West Virginia University
Petroleum and Natural Gas Engineering
College of Engineering and Mineral Resources
PNGE 295: Petroleum Engineering Design

Petroleum Engineering Design

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Executive Summary

The objective of this project is to select two hydrocarbon formations in order to: design casing program and completion for both wells, analyze well logs from those wells, analyze buildup test data from the wells, perform a reservoir engineering study on both wells to predict the performance of the reservoir, and last to do economical study on each wells and choose the best wells based on the economical analysis.

For this project, two gas wells were selected in West Virginia and all available information were gathered so that casing programs and completion designs can be preformed on the selected wells. For the first well, the conductor casing 13 3/8” H-40 48 lb/ft is set at 30 ft, the surface casing 9 5/8” H-40 32.3 lb/ft is set at 1133 ft, the intermediate casing 7” H-40 17 lb/ft is set at 2432 ft, and the production casing 4 ½” J-55 10.5 lb/ft is set at 5987 ft. For the second well, the conductor casing 13 3/8” H-40 48 lb/ft is set at 36.5 ft, the surface casing 9 5/8” H-40 32.3 lb/ft is set at 786.5 ft, the intermediate casing 7” H-40 17 lb/ft is set at 2211 ft, and the production casing 4 ½” J-55 10.5 lb/ft is set at 5077.9 ft.

Well logs for both wells that were selected were analyzed in order to estimate the reserves. The original gas in place for both wells was calculated using the volumetric method. The bulk density, porosity neutron, and resistivity of deep induction were read every two feet in the target formation for each well from the logs and were used in the calculation of the reserves. The initial gas in place was calculated for both wells first by averaging the original gas in place for the entire proposed formation. Then the original

gas in place was calculated by averaging the parameters involved in calculating the original gas in place.

The volumetric method underestimates the gas in place when the rock matrix is shale because the matrix of this kind of rock contains gas besides the one in the porous volume. The amount of gas contained in the shale matrix can not be determined by the volumetric method. Estimation of initial gas in place in shale formation needs special treatments; however, For practical analysis, the volumetric method is going to be used to estimate the initial gas in place.

The first well has two pay zones. The first pay zone (4780'–5280) has an average porosity of 5.23 % ,average water saturation 40.014 % , and original gas in place of 6,545,199 (scf/ac-ft). The second pay zone (5710' – 5994) has an average porosity of 5.678 % ,average water saturation 43.221 % , and original gas in place 6,701,346 (scf/ac-ft). The second well has only one pay zone. The pay zone (4420 – 5020) has an average porosity of 4.715 % ,average water saturation of 44.507 % , and original gas in place 5,702,171 (scf/ ac-ft).

The permeability, k, skin factor, S` and flow efficiency, E, are determined for the two gas wells by analyzing the buildup data that were provided by Dr. Shahab Mohaghegh. A computer program was developed in Fortran to convert pressures to pseudo-pressures. Then using the Horner method, The permeability, skin factor and Flow efficiency were determined and the results are tubulated in table(3.3). The initial formation pressure could not be determined because the two wells were assumed not to be new wells in a new reservoir.

Reservoir engineering is concerned particularly with three important aspects:

1. The calculation of the gas deviation factor versus pseudo-reduce pressure for different pseudo-reduced temperatures. The main purpose of this point was to obtain a plot similar to the standing-Katz correlation by using any method we fell comfortable with. The method we used is called the Dranchuck, Purvis and Robinson Method, which fits the standing- Katz z-factor correlation by means of an eight-coefficient Benedict-Webb-Rubin type equation of state.

2. The determination of a polynomial equation that fits the viscosity versus pressure plot for our particular system. For this case, an analytical expression to evaluate the viscosity of natural gases called the lee, Gonzalez, and Eakin Method (Natural Gas Production Engineering Book), is used to generate the viscosity versus pressure plot.

3. Pressure profile (pressure Vs time) had to be generated using the line-source solution of the diffusivity equation in terms of Pseudo-pressure. In this case several assumption had to be done:

- The system behaves as infinitely large during the period of time covered (seven years).
- The initial pressure (Pi) is uniformly distributed through out the reservoir.

The line-sours solution was approximated with the logarithmic approximation, since it is almost always valid for transient analysis.

An abandonment pressure was assumed having the criteria of 100 psia /1000 ft, which is reasonable for a small fields. The purpose here was to produce a sustained constant flow rate (the maximum flow rate) for a period of seven years. The procedure followed to calculate this maximum flow rate was:

a) Assume a flow rate range.

b) Calculate a pressure profile for each flow rate.

- a higher flow rate than the optimum flow rate will give us an abandonment pressure leas than the one we assumed by the year seventh.
- a lower flow rate than the optimum flow rate will give us an abandonment pressure greater than the one we assumed by the year seventh.
- the optimum flow rate will be the one that will give us the abandonment pressure be the year seventh.

c). If with the flow rate range assumed in part a, the optimum flow rate is not obtained, the flow rate can be change and follow the procedure again.

After all the necessary calculations have been made and the result were obtained, a comparison between the two wells were made to determine which well is more profitable. A simple Monte Carlo simulator were developed in visual basic to determine the probability distribution of anticipated rate of return for wells. The discount cash flow rate of return for the first well was determined to be 75 % where for the second well the discount rate of return is determined to 50 %. As a result of this economic analysis, well number one is chosen.

Petroleum Engineering Designs

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Introduction

This project deals with five aspects of petroleum engineering which are designing casing program and completion, analyzing well logs, analyzing well test data, prediction of reservoir performance, and economic analysis. Let us briefly introduce the five aspects of our project.

Casing Design

Casing serves several important functions in drilling and completing a well. It prevents collapse of the borehole during drilling and hydraulically isolates the wellbore fluids from the subsurface formations and formation fluids. It minimizes damage of both the subsurface environments by the drilling process and the well by a hostile subsurface environment. It provides a high-strength flow conduit for the drilling fluid to the surface and, with the blowout prevents (BOP), permits the safe control of formation pressure. As the search for commercial hydrocarbons deposits reaches greater depths, the number and sizes of the casing strings required to drill and to complete a well successfully also increases. Casing has one of the most expensive parts of a drilling program; studies have shown that the average cost of tubular is about 18 % of the average cost of a completed well. Thus an important responsibility of the drilling engineer is to design the least expensive casing program that will allow the well to be drilled and operated safely throughout its life.

Well Logging Analysis

Petrophysical characteristics of the subsurface can be estimated using information from geophysical logs. The diversity and accuracy of the estimates depends upon the number of logs available. As logging tools are being pulled up in the well, their sensors are measuring certain physical properties of formations. These measurements-recorded on long strips of paper and, digitally, on magnetic tapes-are called well logs. A few dozen different logs can be run today, including such measured properties as resistivity or conductivity of the rocks, intensity of natural radioactivity, electrical potentials existing in the well, and velocity of sound waves.

The task of the log analyst, after all measurements have been collected, is to determine the presence and amount of hydrocarbons in the well. It is also important to determine various characteristics such as permeability and the types of minerals present in the producibility of hydrocarbons. Thus, many parameters can be computed from well logs. In this project, the well logs for the selected wells are analyzed in order to estimate the gas reserves. Several log have run through the two selected well (such as gamma ray log, density log, resistivity log, and temperature log).

Well Test Analysis

The pressure buildup test is the most commonly used pressure transient test. This test requires that a producing well be shut in and the resulting increase in formation face pressure be measured as a function of shut-in time. It is assumed that the test well was produced at constant formation face rate for a time, tp, prior to being shut in. shut-in time is denoted by the symbol t.

The Advantage and Disadvantage of the Buildup Test:

The advantages:

1. The problem of rate control, which is the greatest disadvantage of flowing tests, is eliminated since the well is shut in during the test.
2. Wellbore storage can be reduced, or eliminated, by using a bottomhole shut-in device
3. Average pressure within the drainage volume of the shut-in period.
4. The test can be used on wells with certain types of artificial life where subsurface pressure measurements would be difficult to obtain under flowing conditions.

The disadvantages:

1. Loss of production during the test.
2. Redistribution of fluids in the wellbore during shut-in can make analysis of some data difficult, or impossible, if a bottomhole shut-in device is not used.
3. Well can sand up, or experience other mechanical problem, during shut-in.
4. Requires a reasonably constant rate for a period of time prior to shut-in.
5. The pressure buildup test is a two- rate test; accordingly, superposition methods must be used to evaluate the data.

