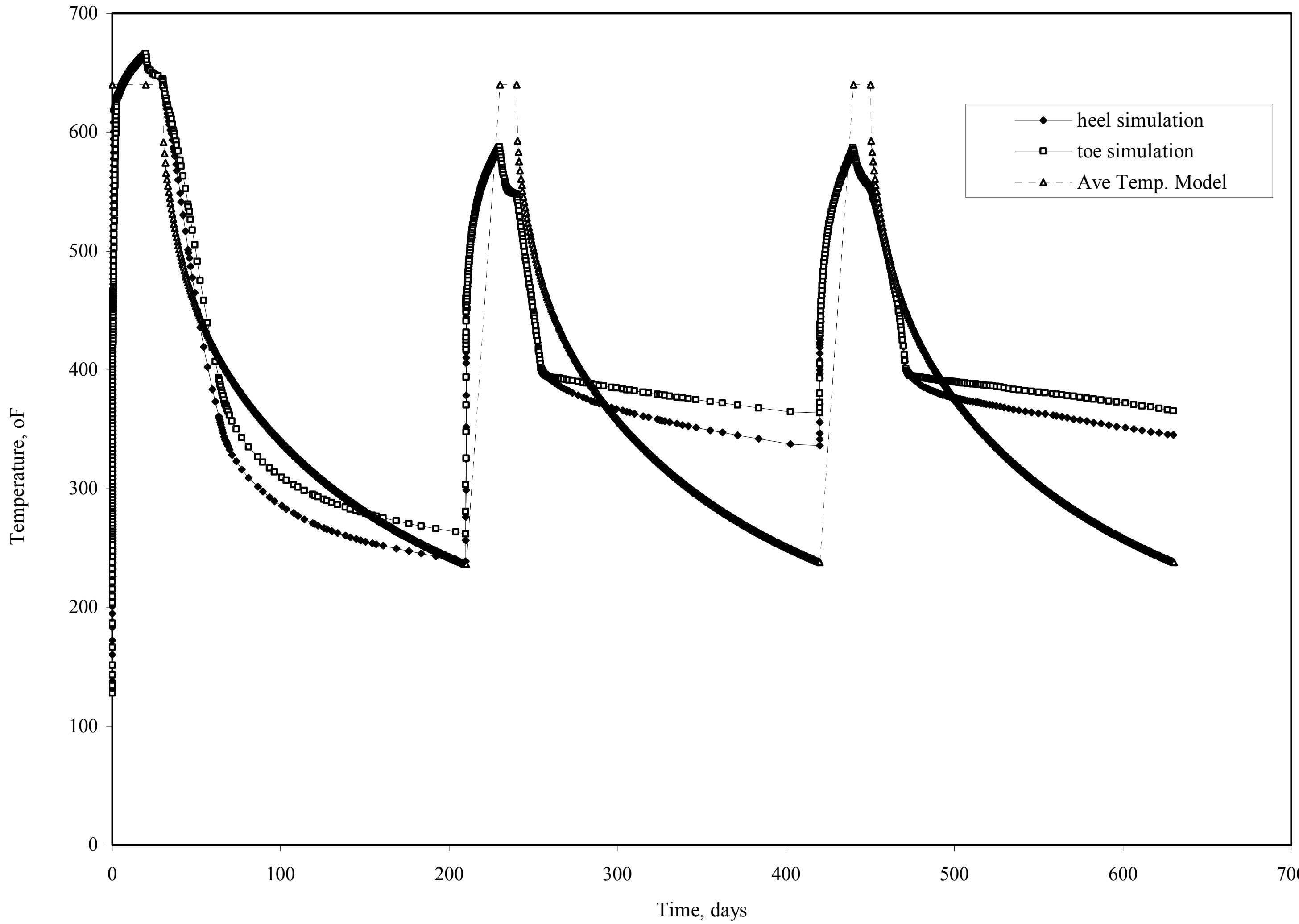

Fig. 5.7 Average Temperature Profile Simulation vs Analytical Model at Mid-Reservoir Height