Prediction of Reservoir Performance

This petroleum area shares the distinction with geology in being one of the great “under ground science” attempting to describe what occurs in the wide open spaces of the reservoir between sparse points of observation the well. Reservoir engineering is a complex subject for two reasons:

a) We never see enough of the reservoir we are trying to describe. Therefore, it is difficult to define the physics of the system and, therefore, select the correct mathematics to describe the physics with any degree of certainty.

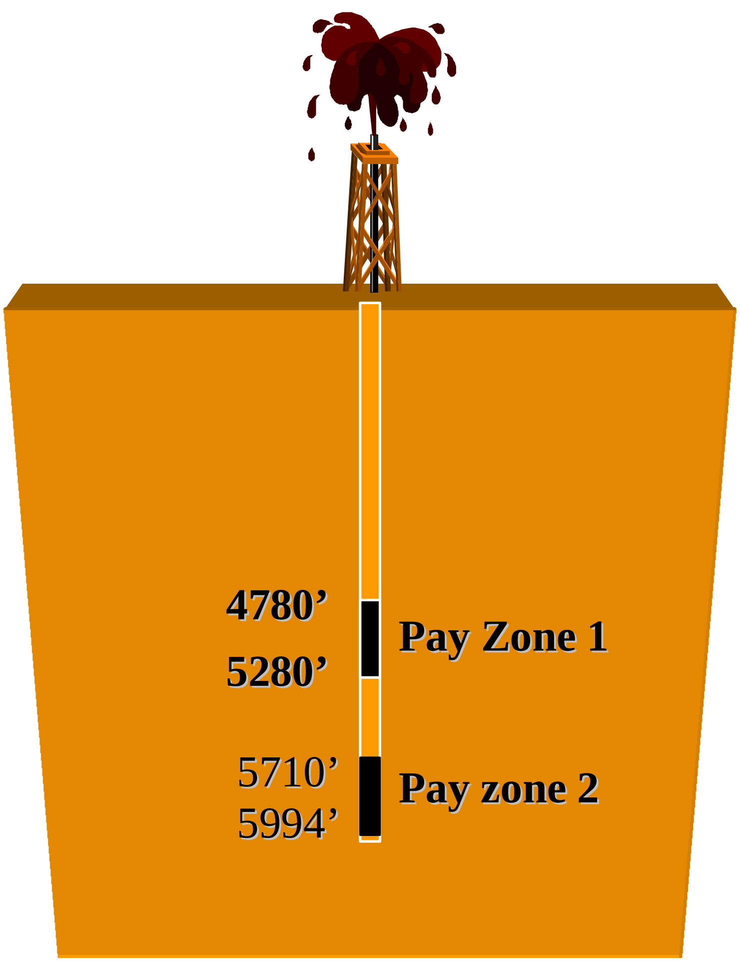
b) Even having selecting a sensible mathematical model, there are never enough equations to solve for the number of unknowns involved. The later problem extends across the broad spectrum of the subject, from material balance application to well test interpretation and leads to an inevitable lack of uniqueness in describing reservoirs. Given the basic limitations, the only approach to the subject must be one of simplicity, in fact the basic tenet of science: There are two ways to account for a physical phenomenon, it is the simpler that is the more useful.

Economic Analysis

Economic analysis is one of the most important parts of any design and in most of the time economic analysis is the decision-maker. In this project, Monte Carlo Simulation method is used to evaluate the economic conditions of the two wells. A simple simulator was developed in visual basic to determine the probability distribution of anticipated rate of return. Discount cash flow of return will be the yardstick in the comparison of the two wells.

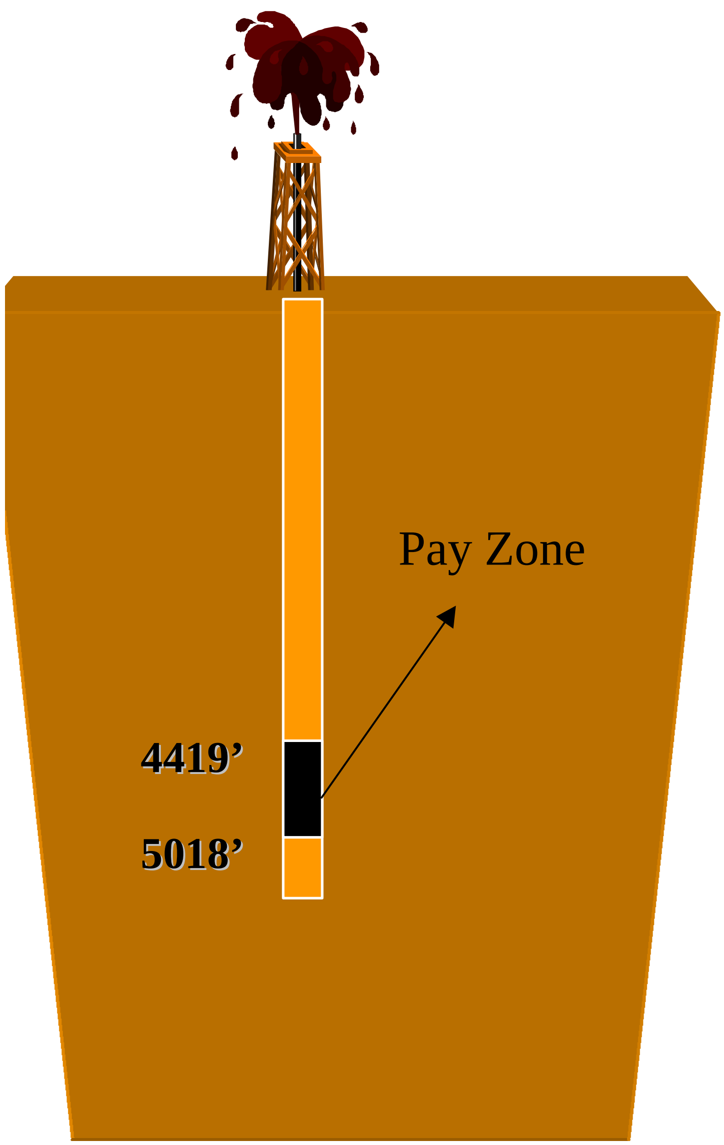
<u>Back Ground and Geological Information</u>

The first well is a gas well. It is located in Sylvester quadrangle at latitude of 520 feet south of 38° 05’ 0”, and a longitude of 9380 feet west of 81° 30’ 0” in Kanawha County, WV. The well is owned and operated by the Eastern American Energy Corporation. The well has a depth of 5967 ft. The first pay zone formation of Rhinestreet lies at a depth of (5994.5 – 5710) ft, and the second pay zone formation of Java, and Basal Lower Huron lies at a depth of (5280 – 4780) ft. The well has initial gas flow of 237 MCF/D and final open flow of 211 MCF/D. The static rock pressure of the well is 725 psig.



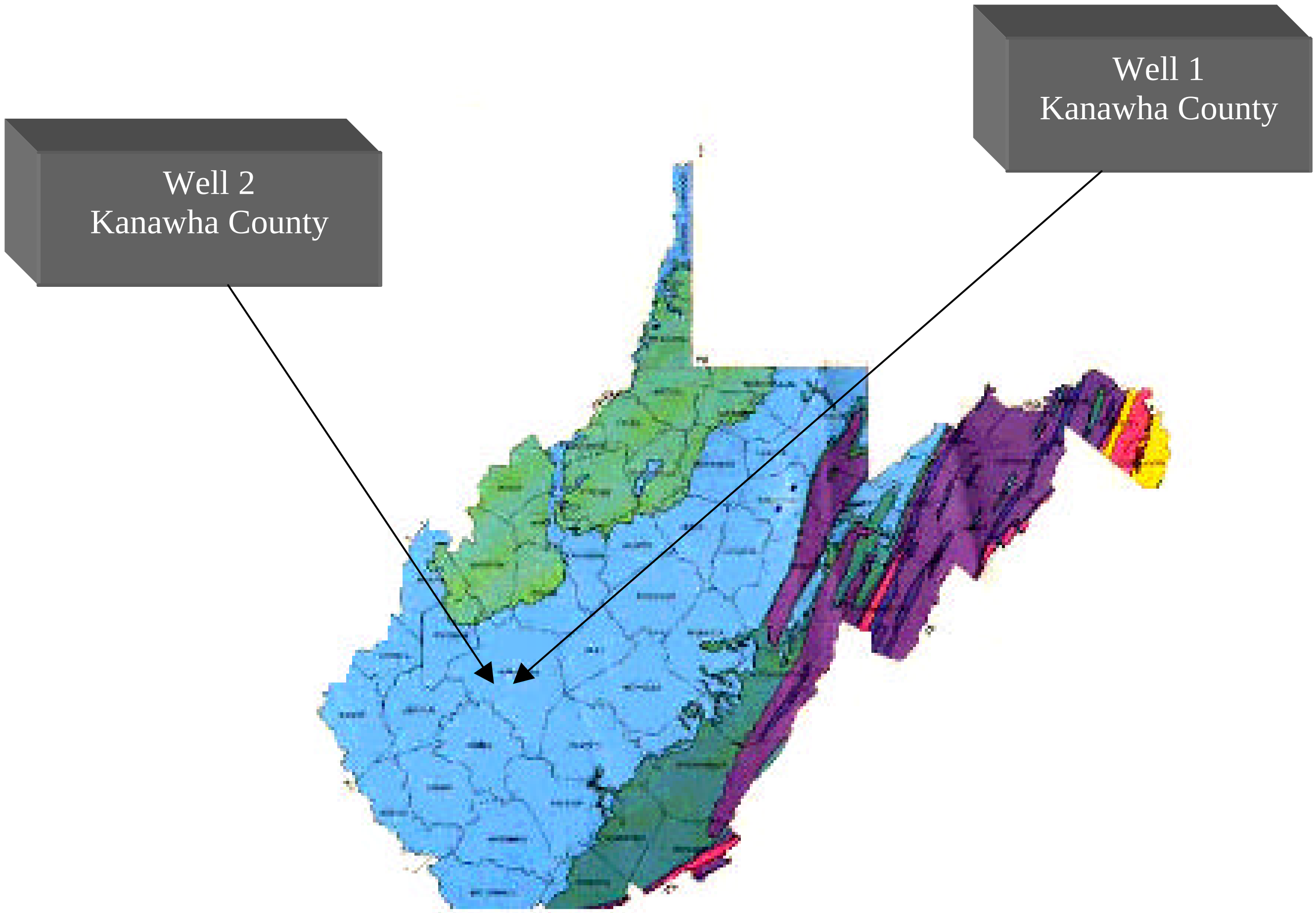
- Proposed target formation: Devoian shale
- Initial Open test : 237 MCF/d
- Final Open test: 211 MCF/d
- Time of open flow between initial and fin test tests 15 hrs.
- Static Rock Pressure: 725 psig @ surface pressure after 24 hrs.

The second well is also a gas well. It is located in the Eskdale quadrangle at a latitude of 11480 feet south of 38° 07’ 30”, and a longitude of 10640 feet west of 81° 27’ 30” in Kanawha County, WV. It is owned and operated by the same company that owns the first well. The well has a depth of 5185 ft. The pay zone formation of Java and Basal Lower Huron lies at a depth of (5018.5 – 4419.5) ft. The well has initial gas flow of 189 MCF/D and final open flow of 133 MCF/D. The static rock pressure of the well is 725 psig.



- Proposed target formation: Devonian shale.
- Pay Zone: 4419- 5018 (ft)
- Initial Open test : 189 MCF/d
- Final Open test: 133 MCF/d
- Time of open flow between initial and final test tests 15 hrs.
- Static Rock Pressure: 725psig @ surface pressure after 24 hrs.

Well Locations



State of West Virginia

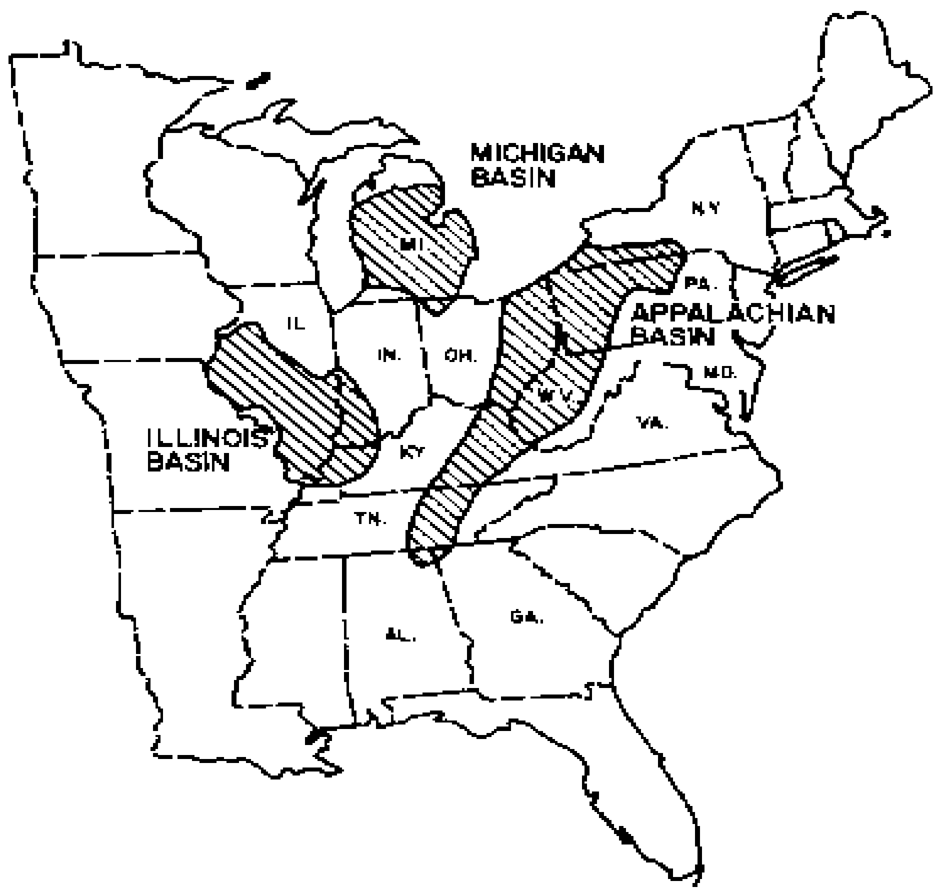
Devonian Regional Setting

The in-place natural gas resource from the Devonian shale of the eastern Unite States has been estimated to be between 277 and 900 trillion cubic feet (Tcf). The Devonian shale reservoir containing this resource underlies an area of approximately 275,000 square miles within the confines of the Appalachian, Michigan and Illinois basin. The regional setting of the three basins within the area of the eastern United States shown on (figure 1) page 15. Although deposition in the three basins was not contiguous throughout Devonian time, each of the basins was a site for accumulation of thick deposits of high organic black muds during Middle and Late Devonian time. The high organic content the black muds which lithified into the black petroliferous shales is considered to be the source for the matrix gas now trapped in the Devonian shales and sandstones as well as for the free gas found in areas of secondary fracture porosity within the Appalachian basin.

Facts about the Devonian Shale

The Late Devonian-age dark shales of the Eastern Interior Basins contain a prodigious amount of natural gas underlying thousands of square miles of the United States. This potential gas source is of great economic interest because of its proximity to major concentrations of energy-consuming industrial and population component centers. However, the gas is so tightly held in the shale's low-permeability, low-porosity pore network that it does not currently constitute an economically attractive drilling target for gas explorationists or producers.

Although, the Late Devonian-age dark shales of the Eastern Interior basins are thought to be uniformly gassy. Organic geochemical studies in the Appalachian, and Illinois Basins show that the gas is not uniformly distributed and that most of the gas is probably sourced and largely retained in thin, organic-rich zones that were deposited in restricted marine environments. These restricted conditions occurred intermittently as the basins subsided and the structural highs were periodically uplifted and shed their sediments and detrital organic matter. As the Devonian-age basin filled, the environments of deposition of the Appalachian Basin and Illinois Basin became non-marine more and more northerly and northwestwardly, respectively.



Distribution of gas-bearing Devonian-age shales in the eastern Unites States

Figure 1

Casing serves several important functions in drilling and completing a well. It prevents collapse of the bore hole during drilling and hydraulically isolates the well bore fluids from the subsurface formations and formation fluids. It minimizes damage of both the subsurface environment by the drilling process and the well by a hostile subsurface environment. It provides a high-strength flow conduit for the drilling fluid to the surface and, with the blowout prevents (BOP), permits the safe control of formation pressure.

As the search for commercial hydrocarbons deposits reaches greater depths, the number and sizes of the casing strings required to drill and to complete a well successfully also increases. Casing has one of the most expensive parts of a drilling program; studies have shown that the average cost of tubular is about 18 % of the average cost of a completed well. Thus an important responsibility of the drilling engineer is to design the least expensive casing program that will allow the well to be drilled and operated safely throughout its life.

The four general casing strings run in a well are conductor, surface, intermediate, and production. These may be run to different depths, and one or more may be omitted. Two or perhaps three strings may be used (such as two strings of intermediate casing.). they may be run as liners or in combination with liners.