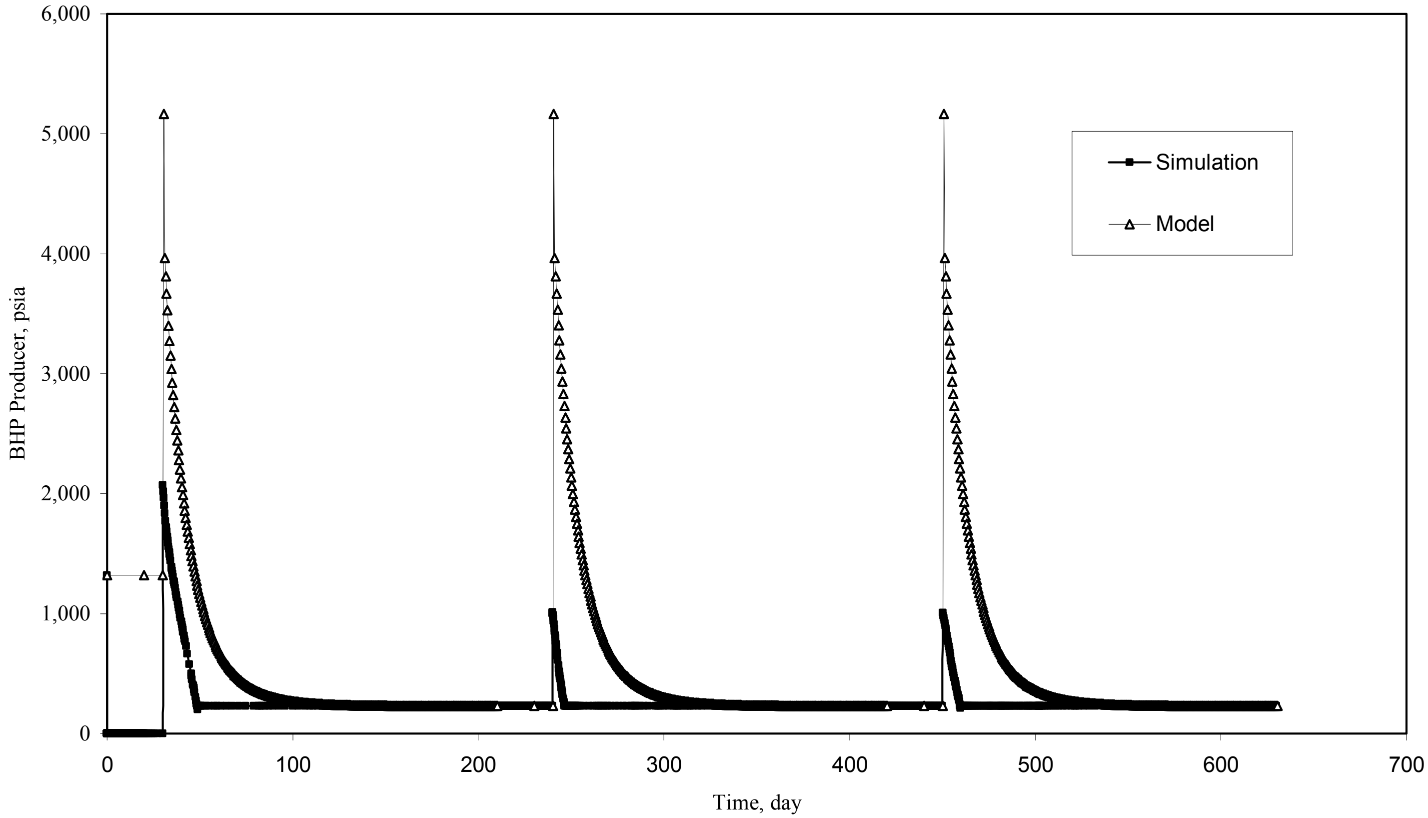

Fig. 5.8 BHP Injector Simulation vs. Analytical Model at Mid-Reservoir Height

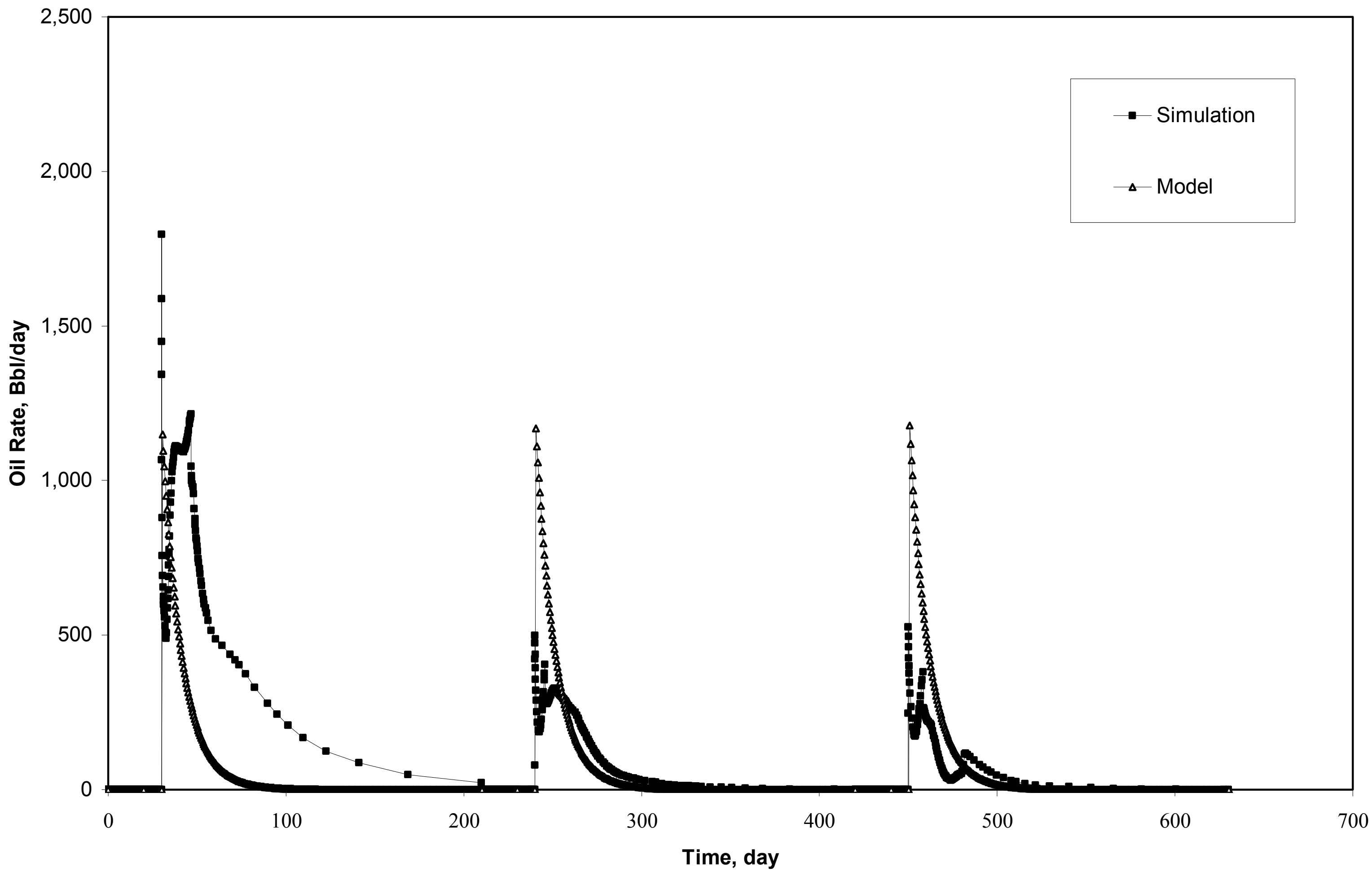

Fig. 5.9 Oil Rate Simulation vs. Analytical Model at Reservoir Base

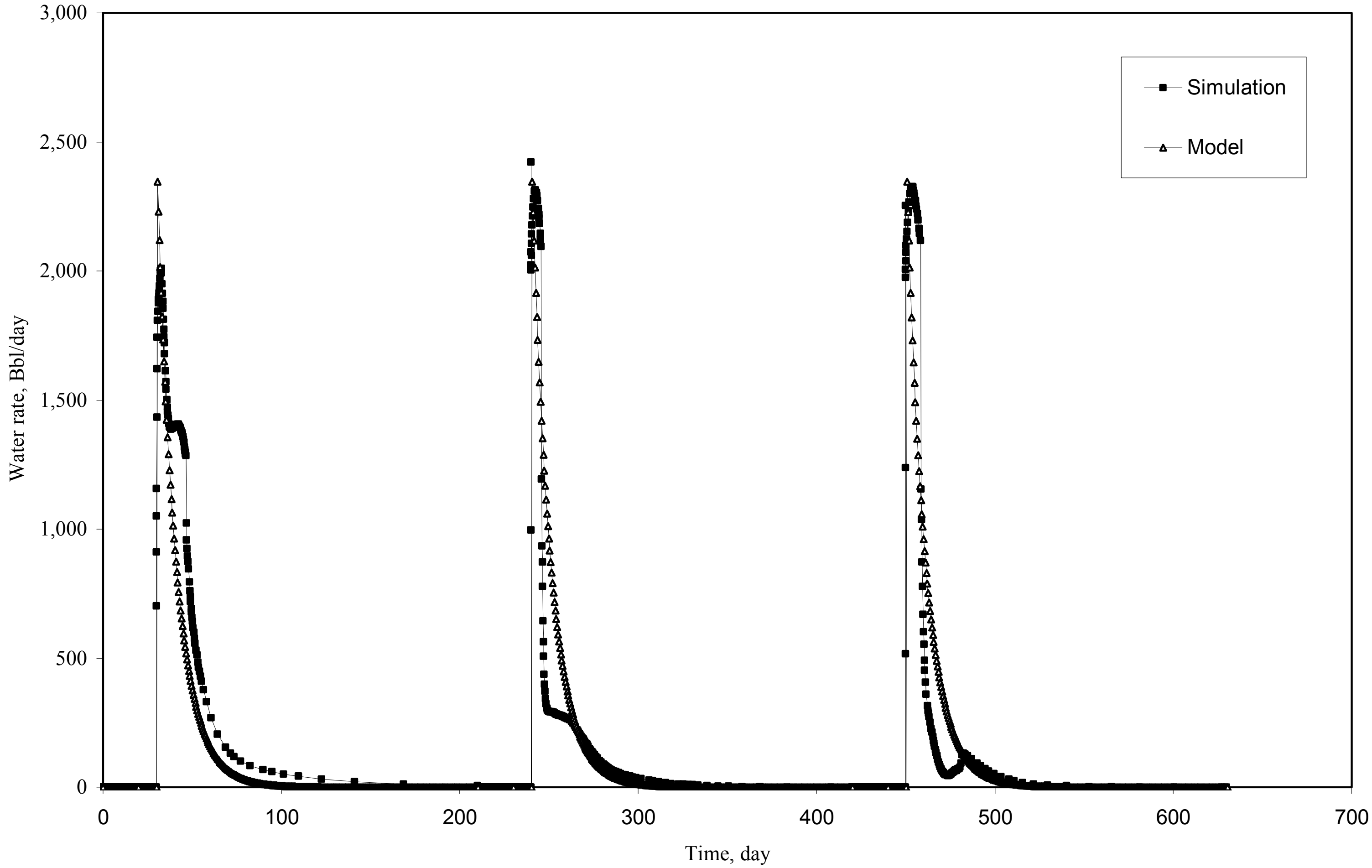

Fig. 5.10 Water Rate Simulation vs. Analytical Model at Reservoir Base

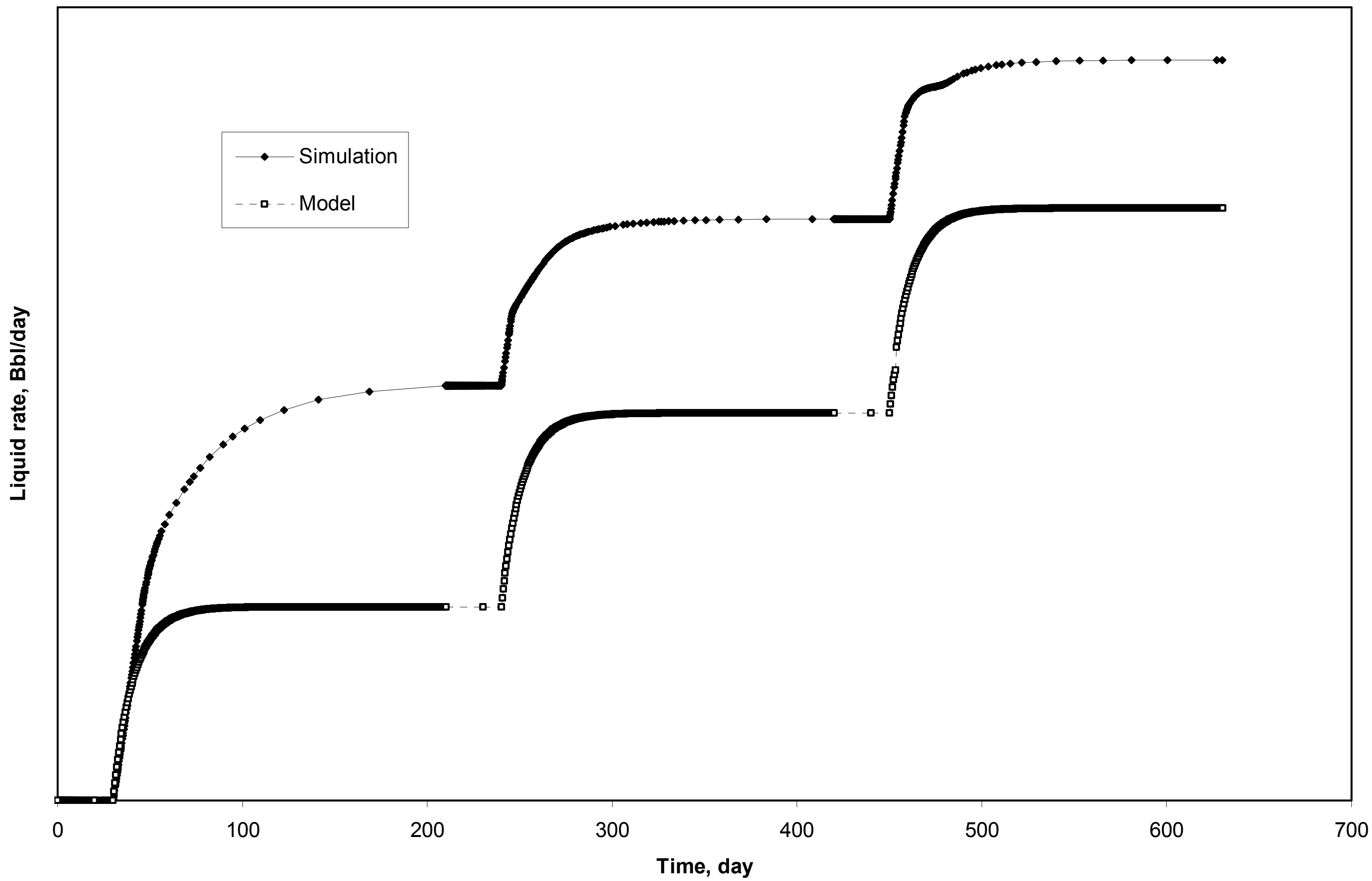

Fig. 5.11 Liquid Rate Simulation vs. Analytical Model at Reservoir Base

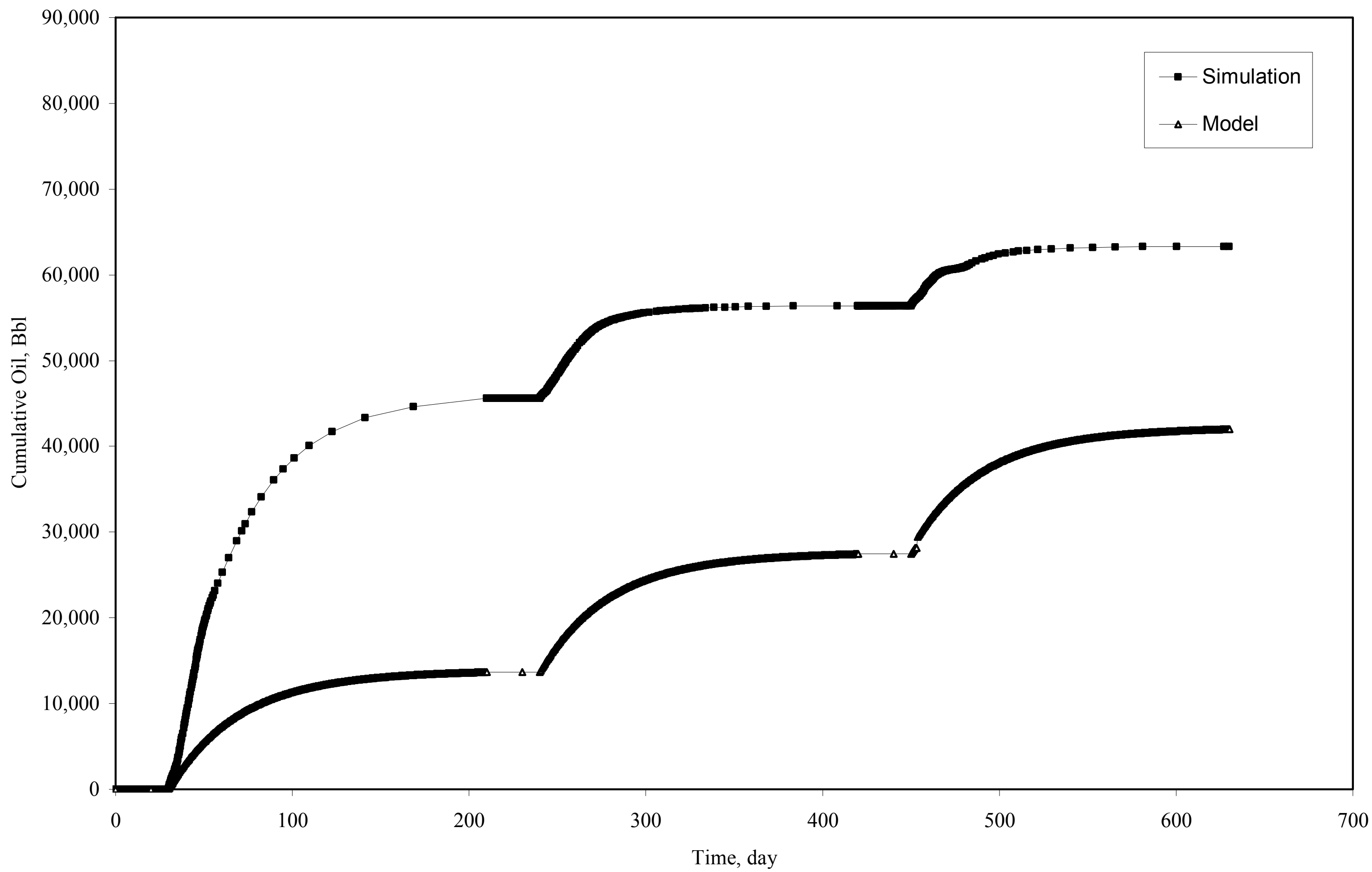

Fig. 5.12 Cumulative Oil Simulation vs. Analytical Model at Reservoir Base

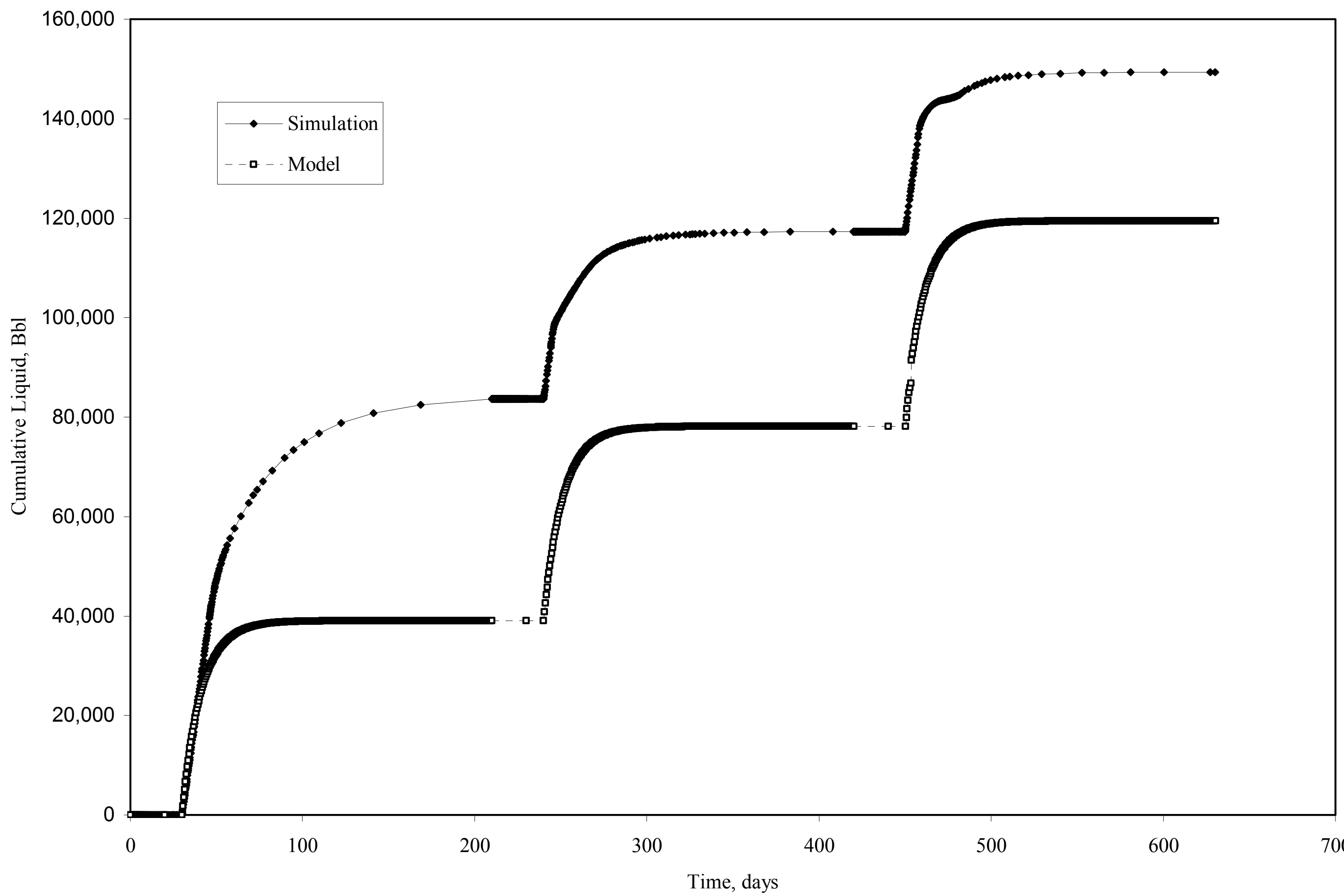

Fig. 5.13 Cumulative Water Simulation vs. Analytical Model at Reservoir Base

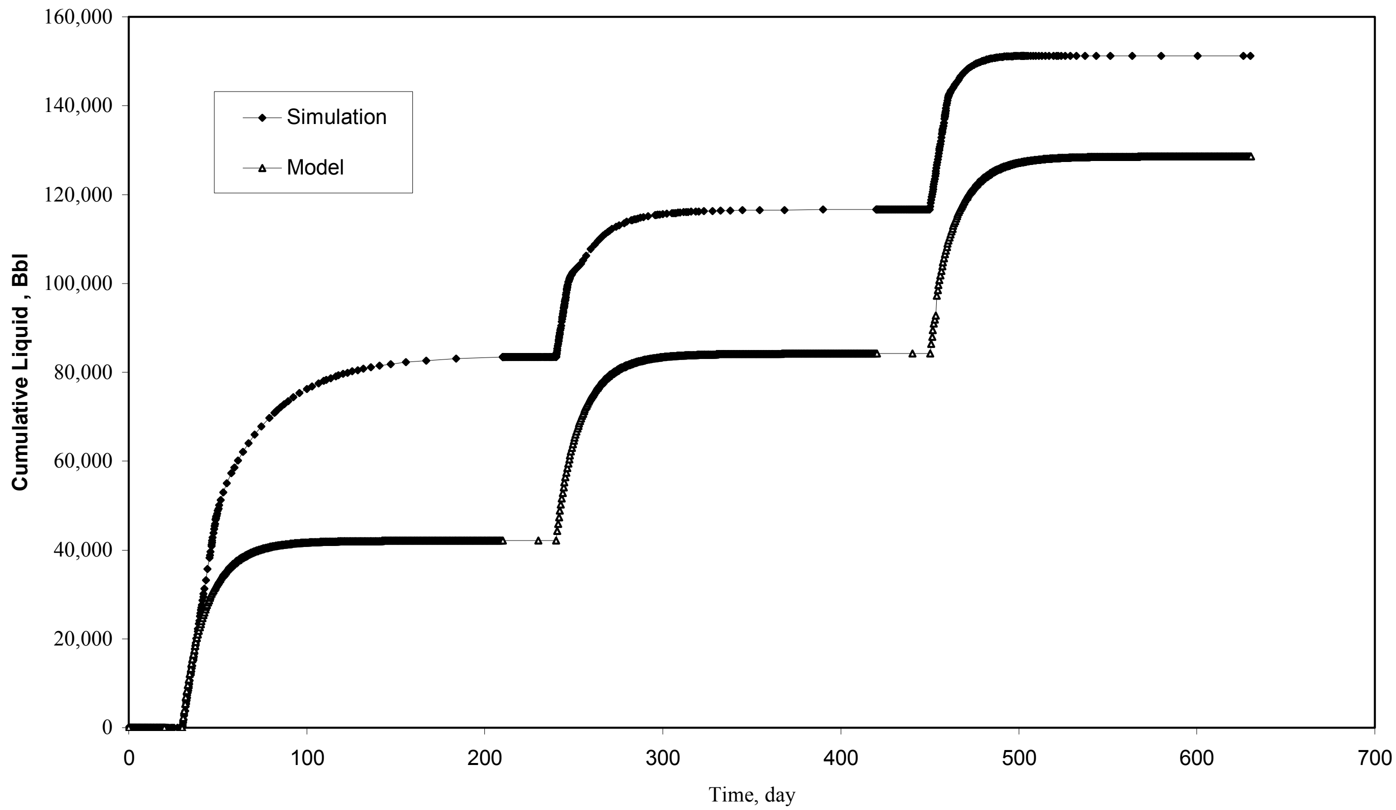

Fig. 5.14 Cumulative Liquid Simulation vs. Analytical Model at Reservoir Base

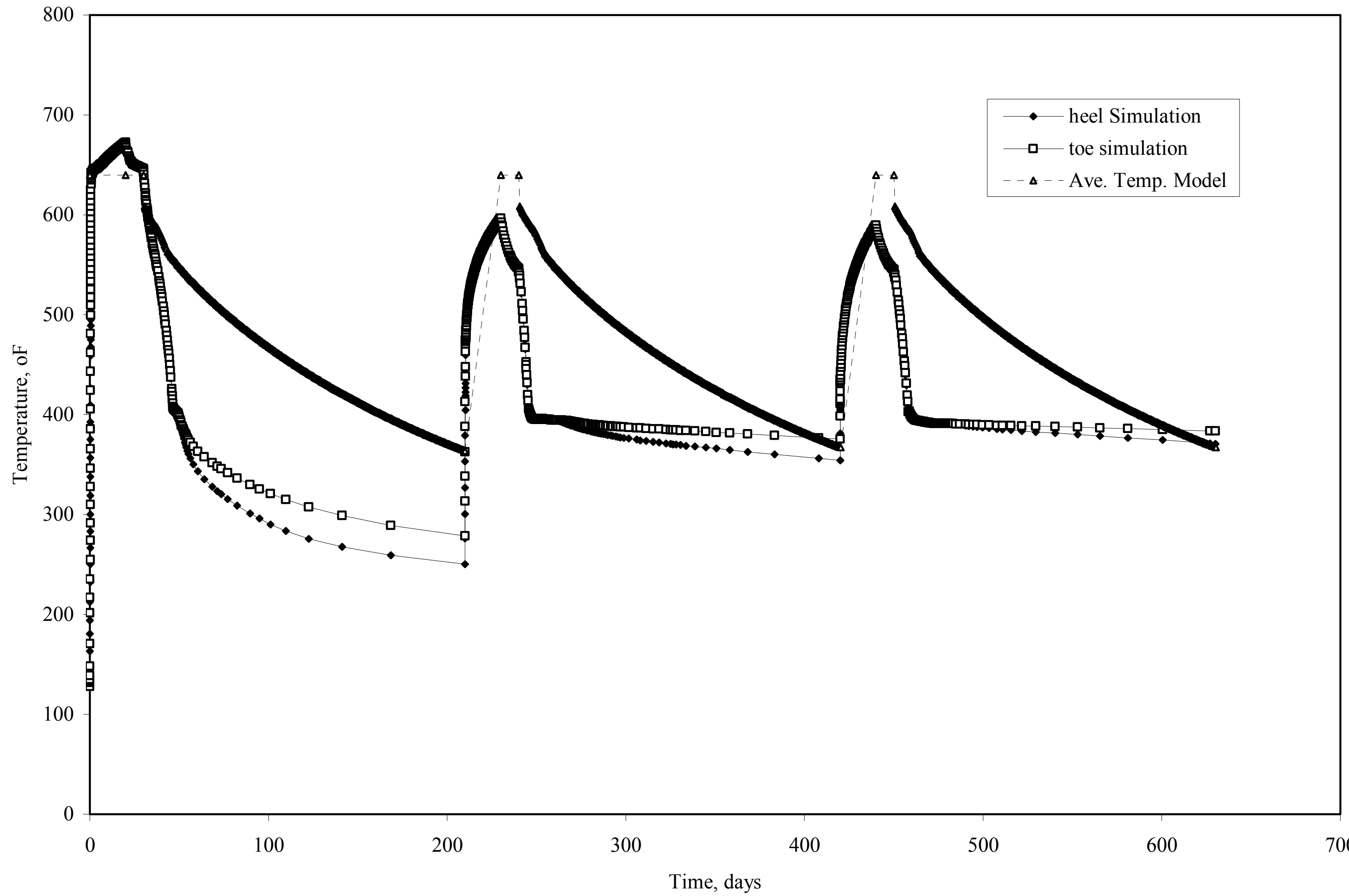

Fig. 5.15 Average Temperature Profile Simulation vs. Analytical Model at Reservoir Base

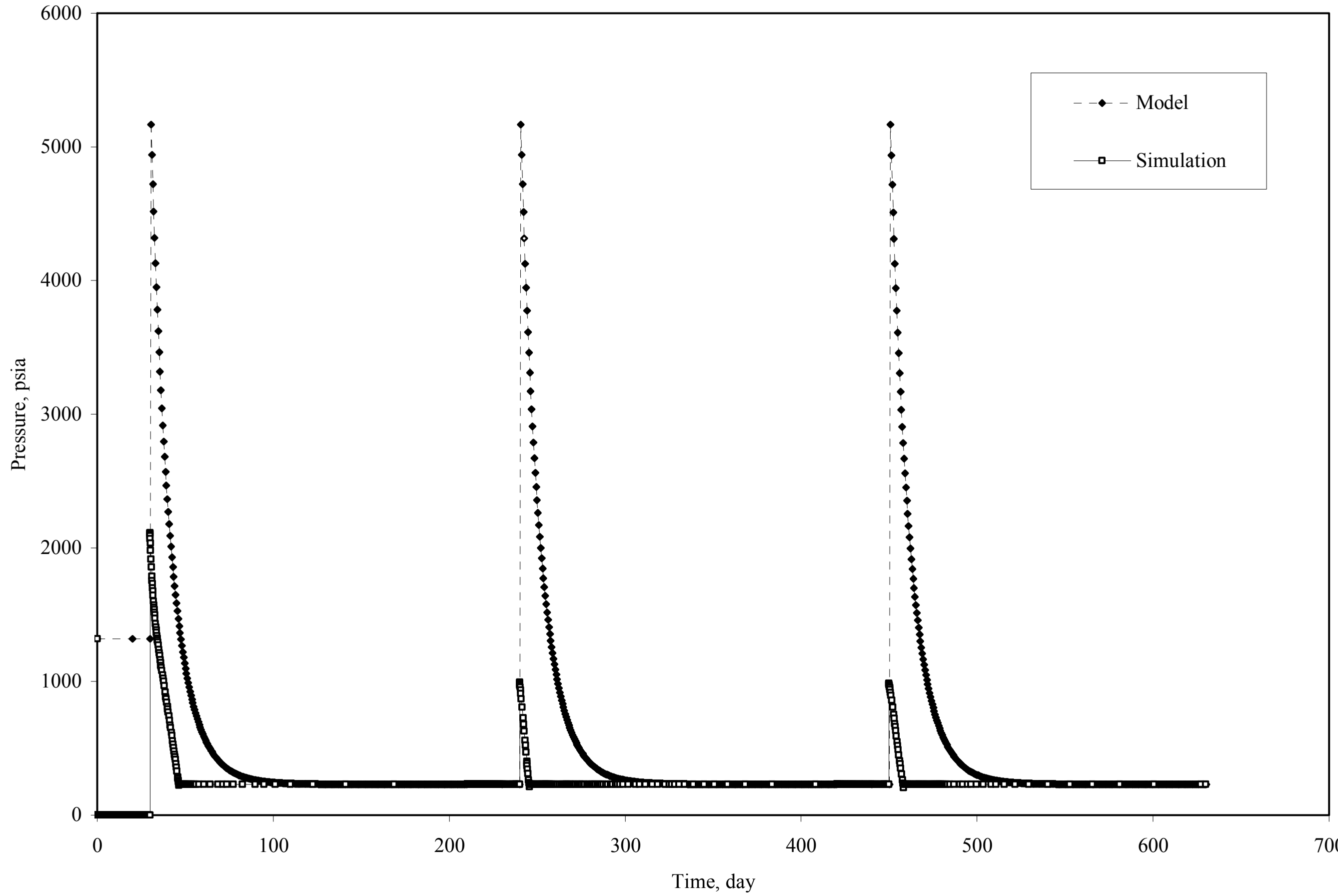

Fig. 5.16 BHP Producer Simulation vs. Analytical Model at Reservoir Base

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

A simulation study of cyclic steam injection in a horizontal well using Bachaquero-01 data has been conducted to verify the cyclic steam injection model developed by Gunadi. Thermal simulation was done using black oil option in CMG's STARS simulator. Two cases were modeled with the horizontal well placed on one side of the model in two vertical positions: at mid reservoir height and at the reservoir base.

The field Bachaquero-01 conditions were scaled to the laboratory conditions to verify the analytical model developed by Bambang Gunadi. The analytical model results are in reasonable agreement with the simulation results.

6.2 Conclusions

Main conclusions of this study are as follows:

1. The analytical model may be used to give a first-pass estimate of the performance of cyclic steam injection in horizontal wells, prior to conducting more detailed thermal reservoir simulation.
2. The length of the steam zone in a horizontal well is dependent on the oil type especially the oil viscosity and operational conditions during cycle steam injection.
3. Laboratory scale simulation presents limitations associated with numerical dispersion to mach the behavior of the cyclic steam injection process.
4. The representation of the horizontal well in field scale simulation as a line source within the coarse grid block is not adequate to study in detail the growth of the steam zone.