Conductor. The main purpose of this casing is to hold back the unconsolidated surface formations and prevent them from falling into the hole. This could result in additional drilling time and possible loss of the lower hole. The conductor also provides a flow line to return the mud to the pits and a base or partial support for the suspended weight of the other casing string. The conductor is generally a larger-diameter pipe, commonly from 9 5/8 to over 30-in. diameter, and is usually set at depths of 20 to 1,000 feet.

Surface Casing. The surface casing serves various purposes. It holds back unconsolidated shallow formations that can fall into the hole and cause problems similar to those in the conductor hole. It cases off or isolates shallow water zones to prevent contamination from the deeper horizons (usually in accordance with government regulations). Surface casing provides a back-up or relief outlet for the next inner casing string in case the string ruptures. It acts as a base to support the suspended weight of the subsequent casing strings. Surface casing is usually 8 5/8 to 13 3/8-in. diameter, set at depths of 300 to 5,000 feet and cemented to the surface.

Intermediate. Intermediate or protective casing is set at intermediate depths between the surface and production casing. The main reason for setting intermediate casing is to case or shut off a hole condition that will prevent the well from being drilled safely to total depth. The most common reason to shut off lost circulation zones, especially when higher-pressure zones are expected at deeper depths. It also used to isolate troublesome shales, shallow gas flow, or water flows. These can hinder or prevent deeper drilling.

Production. Production pipe or the long string is set through the prospective productive zones except in open-hole completions. It usually designed to hold the maximum shut-in pressure of the producing formations and may be designed for stimulating pressure during completion. When two intermediate casing strings have been run and hung in the bottom of the drilling liner. The drilling liner is extended back to surface with tie-back completion (production) casing. In this case the drilling liner then becomes part of the completion casing.

Well Logging Tolls:

All onshore well logging operations utilize similar surface equipment systems for a wide variety of downhole tools. Variations, however, are present between these and offshore systems, which consist of a permanently mounted equipment assembly. In each case, the same surface equipment can be used for any electrically operated, wire-line tool by changing the control panel connections in the logging unit.

Well Setup. Three basic setups are used, depending on the wellsite and type of downhole tool. The first is when the drilling rig is still on location. Figure 1 gives a basic diagram of the setup. From the logging unit, the cable is threaded through the lower sheave, which is anchored to the rig floor, and up over the upper sheave hanging from a strain gauge (weight indicator) which is coupled to the traveling block. The second and third setups are when the drilling rig has been removed from the wellsite. Using large, heavy tools requires a mast over the hole so the tool can be raised to a vertical position. A portable hydraulic mast is usually used for this purpose. Finally, small, easily handled downhole tools can be run into the hole simply by setting up a single sheave at the wellhead.

Logging Unit. The logging unit is the control center for all well logging operations. A unit can be either truck, barge, or platform-mounted for offshore operations. It contains a control panel for monitoring all logging activities, from moving the tool to recording data. More recently, sophisticated computers have enhanced the ease with which the engineer may operate the logging procedure.

Hoisting Equipment. The hoisting equipment required for well logging operations includes a power source, hoisting drum, and power supply. The power supply, which operates the the hoisting drum, is a variable-displacement hydraulic pump with a reversible hydraulic motor either electrically or gasoline operated.

Cable Construction. A typical logging cable consists of seven rubber-insulated symmetrically spaced stranded copper wires with a cloth-braid wrapping separating the conductors from the outer steel jackets (see Figure 2). Usually, a seven-conductor cable is used for electrical-logging operations, and a one- or three-conductor cable for

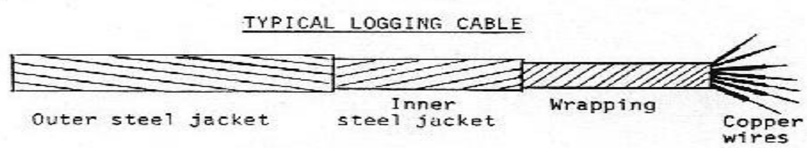
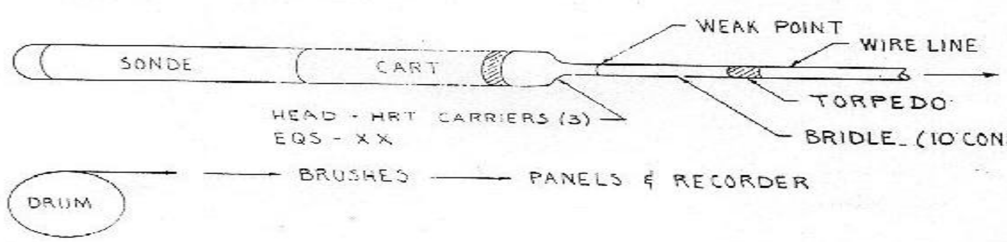


Figure 2

Typical downhole logging tool



Main components of a typical (downhole) logging tool are as follows:

a. Sonde
b. Cartridge
c. Head
d. Bridle
e. Weak Point
f. Wire Line
g. Drum
h. Brushes, Panels and Recorder

perforating. The number of conductors depends on the number of applications on the downhole tool.

Types of Logs

The Gamma Ray Logs

The GR is a measurement of the natural radioactivity of the formation. In sedimentary formation the log normally reflects the shale content of the formations. This is because the radioactive elements tend to concentrate in clay and shale. Clean formations usually have a very low level of radioactivity, unless radioactive contaminant such as volcanic ash or granite wash is present or the formation waters contain dissolved radioactive salts.

The GR log can be recorded in cased wells, which makes it very useful as a correlation curve in completion and workover operation. It is frequently used to complement the SP log and as substitute for the SP curve in wells drilled with salt mud, air, or oil-based muds. In each case, it is useful for location of shales and nonshaly beds and, most importantly, for general correlation.

Applications

The GR is particularly useful for defining shale beds when the SP is distorted (in very resistive formations), when the SP is featureless (in freshwater-bearing formations or in salty mud; i.e., when $R_{mf} \approx R_w$), or when the SP cannot be recorded (in nonconductive mud, empty or air-drilled holes, cased holes). The bed boundary is picked at a point mid way between the maximum and minimum deflection of the anomaly.

The GR log reflects the proportion of shale and, in many regions, can be used quantitatively as a shale indicator. It is also used for the detection and evaluation of radioactive minerals, such as potash or uranium ore. Its response, corrected for borehole effect, is practically proportional to the K_2O content, approximately 15 API units per 1 percent of K_2O. The GR log can also be used for delineation of non -radioactive minerals.

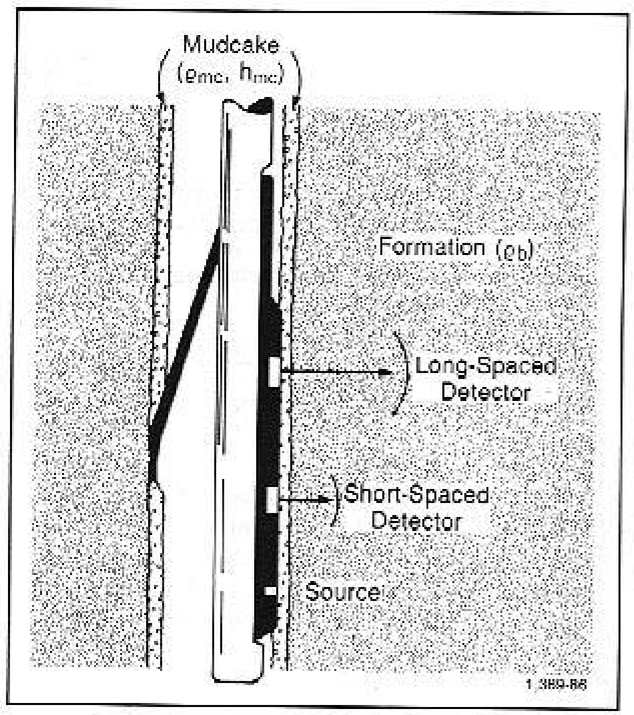
This traditional correlation log is part of most logging programs in both open and cased hole. Furthermore, because it is readily combinable with most other logging tools, it permits the accurate correlation of logs made on one trip into the borehole with those made on another trip.

Density logs

Density logs are primarily used as porosity logs. Other uses include identification of minerals in evaporate deposits, detection of gas, determination of hydrocarbon density, evaluation of shaly sands and complex lithologies, determinations of oil-shale yield, calculation of overburden pressure and rock mechanical properties.

Principle

A radioactive source, applied to the borehole wall in a shielded sidewall skid, emits medium- energy gamma rays into the formations. These gamma rays may be thought of as high- velocity particles that collide with the electrons in the formation. At each collision a gamma ray loses some, but not all, of its energy to the electron, and then continues with diminished energy. This type of interaction is known as Compton scattering. The scatted gamma rays reaching the detector, at a fixed distance from the source, are counted as an indication of formation density. The number of Compton-scattering collisions is related directly to the number of electrons in the formation. Consequently, the response of the density tool is determined essentially by the electron density (number of electrons per cubic centimeter) of the formation. Electron density is related to the true bulk density, ρb, which, in turn, depends on the density of the rock matrix material, the formation porosity, and the density of the fluids filling the pores.



Schematic drawing of the dual spacing formation density logging device

Neutron logs

Neutron logs are used principally for delineation of porous formation and determination of their porosity. They respond primarily to the amount of hydrocarbon in the formation. Thus, in clean formation whose pores are filled with water or oil, the neutron log reflects the amount of liquid-filled porosity.

Gas zones can be often be identified by comparing the neutron log with another porosity log or a core analysis. A combination of the neutron log with one or more porosity logs yield even more accurate porosity values and lithology identification-even an evaluation of shale content.

Principle

Neutrons are electrically neutral, each having a mass almost identical to the mass of a hydrogen atom. High –energy (fast) neutrons are continuously emitted from a radioactive source in the sonde. These neutrons collide with nuclei of the formation materials in what may be thought of as elastic “billiard-ball” collision. Whit each collision, the neutron loses some of its energy.

The amount of energy lost per collision depends on the relative mass of the nucleus with which the neutron collides. The greater energy loss occurs when the neutron strikes a nucleus. Collisions with which the neutron strikes a nucleus of practically equal mass – i.e., a hydrogen nucleus. Collisions with heavy nuclei do not slow the neutron very much. Thus, the slowing of neutrons depends largely on the amount of hydrogen in the formation.

Within a few microseconds the neutrons have been slowed by successive collisions to thermal velocities, corresponding to energies of around 0.025 eV. They then diffuse randomly, without losing more energy, until they are captured by the nuclei of atoms such as chlorine, hydrogen, or silicon.

The capturing nucleus becomes intensely and emits a high-energy gamma ray of capture. Depending on the type of neutron tool, either these capture gamma rays or the neutrons themselves are counted by detector in the sonde.

When the hydrogen concentration of the material surrounding the neutron source is large, most of the neutrons are slowed and captured within a short distance of the source. On the contrary, if the hydrogen concentration is small, the neutrons travel farther from the source before being captured. Accordingly, the counting rate at the detector increases for decreased hydrogen concentration, and vice versa.

Induction logs

The induction-logging tool was originally developed to measure formation resistivity in boreholes containing oil-base muds and in air-drilled borehole. Electrode devices did not work in there nonconductive muds, and attempts to use wall-scratchier electrodes were unsatisfactory.

Experience soon demonstrated that the induction log had many advantages over the conventional ES log when used for logging wells drilled with water-base muds. Designed for deep investigation, induction logs can be focused in order to minimize the influences of the borehole, the surrounding formations, and the invaded zone.

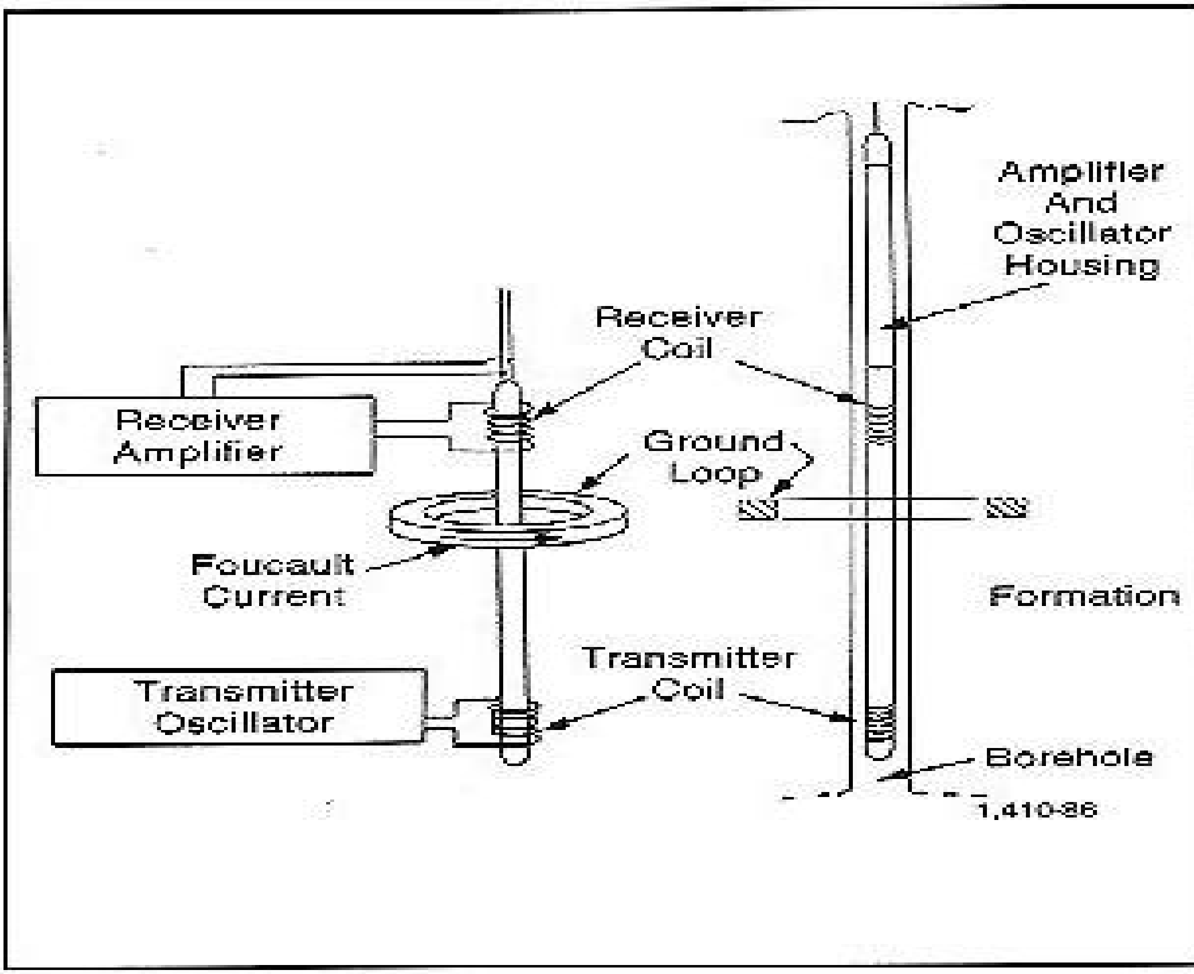
Principle

Today's induction tools have many transmitter and receiver coils. However, the principle can be understood by considering a sonde with only one transmitter coil and one receiver coil Fig (3).

A high-frequency alternating current of constant intensity is sent through a transmitter coil. The alternating magnetic field created induction currents in the formation surrounding the borehole. These currents flow in circular ground loops coaxial with the transmitter coil and create, in turn, a magnetic field that induces a voltage in the receiver coil.

Because the alternating current in the transmitter coil is of constant frequency and amplitude, the ground loop currents are directly proportional to the formation conductivity. The voltage induced in the receiver coil is proportional to the ground loop currents and, therefore, to the conductivity of the formation.

There is also a direct coupling between the transmitter and receiver coils. Using "bucking" coils eliminates the signal originating from this coupling. The induction tool works best when the borehole fluid is an insulator-even air or gas. The tool also works well when the borehole contains conductive mud unless the mud is too salty. The formations are too resistive, or the borehole diameter is too large.


Amplifier
And
Oscillator
Housing
Receiver
Coil
Receiver
Amplifier
Ground
Loop
Foucault
Current
Formation
Transmitter
Coil
Transmitter
Oscillator
Borehole
1,410-26

Theory

The approach that were used in this project for casing and completion, well logs analysis, buildup test data analyzing, prediction of reservoir performance, and economic analysis as follows:

Casing Design

Casing Design Criteria

The design of a casing program begins with specification of the surface and bottomhole well locations and the size of the production casing that will be used if hydrocarbons are found in commercial quantities. The number and sizes of tubing strings and the type of subsurface artificial lift equipment that may eventually be placed in the well determine the minimum ID of the production casing.

To obtain the most economical design, casing strings often consist of multiple sections of different steel grade, wall thickness, and coupling types. Such a casing string is called a combination string.