NOMENCLATURE

a_e = the large half axis of the drainage ellipse formed by a horizontal well,ft

C_c = volumetric heat Capacity of cap rock, Btu/ft^3 ^{o}F

C_o = volumetric heat Capacity of oil, Btu/ft^3 ^{o}F

C_{RF} = volumetric heat Capacity of reservoir, Btu/ft^3 ^{o}F

C_w ΔT= volumetric heat Capacity of cap rock, Btu/ft^3 ^{o}F

C= compressibility, 1/psia

D = hydraulic diameter, ft

d, e = constants from heat balance

f_s = steam quality, dimensionless

f_{sM} = steam quality in the model, dimensionless

q = production or injection rate, Bbl/day

h = reservoir thickness, ft

h_{fg} =enthalpy of vaporization, Btu/Lb

h_{fr} =enthalpy of water at reservoir temperature, Btu/Lb

H_s =steam enthalpy, Btu/Lb

HCF =heat conduction across the front of steam zone, Btu

HCB =heat conduction across the back of steam zone, Btu

I_w =mass rate of steam injected, lb/sec

J =well productivity index, $Bbl/day/psia$

k =absolute permeability, Darcy

k_{ro} =relative permeability to oil, dimensionless

k_{rw} =relative permeability to water, dimensionless

K =formation conductivity, Btu/hr ft ^{o}F

ΔL =length of the steam zone segment in the model, cm

L_R =length of reservoir, ft

L_M =length of model, ft

M_s =Mass of steam injected, lb

N_s =number of sand layer, dimensionless

P =pressure, psia

P_p, P_{wf} =flowing pressure, psia

P_w =wellbore pressure, psia

P_{ij} =block pressure in the simulation, psia

q =fluid rate, bbl/D

q_s =volumetric rate of steam entering the formation, cc/sec

q_o =volumetric rate of oil displaced to the formation, cc/sec

r_t =radius of well or tubing in scaled model, ft

r = steam zone radius in the mathematical model, cm

R_{av} = average radius of the steam zone, cm

$\Delta S_R = \left(S_{oi} - S_{or}\right)_R$

$\Delta S_M = \left(S_{oi} - S_{or}\right)_M$

S_{oi} =initial oil saturation, dimensionless

S_{oR} =residual oil saturation, dimensionless

S =damage factor, dimensionless

t =time, sec

ti =injection time, day

Δt = time step, sec

T = temperature, ^{o}F

T_{av} = average temperature of steam zone, ^{o}F

T_{Ri} = initial reservoir temperature, ^{o}F

T_{Mi} = initial model temperature, ^{o}F

v_r = unit solution of heat conduction in the radial direction, dimensionless

v_z = unit solution of heat conduction in the vertical direction, dimensionless

β =index of horizontal to vertical permeability anisotropy, dimensionless

ϕ = porosity, dimensionless

δ = correction factor for heat removed by produced fluid, dimensionless

ρ_c = density cap rock, lb/cuft

α = thermal diffusivity, ft^2/hr

λ = thermal conductivity, Btu/hr ft ^oF

λ_{M}=fluid mobility in the simulation, md/cp

μ = viscosity, cp

χ_{B1j} = conduction heat losses across the back of the steam zone, Btu

χ_{Fij} = conduction heat losses across the front of the steam zone, Btu

Subscripts

av = average

c = critical

cz = cold zone

g = gas

hz = hot zone

i = irreducible

M = model

o = oil

R = reservoir

s = steam

sz = steam zone

T = total

w = water

x = distance ahead of the hot zone- warm zone interface

ij = indices for segment number and time step number

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APPENDIX A

RESERVOIR SIMULATION FILES: HORIZONTAL WELL AT MID- RESERVOIR HEIGHT AND AT RESERVOIR BASE

Case Horizontal Well at Mid-Reservoir Height

```
RESULTS SIMULATOR STARS
RESULTS SECTION INOUT
*TITLE1  'Bachaquero-01 reservoir'
*TITLE2  'Horizontal well'
*CASEID  'Middle'
*INUNIT *FIELD
*INTERRUPT *INTERACTIVE
*WPRN *GRID  *TIME
*WPRN *SECTOR  0
*WSRF *GRID 1
*WSRF *SECTOR  0
*WPRN *ITER *TIME
*OUTPRN *WELL *ALL
*OUTPRN *GRID *ALL
*OUTPRN *RES *ALL
*OUTPRN *ITER *BRIEF
*OUTSRF *WELL *COMPONENT *ALL *LAYER *ALL
*OUTSRF *GRID *PRES *SO *SW *SG *TEMP *VISO
*XDR *ON
*PRINT_REF *ON
*OUTSOLVR *OFF
*MAXERROR  20
*SR2PREC *DOUBLE

GRID VARI 50 50 20
KDIR DOWN
DI CON 6.6
DJ CON 6.6
DK CON 6

REFINE 50 1 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 2 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 3 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 4 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 5 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 6 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 7 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 8 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
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REFINE 50 9 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 10 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 11 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 12 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 13 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 14 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

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REFINE 50 16 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 17 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 18 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 19 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 20 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 21 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 22 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 23 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 24 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 25 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 26 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 27 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 28 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 29 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 30 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 31 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 32 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 33 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 34 10 INTO 2 1 2 HYBRID JDIR RW 0.29 alphai 3.37332 alpha 3.37332

```
REFINE 50 35 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 36 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 37 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 38 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 39 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 40 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 41 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 42 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 43 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 44 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 45 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 46 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 47 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 48 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 49 10 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 50 10 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332


WELLBORE 0.292
  LAMINAR
  RANGE       50:50 1:50 10:10

**$ RESULTS PROP NULL  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
**$ 0 = NULL block, 1 = Active block
NULL CON 1.

**$ RESULTS PROP PINCHOUTARRAY  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
**$ 0 = PINCHED block, 1 = Active block
PINCHOUTARRAY CON 1.
RESULTS SECTION GRID
RESULTS SPEC 'Grid Thickness'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC 'Grid Thickness'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'Layer 1 - Whole layer'
```

```
    RESULTS SPEC REGIONTYPE 1
    RESULTS SPEC LAYERNUMB 1

RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 2 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 3 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 4 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 5 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 6 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 7 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 8 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 9 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 10 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 11 - Whole layer'
RESULTS SPEC REGIONTYPE 1
```

```
    RESULTS SPEC LAYERNUMB 5
    RESULTS SPEC PORTYPE 1

RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 12- Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 13 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 14 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 15 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 16 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 17 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 18 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 19 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 20 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC STOP
RESULTS PINCHOUT-VAL      0.0002 'cm'
RESULTS SECTION NETPAY
```

```
RESULTS SECTION NETGROSS
RESULTS SECTION POR
RESULTS SPEC 'Porosity'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 0.335
RESULTS SPEC STOP

**$ RESULTS PROP POR  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0.335  Maximum Value: 0.335
POR CON 0.335

RESULTS SECTION PERMS

RESULTS SPEC 'Permeability I'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 2000
RESULTS SPEC STOP

RESULTS SPEC 'Permeability J'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 2000
RESULTS SPEC STOP

RESULTS SPEC 'Permeability K'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 2000
RESULTS SPEC STOP

**$ RESULTS PROP PERMI  Units: md
**$ RESULTS PROP Minimum Value: 2000.  Maximum Value: 2000.
PERMI CON 2000.

**$ RESULTS PROP PERMJ  Units: md
```

```
     **$ RESULTS PROP Minimum Value:  Maximum Value: 2000.
     PERMJ CON 2000.


**$ RESULTS PROP PERMK  Units: md
**$ RESULTS PROP Minimum Value: 2000.  Maximum Value: 2000.
PERMK CON 2000.
RESULTS SECTION TRANS
RESULTS SECTION FRACS
RESULTS SECTION GRIDNONARRAYS
RESULTS SECTION VOLMOD
RESULTS SECTION VATYPE
RESULTS SECTION SECTORLEASE

RESULTS SECTION THTYPE
END-GRID

ROCKTYPE 1
  CPOR   60.e-6     **100.E-06
  ROCKCP 32.7
  THCONR 26.4
  thconw 0.406164
  thcono 0.00204
  HLOSST 128.
  HLOSSTDIFF 0.01
  HLOSSPROP OVERBUR 1. 1.
  UNDERBUR 1. 1.

RESULTS SECTION GRIDOTHER
RESULTS SECTION MODEL
*MODEL     2 2 2 1
*COMPNAME 'Water' 'Dead_Oil'
*KV1       0.E+00 0.E+00
*KV2       0.E+00 0.E+00
*KV3       0.E+00 0.E+00
*KV4       0.E+00 0.E+00
*KV5       0.E+00 0.E+00
*CMM       18. 460.
*PCRIT     0.0 0.0  **121.
*TCRIT     0.0 0.0  **1673.
*PRSR     14.7     ****  940.
*TEMR     128.     ****  140.
*PSURF    1.47E+1
*TSURF    6.0E+1
*MASSDEN   0.0  61.6280508
*CP        0.0  3.179E-6
*CT1       0.0  3.611E-4
*CT2       0.0E+0 0.0E+0

*VISCTABLE
630.7600.
128        0.635.
160        0.          351.74
```

```
    1630.335.0431
    1900.86.20


2200.66.29
250     0.      46.36
2800.26.42
3100.12.68
340     0.       11.42
3700.10.17
4000.8.91
4300.7.66
4900.5.15
5200.   3.90
600     0.0   2.9
610     0.    2.3
750     0.0   2.3

RESULTS SECTION MODELARRAYS
RESULTS SECTION ROCKFLUID

*ROCKFLUID


*RPT 1 *WATWET *STONE2
*SWT
0.20000         1.
0.22500.0015403080.891835072
0.25000.0031332560.794045481
0.27500.0048039250.705858353
0.30000.0065792860.626527513
0.32500.0084939040.55533373
0.35000.0105892090.491584968
0.37500.0129138560.43461666
0.40000.0155240710.383791992
0.42500.0184840060.338502208
0.45000.0218660760.298166943
0.47500.0257512920.262234567
0.50000.0302295840.230182569
0.52500.0354001220.201517969
0.55000.0413716280.175777767
0.57500.048262680.152529434
0.60000.0562020090.131371462
0.62500.0653288020.111933976
0.65000.075792980.093879427
0.67500.087755490.076903382
0.70000.1013885810.060735461
0.72500.1168760790.045140442
0.75000.134413660.029919641
0.77500.1542091140.014912685
0.80000.1764826090

*SLT  *NOSWC
```

```
    0.45000.43410.000000000000
    0.50000.39060.000160772291

0.55000.34720.001191402073
0.60000.30380.004573078512
0.65000.26040.013022555608
0.70000.21700.031013173505
0.75000.17360.065385197754
0.80000.13020.126045476498
0.85000.08680.226756415612
0.90000.04340.386014271775
0.95000.00000.628016763482
0.97000.00000.754667699411
1.00000.00001.00000000000

*RPT 2
*SWT
0.00000  0.000000   1.000000  0.000000
1.00000  1.00000    0.000000  0.000000

*SLT
0.000000  1.000000  0.000000  0.000000
1.000000  0.000000  1.000000  0.000000



RESULTS SECTION ROCKARRAYS

**$ RESULTS PROP KRTYPE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
KRTYPE CON 1.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 1 10 / 1 1 1  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 1 10 / 1 1 2  CON 2.


**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 2 10 / 1 1 1  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 2 10 / 1 1 2  CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 3 10 / 1 1 1  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
```

```
KRTYPE WELLBORE 50 3 10 / 1 1 2  CON 2.


**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 4 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 4 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 5 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 5 10 / 1 1 2 CON 2.


**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 6 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 6 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 7 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 7 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 8 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 8 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 9 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 9 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 10 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 10 10 / 1 1 2 CON 2.
```

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 11 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 11 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 12 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 12 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 13 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 13 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 14 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 14 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 15 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 15 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 16 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 16 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 17 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 17 10 / 1 1 2 CON 2.

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        **$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
        **$ RESULTS PROP Minimum Value: 2  Maximum Value: 2


KRTYPE WELLBORE 50 18 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 18 10 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 19 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 19 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 20 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 20 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 21 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 21 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 22 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 22 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 23 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 23 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 24 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 24 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 25 10 / 1 1 1 CON 2.
```

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2

KRTYPE WELLBORE 50 25 10 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 26 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 26 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 27 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 27 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 28 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 28 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 29 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 29 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 30 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 30 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 31 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 31 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 32 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2

KRTYPE WELLBORE 50 32 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 33 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 33 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 34 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 34 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 35 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 35 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 36 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 36 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 37 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 37 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 38 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 38 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 39 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 39 10 / 1 1 2 CON 2.

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	**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless

**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 40 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 40 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
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**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 41 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
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**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 42 10 / 1 1 2 CON 2.


**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
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**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 43 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 44 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 44 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 45 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 45 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 46 10 / 1 1 2 CON 2.
```

```
    **$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
    **$ RESULTS PROP Minimum Value: 2  Maximum Value: 2


KRTYPE WELLBORE 50 47 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 47 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 48 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 48 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 49 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 49 10 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 50 10 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 50 10 / 1 1 2 CON 2.

RESULTS SECTION INIT
*INITIAL
*VERTICAL *OFF
**$ Data for PVT Region 1
**$ -------------------------------------
*INITREGION 1
*REFDEPTH 2800
*REFPRES 11019.
**DWOC  4000.

RESULTS SECTION INITARRAYS

**$ RESULTS PROP SW  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0.0  Maximum Value: 0.0
SW CON 0.2

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 1 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 1 10 / 1 1 2 CON 0.
```

```
    **$ RESULTS PROP SW WELLBORE  Units: Dimensionless
    **$ RESULTS PROP Minimum Value: 0  Maximum Value: 0

SW WELLBORE 50 2 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 2 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 3 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 3 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
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SW WELLBORE 50 4 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 4 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 5 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 5 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 6 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 6 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
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**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 7 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 8 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 8 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
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SW WELLBORE 50 9 10 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 9 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 10 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 11 10 / 1 1 2 CON 0.

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SW WELLBORE 50 12 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 13 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 14 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 15 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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**$ RESULTS PROP SW WELLBORE Units: Dimensionless

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SW WELLBORE 50 16 10 / 1 1 2 CON 0.

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SW WELLBORE 50 17 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 18 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 19 10 / 1 1 2 CON 0.

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SW WELLBORE 50 20 10 / 1 1 2 CON 0.

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SW WELLBORE 50 21 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 22 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 23 10 / 1 1 2 CON 0.

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SW WELLBORE 50 24 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 25 10 / 1 1 2 CON 0.

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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 29 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 30 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless

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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 34 10 / 1 1 2 CON 0.

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**$ RESULTS PROP SW WELLBORE Units: Dimensionless

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**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 40 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 46 10 / 1 1 2 CON 0.

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SW WELLBORE 50 47 10 / 1 1 2 CON 0.

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SW WELLBORE 50 48 10 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
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SW WELLBORE 50 49 10 / 1 1 2 CON 0.

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SW WELLBORE 50 50 10 / 1 1 2 CON 0.

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SO CON 0.8

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 1 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 2 10 / 1 1 2 CON 1.

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SO WELLBORE 50 3 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 4 10 / 1 1 2 CON 1.

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SO WELLBORE 50 5 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 6 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 7 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 8 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 9 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 10 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 11 10 / 1 1 1 CON 1.

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SO WELLBORE 50 13 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 14 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 14 10 / 1 1 2 CON 1.

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SO WELLBORE 50 15 10 / 1 1 1 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless

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SO WELLBORE 50 16 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 16 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 17 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 17 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 18 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 18 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 19 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 19 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 20 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 20 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 21 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 21 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 22 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 22 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 23 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 23 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 24 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 24 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 25 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 25 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 26 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 26 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 27 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 27 10 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 28 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 28 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 29 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 29 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 30 10 / 1 1 1 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 30 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 31 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 31 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 32 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 32 10 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 33 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 33 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 34 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 34 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 35 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 35 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 36 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 36 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 37 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 37 10 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 38 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 38 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 39 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 39 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 40 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 40 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 41 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 41 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 42 10 / 1 1 1 CON 1
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 42 10 / 1 1 2 CON 1
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 43 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 43 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 44 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 44 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 45 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 45 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 46 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 46 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 47 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 48 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 48 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 49 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 49 10 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 50 10 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 50 10 / 1 1 2 CON 1.

RESULTS SECTION INITARRAYS

RESULTS SPEC 'Temperature'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'Layer 1 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1

```
    RESULTS SPEC PORTYPE 1
    RESULTS SPEC CON 128.  **140

RESULTS SPEC REGION 'Layer 2 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.   **140.
RESULTS SPEC REGION 'Layer 10 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 4 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 5 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC CON 128.    **140.0
RESULTS SPEC STOP
RESULTS SPEC REGION 'Layer 6 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140
RESULTS SPEC REGION 'Layer 7 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140
RESULTS SPEC REGION 'Layer 8 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.   **140.
RESULTS SPEC REGION 'Layer9 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 10 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 11 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.0
```

```
    RESULTS SPEC STOP
    RESULTS SPEC REGION 'Layer 12 - Whole layer'


RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140
RESULTS SPEC STOP

**$ RESULTS PROP SO  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0.8  Maximum Value: 0.8
SO CON 0.8

**$ RESULTS PROP PRES  Units: psi
**$ RESULTS PROP Minimum Value: 700  Maximum Value: 700
PRES CON 1319  ** 940.

**$ RESULTS PROP TEMP  Units: F
**$ RESULTS PROP Minimum Value: 128  Maximum Value: 128
TEMP CON 128        **140.


RESULTS SECTION NUMERICAL
*NUMERICAL
*MAXSTEPS 2500
*DTMAX 90.
*ITERMAX 30
*NORM *PRESS 150.
** SATUR 0.1
   *TEMP 30.

*MAXPRES 1.450377E+05

RESULTS SECTION NUMARRAYS
RESULTS SECTION GBKEYWORDS
RUN

DATE 2003 01 01.

DTWELL 0.05
WELL  1 'injector'
INJECTOR MOBWEIGHT 'injector'
TINJW 640
QUAL  0.80
INCOMP WATER  1.0 0.0
OPERATE MAX STW  1500. CONT
OPERATE MAX BHP  3000. CONT

GEOMETRY J 0.292 0.363 0.5 0.
PERF GEO   'injector'
** i  j  k ff
50 1 10 / 1 1 1 / 1 1 1  1.
```

```
WELL  2 'producer'
PRODUCER 'producer'
OPERATE MAX STL 1500. CONT
OPERATE MIN BHP 230. CONT

GEOMETRY J 0.292 0.363 0.5 0.
PERF GEO   'producer'
** i  j  k ff
      50 1 10 / 1 1 1 / 1 1 1  1.
OPEN 'injector'
SHUTIN 'producer'
TIME 20
*OUTSRF *GRID *TEMP *SW *SO
SHUTIN 'injector'
TIME 30
*OUTSRF *GRID *TEMP *SW *SO
DTWELL 0.005
OPEN 'producer'
TIME 210
*OUTSRF *GRID *TEMP *SW *SO
OPEN 'injector'
SHUTIN 'producer'
TIME 230
*OUTSRF *GRID *TEMP *SW *SO

SHUTIN 'injector'
TIME 240
*OUTSRF *GRID *TEMP *SW *SO

DTWELL 0.005
OPEN 'producer'
TIME 420
*OUTSRF *GRID *TEMP *SW *SO

SHUTIN 'producer'
OPEN 'injector'
TIME 440
*OUTSRF *GRID *TEMP *SW *SO
SHUTIN 'injector'
TIME 450
*OUTSRF *GRID *TEMP *SW *SO
DTWELL 0.005
OPEN 'producer'
TIME 630
*OUTSRF *GRID *TEMP *SW *SO
STOP
**************************** TERMINATE SIMULATION ****************************

RESULTS SECTION WELLDATA
RESULTS SECTION PERFS
```