Selection of Casing Setting Depths

The selection of the number of casing strings and their respective setting depths generally is based on a consideration of the pore-pressure gradients and fracture gradients of the formations to be penetrated. The pore pressure gradient and fracture gradient are expressed as an equivalent density, and are plotted vs. depth. Normally, pore pressure average about 0.46 psi/ft and range from as low as 0.25 psi/ft to over 1.05 psi/ft. Fracture gradient normally exceed the pore pressure by a few lb/gal. Pressure gradients are relatively constant over long interval. When this occurs, the interval can be drilled with a relatively constant mud weight. Frequently, the pore pressure gradient increases with depth. This normally requires an increase in the mud weight.

Selection of Casing Sizes

The size of the casing strings is controlled by the necessary ID of the production string and the number of intermediate casing strings required to reach the depth objective. To enable the production casing to be placed in the well, the bit size used to drill the last interval of the well must be slightly larger than the OB of the casing connectors. The selected bit size should provide sufficient clearnace beyond the OD of the coupling to allow for mud cake on the borehole wall and for casing appliances, such as centralizers and scratchers. The bit used to drill the lower portion of the well also must fit inside the casing string above. This, in turn, determines the minimum size of the second-deepest casing string. With similar considerations, the bit size and casing size of successively more shallow well segments are selected.

Selection of Weight, Grade, and Couplings

Once the length and OD of each casing string is established, the weight, grade, and couplings used in each string can be determined. In general, each casing string is designed to withstand the most severe loading conditions anticipated during casing placement and the life of the well. The loading conditions that are always considered are burst, collapse, and tension. To achieve a minimum-cost casing design, the most economical casing and coupling that will meet the design loading conditions must be used for all depths because casing prices change frequently. In general, minimum cost is achieved when casing with the minimum possible weight per foot in the minimum grade that will meet the design load criteria is selected.

Well Logging Analysis

The main method that was used to determine the original gas in place for the two wells that were selected is by using the Volumetric Method.

Volumetric Method

This approach is used early in the life of the reservoir (For instance, before 5 % of the reserves have been produced). The simplest form of the equation for the volumetric method that assumes a homogeneous, isotropic reservoir is:

$$\mathbf{G} = (43560)\,(A)\,(h)\,(\phi)\,(1 - S_w)\,(1/B_{gi}) \qquad \text{Eq.(B1)}$$

Where:

G = original gas in place, scf
43560 = conversion factor: square ft per ac
A = reservoir productive area, ac, h = net Thickness ft,
ϕ = porosity, fraction,
S_w = average water saturation, fraction, and
B_{gi} = initial gas formation volume factor, res. cu ft / scf.

$$\mathbf{Bgi} = 0.0283\ z\ T / P \qquad \text{Eq.(B2)}$$

Where:

B_{gi} = initial gas formation volume factor, res. cu ft / scf
Z = deviation factor
T = temperature in R
P = pressure in psia

Notice here that B_{gi} is the initial gas formation factor. It is assumed that the pressure base, Psc, is 14.7 psia and temperature base, Tsc, is 520 R.

The volumetric method underestimates the gas in place when the rock matrix is shale, since the matrix of this kind of rock contains gas besides the one in the porous volume. The amount of gas contained in the shale matrix can not be determined by the volumetric method. However, for practical analysis the volumetric method was used to estimate the original amount of gas in the porous media.

Determination of Porosity

Porosity is a measure of the void space within a rock. It indicates what fraction of the rock volume could contain oil or gas. Porosity for both wells is calculated using the following equation: -

$$\Phi = [(\rho m - \rho B) + \Phi N] / \rho m \qquad \text{Eq.(B3)}$$

where:

Φ = Porosity, fraction
ΦN = Neutron Porosity, fraction
ρm = matrix Density (g/cc)
ρB = Bulk Density (g/cc)

Values of Φ_N and ρ_B are read from the logs for both wells.

Determination of Water Saturation

Water saturation for both wells is determined by using the Apparent Water Resistivity method. The following equations were used to determine the water saturation:

$$R_{ID} = R_t \qquad \text{Eq.(B4)}$$

$F_R = 1/(\Phi^2)$ Eq.(B5)

$R_w = R_t / F_R$ Eq.(B6)

$I = R_w / R_{w\ min}$ Eq.(B7)

$S_W = 1 / (I)^{.5}$ Eq.(B8)

Where:

S_W = water saturation (%)

F_R = formation resistivity factor

R_W = resistivity of water

R_t = resistivity of uninvaded formation

I = resistivity index

Buildup Test Analysis

A pressure buildup test is the simplest test that can be run on a gas well. If the effects of wellbore storage can be determined, much useful information can be obtained. This information includes permeability, K, apparent skin factor, S`, average reservoir pressure, and flow efficiency. Generally, there are several methods of analysis that can beused to analyze the buildup test data.

P^2 - Method

This method is subjected to three major limitations:

1) It is assumed that pressure gradient around the wellbore of the test well are small.
2) Laminar flow is assumed, where most gas wells experience turbulent flow to some degree.
3) The ìZ product is assumed to be constant. This effectively limits the application of this method to pressures less than 2000 psia.

Therefore, this method of analysis is not going to be used to analyze the build-up data of the two wells.

Real Gas Pseudo-Pressure Method, m(p)

In 1966, Al-Hussainy introduced the concept of the real gas pseudo-pressure, m(p). This function is defined as:

$$M(p) = 2 \quad \frac{p}{\text{ìz}} \; dp \; , \; psi^2 / cp$$

where ìz are function only of pressure.

Since ì and z are integrated as a function of pressure, there are no limits on the pressure range. It is also important to observe that it does not contain the limitation that pressure gradients must be small.

In this project, the real gas pseudo-pressure method would be used to analyze the buildup test data. Therefor, a computer program is developed in Fortran to convert pressure to pseudo-pressure.

Real Gas Pseudo-Pressure Method

The relationship between p and m(p) can be obtained using the following procedure:

1- Determine viscosity and z as function of pressure for the entire range of pressures involved in the test analysis. Pressure increments of 50-100 psi are normally adequate.

2- Compute $2p/\Delta z$ for each pressure in step 1.

3- Compute m(p) as a function of pressure using numerical integration. In order to compute the value of m(p) at some pressure p1 it is necessary to compute the area under the curve between p1 and p2.This area, A1 is equal to

$$A = \int 2p/\mu z \, dp$$

If the pressure increment, p1- p2 is sufficiently small, the area can be assumed to be a trapezoid. The values of m(p) at other pressure can be determined in a similar manner.

The Z factor was calculated using Dranchuk, Purvis and Robinson Method (1974).

The Z factor equation is:

$$Z = 1 + (A1 + A2/T_r + A3/T_r^3)\,\rho_r + (A4 + A5/T_r)\,\rho_r^2 + (A5\ A6\ \rho_r\text{^}5)/T_r + A7\,\rho_r^2/T_r^3\,(1 + A8\,\rho_r^2)\exp(-A8\rho_r^2) \qquad \text{eq(c1)}$$

Where:

$$\rho_r = \frac{0.27\ Pr}{Z\ T_r}$$

A1 = 0.31506237	A4 = 0.53530771	A7 = 0.68157001
A2 = -1.046709.90	A5 = -0.61232032	A8 = 0.68446549
A3 = -0.57832729	A6 = -0.10488813	

The following method will be used to calculate the viscosity as a function of pressure:

Lee, Gonzalez and Eakin method.

This method does not include corrections for impurities, and values obtained would be corrected for pure hydrocarbon gases. The empirical equations for viscosity is

$$\mu_g = K * 10\text{^}{-4} \exp(X\rho_g\text{^}Y) \qquad \text{eq(c2)}$$

where

$$K = \underline{(9.4 + 0.02M)T^{1.5})}$$

$$209 + 19M + T$$

$$X = 3.5 + \underline{986} + 0.01M$$

$$Y = 2.4 - 0.2\,X$$

In these eqs., μ_g = cp, ρ_g = g/cm³, M = molecular weight of gas, and T = R

The delta pseudo-pressure m(p) was calculated with the formula:

$$Dm[p] = m[Pws] - m[Pwf]$$

Horner Analysis

The horner buildup test equation written in terms of m(p) is:

m(psw) = m(pi) – [(1637 qT / kh). Log ((tp + Ät) / Ät)] Eq.(c3)

Where:

m(psw) = formation face pseudo-pressure at shut in time Ät, psia.
m(pi) = initial pseudo-pressure, psia.
q = flow rate, Mscf / D.
T = temperatre, R.
k = permeability, md.
h = formation thickness, ft.