Case Horizontal Well at Mid-Reservoir Height

```
RESULTS SIMULATOR STARS
RESULTS SECTION INOUT
*TITLE1  'Bachaquero-01 reservoir'
*TITLE2  'Horizontal well'
*CASEID  'Bottom'
*INUNIT *FIELD
*INTERRUPT *INTERACTIVE
*WPRN *GRID  *TIME
*WPRN *SECTOR  0
*WSRF *GRID 1
*WSRF *SECTOR  0
*WPRN *ITER *TIME
*OUTPRN *WELL *ALL
*OUTPRN *GRID *ALL
*OUTPRN *RES *ALL
*OUTPRN *ITER *BRIEF
*OUTSRF *WELL *COMPONENT *ALL *LAYER *ALL
*OUTSRF *GRID *PRES *SO *SW *SG *TEMP *VISO
*XDR *ON
*PRINT_REF *ON
*OUTSOLVR *OFF
*MAXERROR  20
*SR2PREC *DOUBLE

GRID VARI 50 50 20
KDIR DOWN
DI CON 6.6
DJ CON 6.6
DK CON 6

REFINE 50 1 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 2 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 3 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 4 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 5 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 6 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 7 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 8 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 9 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 10 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 11 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 12 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 13 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 14 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 15 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 16 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 17 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 18 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 19 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
```

```
    REFINE 50 20 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332

REFINE 50 21 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 22 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 23 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 24 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 25 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 26 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 27 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 28 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 29 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 30 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 31 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 32 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 33 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 34 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 35 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 36 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 37 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 38 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 39 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 40 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 41 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 42 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 43 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 44 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 45 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 46 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 47 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 48 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 49 20 INTO 2 1 2 HYBRID  JDIR RW 0.29 alphai 3.37332 alpha 3.37332
REFINE 50 50 20 INTO 2 1 2 HYBRID  JDIR  RW 0.29 alphai 3.37332 alpha 3.37332
WELLBORE 0.292
  LAMINAR
  RANGE       50:50 1:50 20:20
**$ RESULTS PROP NULL  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
**$ 0 = NULL block, 1 = Active block
NULL CON 1.

**$ RESULTS PROP PINCHOUTARRAY  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
**$ 0 = PINCHED block, 1 = Active block
PINCHOUTARRAY CON 1.
RESULTS SECTION GRID
RESULTS SPEC 'Grid Thickness'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC 'Grid Thickness'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'Layer 1 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
```

```
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 2 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 3 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 4 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 5 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 6 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 7 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 8 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 9 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 10 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 11 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
```

```
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 12- Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 13 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 14 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 15 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 16 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 17 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 18 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 19 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC REGION 'Layer 20 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 6
RESULTS SPEC STOP
RESULTS PINCHOUT-VAL       0.0002 'cm'
RESULTS SECTION NETPAY
RESULTS SECTION NETGROSS
RESULTS SECTION POR
```

```
RESULTS SPEC 'Porosity'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 0.335
RESULTS SPEC STOP

**$ RESULTS PROP POR  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0.335  Maximum Value: 0.335
POR CON 0.335

RESULTS SECTION PERMS

RESULTS SPEC 'Permeability I'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 2000
RESULTS SPEC STOP
RESULTS SPEC 'Permeability J'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 2000
RESULTS SPEC STOP

RESULTS SPEC 'Permeability K'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'All Layers (Whole Grid)'
RESULTS SPEC REGIONTYPE 0
RESULTS SPEC LAYERNUMB 0
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 2000
RESULTS SPEC STOP

**$ RESULTS PROP PERMI  Units: md
**$ RESULTS PROP Minimum Value: 2000.  Maximum Value: 2000.
PERMI CON 2000.

**$ RESULTS PROP PERMJ  Units: md
**$ RESULTS PROP Minimum Value:  Maximum Value: 2000.
PERMJ CON 2000.
**$ RESULTS PROP PERMK  Units: md
**$ RESULTS PROP Minimum Value: 2000.  Maximum Value: 2000.
PERMK CON 2000.
```

```
RESULTS SECTION TRANS
RESULTS SECTION FRACS
RESULTS SECTION GRIDNONARRAYS
RESULTS SECTION VOLMOD
RESULTS SECTION VATYPE
RESULTS SECTION SECTORLEASE
RESULTS SECTION THTYPE
END-GRID

ROCKTYPE 1
  CPOR   60.e-6     **100.E-06
  ROCKCP 32.7
  THCONR 26.4
  thconw 0.406164
  thcono 0.00204
  HLOSST 128.
  HLOSSTDIFF 0.01
  HLOSSPROP OVERBUR 1. 1.
  UNDERBUR 1. 1.

RESULTS SECTION GRIDOTHER
RESULTS SECTION MODEL
*MODEL     2 2 2 1
*COMPNAME 'Water' 'Dead_Oil'
*KV1       0.E+00 0.E+00
*KV2       0.E+00 0.E+00
*KV3       0.E+00 0.E+00
*KV4       0.E+00 0.E+00
*KV5       0.E+00 0.E+00
*CMM        18. 460.
*PCRIT     0.0 0.0  **121.
*TCRIT     0.0 0.0  **1673.

*PRSR     14.7     ****  940.
*TEMR     128.     ****  140.
*PSURF    1.47E+1
*TSURF    6.0E+1
*MASSDEN   0.0  61.6280508
*CP       0.0  3.179E-6
*CT1      0.0  3.611E-4
*CT2      0.0E+0 0.0E+0

*VISCTABLE
63            0.   7600.
128           0.   635.
160           0.   351.74
163           0.   335.0431
190           0.    86.20
220           0.    66.29
250           0.    46.36
280           0.    26.42
```

```
310            0.    12.68
340            0.    11.42
370            0.    10.17
400            0.      8.91
430            0.     7.66
490            0.     5.15
520           0.     3.90
600          0.0    2.9
610          0.     2.3
750          0.0    2.3

RESULTS SECTION MODELARRAYS
RESULTS SECTION ROCKFLUID

*ROCKFLUID
*RPT 1 *WATWET *STONE2
*SWT
0.2000        0                    1.
0.22500.0015403080.891835072
0.25000.0031332560.794045481
0.27500.0048039250.705858353
0.30000.0065792860.626527513
0.32500.0084939040.55533373
0.35000.0105892090.491584968
0.37500.0129138560.43461666
0.40000.0155240710.383791992
0.42500.0184840060.338502208
0.45000.0218660760.298166943
0.47500.0257512920.262234567
0.50000.0302295840.230182569
0.52500.0354001220.201517969
0.55000.0413716280.175777767
0.57500.048262680.152529434
0.60000.0562020090.131371462
0.62500.0653288020.111933976
0.65000.075792980.093879427
0.67500.087755490.076903382
0.70000.1013885810.060735461
0.72500.1168760790.045140442
0.75000.134413660.029919641
0.77500.1542091140.014912685
0.80000.1764826090

*SLT  *NOSWC
0.45000.4341  0.000000000000
0.50000.3906  0.000160772291
0.55000.3472  0.001191402073
0.60000.3038  0.004573078512
0.65000.2604  0.013022555608
0.70000.2170  0.031013173505
0.75000.1736  0.065385197754
```

```
0.80000.1302 0.126045476498
0.85000.0868 0.226756415612
0.90000.0434 0.386014271775
0.95000.0000 0.628016763482
0.97000.0000 0.754667699411
1.00000.0000 1.00000000000

*RPT 2
*SWT
0.00000  0.000000   1.000000  0.000000
1.00000  1.00000    0.000000  0.000000

*SLT
0.000000  1.000000  0.000000  0.000000
1.000000  0.000000  1.000000  0.000000

RESULTS SECTION ROCKARRAYS

**$ RESULTS PROP KRTYPE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
KRTYPE CON 1.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 1 20 / 1 1 1  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 1 20 / 1 1 2  CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 2 20 / 1 1 1  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 2 20 / 1 1 2  CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 3 20 / 1 1 1  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 3 20 / 1 1 2  CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 4 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 4 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 5 20 / 1 1 1 CON 2.
```

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 5 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 6 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 6 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 7 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 7 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 8 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 8 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 9 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 9 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 10 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 10 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 11 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 11 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 12 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 12 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 13 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 13 20 / 1 1 2 CON 2.

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**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 14 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 14 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 15 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 15 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 16 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 16 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 17 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 17 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 18 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 18 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 19 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 19 20 / 1 1 2 CON 2.
*$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 20 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 20 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 21 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 21 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 22 20 / 1 1 1 CON 2.
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
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KRTYPE WELLBORE 50 22 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 23 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 23 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 24 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 24 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 25 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 25 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 26 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 26 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 27 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 27 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 28 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 28 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 29 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 29 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 30 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2

KRTYPE WELLBORE 50 30 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 31 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 31 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 32 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 32 20 / 1 1 2 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2

KRTYPE WELLBORE 50 33 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 34 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 35 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 36 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 37 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 37 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 38 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 38 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 39 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 39 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 40 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 41 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 41 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 42 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 42 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
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**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 43 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 44 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2 Maximum Value: 2
KRTYPE WELLBORE 50 44 20 / 1 1 2 CON 2.

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    **$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 45 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 45 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 46 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 46 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 47 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 47 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 48 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 48 20 / 1 1 2 CON 2.


**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 49 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 49 20 / 1 1 2 CON 2.

**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 50 20 / 1 1 1 CON 2.
**$ RESULTS PROP KRTYPE WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 2  Maximum Value: 2
KRTYPE WELLBORE 50 50 20 / 1 1 2 CON 2.

RESULTS SECTION INIT
*INITIAL
*VERTICAL *OFF
**$ Data for PVT Region 1
**$ -------------------------------------
*INITREGION 1
*REFDEPTH 2800
*REFPRES 11019.
**DWOC  4000.
```

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RESULTS SECTION INITARRAYS

**$ RESULTS PROP SW  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0.0  Maximum Value: 0.0
SW CON 0.2

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 1 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 1 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 2 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 2 20 / 1 1 2 CON 0.


**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 3 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 3 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 4 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 4 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 5 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 5 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 6 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 6 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 7 20 / 1 1 1 CON 0.
```

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	**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
	**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 7 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 8 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 8 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 9 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 9 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0


SW WELLBORE 50 10 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 10 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 11 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 11 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 12 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 12 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 13 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 13 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
SW WELLBORE 50 14 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0  Maximum Value: 0
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SW WELLBORE 50 14 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 15 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 15 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 16 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 16 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 17 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 17 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 18 20 / 1 1 1 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 18 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 19 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 19 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 20 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 20 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 21 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 21 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 22 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 22 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 23 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 23 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 24 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0

SW WELLBORE 50 24 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 25 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 25 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 26 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 26 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 27 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 27 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 28 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 28 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 29 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 29 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 30 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 30 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 31 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 31 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 32 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 32 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 33 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 33 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 34 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 34 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 35 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 35 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 36 20 / 1 1 1 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 36 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 37 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 37 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 38 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 38 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 39 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 39 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 40 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 40 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 41 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 41 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 42 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 42 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 43 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 43 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 44 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 44 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 45 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 45 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 46 20 / 1 1 1 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 46 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 47 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 47 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 48 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 48 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 49 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 49 20 / 1 1 2 CON 0.

**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 50 20 / 1 1 1 CON 0.
**$ RESULTS PROP SW WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0 Maximum Value: 0
SW WELLBORE 50 50 20 / 1 1 2 CON 0.

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    **$ RESULTS PROP SO  Units: Dimensionless
    **$ RESULTS PROP Minimum Value: 1.0  Maximum Value: 1.0

SO CON 0.8

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 1 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 1 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 2 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 2 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless


**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 3 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 3 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 4 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 4 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 5 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 5 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 6 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 6 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 7 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
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**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 7 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 8 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 8 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 9 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 9 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 10 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 10 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 11 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 11 20 / 1 1 1 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 12 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 12 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 13 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 13 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 14 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1

SO WELLBORE 50 14 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 15 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 15 20 / 1 1 1 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 16 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 16 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 17 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless

**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 17 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 18 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 18 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 19 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 19 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 20 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 21 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 21 20 / 1 1 2 CON 1.

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    **$ RESULTS PROP SO WELLBORE  Units: Dimensionless
    **$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 22 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 22 20 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 23 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 23 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 24 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 24 20 / 1 1 2 CON 1.



**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 25 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 25 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 26 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 26 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 27 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 27 20 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 28 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 28 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 29 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
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**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 29 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 30 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 30 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 31 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 31 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 32 20 / 1 1 1 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 32 20 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 33 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 33 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 34 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 34 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 35 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 35 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 36 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 36 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
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SO WELLBORE 50 37 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 37 20 / 1 1 2 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 38 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 38 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 39 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 39 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 40 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 40 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 41 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 41 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 42 20 / 1 1 1 CON 1
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 42 20 / 1 1 2 CON 1
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 43 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 43 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1 Maximum Value: 1
SO WELLBORE 50 44 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE Units: Dimensionless

```
    **$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
    SO WELLBORE 50 44 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 45 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 45 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 46 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 46 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 47 20 / 1 1 1 CON 1.


**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 47 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 48 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 48 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 49 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 49 20 / 1 1 2 CON 1.

**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 50 20 / 1 1 1 CON 1.
**$ RESULTS PROP SO WELLBORE  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 1  Maximum Value: 1
SO WELLBORE 50 50 20 / 1 1 2 CON 1.

RESULTS SECTION INITARRAYS

RESULTS SPEC 'Temperature'
RESULTS SPEC SPECNOTCALCVAL 0
RESULTS SPEC REGION 'Layer 1 - Whole layer'
RESULTS SPEC REGIONTYPE 1
```

```
    RESULTS SPEC LAYERNUMB 1
    RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140
RESULTS SPEC REGION 'Layer 2 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.   **140.
RESULTS SPEC REGION 'Layer 3 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 4 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 5 - Whole layer'
RESULTS SPEC REGIONTYPE 1


RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.0
RESULTS SPEC STOP
RESULTS SPEC REGION 'Layer 6 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140

RESULTS SPEC REGION 'Layer 7 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 1
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140
RESULTS SPEC REGION 'Layer 8 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 2
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.   **140.
RESULTS SPEC REGION 'Layer9 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 3
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 10 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 4
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.
RESULTS SPEC REGION 'Layer 11 - Whole layer'
```

```
        RESULTS SPEC REGIONTYPE 1
        RESULTS SPEC LAYERNUMB 5
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.    **140.0
RESULTS SPEC STOP
RESULTS SPEC REGION 'Layer 12 - Whole layer'
RESULTS SPEC REGIONTYPE 1
RESULTS SPEC LAYERNUMB 6
RESULTS SPEC PORTYPE 1
RESULTS SPEC CON 128.  **140


RESULTS SPEC STOP

**$ RESULTS PROP SO  Units: Dimensionless
**$ RESULTS PROP Minimum Value: 0.8  Maximum Value: 0.8
SO CON 0.8

**$ RESULTS PROP PRES  Units: psi
**$ RESULTS PROP Minimum Value: 700  Maximum Value: 700


PRES CON 1319  ** 940.

**$ RESULTS PROP TEMP  Units: F
**$ RESULTS PROP Minimum Value: 128  Maximum Value: 128
TEMP CON 128        **140.

RESULTS SECTION NUMERICAL
*NUMERICAL
*MAXSTEPS 2500
*DTMAX 90.
*ITERMAX 30
*NORM *PRESS 150.
** SATUR 0.1
     *TEMP 30.
*MAXPRES 1.450377E+05

RESULTS SECTION NUMARRAYS
RESULTS SECTION GBKEYWORDS
RUN

DATE 2003 01 01.
DTWELL 0.0005
WELL  1 'injector'
INJECTOR MOBWEIGHT 'injector'
TINJW 640
QUAL  0.80
INCOMP WATER  1.0 0.0
OPERATE MAX STW  1500. CONT
OPERATE MAX BHP  3000. CONT

GEOMETRY J 0.292 0.363 0.5 0.
```

```
        PERF GEO   'injector'
        ** i  j  k ff
50 1 20 / 1 1 1 / 1 1 1  1.

WELL  2 'producer'
PRODUCER 'producer'
OPERATE MAX STL 2500. CONT
OPERATE MIN BHP 230. CONT

GEOMETRY J 0.292 0.363 0.5 0.
PERF GEO   'producer'
** i  j  k ff
      50 1 20 / 1 1 1 / 1 1 1  1.

OPEN 'injector'
SHUTIN 'producer'
TIME 20
*OUTSRF *GRID *TEMP *SW *SO

SHUTIN 'injector'


TIME 30
*OUTSRF *GRID *TEMP *SW *SO

DTWELL 0.005
OPEN 'producer'
TIME 210
*OUTSRF *GRID *TEMP *SW *SO

OPEN 'injector'
SHUTIN 'producer'
TIME 230
*OUTSRF *GRID *TEMP *SW *SO

SHUTIN 'injector'
TIME 240
*OUTSRF *GRID *TEMP *SW *SO

DTWELL 0.005
OPEN 'producer'
TIME 420
*OUTSRF *GRID *TEMP *SW *SO

SHUTIN 'producer'
OPEN 'injector'
TIME 440
*OUTSRF *GRID *TEMP *SW *SO

SHUTIN 'injector'
TIME 450
*OUTSRF *GRID *TEMP *SW *SO
```

```
    DTWELL 0.005
    OPEN 'producer'
TIME 630
*OUTSRF *GRID *TEMP *SW *SO

STOP
***************************** TERMINATE SIMULATION *****************************

RESULTS SECTION WELLDATA
RESULTS SECTION PERFS
```