The theory used to analyze pressure buildup test data assumes the test well flowed at constant rate for a time tp before being shut in. tp is generally computed using the following equation:

$$tp = \left[\frac{\text{cumulative volume produced since last pressure equalization}}{\text{Constant rate just before shut- in}} \right]$$

According to Eq.c3, buildup data plotted as m(pws) versus ((tp + Ät) / Ät) on a semi log paper should yield a straight line during transient flow with a slope equal to

$$m = \left[-\frac{1637\, qT}{kh} \right] \qquad \text{eq. (c4)}$$

Determination of permeability

$$K = \left[-\frac{1637\, qT}{mh} \right] \qquad \text{eq.(c5)}$$

Determination of skin factor

$$S` = 1.151 \left[\frac{m(pws) - m(p1hr)}{m} - \log \frac{k}{ö\ ì * Ct * rw^2} + 3.23 \right] \qquad \text{eq.(c6)}$$

where ì* and Ct* are evaluated at p* .

Determination of flow Efficiency

$$E = \left[\frac{m(p^*) - m(pws) - Äm(p)s}{m(p^*) - m(pws)} \right] \qquad \text{eq.(c7)}$$

where:

Äm(p)s = -0.87 m s

m = slop, (psi^2 /cp)/ cycle.

S = skin factor.

Prediction of Reservoir Performance

It is possible to define four major activities in reservoir engineering, which are:

- Observation
- Assumption
- Calculation
- Development Decision

And this can be described as follows:

The observation activities include the geological model, the drilling of wells and data required in each: cores, logs, tests, fluid samples. Following the start of field production, the oil, gas and water rates must be continuously and accurately monitored together with any injection of water and gas. Frequent pressure and production logging surveys should also be conducted through out the lifetime of the production.

Once the data has been collected and verified, the engineer must interpret them very carefully and collect them from well to well through out the reservoir and adjoining aquifer (if any). This is a must delicate phase of the whole business of understanding reservoir, in which it can prove dangerous to rely too much on automated techniques.

Having thoroughly examined and collated all the available data, the engineer is usually obligate to make a set of assumptions concerning the physical state of the system for which an appropriate mathematical description must be sought. For instance:

- The oil or gas reservoir is or not effected by natural water inflow from an adjoining aquifer.

- There will or will not be complete pressure equilibrium across the reservoir section under the depletion or water drive conditions.
- The late-time upward corrective of points in a pressure build up survey result from: the presence of faults, dual porosity behavior or the break out of free gas under the well bore.

The assumptions are a crucial step in practical engineering, so much that once they have been made that is effectively the end of the reservoir engineering. The third activity, calculation, is entirely dependant on the nature of the assumptions made as is the fourth, development decisions, which rely on the results of the calculations. It is therefore necessary to be extremely cautious when making physical assumption and the most convincing reservoir study are those containing the least numbers.

The above mentioned give us an idea what is reservoir engineering.

Our project specifically is concerned with three aspects of reservoir engineering and will be discussed as follows:

The first aspect will be to generate the graph of compressibility factor versus pseudo-reduced pressure for different pseudo- reduced temperature.

The second aspect will be also to generate a graph, but this time viscosity versus pressure for the particular gas we are dealing with and then fit it into a polynomial.

In this part of the project, (the third aspect), The real gas potential approach will be used to predict the pressure profile of our two wells for the next seven years.

The following assumption are made:

A. We are working for a company that is involved in a contract that obligates us to provide a certain flow rate for a minimum of seven years.

B. A reasonable abandonment pressure.

C. The reservoir will act as it is infinitely large during the seven years

Let us examine in details how are we going to deal with these three aspects:

- **Compressibility factor versus pseudo-reduced pressure for several pseudo-reduced temperatures**.

The following method will be used:

Dranchuk, Purvis and Robinson Method (1974).

This method fits the standing-Katz Z-factor correlation by means of an eight-coefficient Bendict-Webb- Rubin type equation of state.

The Z factor equation is:

$$Z = 1 + (A1 + A2/T_r + A3/T_r^3)\,\rho_r + (A4 + A5/T_r)\,\rho_r^2 + (A5\ A6\ \rho_r\text{^}5)/\,T_r + A7\,\rho_r^2/\,T_r^3\,(1 + A8\,\rho_r^2)\exp(-A8\rho_r^2) \qquad \text{eq.(D1)}$$

Where:

$$\rho_r = \frac{0.27\ Pr}{Z\ T_r}$$

A1 = 0.31506237
A2 = -1.046709.90
A3 = -0.57832729
A4 = 0.53530771
A5 = -0.61232032
A6 = -0.10488813
A7 = 0.68157001
A8 = 0.68446549

A program will be made in Visual Basic using equation (D1) to generate the graph of the compressibility factor versus pseudo-reduced pressure for the given Pseudo-temperatures.

- **<u>Generation of viscosity versus pressure graph for the gas in our reservoir.</u>**

The following method will be used to calculate the viscosity as a function of pressure:

Lee, Gonzalez, and Eakin method.

This method does not include corrections for impurities, and values obtained would be corrected for pure hydrocarbon gases. The empirical equations for viscosity is

$$\mu_g = K * 10^{-4} \exp(X\rho_g{}^{Y}) \qquad \text{eq.(D2)}$$

where

$$K = \frac{(9.4 + 0.02M)T^{1.5})}{209 + 19M + T}$$

$$X = 3.5 + \frac{986}{} + 0.01M$$

$$Y = 2.4 - 0.2\,X$$

In these eqs., μ_g = cp, ρ_g = g/cm³, M = molecular weight of gas, and T = R

As can be seen, equation (D2) is intrinsically pressure dependent due to the gas density.

Our initial reservoir pressure will be taken from part 3 of this semester long project (P=1097psia) and our abandoned pressure will be assumed to be P=100psia /1000 ft of depth. The abandoned pressure used depend on the price of gas, the productivity index of the wells, the size of the field, its location with respect to market, and the type market. If the market is a transmission pipeline, the operating pressure of the line may be a controlling factor in the abandonment pressure for the small field; but for large fields, installation of compressor plants may be economically feasible. Thus, lowering the abandonment pressure substantially below the operating pressure of the pipeline serving the area.

Pressure production profile for seven years at constant flow rate (the highest flow rate possible)

Conditions:

- The well should be active and producing for seven years.
- The well has to produce at its highest possible rate.

Assumption: The reservoir will act as it is infinitely large during seven years.

The line source solution, Ei(-x), of the following partial differential equation

$$\frac{1}{r}\frac{d}{dr}\left(r\frac{dm(p)}{dr}\right) = \frac{\phi\mu C}{k}\frac{dm(p)}{dt}$$

will be used to calculate the pressure profile for the next seven years.

The solution is the following:

$$m(pi - p) = C_1 \frac{qB\mu}{kh} \left[- Ei \left(- C_2 \frac{\phi\mu C_t r^2}{kt}\right) \right]$$

where

C_1 = 70.6 and C_2 = 948 if q [bbl/d], K [md], h[ft], C [LPC^-1], and t [hrs] .

The viscosity and compressibility will be evaluated at the initial reservoir pressure.

Parameters like porosity and permeability will be taken from parts 2 and 3 of this semester long project respectively.

The line source solution is adequate if it is assumed that:

1- The reservoir is infinite in size.

2- The wellbore radius is zero.

3- The formation is producing at a constant rate.

4- The reservoir is at a uniform pressure, Pi, when production begins.

Recall that the solution of the diffusivity equation having in account the assumption above mentioned is:

$$m(p(r,t)) = m(pi) + \frac{qB\mu}{kh} \left[- Ei \left(\frac{- 948 \ \phi\mu C_t r^2}{kt} \right) \right] \qquad \text{eq.(D4)}$$

where

$$Ei(-x) = -\int \frac{e^{-\mu}}{\mu} d\mu \ \ (x, \infty) \qquad \text{eq.(D5)}$$

Ei = exponential-Integral Function.

This equation is sufficiently accurate for most applications of pressure Transient analysis during the transient flow period.

A logical question to ask is: Given a number (x), how do you evaluate Ei(-x)?

Ei(-x) is defined by equation (D5); fortunately, numerical solutions of this equation already exist and it will be necessary to evaluate this integral.

When $x < 0.01$, E(-x) can be approximated with less than 0.25 percent error by the following equation:

$$Ei(-x) = Ln\ (1.781\ x) \qquad \text{eq.(D6)}$$

From equation (D4) $x = \frac{948\ \phi\ \mu\ C_t r^2}{Kt}$,which means that equation (D6) can be used when $T > 9.48*10^{4} \frac{\phi \mu C_t r^2}{k}$.