APPENDIX B

MODIFIED ANALYTICAL MODEL CODES: HORIZONTAL WELL AT MID – RESERVOIR HEIGHT AND AT RESERVOIR BASE

'Program MIDDLE.VBP – MIDFinalYZRR2.VBP

```
Attribute VB_Name = "Module1"
Public KROM, KRWM, KS
Public CYCLE, TINJT, TSOAKT, TPRODT, I, NN
Public QI, LT, TS, TR, ROS, ROW, CID, COD, IW
Public HS, POR, SOR, SWC
Public CPRF, CPO, MUS, MUOC
Public TA, PI
Public DT
Public LMDRES, ALPHRES, LMDTS, LMDBACK, COND, CHTKN

Sub INPUTDATA()
CYCLE = Val(Form7.Text1(0).Text)
KROM = Val(Form7.Text1(22).Text)
KRWM = Val(Form7.Text1(23).Text)

NN = CYCLE
ReDim TINJT(NN), TSOAKT(NN), TPRODT(NN)
For I = 1 To NN
TINJT(I) = Val(Form7.Text1(I).Text)
TSOAKT(I) = Val(Form7.Text1(I + 6).Text)
TPRODT(I) = Val(Form7.Text1(I + 12).Text)
Next I

QI = Val(Form1.Text1(0).Text)
LT = Val(Form1.Text1(1).Text)
TS = Val(Form1.Text1(2).Text)
TR = Val(Form1.Text1(3).Text)
ROS = Val(Form1.Text1(4).Text)
```

```
        ROW = Val(Form1.Text1(5).Text)
        CID = Val(Form1.Text1(6).Text)
COD = Val(Form1.Text1(7).Text)

'TINJ = Val(Form1.Text1(8).Text)
HS = Val(Form1.Text1(9).Text)
POR = Val(Form1.Text1(10).Text)
SOR = Val(Form1.Text1(11).Text)
SWC = Val(Form1.Text1(12).Text)

CPRF = Val(Form1.Text1(13).Text)
CPO = Val(Form1.Text1(14).Text)
MUOC = Val(Form1.Text1(15).Text)
MUS = Val(Form1.Text1(16).Text)

DT = Val(Form1.Text1(17).Text)
'Ambient Temperature, oF'
TA = 63
KS = Val(Form7.Text1(19).Text)

' ****************** C O N S T A N T S *******************************
PI = 3.14159
'Heat Conduction Area Constant, CACON'
COND = Val(Form1.Text1(21).Text)
'Heat Taken Constant, CHTKN'
CHTKN = Val(Form1.Text1(24).Text)
'Heat conductivity reservoir,LMDRES,Btu/sec-cm-oF  2.2 btu/hr-ft-oF'
'Heat diffusivity reservoir, ALPHRES,cm^2/sec'
'Heat conductivity to side,  LMDTS,Btu/sec-cm-oF'
'Heat conductivity to back,  LMDBACK,Btu/sec-cm-oF'
'Heat conduction constant to back, LMDBACK, BTU/cm^2-sec ***(=(TS-TA)/((L/lambda))

LMDRES = 0.00002
```

```
        ALPHRES = 0.01
        LMDTS = 0.00000550642
LMDBACK = 0.0000035429
'Heat capacity tubing,    CPTUB,Btu/gr-oF'
'Heat Conductivity tubing,LMDTUB,Btu/sec-cm-oF'
'Density tubing,          ROTUB,gr/cc'
'Heat diffusivity tubing, ALPHTUB,cm^2/sec'
'Tubing length,           LTUB,cm'
CPTUB = 0.000249
LMDTUB = 0.000182
ROTUB = 7.80112
ALPHTUB = 0.0961
LTUB = 10#

'ALUMINUM'
'Heat Conductivity,LMDAL,Btu/sec-cm-oF'
'Heat diffusivity, ALPHAL,cm^2/sec'
'Length,          LAL,cm'

LMDAL = 0.001086
ALPHAL = 0.9458
LAL = 0.635
End Sub

Attribute VB_Name = "Module2"
Public VR, TETAR
Public Sub VRCALC()
TETAR = ALPHRES * SIT / (RAVRG ^ 2)
If TETAR >= 0.02 And TETAR <= 0.025 Then
VR = 0.92 + (((TETAR - 0.025) / 0.005) * (-0.03))
GoTo 10
End If
If TETAR < 0.02 Then
```

```
        VR = 0.95 + (((TETAR - 0.02) / 0.02) * (-0.05))
        GoTo 10
End If
SK = 0.25
SK2 = 0#
For K = 1 To 300
SK2 = SK2 + SK
SK1 = ((-1 / TETAR) * (K + 1.5) / ((2 + K) * (3 + K))) * SK
SK = SK1
Next K
VR = (1 / TETAR) * SK2
10
End Sub

Attribute VB_Name = "Module3"
Public VZ, TETAZ, HBAR
Public Sub VZCALC()
'** Heat injected 2 times actual **
Z1 = 2 * IW * HS * TINJT(KK)
Z2 = PI * RAVRG ^ 2 * CPRF * (TS - TR)
ZZ = Z1 / Z2 - LTOT
'  HBAR = ZZ + LAVRG
HBAR = ZZ + LTOT
X1 = 4 * ALPHRES * (SIT)
X2 = (X1 / (PI * HBAR ^ 2)) ^ 0.5
X3 = Exp(-HBAR ^ 2 / X1)
'ERROR FUNCTION CALCULATIONS - from Abramowitz & Stegun'
'Y = ERF(HBAR/(X1^0.5)'
A1 = 0.0705230784
A2 = 0.0422820123
A3 = 0.0092705272
A4 = 0.0001520143
A5 = 0.0002765672
```

```
        A6 = 0.0000430638
        X = HBAR / (X1 ^ 0.5)
 Y1 = (1 + A1 * X + A2 * X ^ 2 + A3 * X ^ 3 + A4 * X ^ 4 + A5 * X ^ 5 + A6 * X ^ 6) ^ 16
Y = 1 - (1 / Y1) + 0.0000003
VZ = Y - X2 * (1 - X3)
TETAZ = ALPHRES * SIT / (HBAR / 2)
End Sub

Attribute VB_Name = "Module4"
Public L, RT, RTO

Sub CHANGEUNIT()
'Injection Rate,         QI cc/min to cc/sec'
'Wellbore Length,         L  inch   to cm'
'Steam Density,           ROS lb/cuft to lb/cc'
'Water Density,           ROW lb/cuft to lb/cc'
'ID Casing,               CID inch    to cm'
'OD Casing,               CID inch    to cm'
'Heat Capacity Reservoir, CPRF btu/cuft-oF to btu/cc-oF'
'Heat Conductivity Oil,   CPO btu/cuft-oF to btu/cc-oF'
 QI = QI / 60#
 L = LT * 2.54
 ROS = ROS / (30.48 ^ 3#)
 ROW = ROW / (30.48 ^ 3#)
 CID = CID * 2.54
 COD = COD * 2.54
 CPRF = CPRF / (30.48 ^ 3)
 CPO = CPO / (30.48 ^ 3)
'Heat Conductivity Teflon, LMDT, BTU/hr ft oF to BTU/sec cm oF'
 LMDT = 0.1333
 LMDT = LMDT / (3600 * 30.48)
'  *** VARIABLES CALCULATIONS ****
'TUBING RADIUS,           RT, CM
```

```
        'TUBING SEGMENT LENGTH,     DL, CM
        'Tubing Area,               ATUB, cm^2
'TEMP AVERAGE,              TAVG, oF
'MASS INJECTION RATE,       IW, LB/SEC
RT = CID / 2
RTO = COD / 2
ATUB = PI * (RTO ^ 2 - RT ^ 2)
IW = QI * ROW
'Form2.Show
'Form2.Print RT, RTO, TAVG, IW
End Sub

Attribute VB_Name = "Module5"
Public TSIPS, VWIPS
Public THINJSEGT, THCOND, THCVRES, TOTHTKN
Public N
Public DL, RH, QS, LTOT
Sub STEAMZONE()
'********* INITIALIZATIONS **************
' ******** Number of Segment, N ************
 N = Int(TINJ / DT)
ReDim RH(N, N), QS(N), DL(N)
ReDim THINJSEGT(N), THCOND(N), THCVRES(N), TOTHTKN(N)
ReDim TSIPS(N), VWIPS(N)
For I = 1 To N
TSIPS(I) = 0
Next I
TTOT = 0
LTOT = 0
THINJTOT = 0
THCCAP = 0
THINJMOD = 0
THCBACK = 0
```

```
        THCSIDE = 0
        THCRES = 0
FACR = (DT ^ 0.5)

For K = 2 To N
For I = 1 To K - 1
RH(K, I) = RT
Next I
Next K
CCONV = CPRF * (TS - TR)
CCONDR = 2 * LMDRES * (TS - TR) * (DT ^ 0.5) / ((PI * ALPHRES) ^ 0.5)
CCONDB = LMDBACK * DT
CCONDS = LMDTS * DT

' Condition of NO CONDUCTIONS
If COND = 0 Then
CCONDR = 0
CCONDB = 0
CCONDS = 0
End If
For I = 1 To N
TTOT = TTOT + DT
If KK > 1 Then
If O >= I Then
HREM = HR(I) / ((O - I) + 1)
Else
HREM = 0
End If
End If
If I = 1 Then
ROS2 = ROS
HS2 = HS
If KK > 1 Then
```

```
    'Change in Bambang Model, Relative permeability End point
    'from Honarpour  correlations, Krg=0.4341

DLL1 = (IW * HS2 * DT) - (IW * HS2 * DT / (1 + MUS / MUO * 0.4341))
Else
DLL1 = (IW * HS2 * DT) - (IW * HS2 * DT / (1 + MUS / MUO * 0.4341))
TRW = TR
End If
DLL2 = PI * RT ^ 2 * (ROS2 * HS2 + CPO * (TS - TRW) - (ROS2 * HS2) / (1 + MUS / MUO * 0.4341))
DL(I) = DLL1 / DLL2
LTOT = LTOT + DL(I)
QSI = ((IW / ROS2) - (PI * RT ^ 2 * DL(I) / DT)) / (1 + MUS / MUO * 0.4341)
CHIN = ROS2 * HS2 * DT * QSI
GoTo 150
Else

ROS2 = ROS
HS2 = HS
End If
If KK > 1 And O >= I Then
' TRW = TAVG(I)
'Else
TRW = TR
End If
LL1 = (IW * HS2 * DT) - QSI * ROS2 * HS2 * DT
LL2 = PI * RT ^ 2 * (ROS2 * HS2 + CPO * (TS - TRW))
DL(I) = LL1 / LL2
' Form2.Print I, RT, ROS2, HS2, CPO
 LTOT = LTOT + DL(I)
 QS(I) = (DL(I) / LTOT) * QSI
150  For K = I To 1 Step -1
THCBACK = 0
THCSIDE = 0
```

```
        THCRES = 0
        If KK > 1 Then
If O >= I Then
HREM = HR(K) / ((O - K) + 1)
Else
HREM = 0
End If
End If

If K = I Then
RX = RT
RY = RT
Else
RX = RH(K + 1, I)
RY = RH(K, I - 1)
End If

If K = 1 And I = 1 Then
A1 = 0.5 * PI * DL(1) * CCONV
A2 = COND * (0.5 * PI) * CCONDB
A3 = FACR * COND * (0.5 * PI) * CCONDR
A = A1 + A2 + A3
B = COND * 2 * DL(1) * CCONDS
C1 = -0.5 * PI * RT ^ 2 * DL(1) * CCONV
C2 = -COND * (0.5 * PI) * RT ^ 2 * CCONDB
C3 = -FACR * COND * (0.5 * PI) * RT ^ 2 * CCONDR
C4 = -(DL(1) / LTOT) * CHIN - HREM
C5 = 0
C = C1 + C2 + C3 + C4 + C5
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
THINJSEG = (DL(1) / LTOT) * QSI * ROS2 * HS2 * DT
HCVRES = 0.5 * PI * (RRI ^ 2 - RT ^ 2) * DL(1) * CCONV
HCBACK = COND * (0.5 * PI) * (RRI ^ 2 - RT ^ 2) * CCONDB
```

```
        HCSIDE = COND * 2 * RRI * DL(1) * CCONDS
        HCRES = FACR * COND * (0.5 * PI) * (RRI ^ 2 - RT ^ 2) * CCONDR
THINJSEGT(K) = THINJSEGT(K) + THINJSEG
THCVRES(K) = THCVRES(K) + HCVRES
THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
' Heat Balance
' THINJSEG = HCVRES + HCBACK + HCRES + HCSIDE
GoTo 100
End If
If K = 1 Then
A1 = (0.5) * PI * DL(1) * CCONV
A2 = COND * (0.5 * PI) * CCONDB
A3 = FACR * COND * (0.5 * PI) * CCONDR
A = A1 + A2 + A3
B = COND * 2 * DL(1) * CCONDS
C1 = -(0.5) * PI * RH(K, I - 1) ^ 2 * DL(1) * CCONV
C2A = -COND * (0.5 * PI) * RH(K, I - 1) ^ 2 * CCONDB
C2B = 0.5 * PI * (RH(K, I - 1) ^ 2 - RT ^ 2) * CCONDB
C2 = C2A + C2B
C3A = -FACR * COND * (0.5 * PI) * RH(K + 1, I) ^ 2 * CCONDR
C3B = FACR * COND * (1 - CHTKN) * (0.5 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
C3B = 0
End If
C3 = C3A + C3B
C4 = -(DL(1) / LTOT) * CHIN - HREM
C5 = 0
C6A = -COND * 2 * (RH(K, I - 1)) * DL(1) * CCONDS
 C6B = 2 * (RH(K, I - 1)) * DL(1) * CCONDS
 C6 = C6A + C6B
C = C1 + C2 + C3 + C4 + C5 + C6
```

```
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
THINJSEG = (DL(1) / LTOT) * QSI * ROS2 * HS2 * DT
HCVRES = (0.5) * PI * (RRI ^ 2 - RH(K, I - 1) ^ 2) * DL(1) * CCONV
HCBACK1 = COND * (0.5 * PI) * (RRI ^ 2 - RH(K, I - 1) ^ 2) * CCONDB
HCBACK2 = 0.5 * PI * (RH(K, I - 1) ^ 2 - RT ^ 2) * CCONDB
HCBACK = HCBACK1 + HCBACK2
HCSIDE1 = COND * 2 * (RRI - RH(K, I - 1)) * DL(1) * CCONDS
HCSIDE2 = 2 * (RH(K, I - 1)) * DL(1) * CCONDS
HCSIDE = HCSIDE1 + HCSIDE2
HCRES1 = FACR * COND * (0.5 * PI) * (RRI ^ 2 - RH(K + 1, I) ^ 2) * CCONDR
HCRES2 = FACR * COND * (1 - CHTKN) * (0.5 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
HCRES2 = 0
End If
HCRES = HCRES1 + HCRES2
THINJSEGT(K) = THINJSEGT(K) + THINJSEG
THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
THCVRES(K) = THCVRES(K) + HCVRES
TOTHTKN(K) = 0

TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
GoTo 100
End If
If K = I Then
Z = 0
A1 = 0.5 * PI * DL(K) * CCONV
A2 = 0
A3 = FACR * COND * (0.5 * PI) * CCONDR
A4 = -FACR * CHTKN * COND * (0.5 * PI) * CCONDR
B = COND * 2 * DL(K) * CCONDS
C1 = -0.5 * PI * (RT ^ 2) * DL(K) * CCONV
C2 = 0!
```

```
        C3A = -FACR * COND * (0.5 * PI) * RT ^ 2 * CCONDR
        C3B = FACR * CHTKN * COND * (0.5 * PI) * RT ^ 2 * CCONDR
' C3 = C3A + C3B
 C4 = -(DL(K) / LTOT) * CHIN - HREM
 510     A = A1 + A2 + A3 + A4
C = C1 + C2 + C3A + C3B + C4
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
 RX = RRI
 If Z = 1 Then GoTo 520
 If RRI > RH(K - 1, I - 1) Then
 Z = 1
 RX = RH(K - 1, I - 1)
 A4 = 0
 C3B = -FACR * CHTKN * COND * (0.5 * PI) * (RX ^ 2 - RT ^ 2) * CCONDR
 GoTo 510
 End If
' THINJSEG=HCVRES+HCBACK+HCSIDE+HCRES-THTKN'
520     THINJSEG = (DL(K) / LTOT) * CHIN
THTKN = FACR * CHTKN * COND * (0.5 * PI) * (RX ^ 2 - RT ^ 2) * CCONDR
HCVRES = 0.5 * PI * (RRI ^ 2 - RT ^ 2) * DL(K) * CCONV
HCBACK = 0
HCSIDE = COND * 2 * RRI * DL(K) * CCONDS
HCRES = FACR * COND * (0.5 * PI) * (RRI ^ 2 - RT ^ 2) * CCONDR

 THINJSEGT(K) = THINJSEGT(K) + THINJSEG + THTKN
 THCVRES(K) = THCVRES(K) + HCVRES
 THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
TOTHTKN(K) = TOTHTKN(K) + THTKN
 TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
GoTo 100
Else
Z = 0
A1 = (0.5) * PI * DL(K) * CCONV
```

```
        A2 = 0
        A3 = FACR * COND * (0.5 * PI) * CCONDR
 A4 = -FACR * CHTKN * COND * (0.5 * PI) * CCONDR
 B = COND * 2 * DL(K) * CCONDS
C1 = -(0.5) * PI * (RH(K, I - 1) ^ 2) * DL(K) * CCONV
C2 = 0!
C3A = -FACR * COND * (0.5 * PI) * RH(K + 1, I) ^ 2 * CCONDR
C3B = FACR * CHTKN * COND * (0.5 * PI) * RH(K, I - 1) ^ 2 * CCONDR
C3C = FACR * COND * (1 - CHTKN) * (0.5 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
C3C = 0
End If
C3 = C3A + C3B + C3C
C4 = -(DL(K) / LTOT) * CHIN - HREM
C6A = -COND * 2 * RH(K, I - 1) * DL(K) * CCONDS
C6B = 2 * RH(K, I - 1) * DL(K) * CCONDS
C6 = C6A + C6B
610     A = A1 + A2 + A3 + A4
C = C1 + C2 + C3 + C4 + C6
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
If Z = 1 Then
GoTo 620
End If

RX = RRI
If RRI > RH(K - 1, I - 1) Then
Z = 1
RX = RH(K - 1, I - 1)
A4 = 0
C3B = -FACR * CHTKN * COND * (0.5 * PI) * (RX ^ 2 - RH(K, I - 1) ^ 2) * CCONDR
GoTo 610
End If
```

```
620     THINJSEG = (DL(K) / LTOT) * QSI * ROS2 * HS2 * DT
THTKN = FACR * CHTKN * COND * (0.5 * PI) * (RX ^ 2 - RH(K, I - 1) ^ 2) * CCONDR
HCVRES = (0.5) * PI * (RRI ^ 2 - RH(K, I - 1) ^ 2) * DL(K) * CCONV
HCBACK = 0
HCRES1 = FACR * COND * (0.5 * PI) * (RRI ^ 2 - RH(K + 1, I) ^ 2) * CCONDR
HCRES2 = FACR * COND * (1 - CHTKN) * (0.5 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
HCRES2 = 0
End If
HCRES = HCRES1 + HCRES2
HCSIDE1 = COND * 2 * (RRI - RH(K, I - 1)) * DL(K) * CCONDS
HCSIDE2 = 2 * RH(K, I - 1) * DL(K) * CCONDS
HCSIDE = HCSIDE1 + HCSIDE2
THINJSEGT(K) = THINJSEGT(K) + THINJSEG + THTKN
THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
THCVRES(K) = THCVRES(K) + HCVRES
TOTHTKN(K) = TOTHTKN(K) + THTKN
End If
TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
100     RH(K, I) = 1 * RRI
If I = N Then
VWIPS(K) = TSIPS(K) * ROS / ROW
TVWI = TVWI + VWIPS(K)
'Form2.Print I, K, RH(K, I), LTOT, Y
Form3.MSFlexGrid1.Col = 0
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = I
Form3.MSFlexGrid1.Col = 1
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = K
Form3.MSFlexGrid1.Col = 2
Form3.MSFlexGrid1.ROW = N - K + 1
```

```
        Form3.MSFlexGrid1.Text = Round(RH(K, I), 6)
        Form3.MSFlexGrid1.Col = 3
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(LTOT, 4)
Form3.MSFlexGrid1.Col = 4
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(THINJSEGT(K), 3)
Form3.MSFlexGrid1.Col = 5
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(THCVRES(K), 3)
Form3.MSFlexGrid1.Col = 6
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(THCOND(K), 3)
Form3.MSFlexGrid1.Col = 7
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(VWIPS(K), 3)
THINJTOT = IW * DT * HS2
Print #1, I, K, DL(K), RH(K, I), THINJTOT, THINJSEGT(K), THCVRES(K), THCOND(K), LL1, LL2,
IW, HS2, MUS, MUO, TS, TRW, QSI
End If
Next K
10
Next I
'Call Module14.SWINITIAL
10000
End Sub

Attribute VB_Name = "Module6"
Public TINJ, SIT, TPROD, KK, O, COUNTO

Sub MAINCALC()
'*****OPEN OUTPUT FILES*****'
FOUT1$ = Form1.Text1(22).Text
```

```
        FOUT2$ = Form1.Text1(23).Text
        Open FOUT1$ For Append As #1
Open FOUT2$ For Append As #2
Form1.Hide
Form3.Show
Call Form1.HEADER
For KK = 1 To CYCLE
Form3.Text1.Text = KK
TINJ = TINJT(KK)
SIT = TSOAKT(KK)
TPROD = TPRODT(KK)
COUNTO = 1
Call Module8.OILPROP
Call Module5.STEAMZONE
'GoTo 807
Call Module13.LAVG
Call Module7.SOAK
COUNTO = 0
Call Module8.OILPROP
Call Module11.WATERVISC
Call Module14.SWINITIAL
Form4.Show
Call Form1.GRAPH
Call Module9.PROD
Call Module10.REMAINING
O = N
807   Next KK
Close #1

Attribute VB_Name = "Module7"
Public TAVRG, ZZ
Sub SOAK()
STTOT = 0
```

```
    Call Module2.VRCALC
    Call Module3.VZCALC
TAVRG = TR + (TS - TR) * (VR * VZ)
Call Module19.TCOLDZONE
Form11.Print TAVRG
GoTo 808
'Next I
Form5.Hide
'Form6.Show
'Form6.Scale (-1, 200)-(13, -10)
'Form6.Line (0, 0)-(12.77, 0)
'Form6.Line (0, 200)-(0, 0)
'X = 0#
'For I = 1 To N
'X = X + DL(I)
'Y = TAVRG(I)
'Form4.Print X, Y
'Form6.PSet (X, Y)
'Next I
808
End Sub

Attribute VB_Name = "Module8"
Public MUOcal(1 To 15) As Double, TW As Double, TOILcal(1 To 15) As Double, MUO As Double
Public TOIL As Double
Sub OILPROP()
If COUNTO = 1 Then
TOIL = TS
Else
TOIL = TAVRG
End If
If COUNTO = 3 Then
'TOIL = (TR + (TAVRG - TR) / 2)
```

```
        TOIL = TCZ
        TW = TOIL
End If
TOILcal(1) = 63#
TOILcal(2) = 128#
TOILcal(3) = 160#
TOILcal(4) = 190#
TOILcal(5) = 220#
TOILcal(6) = 250#
TOILcal(7) = 280#
TOILcal(8) = 310#
TOILcal(9) = 340#
TOILcal(10) = 370#
TOILcal(11) = 400#
TOILcal(12) = 430#
TOILcal(13) = 460#
TOILcal(14) = 490#
TOILcal(15) = 520#

MUOcal(1) = 7600#
MUOcal(2) = 635#
MUOcal(3) = 351.74
MUOcal(4) = 86.2
MUOcal(5) = 66.29
MUOcal(6) = 46.36
MUOcal(7) = 26.42
MUOcal(8) = 12.68
MUOcal(9) = 11.42
MUOcal(10) = 10.17
MUOcal(11) = 8.91
MUOcal(12) = 7.66
MUOcal(13) = 6.41
MUOcal(14) = 5.15
```

```
MUOcal(15) = 3.9
MUO = Interpol(15, TOILcal, MUOcal, TOIL)
End Sub
Function Interpol(np As Integer, x_Prop() As Double, y_Prop() As Double, x_XX As Double)
Dim u As Integer, check As Boolean, x1 As Double, x2 As Double, y1 As Double, y2 As Double
'Extrapolation for values < Min.
If x_XX < x_Prop(1) Then
Interpol = y_Prop(1) + (x_XX - x_Prop(1)) * (y_Prop(2) - y_Prop(1)) / (x_Prop(2) - x_Prop(1))
End If
'Extrapolation for values > Max.
If x_XX > x_Prop(np) Then
Interpol = y_Prop(np - 1) + (x_XX - x_Prop(np - 1)) * (y_Prop(np) - y_Prop(np - 1)) / (x_Prop(np) -
x_Prop(np - 1))
End If
'Interpolation for values within the range of the property table
If x_XX >= x_Prop(1) And x_XX <= x_Prop(np) Then
u = 1
check = False      'boolean to check for the condition
 Do
If x_XX >= x_Prop(u) And x_XX <= x_Prop(u + 1) Then
check = True
 x1 = x_Prop(u)
 x2 = x_Prop(u + 1)
 y1 = y_Prop(u)
 y2 = y_Prop(u + 1)
 End If
u = u + 1
Loop Until check = True
Interpol = y1 + (x_XX - x1) * (y2 - y1) / (x2 - x1)
End If
End Function

Attribute VB_Name = "Module9"
```

```
        Public TOTOILPROD, TOTQOH
        Public TCOLD
Public HFCZT, HFCZ
Public J, DTP
Public TOIL, THF, TQWH, TQOH, COUNT, TOTQW, JCS2, VWIREM, RW, PR, DV1, Soi, Swi, Cw,
Co, JCW, JCW2
Sub PROD()
ReDim TQO(N)
ReDim TQW(N)
'CPW=1 BTU/LB-oF .......PRATTS, pg.224, FIG.B-64'
'ROW*CPW = 62.4 BTU/CUFT-oF = 0.0022036 BTU/CC-oF'
CPW = 0.0022036
MUWC = 1.0825
PR = Val(Form7.Text1(20).Text)
PW = Val(Form7.Text1(21).Text)
'Interval production time, 1 sec.
 DTP = 1
'*** INITIALIZATION ****
TOTQO = 0
TOTQOH = 0
TOTQW = 0
HFCZT = 0
 '*** SW = SW initial ****
COUNT = 1
THF = 0
SWW = SWIN
' Changes in original Bambang Model
' Bachaquero Compresibility, Co=10.14e-6

 Cw = 3 * 10 ^ -6
 Co = 10.14 * 10 ^ -6
 Cg = 0.2
 'Cg = 1 / PR
```

```
        Soi = 0.798
        Swi = 0.199
 Sgi = 0.002758
 CT = Swi * Cw + Soi * Co + Sgi * Cg

' End of the modification
 ' Bambang original
 'Cw = 3 * 10 ^ -6
 'CG = 1 / PR
 'CT = 0.965 * Cw + 0.035 * CG
 DV = QI * TINJ
 V = (500 * (2.54 ^ 3)) * POR
 DP = DV / (V * CT)
PR1 = PR + DP
JJ = TPROD / DTP
RE = 6.35
For J = 1 To JJ
RW = RTO
COUNTO = 0
TOIL = TAVRG
Call Module8.OILPROP
MUOH = MUO
Call Module11.WATERVISC
Call Module15.KROKRW
C1A = Log(RAVRG / RW)
C1B = Log(RE / RW)
C1 = C1A / C1B
C2A = Log(RE / RAVRG)
C2B = Log(RE / RW)
C2 = C2A / C2B
JBAR = 1 / ((MUOH / MUOC) * C1 + C2)
Call Module12.JCOLD
' QOH1 = (JBAR * JCS * (PR1 - PW) / 14.7)
```

```
    ‘ Change in Bambang model
    QOH1 = (JBAR * JCS * KRO * (PR1 - PW) / 14.7)
COUNTO = 3
Call Module8.OILPROP
 MUOW = MUO
' Change in Bambang Model

JCS2 = JCS * ((L - LTOT) / LTOT) * (MUOC / MUOW)
'JCS2 = JCS * ((L - LTOT) / L) * (MUOC / MUOW)
QOC = JCS2 * ((PR1 - PW) / 14.7)
 ' QOH = (QOH1 + QOC)
'QOC = 2 * PI * (L - LTOT) * KS * KROM * ((PR1 - PW) / 14.7) / (MUOW * Log(RE / RW))
QOH = (QOH1 + QOC) * 0.5
COUNTO = 0
If KRO = 0 Then
JBAR = 0
RWO = 0
GoTo 4
End If
4     TQOH = QOH * DTP
TOTQO = TOTQO + TQOH
' Bambang original
TOTQOH = TOTQOH + QOH1 * 0.5
'Changes in Bambang Model
'QW1 = 2 * PI * LTOT * KS * KRWQW * (PR1 - PW) / 14.7
'QW2 = MUW * Log(RAVRG / RW) + MUWC * Log(RE / RAVRG)
'QW = (QW1 / QW2)
'QW = (QW1 / QW2) * 0.5
'JCW = JCS * (KRWM / MUWC) * (MUOC / KROM)
JCW = JCS * (1 / MUWC) * (MUOC / 1)
JCW2 = JCW * (MUWC / MUW)
'JCW2 = JCW * (MUWC / MUW) * (KRWQW / KRWM)
QW = 0.5 * (LTOT / L) * JCW2 * ((PR1 - PW) / 14.7)
```

```
        'JCW2 = JCW * (MUWC / MUW) * (KRWQW / KRWM)
        'QW = JCW2 * ((PR1 - PW) / 14.7)
'End modification
TQWH = QW * DTP
TOTQW = TOTQW1 + TQWH
If TOTQW > 1 * VWI Then
TQWH = 1 * VWI - TOTQW1
QW = TQWH / DTP
TOTQW = TOTQW1 + TQWH
End If
TOTQW1 = TOTQW
'Heat loss by fluid produced'
HF = ((QOH1 * CPO + 2 * QW * CPW) * (TAVRG - TR)) * DTP
THF = THF + HF
'Calculate Temp. Cold zone
HFCZ = QOC * 0.5 * CPO * (TCZ - TR) * DTP
HFCZT = HFCZT + HFCZ
Call Module20.TCOLDZPROD
TCZ = TCZP
Form9.Show
If J = JJ Then
Form9.Print J, TAVRG, TOTQO, TOTQW, KRW, KRO, MUO, MUW, JBAR
End If
' Print #2, J, TAVRG, TOTQO, TOTQW, SWX, KRW, KRO, QOH, QW, RWO, JBAR, JCS, PR1, TCZ,
HFCZT, HFCZ, RAVRG, LTOT
' Changes BB original model
Print #2, J, TAVRG, TOTQO, TOTQW, SWX, KRW, KRO, QOH, QW, JBAR, JCS, PR1, TCZ,
RAVRG, LTOT, MUO, MUW, RW, RE, C1, C2, QOH1, MUOH, MUOC, VMOISZ1, VMWIC
'End of changes
'   Print #2, J, TAVRG, TOTQO, TOTQW, TETAR, VR, TETAZ, VZ, SIT
Call Module16.TAVGPROD
TAVRG = TAVRG1
'Sw calculation for next time step production'
```

```
        Call Module17.SWCAL
        COUNT = 0
DV1 = QI * TINJ - (TOTQW + TOTQO)
Call Module18.PRCALC
Next J
PR = PR1
TCOLD = TCZ
VWIREM = 0 * (VWI - TOTQW)
 If VWIREM < 0 Then
 VWIREM = 0
 End If

 TOTOILPROD = TOTOILPROD + TOTQOH
End Sub
Attribute VB_Name = "Module10"
Public HR
Sub REMAINING()
ReDim HR(N)
HRTOT = 0
For I = 1 To N
HR(I) = 0.5 * PI * (RAVRG ^ 2) * DL(I) * CPRF * (TAVRG - TR)
HRTOT = HRTOT + HR(I)
'  Print #1, I, TAVRG, HR(I), HRTOT
Next I
End Sub

Attribute VB_Name = "Module11"
Public MUW
Sub WATERVISC()
TW = TAVRG
If 60 <= TW And TW < 80 Then
MUW = (TW - 60) * (0.88 - 1.15) / 20 + 1.15
GoTo 71
```

```
        End If
        If 80 <= TW And TW < 100 Then
MUW = (TW - 80) * (0.68 - 0.88) / 20 + 0.88
GoTo 71
End If
If 100 <= TW And TW < 120 Then
MUW = (TW - 100) * (0.57 - 0.68) / 20 + 0.68
GoTo 71
End If
If 120 <= TW And TW < 140 Then
MUW = (TW - 120) * (0.45 - 0.57) / 20 + 0.57
GoTo 71
End If
If 140 <= TW And TW < 160 Then
MUW = (TW - 140) * (0.39 - 0.45) / 20 + 0.45
GoTo 71
End If
If 160 <= TW And TW < 180 Then
MUW = (TW - 160) * (0.35 - 0.39) / 20 + 0.39
GoTo 71
End If
If 180 <= TW And TW < 200 Then
MUW = (TW - 180) * (0.3 - 0.35) / 20 + 0.35
End If
71
End Sub

Attribute VB_Name = "Module12"
Public JCS, JCSW, MUWC
Sub JCOLD()
'Change in Bambang Model
MUWC = 1.0825
MUWC = 0.8
```

```
        'End change
        COUNTO = 3
Call Module8.OILPROP
MUOW = MUO
KS = Val(Form7.Text1(19).Text)
'Change in Bambang Model
 'JCS = 2 * PI * KS * KRO * LTOT / (MUOC * Log(RE / RW))
 JCS = 0.007816
 'Cold Productivity index according Economides- Joshi equation and also simulation results (cc/sec)/atm
 'End of change
  COUNTO = 0
End Sub

Attribute VB_Name = "Module13"
Public RAVRG
Sub LAVG()
TAREAR = 0
TOTVOL = 0
AREAV = 0.5 * PI * (RH(1, N)) ^ 2
For I = 1 To N
AREAR = PI * RH(I, N) * DL(I)
TAREAR = TAREAR + AREAR
VTOT = 0.5 * PI * RH(I, N) ^ 2 * DL(I)
TOTVOL = TOTVOL + VTOT
Next I
RAVG = TAREAR / (PI * LTOT)
RAVRG = (TOTVOL / (0.5 * PI * LTOT)) ^ 0.5
VAVRG = PI * RAVRG ^ 2 * LTOT * 0.5
Form11.Show
End Sub

Attribute VB_Name = "Module14"
Public SWQW, KRWQW, VMWIC, VMOISZ1, RE
```

```
    Public SWIN, VPOR, VWINT1, VWI, VWIS, VWINJC1
    Sub SWINITIAL()
Form2.Show
VWINT1 = 0
VWINJC1 = 0
VWI = 0
 '*** CALCULATE TOTAL WATER INJECTED,VWI @ CYCLE ***
For I = 1 To N
VWI = VWI + VWIPS(I)
Next I
' *** TOTAL WTR INJCTD = WTR INJCTD @ CYCLE + WTR INJCTD REMAINING ***
If KK > 1 Then
VWI = VWI + VWIREM
End If
RE = 6.35
'If KK > 3 Then
' RE = RAVRG
'End If
If KK > 1 And TINJ < 100 Then
RE = RAVRG
 End If
VBULK = 0.5 * PI * RE ^ 2 * LTOT
VPOR = VBULK * POR
VS = VBULK * POR * (1 - 0.2 - 0.2)
SE = 0.01
' SE = 0.05
'VOL MOVEABLE WATER IN THE CHANNEL=VMWIC
VMWIC = SE * (1 - SOR - SWC) * VPOR
'WATER SATURATION FOR WTR PROD'
SWQW = SWC + VMWIC / VPOR
If KK = 1 Then
SWIN = SWQW
COUNT = 1
```

```
        Call Module15.KROKRW
        KRWQW = KRW
VMOISZ1 = (1 - SWC - SOR) * VPOR - VMWIC
Else
VMOISZ1 = (1 - SWC - SOR) * VPOR - VMWIC - TOTOILPROD
VMWISZ1 = (1 - SWC - SOR) * VPOR - VMOISZ1
SWIN = SWC + VMWISZ1 / VPOR
End If
End Sub

Attribute VB_Name = "Module15"
Public KRO, KRW, SWX
Sub KROKRW()
If COUNT = 1 Then
SWX = SWIN
Else
SWX = SWW
End If
If SWX >= 0.8 Then
SWX = 0.8
End If
If SWX < 0.2 Then
SWX = 0.2
End If
'HONARPOUR CALCULATION
KRW1 = 0.035388 * ((SWX - SWC) / (1 - SWC - SOR))
KRW2 = 0.010874 * ((SWX - SOR) / (1 - SWC - SOR)) ^ 2.9
KRW3 = 0.56556 * (SWX ^ 3.6) * (SWX - SWC)
KRW = KRW1 - KRW2 + KRW3
'NORMALIZED KRO
SWXX = SWC
KRO1 = 0.76067 * (((1 - SWXX) / (1 - SWC) - SOR) / (1 - SOR)) ^ 1.8
KRO2 = ((1 - SWXX - SOR) / (1 - SWC - SOR)) ^ 2
```

```
        KRO3 = 2.6318 * POR * (1 - SOR) * (1 - SWXX - SOR)
        CNORM = KRO1 * KRO2 + KRO3
KRO1 = 0.76067 * (((1 - SWX) / (1 - SWC) - SOR) / (1 - SOR)) ^ 1.8
KRO2 = ((1 - SWX - SOR) / (1 - SWC - SOR)) ^ 2
KRO3 = 2.6318 * POR * (1 - SOR) * (1 - SWX - SOR)
KRO = (KRO1 * KRO2 + KRO3) / CNORM
End Sub

Attribute VB_Name = "Module16"
Public TAVRG1
Sub TAVGPROD()
DELTA1 = THF
DELTA2 = HBAR * PI * RAVRG ^ 2 * CPRF * (TS - TR)
DELTA = DELTA1 / DELTA2
SIT = TSOAKT(KK) + J * DTP
Call Module2.VRCALC
Call Module3.VZCALC
TAVRG1 = TR + (TS - TR) * ((VR * VZ) * (1 - DELTA) - DELTA)
If TAVRG1 < TR Then
TAVRG1 = TR
End If
End Sub

Attribute VB_Name = "Module17"
Public SWW
Sub SWCAL()
VOP = TQOH
VMOISZ = VMOISZ1 - TOTQOH
VMWISZ = (1 - SOR - SWC) * VPOR - VMOISZ
SWW = SWC + VMWISZ / VPOR

'ReDim SW(N)
'TOTAL FLUID PRODUCED @ DTP, VFP'
```

```
        'VFP = TQWH + TQOH
        'VOCC = VFP
'VWIS1 = VWIS - TQWH
'VWIS = 0.8 * VWI - TOTQW
'SWW = VWIS / VPOR
'If SWW < 0 Then
'   SWW = 0
'End If
'If SWW > 0.80 Then
'   SWW = 0.80
'End If
'TOIL = TAVRG1
'Call Module8.OILPROP
'Call Module11.WATERVISC
'**FLUID MOVE INTO THE STEAMZONE'
'VOIN = (MUW / (MUO + MUW)) * VOCC
'VWIN = (MUO / (MUO + MUW)) * VOCC
'VOIN = ((KRO * MUW) / (MUO * KRW + MUW * KRO)) * VOCC
'VWIN = ((KRW * MUO) / (MUO * KRW + MUW * KRO)) * VOCC
'VWINT = VWINT1 + VWIN
'If (VWINJC1 + VWIN) > VWI Then
'   VWIN = VWI - (VWINJC1)
'End If
'If VWIN < 0 Then
'   VWIN = 0
'End If
'VWIS = VWIS1 + VWIN
'VWINJC1 = VWINJC1 + VWIN
'SWW = 0.20 + (VWINT1 / VPOR)
'SWW = VWIS / VPOR
'VWINT1 = VWINT
'VWIS = VWI - TOTQW
'SW(I) = (0.20* VP(I) + VWIS) / VP(I)
```

```
        'SWW = 0.20 + VWIS / VPOR
        'Print #2, I, SW(I)
'Next I
'WWW = 1 / 0
End Sub

Attribute VB_Name = "Module18"
Public PR1
Public Sub PRCALC()
' Changes in original Bambang Model
' Bachaquero Compresibility, Co=10.14e-6
 Cw = 3 * 10 ^ -6
 Co = 10.14 * 10 ^ -6
 Cg = 0.2
 Soi = 0.797
 Swi = 0.199
 Sgi = 0.003744
 CT = Swi * Cw + Soi * Co + Sgi * Cg
'End of the modification
'Original Bambang
' Cw = 3 * 10 ^ -6
' CG = 0.2
' CT = 0.965 * Cw + 0.035 * CG
' End original

DV = QI * TINJ
V = (500 * (2.54 ^ 3)) * POR
DP = DV1 / (V * CT)
PR1 = PR + DP
End Sub

Attribute VB_Name = "Module19"
Public TCZ, TDX, TCZ1
```

```
        Public Sub TCOLDZONE()
        TAVSZ = (TS + TAVRG) / 2
DLCZ = (L - LTOT) / 100
TDX = 0
For I = 1 To 100
NU = (I * DLCZ) / ((4 * ALPHRES * SIT) ^ 0.5)
'ERROR FUNCTION CALCULATIONS - from Abramowitz & Stegun'
'Y = ERF(NU)'
A1 = 0.0705230784
A2 = 0.0422820123
A3 = 0.0092705272
A4 = 0.0001520143
A5 = 0.0002765672
A6 = 0.0000430638
X = NU
Y1 = (1 + A1 * X + A2 * X ^ 2 + A3 * X ^ 3 + A4 * X ^ 4 + A5 * X ^ 5 + A6 * X ^ 6) ^ 16
Y = 1 - (1 / Y1) + 0.0000003
If KK = 1 Then
TC = TR
Else
TC = TCZ
End If
T = (TAVSZ - TC) * (1 - Y) + TC
TDX = TDX + T * DLCZ
Next I
121  TCZ = TDX / (L - LTOT)
TCZ1 = TCZ

End Sub

Attribute VB_Name = "Module20"
Public TCZP, H1CZ, H1CZ1
Public Sub TCOLDZPROD()
```

```
    'INITIAL HEAT STORED AFTER SOAK
    H1CZ = 0.5 * (TCZ - TR) * CPRF * (PI * RAVRG ^ 2 * (L - LTOT))
If J = 1 Then
H1CZ1 = H1CZ
End If
SITCZ = J * DTP
TETAR = ALPHRES * SITCZ / (RAVRG ^ 2)
If TETAR >= 0.02 And TETAR <= 0.025 Then
VR = 0.92 + (((TETAR - 0.025) / 0.005) * (-0.03))
GoTo 10
End If
If TETAR < 0.02 Then
VR = 0.95 + (((TETAR - 0.02) / 0.02) * (-0.05))
GoTo 10
End If
SK = 0.25
SK2 = 0#
For K = 1 To 300
SK2 = SK2 + SK
SK1 = ((-1 / TETAR) * (K + 1.5) / ((2 + K) * (3 + K))) * SK
SK = SK1
Next K
VR = (1 / TETAR) * SK2
10
VZ = 1
DELTA1 = HFCZT
DELTA2 = H1CZ1
DELTA = DELTA1 / DELTA2
TCZP = TR + (TCZ1 - TR) * ((VR * VZ) * (1 - DELTA) - DELTA)
If TCZP < TR Then
TCZP = TR
End If
End Sub
```

```
'Program BOTTOM.VBP – BFinalR4.VBP
Attribute VB_Name = "Module1"
Public KROM, KRWM, KS
Public CYCLE, TINJT, TSOAKT, TPRODT, I, NN, ROST
Public TST, HST
Public QI, LT, TR, ROW, CID, COD, IW
Public POR, SOR, SWC
Public CPRF, CPO, MUS, MUOC
Public TA, PI
Public DT
Public LMDRES, ALPHRES, LMDTS, LMDBACK, COND, CHTKN
Sub INPUTDATA()
CYCLE = Val(Form7.Text1(0).Text)
KROM = Val(Form7.Text1(40).Text)
KRWM = Val(Form7.Text1(41).Text)
KS = Val(Form7.Text1(37).Text)
NN = CYCLE
ReDim TINJT(NN), TSOAKT(NN), TPRODT(NN)
ReDim TST(NN), HST(NN)
ReDim ROST(NN)
For I = 1 To NN
TINJT(I) = Val(Form7.Text1(I).Text)
TSOAKT(I) = Val(Form7.Text1(I + 6).Text)
TPRODT(I) = Val(Form7.Text1(I + 12).Text)
TST(I) = Val(Form7.Text1(I + 18).Text)
HST(I) = Val(Form7.Text1(I + 24).Text)
ROST(I) = Val(Form7.Text1(I + 30).Text)
Next I
QI = Val(Form1.Text1(0).Text)
LT = Val(Form1.Text1(1).Text)
TR = Val(Form1.Text1(3).Text)
ROW = Val(Form1.Text1(5).Text)
CID = Val(Form1.Text1(6).Text)
COD = Val(Form1.Text1(7).Text)
```

```
        POR = Val(Form1.Text1(10).Text)
SOR = Val(Form1.Text1(11).Text)
SWC = Val(Form1.Text1(12).Text)
CPRF = Val(Form1.Text1(13).Text)
CPO = Val(Form1.Text1(14).Text)
MUOC = Val(Form1.Text1(15).Text)
MUS = Val(Form1.Text1(16).Text)
DT = Val(Form1.Text1(17).Text)
'Ambient Temperature, oF'
TA = 63

' ****************** C O N S T A N T S ******************************
PI = 3.14159
'Heat Conduction Area Constant, CACON'
COND = Val(Form1.Text1(21).Text)
'Heat Taken Constant, CHTKN'
CHTKN = Val(Form1.Text1(24).Text)
'Heat conductivity reservoir,LMDRES,Btu/sec-cm-oF  2.2 btu/hr-ft-oF'
'Heat diffusivity reservoir, ALPHRES,cm^2/sec'
'Heat conductivity to side,  LMDTS,Btu/sec-cm-oF'
'Heat conductivity to back,  LMDBACK,Btu/sec-cm-oF'
'Heat conduction constant to back, LMDBACK, BTU/cm^2-sec ***(=(TS-TA)/((L/lambda))
 LMDRES = 0.00002
 ALPHRES = 0.01
 LMDTS = 0.00000550642
 LMDBACK = 0.0000035429
'Heat capacity tubing,    CPTUB,Btu/gr-oF'
'Heat Conductivity tubing,LMDTUB,Btu/sec-cm-oF'
'Density tubing,          ROTUB,gr/cc'
'Heat diffusivity tubing, ALPHTUB,cm^2/sec'
'Tubing length,           LTUB,cm'
 CPTUB = 0.000249
 LMDTUB = 0.000182
```

```
        ROTUB = 7.80112
 ALPHTUB = 0.0961
 LTUB = 10#
'ALUMINUM'
'Heat Conductivity,LMDAL,Btu/sec-cm-oF'
'Heat diffusivity, ALPHAL,cm^2/sec'
'Length,          LAL,cm'
LMDAL = 0.001086
ALPHAL = 0.9458
LAL = 0.635
End Sub
Attribute VB_Name = "Module2"
Public VR, TETAR
Public Sub VRCALC()
TETAR = ALPHRES * SIT / (RAVRG ^ 2)
If TETAR >= 0.02 And TETAR <= 0.025 Then
VR = 0.92 + (((TETAR - 0.025) / 0.005) * (-0.03))
GoTo 10
End If
If TETAR < 0.02 Then
VR = 0.95 + (((TETAR - 0.02) / 0.02) * (-0.05))
GoTo 10
End If
SK = 0.25
SK2 = 0#
For K = 1 To 300
SK2 = SK2 + SK
SK1 = ((-1 / TETAR) * (K + 1.5) / ((2 + K) * (3 + K))) * SK
SK = SK1
Next K
VR = (1 / TETAR) * SK2
10
End Sub
```

```
Attribute VB_Name = "Module3"
Public VZ, TETAZ, HBAR
Public Sub VZCALC()
Z1 = 4 * IW * HS * TINJT(KK) + HRTOT
Z2 = PI * RAVRG ^ 2 * CPRF * (TS - TR)
ZZ = Z1 / Z2 - LTOT
HBAR = ZZ + LTOT
X1 = 4 * ALPHRES * (SIT)
X2 = (X1 / (PI * HBAR ^ 2)) ^ 0.5
X3 = Exp(-HBAR ^ 2 / X1)
'ERROR FUNCTION CALCULATIONS - from Abramowitz & Stegun'
'Y = ERF(HBAR/(X1^0.5)'
A1 = 0.0705230784
A2 = 0.0422820123
A3 = 0.0092705272
A4 = 0.0001520143
A5 = 0.0002765672
A6 = 0.0000430638
X = HBAR / (X1 ^ 0.5)
Y1 = (1 + A1 * X + A2 * X ^ 2 + A3 * X ^ 3 + A4 * X ^ 4 + A5 * X ^ 5 + A6 * X ^ 6) ^ 16
Y = 1 - (1 / Y1) + 0.0000003
VZ = Y - X2 * (1 - X3)
TETAZ = ALPHRES * SIT / ((HBAR / 2) ^ 2)
End Sub

Attribute VB_Name = "Module4"
Public L, RT, RTO
Sub CHANGEUNIT()
'Injection Rate,        QI cc/min to cc/sec'
'Wellbore Length,        L  inch   to cm'
'Steam Density,         ROS lb/cuft to lb/cc'
'Water Density,         ROW lb/cuft to lb/cc'
'ID Casing,             CID inch    to cm'
```

```
    'OD Casing,              CID inch    to cm'
'Heat Capacity Reservoir, CPRF btu/cuft-oF to btu/cc-oF'
'Heat Conductivity Oil,   CPO btu/cuft-oF to btu/cc-oF'

QI = QI / 60#
L = LT * 2.54
ROW = ROW / (30.48 ^ 3#)
CID = CID * 2.54
COD = COD * 2.54
CPRF = CPRF / (30.48 ^ 3)
CPO = CPO / (30.48 ^ 3)
'Heat Conductivity Teflon, LMDT, BTU/hr ft oF to BTU/sec cm oF'
LMDT = 0.1333
LMDT = LMDT / (3600 * 30.48)
'  *** VARIABLES CALCULATIONS ****
'TUBING RADIUS,            RT, CM
'TUBING SEGMENT LENGTH,     DL, CM
'Tubing Area,              ATUB, cm^2
'TEMP AVERAGE,             TAVG, oF
'MASS INJECTION RATE,      IW, LB/SEC
RT = CID / 2
RTO = COD / 2
ATUB = PI * (RTO ^ 2 - RT ^ 2)
IW = QI * ROW
End Sub

Attribute VB_Name = "Module5"
Public I1, CCONV, CCONDR, CCONDB, CCONDS, FACR
Public TSIPS, VWIPS
Public THINJSEGT, THCOND, THCVRES, TOTHTKN
Public N
Public DL, RH, QS, LTOT
Sub STEAMZONE()
```

```
    '********* INITIALIZATIONS **************
' ******** Number of Segment, N ************
 N = Int(TINJ / DT)
ReDim RH(N, N), QS(N), DL(N)
ReDim THINJSEGT(N), THCOND(N), THCVRES(N), TOTHTKN(N)
ReDim TSIPS(N), VWIPS(N)
For I = 1 To N
TSIPS(I) = 0
Next I
TTOT = 0
LTOT = 0
THINJTOT = 0
THCCAP = 0
THINJMOD = 0
THCBACK = 0
THCSIDE = 0
THCRES = 0
FACR = (DT ^ 0.5)
For K = 2 To N
For I = 1 To K - 1
RH(K, I) = RT
Next I
Next K
CCONV = CPRF * (TS - TR)
CCONDR = 2 * LMDRES * (TS - TR) * (DT ^ 0.5) / ((PI * ALPHRES) ^ 0.5)
CONDB = LMDBACK * DT
CCONDS = LMDTS * DT
' Condition of NO CONDUCTIONS
If COND = 0 Then
CCONDR = 0
CCONDB = 0
CCONDS = 0
End If
```

```
    For I = 1 To N
TTOT = TTOT + DT
If KK > 1 Then
If O >= I Then
HREM = HR(I) / ((O - I) + 1)
Else
HREM = 0
End If
End If
If I = 1 Then
ROS2 = ROS
HS2 = HS
If KK > 1 Then
DLL1 = (IW * HS2 * DT) - (IW * HS2 * DT / (1 + MUS / MUO * 0.4341))
TRW = TR
Else
DLL1 = (IW * HS2 * DT) - (IW * HS2 * DT / (1 + MUS / MUO * 0.4341))
TRW = TR
End If
DLL2 = PI * RT ^ 2 * (ROS2 * HS2 + CPO * (TS - TRW) - (ROS2 * HS2) / (1 + MUS / MUO * 0.4341))
DL(I) = DLL1 / DLL2
LTOT = LTOT1 + DL(I)
If LTOT >= L Then
DL(I) = L - LTOT1
LTOT = LTOT1 + DL(I)
End If
LTOT1 = LTOT
QSI = ((IW / ROS2) - (PI * RT ^ 2 * DL(I) / DT)) / (1 + MUS / MUO * 0.4341)
CHIN = ROS2 * HS2 * DT * QSI
GoTo 150
Else
ROS2 = ROS
HS2 = HS
End If
```

```
        If KK > 1 And O >= I Then
        '      TRW = TAVG(I)
'      Else
TRW = TR
End If
LL1 = (IW * HS2 * DT) - QSI * ROS2 * HS2 * DT
LL2 = PI * RT ^ 2 * (ROS2 * HS2 + CPO * (TS - TRW))
DL(I) = LL1 / LL2
LTOT = LTOT1 + DL(I)
If LTOT > L Then
DL(I) = L - LTOT1
LTOT = LTOT1 + DL(I)
I1 = I
Call Module22.ENDWELL
GoTo 10000
End If
LTOT1 = LTOT
QS(I) = (DL(I) / LTOT) * QSI
150  For K = I To 1 Step -1
 THCBACK = 0
 THCSIDE = 0
 THCRES = 0
If KK > 1 Then
 If O >= I Then
 HREM = HR(K) / ((O - K) + 1)
 Else
 HREM = 0
 End If
 End If
If K = I Then
 RX = RT
 RY = RT
 Else
 RX = RH(K + 1, I)
 RY = RH(K, I - 1)
```

```
        End If
        If K = 1 And I = 1 Then
A1 = 0.25 * PI * DL(K) * CCONV
 A2 = COND * (0.25 * PI) * CCONDB
 A3 = FACR * COND * (0.25 * PI) * CCONDR
 A = A1 + A2 + A3
B = COND * 2 * DL(1) * CCONDS

 C1 = -0.25 * PI * RT ^ 2 * DL(K) * CCONV
 C2 = -COND * (0.25 * PI) * RT ^ 2 * CCONDB
 C3 = -FACR * COND * (0.25 * PI) * RT ^ 2 * CCONDR
 C4 = -(DL(1) / LTOT) * CHIN - HREM
 C5 = 0
C = C1 + C2 + C3 + C4 + C5
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
THINJSEG = (DL(1) / LTOT) * QSI * ROS2 * HS2 * DT
HCVRES = 0.25 * PI * (RRI ^ 2 - RT ^ 2) * DL(K) * CCONV
 HCBACK = COND * (0.25 * PI) * (RRI ^ 2 - RT ^ 2) * CCONDB
 HCSIDE = COND * 2 * RRI * DL(1) * CCONDS
 HCRES = FACR * COND * (0.25 * PI) * (RRI ^ 2 - RT ^ 2) * CCONDR
  THINJSEGT(K) = THINJSEGT(K) + THINJSEG
 THCVRES(K) = THCVRES(K) + HCVRES
 THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
' Heat Balance
' THINJSEG = HCVRES + HCBACK + HCRES + HCSIDE
GoTo 100
End If
If K = 1 Then
A1 = 0.25 * PI * DL(1) * CCONV
A2 = COND * (0.25 * PI) * CCONDB
A3 = FACR * COND * (0.25 * PI) * CCONDR
A = A1 + A2 + A3
B = COND * 2 * DL(K) * CCONDS
```

```
C1 = -(0.25) * PI * RH(K, I - 1) ^ 2 * DL(1) * CCONV
C2A = -COND * (0.25 * PI) * RH(K, I - 1) ^ 2 * CCONDB
C2B = 0.25 * PI * (RH(K, I - 1) ^ 2 - RT ^ 2) * CCONDB
C2 = C2A + C2B
C3A = -FACR * COND * (0.25 * PI) * RH(K + 1, I) ^ 2 * CCONDR
C3B = FACR * COND * (1 - CHTKN) * (0.25 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CONDR
If CHTKN = 0 Then
C3B = 0
End If
C3 = C3A + C3B
C4 = -(DL(1) / LTOT) * CHIN - HREM
C5 = 0
C6A = -COND * 2 * (RH(K, I - 1)) * DL(1) * CCONDS
C6B = 2 * (RH(K, I - 1)) * DL(1) * CCONDS
C6 = C6A + C6B
C = C1 + C2 + C3 + C4 + C5 + C6
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
THINJSEG = (DL(1) / LTOT) * QSI * ROS2 * HS2 * DT
HCVRES = (0.25) * PI * (RRI ^ 2 - RH(K, I - 1) ^ 2) * DL(K) * CCONV
HCBACK1 = COND * (0.25 * PI) * (RRI ^ 2 - RH(K, I - 1) ^ 2) * CCONDB
HCBACK2 = 0.25 * PI * (RH(K, I - 1) ^ 2 - RT ^ 2) * CCONDB
HCBACK = HCBACK1 + HCBACK2
HCSIDE1 = COND * 2 * (RRI - RH(K, I - 1)) * DL(1) * CCONDS
HCSIDE2 = 2 * (RH(K, I - 1)) * DL(1) * CCONDS
HCSIDE = HCSIDE1 + HCSIDE2
HCRES1 = FACR * COND * (0.25 * PI) * (RRI ^ 2 - RH(K + 1, I) ^ 2) * CCONDR
HCRES2 = FACR * COND * (1 - CHTKN) * (0.25 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
HCRES2 = 0
End If
HCRES = HCRES1 + HCRES2
THINJSEGT(K) = THINJSEGT(K) + THINJSEG
```

```
        THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES


THCVRES(K) = THCVRES(K) + HCVRES
TOTHTKN(K) = 0
TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
 GoTo 100
 End If
If K = I Then
Z = 0
A1 = 0.25 * PI * DL(K) * CCONV
 A2 = 0
 A3 = FACR * COND * (0.25 * PI) * CCONDR
 A4 = -FACR * CHTKN * COND * (0.25 * PI) * CCONDR
B = COND * 2 * DL(K) * CCONDS
C1 = -0.25 * PI * (RT ^ 2) * DL(K) * CCONV
 C2 = 0!
 C3A = -FACR * COND * (0.25 * PI) * RT ^ 2 * CCONDR
 C3B = FACR * CHTKN * COND * (0.25 * PI) * RT ^ 2 * CCONDR
' C3 = C3A + C3B
 C4 = -(DL(K) / LTOT) * CHIN - HREM
510     A = A1 + A2 + A3 + A4
 C = C1 + C2 + C3A + C3B + C4
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
 RX = RRI
 If Z = 1 Then GoTo 520
 If RRI > RH(K - 1, I - 1) Then
 Z = 1
 RX = RH(K - 1, I - 1)
 A4 = 0
 C3B = -FACR * CHTKN * COND * (0.5 * PI) * (RX ^ 2 - RT ^ 2) * CCONDR
 GoTo 510
 End If
' THINJSEG=HCVRES+HCBACK+HCSIDE+HCRES-THTKN'
```

```
520     THINJSEG = (DL(K) / LTOT) * CHIN
THTKN = FACR * CHTKN * COND * (0.25 * PI) * (RX ^ 2 - RT ^ 2) * CCONDR
HCVRES = 0.25 * PI * (RRI ^ 2 - RT ^ 2) * DL(K) * CCONV
HCBACK = 0
HCSIDE = COND * 2 * RRI * DL(K) * CCONDS
HCRES = FACR * COND * (0.25 * PI) * (RRI ^ 2 - RT ^ 2) * CCONDR
THINJSEGT(K) = THINJSEGT(K) + THINJSEG + THTKN
THCVRES(K) = THCVRES(K) + HCVRES
THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
TOTHTKN(K) = TOTHTKN(K) + THTKN
TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
GoTo 100
Else
Z = 0
A1 = (0.25) * PI * DL(K) * CCONV
A2 = 0
A3 = FACR * COND * (0.25 * PI) * CCONDR
A4 = -FACR * CHTKN * COND * (0.25 * PI) * CCONDR
B = COND * 2 * DL(K) * CCONDS
C1 = -(0.25) * PI * (RH(K, I - 1) ^ 2) * DL(K) * CCONV
C2 = 0!
 C3A = -FACR * COND * (0.25 * PI) * RH(K + 1, I) ^ 2 * CCONDR
 C3B = FACR * CHTKN * COND * (0.25 * PI) * RH(K, I - 1) ^ 2 * CCONDR
 C3C = FACR * COND * (1 - CHTKN) * (0.25 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
 C3C = 0
 End If
C3 = C3A + C3B + C3C
C4 = -(DL(K) / LTOT) * CHIN - HREM
C6A = -COND * 2 * RH(K, I - 1) * DL(K) * CCONDS
C6B = 2 * RH(K, I - 1) * DL(K) * CCONDS
C6 = C6A + C6B
```

```
610     A = A1 + A2 + A3 + A4
C = C1 + C2 + C3 + C4 + C6
RRI = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
If Z = 1 Then
GoTo 620
End If
RX = RRI
If RRI > RH(K - 1, I - 1) Then
Z = 1
RX = RH(K - 1, I - 1)
A4 = 0
C3B = -FACR * CHTKN * COND * (0.25 * PI) * (RX ^ 2 - RH(K, I - 1) ^ 2) * CCONDR
GoTo 610
End If

620     THINJSEG = (DL(K) / LTOT) * QSI * ROS2 * HS2 * DT
THTKN = FACR * CHTKN * COND * (0.25 * PI) * (RX ^ 2 - RH(K, I - 1) ^ 2) * CCONDR
HCVRES = (0.25) * PI * (RRI ^ 2 - RH(K, I - 1) ^ 2) * DL(K) * CCONV
HCBACK = 0
HCRES1 = FACR * COND * (0.25 * PI) * (RRI ^ 2 - RH(K + 1, I) ^ 2) * CCONDR
HCRES2 = FACR * COND * (1 - CHTKN) * (0.25 * PI) * ((RH(K + 1, I) ^ 2 - RH(K + 1, I - 1) ^ 2)) *
CCONDR
If CHTKN = 0 Then
HCRES2 = 0
End If
HCRES = HCRES1 + HCRES2
HCSIDE1 = COND * 2 * (RRI - RH(K, I - 1)) * DL(K) * CCONDS
HCSIDE2 = 2 * RH(K, I - 1) * DL(K) * CCONDS
HCSIDE = HCSIDE1 + HCSIDE2
THINJSEGT(K) = THINJSEGT(K) + THINJSEG + THTKN
THCOND(K) = THCOND(K) + HCBACK + HCSIDE + HCRES
THCVRES(K) = THCVRES(K) + HCVRES
TOTHTKN(K) = TOTHTKN(K) + THTKN
```

```
    End If
TSIPS(K) = TSIPS(K) + (DL(K) / LTOT) * QSI * DT
100     RH(K, I) = 1 * RRI
If I = N Then
VWIPS(K) = TSIPS(K) * ROS / ROW
TVWI = TVWI + VWIPS(K)
' Form2.Print I, K, RH(K, I), LTOT, Y
Form3.MSFlexGrid1.Col = 0
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = I
Form3.MSFlexGrid1.Col = 1
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = K
Form3.MSFlexGrid1.Col = 2
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(RH(K, I), 6)
Form3.MSFlexGrid1.Col = 3
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(LTOT, 4)
Form3.MSFlexGrid1.Col = 4
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(THINJSEGT(K), 3)
Form3.MSFlexGrid1.Col = 5
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(THCVRES(K), 3)
Form3.MSFlexGrid1.Col = 6
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(THCOND(K), 3)
Form3.MSFlexGrid1.Col = 7
Form3.MSFlexGrid1.ROW = N - K + 1
Form3.MSFlexGrid1.Text = Round(VWIPS(K), 3)
THINJTOT = IW * DT * HS2
```

```
Print #1, I, K, DL(K), RH(K, I), LTOT, THINJSEGT(K), THCVRES(K), THCOND(K), VWIPS(K), LL1, LL2, IW, HS2, MUS, MUO, TS, TRW, QSI
End If
Next K
 10
 Next I
10000
End Sub

Attribute VB_Name = "Module6"
Public ROS
Public TS, HS
Public TINJ, SIT, TPROD, KK, O, COUNTO
Sub MAINCALC()
'*****OPEN OUTPUT FILES*****'

FOUT1$ = Form1.Text1(22).Text
FOUT2$ = Form1.Text1(23).Text

Open FOUT1$ For Append As #1
Open FOUT2$ For Append As #2
Form1.Hide
Form3.Show
Call Form1.HEADER
HRTOT = 0
 For KK = 1 To CYCLE
Form3.Text1.Text = KK
TINJ = TINJT(KK)
SIT = TSOAKT(KK)
TPROD = TPRODT(KK)
TS = TST(KK)
HS = HST(KK)
ROS = ROST(KK)
```

```
    'CHANGE UNIT ROS lb/cuft to lb/cc
ROS = ROS / (30.48 ^ 3#)
RE = 12.7
COUNTO = 1
Call Module8.OILPROP
Call Module5.STEAMZONE
Call Module13.LAVG
Call Module7.SOAK
COUNTO = 0
Call Module8.OILPROP
Call Module14.SWINITIAL
Form4.Show
Call Module9.PROD
Call Module10.REMAINING
O = N
807   Next KK
Close #1
Close #2
End Sub

Attribute VB_Name = "Module7"
Public TAVRG, ZZ, TRH
Sub SOAK()
STTOT = 0
Call Module2.VRCALC
Call Module3.VZCALC
If KK = 1 Then
TRH = TR
Else
TRH = TAVRG
End If
TAVRG = TR + (TS - TR) * (VR * VZ)
Form11.Print TAVRG
```

```
        COUNTO = 3
Call Module20.TCOLDZONE
GoTo 808
Form5.Hide
808
End Sub

Attribute VB_Name = "Module8"
Public MUO As Double, MUOcal(1 To 15) As Double, TW As Double, TOIl As Double, TOILcal(1 To
15) As Double
Sub OILPROP()
If COUNTO = 1 Then
TOIl = TS
Else
TOIl = TAVRG
 End If
If COUNTO = 3 Then
TOIl = TCZ
End If
TOILcal(1) = 63#
TOILcal(2) = 128#
TOILcal(3) = 160#
TOILcal(4) = 190#
TOILcal(5) = 220#
TOILcal(6) = 250#
TOILcal(7) = 280#
TOILcal(8) = 310#
TOILcal(9) = 340#
TOILcal(10) = 370#
TOILcal(11) = 400#
TOILcal(12) = 430#
TOILcal(13) = 460#
TOILcal(14) = 490#
```

```
    TOILcal(15) = 520#
MUOcal(1) = 7600#
MUOcal(2) = 635#
MUOcal(3) = 351.74
MUOcal(4) = 86.2
MUOcal(5) = 66.29
MUOcal(6) = 46.36
MUOcal(7) = 26.42
MUOcal(8) = 12.68
MUOcal(9) = 11.42
MUOcal(10) = 10.17
MUOcal(11) = 8.91
MUOcal(12) = 7.66
MUOcal(13) = 6.41
MUOcal(14) = 5.15
MUOcal(15) = 3.9
MUO = Interpol(15, TOILcal, MUOcal, TOIl)
End Sub
Function Interpol(np As Integer, x_Prop() As Double, y_Prop() As Double, x_XX As Double)
Dim u As Integer, check As Boolean, x1 As Double, x2 As Double, y1 As Double, y2 As Double
'Extrapolation for values < Min.
If x_XX < x_Prop(1) Then
Interpol = y_Prop(1) + (x_XX - x_Prop(1)) * (y_Prop(2) - y_Prop(1)) / (x_Prop(2) - x_Prop(1))
End If
'Extrapolation for values > Max.
If x_XX > x_Prop(np) Then
Interpol = y_Prop(np - 1) + (x_XX - x_Prop(np - 1)) * (y_Prop(np) - y_Prop(np - 1)) / (x_Prop(np) -
x_Prop(np - 1))
End If
'Interpolation for values within the range of the property table
If x_XX >= x_Prop(1) And x_XX <= x_Prop(np) Then
u = 1
check = False     'boolean to check for the condition
```

```
    Do
If x_XX >= x_Prop(u) And x_XX <= x_Prop(u + 1) Then
check = True
x1 = x_Prop(u)
x2 = x_Prop(u + 1)
y1 = y_Prop(u)
y2 = y_Prop(u + 1)
End If
u = u + 1
Loop Until check = True
Interpol = y1 + (x_XX - x1) * (y2 - y1) / (x2 - x1)
End If
End Function

Attribute VB_Name = "Module9"
Public TOTQOH
Public J, DTP, Soi, Swi, Sgi, Cw, Co, Cg, JCS2
Public TOIl, THF, TQWH, TQOH, COUNT, TOTQW, VWIREM, RW, PR, DV1
Sub PROD()
ReDim TQO(N)
ReDim TQW(N)
'CPW=1 BTU/LB-oF .......PRATTS, pg.224, FIG.B-64'
'ROW*CPW = 62.4 BTU/CUFT-oF = 0.0022036 BTU/CC-oF'
CPW = 0.0022036
MUWC = 1.0825
PR = Val(Form7.Text1(38).Text)
PW = Val(Form7.Text1(39).Text)
' CHANGE IN BAMBANG MODEL
'CW = 3 * 10 ^ -6
'CG = 1 / PR
'CT = 0.965 * CW + 0.035 * CG
Cw = 3 * 10 ^ -6
Co = 10.14 * 10 ^ -6
```

```
        Cg = 0.2
Soi = 0.798
Swi = 0.199
Sgi = 0.002758
CT = Swi * Cw + Soi * Co + Sgi * Cg
' End of modification
DV = QI * TINJ
V = (500 * (2.54 ^ 3)) * POR
DP = DV / (V * CT)
PR1 = PR + DP
'Interval production time, 1 sec.)
 DTP = 1
'*** INITIALIZATION ****
TOTQO = 0
TOTQW = 0
TOTQW1 = 0
HFCZT = 0
COUNT = 1
THF = 0
SWW = SWIN
JJ = TPROD / DTP
RE = 12.7
For J = 1 To JJ
RW = RTO
COUNTO = 0
TOIl = TAVRG
Call Module8.OILPROP
MUOH = MUO
Call Module11.WATERVISC
Call Module15.KROKRW
RE = 12.7
C1A = Log(RAVRG / RW)
C1B = Log(RE / RW)
```

```
        C1 = C1A / C1B
C2A = Log(RE / RAVRG)
C2B = Log(RE / RW)
C2 = C2A / C2B
JBAR = 1 / ((MUOH / MUOC) * C1 + C2)
Call Module12.JCOLD
' Change in Bambang Model
' QOH1 = (JBAR * JCS * (PR1 - PW) / 14.7)
QOH1 = (JBAR * JCS * KRO * (PR1 - PW) / 14.7)
COUNTO = 3
Call Module8.OILPROP
MUOW = MUO
If LTOT > L Then
LTOT = L
End If
' QOC = (2 * PI * (L - LTOT) * KS * KROM * (PR1 - PW) / 14.7) / (MUOW * Log(RE / RW))
JCS2 = JCS * ((L - LTOT) / LTOT) * (MUOC / MUOW)
QOC = JCS2 * ((PR1 - PW) / 14.7)
 QOH = (QOH1 + QOC) * 0.25
COUNTO = 0
If KRO = 0 Then
RWO = 0
GoTo 4
End If
4     TQOH = QOH * DTP
TQOH1 = QOH1 * DTP * 0.25
TOTQO = TOTQO + TQOH
TOTQOH = TOTQOH + TQOH1
' QW1 = 2 * PI * LTOT * KS * KRWQW * (PR1 - PW) / 14.7
' QW2 = MUW * Log(RAVRG / RW) + MUWC * Log(RE / RAVRG)
' QW = (QW1 / QW2) * 0.25
JCW = JCS * (1 / MUWC) * (MUOC / 1)
JCW2 = JCW * (MUWC / MUW)
```

```
    QW = 0.25 * (LTOT / L) * JCW2 * ((PR1 - PW) / 14.7)
TQWH = QW * DTP
TOTQW = TOTQW1 + TQWH
If TOTQW > 1 * VWI Then
TQWH = 1 * VWI - TOTQW1
QW = TQWH / DT
TOTQW = TOTQW1 + TQWH
End If
TOTQW1 = TOTQW
'Heat loss by fluid produced'
HF = ((0.25 * QOH1 * CPO + QW * CPW) * (TAVRG - TR)) * DTP
THF = THF + HF
'Calculate temp cold zone'
HFCZ = QOC * 0.25 * CPO * (TCZ - TR) * DTP
HFCZT = HFCZT + HFCZ
Call Module21.TCOLDZPROD
TCZ = TCZP
Form9.Show

If J = TPROD Then
Form9.Print J, TAVRG, TOTQO, TOTQW, KRW, KRO, JBAR, RAVRG, 0.25 * HRTOT
End If

Print #2, J, TAVRG, TOTQO, TOTQW, SWX, KRW, KRO, QOH, QW, RWO, JBAR, JCS, PR1, TCZ,
L, LTOT, RAVRG, 0.25 * HRTOT, MUO, MUW, RW, RE, C1, C2, QOH1, MUOH, MUOC
Call Module16.TAVGPROD
TAVRG = TAVRG1
'Sw calculation for next time step production'
Call Module17.SWCAL
COUNT = 0
DV1 = QI * TINJ - (TOTQW + TOTQO)
Call Module18.PRCALC
Next J
```

```
        PR = PR1
TCOLD = TCZ
VWIREM = 0 * (VWI - TOTQW)
If VWIREM < 0 Then
VWIREM = 0
End If
End Sub

Attribute VB_Name = "Module10"
Public HR, HRTOT
Sub REMAINING()
ReDim HR(N)
ReDim HRR(N)
HRTOT = 0
For I = 1 To N
HRR(I) = PI * (RAVRG ^ 2) * DL(I) * CPRF * (TAVRG - TR)
HRTOT = HRTOT + HRR(I)
HR(I) = 0.25 * HRR(I)
'    Print #1, I, TAVRG, HR(I), HRTOT
Next I
End Sub

Attribute VB_Name = "Module11"
Public MUW
Sub WATERVISC()
TW = TAVRG
If 60 <= TW And TW < 80 Then
MUW = (TW - 60) * (0.88 - 1.15) / 20 + 1.15
GoTo 71
End If
If 80 <= TW And TW < 100 Then
MUW = (TW - 80) * (0.68 - 0.88) / 20 + 0.88
GoTo 71
```

```
    End If
If 100 <= TW And TW < 120 Then
MUW = (TW - 100) * (0.57 - 0.68) / 20 + 0.68
GoTo 71
End If
If 120 <= TW And TW < 140 Then
MUW = (TW - 120) * (0.45 - 0.57) / 20 + 0.57
GoTo 71
End If
If 140 <= TW And TW < 160 Then
MUW = (TW - 140) * (0.39 - 0.45) / 20 + 0.45
GoTo 71
End If
If 160 <= TW And TW < 180 Then
MUW = (TW - 160) * (0.35 - 0.39) / 20 + 0.39
GoTo 71
End If
If 180 <= TW And TW < 200 Then
MUW = (TW - 180) * (0.3 - 0.35) / 20 + 0.35
End If
71
End Sub

Attribute VB_Name = "Module12"
Public JCS, JCSW, MUWC
Sub JCOLD()
RE = 12.7
MUWC = 1.0825
‘ Change in Bambang Model according to  Economides –Joshi equation
  JCS = 0.012788
   'JCS = 2 * PI * KS * KRO * LTOT / (MUOC * Log(RE / RW))
‘End of change
End Sub
```

```
    Attribute VB_Name = "Module13"
Public RAVRG
Sub LAVG()
' INITIALIZATION
TAREAR = 0
TOTVOL = 0
For I = 1 To N
AREAR = 2 * PI * RH(I, N) * DL(I) * 0.25
TAREAR = TAREAR + AREAR
VTOT = 0.25 * PI * RH(I, N) ^ 2 * DL(I)
 TOTVOL = TOTVOL + VTOT
Next I
RAVG = TAREAR / (2 * PI * LTOT * 0.25)
RAVRG = (TOTVOL / (0.25 * PI * LTOT)) ^ 0.5
VAVRG = PI * RAVRG ^ 2 * LTOT
Form11.Show
End Sub

Attribute VB_Name = "Module14"
Public SWQW, KRWQW, VMWIC, VMOISZ1, RE
Public SWIN, VPOR, VWINT1, VWI, VWIS, VWINJC1
Sub SWINITIAL()
Form2.Show
VWINT1 = 0
VWINJC1 = 0
VWI = 0
'*** CALCULATE TOTAL WATER INJECTED,VWI @ CYCLE ***
VWI = QI * TINJT(KK)
 ' *** TOTAL WTR INJCTD = WTR INJCTD @ CYCLE + WTR INJCTD REMAINING ***
If KK > 1 Then
VWI = VWI + VWIREM
End If
```

```
        RE = 12.7
VBULK = 0.25 * PI * RE ^ 2 * LTOT
VPOR = VBULK * POR
'SWEEP EFFICIENCY, SE
SE = 0.035
'VOLUME MOVEABLE WATER IN THE CHANNEL, VMWIC
VMWIC = SE * (1 - SWC - SOR) * VPOR
'WATER SATURATION FOR WTR PROD,SWQW
SWQW = SWC + VMWIC / VPOR
If KK = 1 Then
SWIN = SWQW
COUNT = 1
Call Module15.KROKRW
KRWQW = KRW
VMOISZ1 = (1 - SWC - SOR) * VPOR - VMWIC
Else
VMOISZ1 = (1 - SWC - SOR) * VPOR - VMWIC - TOTOILPROD
VMWISZ1 = (1 - SWC - SOR) * VPOR - VMOISZ1
SWIN = SWC + VMWISZ1 / VPOR
End If
Form11.Print VAVRG, VPOR, VS, VC, VOC, SWIN, SOIN, SWIN1, VWI
End Sub

Attribute VB_Name = "Module15"
Public KRO, KRW, SWX
Sub KROKRW()
 If COUNT = 1 Then
 SWX = SWIN
 Else
 SWX = SWW
 End If
 If SWX >= 0.8 Then
 SWX = 0.8
```

```
        End If
    If SWX < 0.2 Then
    SWX = 0.2
    End If
' Krw,  Honarpour Eq. A-1

KRW1 = 0.035388 * ((SWX - SWC) / (1 - SWC - SOR))
KRW2 = 0.010874 * ((SWX - SOR) / (1 - SWC - SOR)) ^ 2.9
KRW3 = 0.56556 * SWX ^ 3.6 * (SWX - SWC)
KRW = KRW1 - KRW2 + KRW3
' Kro, normalized Honarpour Eq. A-3
SWXX = SWC
KRO1 = 0.76067 * (((1 - SWXX) / (1 - SWC) - SOR) / (1 - SOR)) ^ 1.8
KRO2 = ((1 - SWXX - SOR) / (1 - SWC - SOR)) ^ 2
KRO3 = 2.6318 * POR * (1 - SOR) * (1 - SWXX - SOR)
CNORM = KRO1 * KRO2 + KRO3
KRO1 = 0.76067 * (((1 - SWX) / (1 - SWC) - SOR) / (1 - SOR)) ^ 1.8
KRO2 = ((1 - SWX - SOR) / (1 - SWC - SOR)) ^ 2
KRO3 = 2.6318 * POR * (1 - SOR) * (1 - SWX - SOR)
KRO = (KRO1 * KRO2 + KRO3) / CNORM
End Sub

Attribute VB_Name = "Module16"
Public TAVRG1
Sub TAVGPROD()
DELTA1 = THF
DELTA2 = 2 * HBAR * PI * RAVRG ^ 2 * CPRF * (TS - TR)
DELTA = DELTA1 / DELTA2
SIT = TSOAKT(KK) + J * DTP
Call Module2.VRCALC
Call Module3.VZCALC
TAVRG1 = TR + (TS - TR) * ((VR * VZ) * (1 - DELTA) - DELTA)
If TAVRG1 < TR Then
```

```
    TAVRG1 = TR
End If
End Sub

Attribute VB_Name = "Module17"
Public SWW
Sub SWCAL()
VMOISZ = VMOISZ1 - TOTQOH
VMWISZ = (1 - SOR - SWC) * VPOR - VMOISZ
SWW = SWC + VMWISZ / VPOR
End Sub

Attribute VB_Name = "Module18"
Public PR1
Public Sub PRCALC()
' Change in Bambang Model
'  Cw = 3 * 10 ^ -6
'  Cg = 1 / PR
'  CT = 0.965 * Cw + 0.035 * Cg
Cw = 3 * 10 ^ -6
Co = 10.14 * 10 ^ -6
Cg = 0.2
Soi = 0.798
Swi = 0.199
Sgi = 0.002758
CT = Swi * Cw + Soi * Co + Sgi * Cg
V = (500 * (2.54 ^ 3)) * POR
DP = DV1 / (V * CT)
PR1 = PR + DP
End Sub

Attribute VB_Name = "Module19"
Public TOPG
```

```
    Sub GRAVITY()
RG = 5 * 2.54
'G = 981.456 cm/sec^2
G1 = 981.456
'Change in bambang model
'Oil density=0.81*62.4 lb/cuft ---> = 0.81 gr/cc
'ROO = 0.81
 ROO = 0.988128
'Production area
AP = 2 * PI * RW * LTOT / 360
TOPG = 0
For ANGLE = 0 To 90
G = G1 * Sin(ANGLE)
' RO=1 gr/cc,h = 1 cm ---> 1 dyne/cm^2 = 1.3458*10^-4 psi
Cg = 1.3458 * 10 ^ -4
' Grav prod press, PSI
PG = ROO * RG * G * Cg
' OIL PROD
OPG = (KS * KRO * (PG / 14.7)) / (MUO * RW)
TOPG = TOPG + OPG
Next ANGLE
End Sub

Attribute VB_Name = "Module20"
Public TCZ, TDX, TCZ1
Public Sub TCOLDZONE()
TAVSZ = (TS + TAVRG) / 2
DLCZ = (L - LTOT) / 100
TDX = 0
For I = 1 To 100
NU = (I * DLCZ) / ((4 * ALPHRES * SIT) ^ 0.5)
'ERROR FUNCTION CALCULATIONS - from Abramowitz & Stegun'
'Y = ERF(HBAR/(X1^0.5)'
```

```
    A1 = 0.0705230784
A2 = 0.0422820123
A3 = 0.0092705272
A4 = 0.0001520143
A5 = 0.0002765672
A6 = 0.0000430638

X = NU
Y1 = (1 + A1 * X + A2 * X ^ 2 + A3 * X ^ 3 + A4 * X ^ 4 + A5 * X ^ 5 + A6 * X ^ 6) ^ 16
Y = 1 - (1 / Y1) + 0.0000003
If KK = 1 Then
TC = TR
Else
TC = TCZ
End If
T = (TAVSZ - TC) * (1 - Y) + TC
TDX = TDX + T * DLCZ
Next I
If L = LTOT Then
TCZ = TAVRG
GoTo 505
End If
TCZ = TDX / (L - LTOT)
TCZ1 = TCZ
505
End Sub

Attribute VB_Name = "Module21"
Public TCZP, H1CZ1
Public Sub TCOLDZPROD()
'INITIAL HEAT STORED AFTER SOAK
If L = LTOT Then
TCZP = TAVRG
```

```
        GoTo 505
End If
H1CZ = 0.25 * (TCZ - TR) * CPRF * (PI * RAVRG ^ 2 * (L - LTOT))
If J = 1 Then
H1CZ1 = H1CZ
End If
SITCZ = J * DTP
TETAR = ALPHRES * SITCZ / (RAVRG ^ 2)
If TETAR >= 0.02 And TETAR <= 0.025 Then
VR = 0.92 + (((TETAR - 0.025) / 0.005) * (-0.03))
GoTo 10
End If
If TETAR < 0.02 Then
VR = 0.95 + (((TETAR - 0.02) / 0.02) * (-0.05))
GoTo 10
End If
SK = 0.25
SK2 = 0#
For K = 1 To 300
SK2 = SK2 + SK
SK1 = ((-1 / TETAR) * (K + 1.5) / ((2 + K) * (3 + K))) * SK
SK = SK1
Next K
VR = (1 / TETAR) * SK2
10
 VZ = 1
DELTA1 = HFCZT
DELTA2 = H1CZ1
DELTA = DELTA1 / DELTA2
TCZP = TR + (TCZ1 - TR) * ((VR * VZ) * (1 - DELTA) - DELTA)
If TCZP < TR Then
TCZP = TR
End If
```

```
    505
End Sub
Attribute VB_Name = "Module22"
Sub ENDWELL()
For J = I1 To N
For K = J To 1 Step -1
If K > I1 Then
RH(K, J) = 0
GoTo 11
End If
If K = I1 Then
A1 = 0.25 * PI * DL(K) * CCONV
A2 = 0
A3 = 0
A4 = COND * (0.25 * PI) * CCONDB

B = COND * 2 * DL(K) * CCONDS
C1 = -(0.25) * PI * RH(K, J - 1) ^ 2 * DL(K) * CCONV
C2 = 0#
C3 = 0#
C4 = -(0.25 * PI) * CCONDB * RT ^ 2
C5 = -(DL(K) / LTOT) * (IW * HS * DT) - HREM
A = A1 + A2 + A3 + A4
 C = C1 + C2 + C3 + C4 + C5
 RH(K, J) = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
GoTo 11
End If
If K = 1 Then
A1 = 0.25 * PI * DL(1) * CCONV
A2 = COND * (0.25 * PI) * CCONDB
A3 = FACR * COND * (0.25 * PI) * CCONDR
A = A1 + A2 + A3
B = COND * 2 * DL(K) * CCONDS
```

```
        C1 = -(0.25) * PI * RH(K, J - 1) ^ 2 * DL(K) * CCONV
C2 = (0.25 * PI) * RT ^ 2 * CCONDB
C3 = -FACR * COND * (0.25 * PI) * RH(K + 1, J) ^ 2 * CCONDR
C4 = 0
C5 = -(DL(K) / LTOT) * (IW * HS * DT) - HREM
C = C1 + C2 + C3 + C4 + C5
RH(K, J) = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
GoTo 11
End If
If K > 1 And K < I1 Then
A1 = 0.25 * PI * DL(K) * CCONV
A2 = 0
A3 = FACR * COND * (0.25 * PI) * CCONDR
A = A1 + A2 + A3
B = COND * 2 * DL(K) * CCONDS
C1 = -(0.25) * PI * RH(K, J - 1) ^ 2 * DL(K) * CCONV
C2 = 0
C3 = -FACR * COND * (0.25 * PI) * RH(K + 1, J) ^ 2 * CCONDR
C4 = 0
C5 = -(DL(K) / LTOT) * (IW * HS * DT) - HREM
C = C1 + C2 + C3 + C4 + C5
RH(K, J) = (-B + (B ^ 2 - 4 * A * C) ^ 0.5) / (2 * A)
End If
If J = N Then
'Print #1, I, K, DL(K), RH(K, I)
End If
11 Next K
Next J
End Sub
```

APPENDIX C

ECONOMIDES JOSHI COLD PRODUCTIVITY INDEX

Productivity index					
Data					
Wellbore radius	rw	0.29			
Horizontal permeability	Kh	2000	md		
Vertical permeability	Kv	2000	md		
Thickness Formation	h	120	ft		
Reservoir Pressure	Pr	1319	psia		
Bottom Hole pressure	Pwf	230	psia		
Delta P	Pr-Pwf	1089	psia		
Oil Formation volume Factor	Bo	1	resbbl/STB	Dead oil	
Oil viscosity at T=128oF	MUO	635	cp		
Gravity API	oAPI	11.7			
Oil density at reference at T,ρo		Equation E-20 Enhance Oil Recovery Don W Green and G.Paul Willhite			
	Treser	128			
	ρo_R	61.687	Lbm/ft3		
	C1	0.020			
	C2	0.000007			
	ρo	**60.388**	**Lbm/ft3**		
	ρw	62.400	Lbm/ft3		
	γo	0.968			
	L	**330.000**	165		
	reh	**263.30**	**ft**	**263.3019**	**(complete drainage area)**
	Geometry fact	**0.363**			
	reh	**213.720**			
Horizontal - vertical permeability anisotropy	Iani	1			
	L/2	165			
	0.9*reh	236.97			
	L/2<0.9reh	ok			
Large half-axis of the drainage ellipsoid	a	290.28	ft		
	a=L/2	165.00			
Maximun Cold production,Q	Q	841.46	bb/day		
	eq. a	3.21	1.00		
	Ln eqa	1.17	0.00000		
	I*h/L	0.36			
	i*h/(rw*(I+1))	206.90			
	Ln	5.33			
	J	**0.86**	**BBl/day/psia**		

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