For $0.01 < x > 10.9$, Table 1 in Appendix D III can be used to evaluate Ei(-X). However, for

$x > 10.9$, Ei(-x) can be considered zero for practical well test work.

With this approximation of equation (D6), equation (D4) reduces to:

$$m(p(r,t)) = m(pi) - \frac{1637qT}{kh} \left[\text{Log} \left(\frac{kt}{\phi\mu C_t r^2} \right) - 3.23 \right] \qquad \text{eq.(D7)}$$

Where: C1= 1637 when q[MSCF/D], T [R], k[md], h[ft], ϕ[%], μ[cp], C_t[psia^-1], r[ft].

Equation (D7) can be used to compute pseudo-reduced pressure as a function of time at any location, within the stated assumptions.

The viscosity and compressibility factor are integrated as a function of pressure, then there are no limits on the pressure range to which equation (D7) is applied.

Our interest will be the pressure behavior at the formation face of the producing well, then:

$r = r_w \quad m(p(r_w,t)) = m(p(r_w,t) = m(p_{wf})$

Equation (D7) becomes:

$$m(p_{wf}) = m(pi) - \frac{1637qT}{kh} \left[\text{Log} \left(\frac{kt}{\phi\mu_i C_{ti} r_w^2} \right) - 3.23 \right] \qquad \text{eq(D7a)}$$

and with the total skin factor, equation (D7a) becomes:

$$m(p_{wf}) = m(pi) - \frac{1637qT}{kh} \left[\text{Log} \left(\frac{kt}{\phi\mu_i C_{ti} r_w^2} \right) - 3.23 + 0.87\, s` \right] \qquad \text{eq(D8)}$$

μ_i and C_{ti} must be evaluated at p_i.

Equation (D8) will be the one we are going to use to generate the pressure profile for the next seven years in our two wells.

Practically, equation (D8) can be used anytime during the transient flow period to compute pressure at the formation face of the flowing well.

In our case:

For well # 1:

$$\text{Time} > 9.48*10^4 \frac{\phi\, \mu\, C_t\, r^2}{k} \Rightarrow T > \frac{0.052*0.014*0.00202*0.167^2}{0.055} = 0.0711 \text{ hrs}$$

For well # 2:

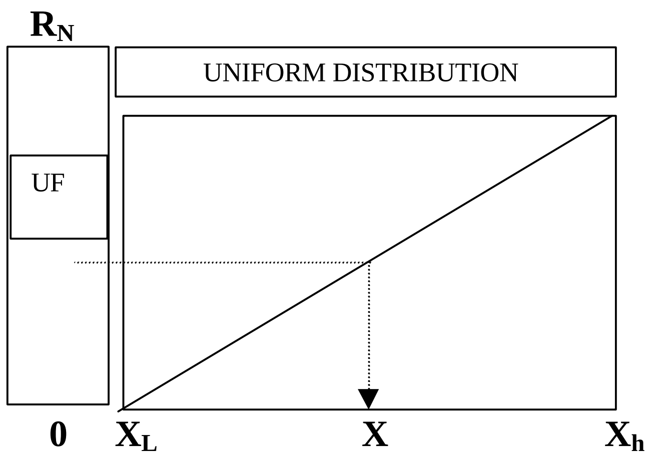
$$\text{Time} > 9.48*10^4 \frac{\phi\, \mu\, C_t\, r^2}{k} \Rightarrow T > \frac{0.04715*0.014*0.00202*0.167^2}{0.023} = 0.1536 \text{ hrs}$$

Economic Analysis

Uncertainty exist regarding feet of net pay, average porosity, fractional gas recovery, and rate at which recovery will take place, so these quantities are treated as probabilistic. In this project three distributions are considered: Uniform, Triangular, discreet.

In many cases detailed data are so limited that no distribution curve maybe developed from that data. But, on the basis of experience and general data, professional judgment maybe exercised. If a minimum, maximum and most probable value maybe developed a triangular distribution is possible. In some instance it's not reasonable to predict a most probable value, only a probable minimum and maximum are possible. For this case a rectangular distribution may be drawn.

Uniform distribution:



Use : when upper and lower limits of the range of the variable can be specified and when any of the values between these limits are as likely to occur as any other value.

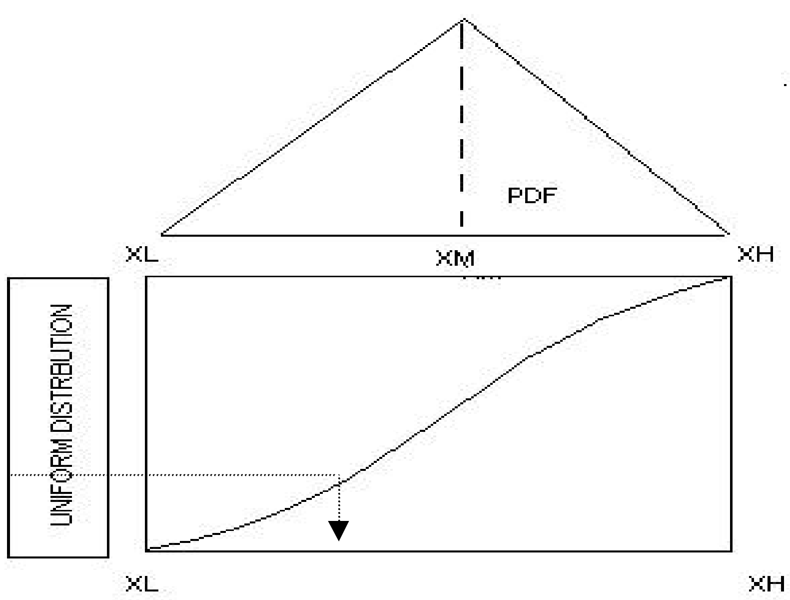
The unmmulative probability of x is given by

$$f(x) = (X - X_L) / (X_h - X_L).$$

Replacing f(x) with R_N , the uniform distributed number and solving for x.

$$X = X_L + R_N (XH - XL)$$

Triangular distribution:



When $X_L \le X \le X_m$

$f(x) = (X-X_L / Xm-X_L)^2 * (X_m-X_L/X_H-X_L)$

When $X_m \le X \le X_H$

$f(x) = 1- (X_H- X/ X_H- X_m)^2 * (X_H- X_m/ X_H-X_L)$

Replacing f(x) by Random Number (R_N).

a) If $R_N \le [(X_m - X_L) / (X_H - X_L)]$

Then $X = X_L+\sqrt{((X_m-X_L) * (X_H-X_L) * R_N)}$

b) If $R_N \ge [(X_m-X_L) / (X_H-X_L)]$

$X = X_H - \sqrt{((X_H-X_m) * (X_H-X_L) * R_N)}$

Discrete Distribution:

Required Condition	**Change of X**
$0 \le R_N \le P_1$	X_1
$P_1 < R_N \le P_1+P_2$	X_2
$P_1+P_2 < R_N \le P_1+P_2+P_3$	X_3
$P_1+P_2+P_3 < R_N \le 1$	X_4

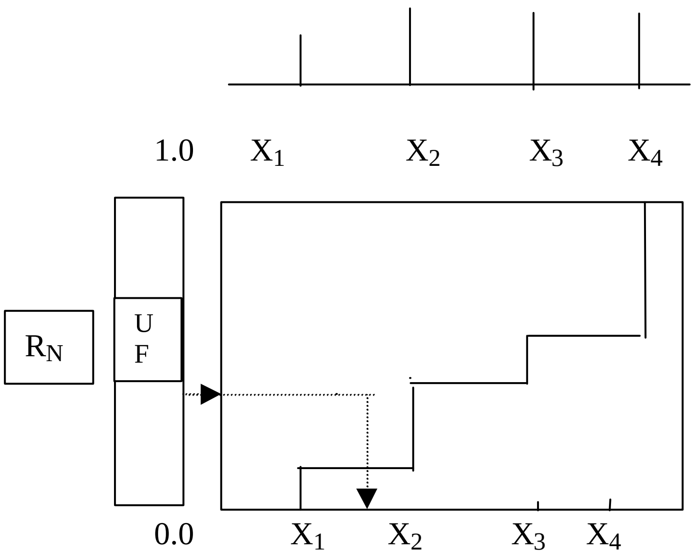
Net Cash Flow (NCF) = Revenue – Initial cost – Operating cost – Taxes

Net Present Value (NPV) = Sum $[NCF_j / (1+i)^j]$, (J=0:J=n)

Where:

J = Number of years
I = Discount rate
n = Toatl number of years

Discount Cash Flow Rate of Return Sum = $\left[NCF_j / (1+i)^j \right] = 0$



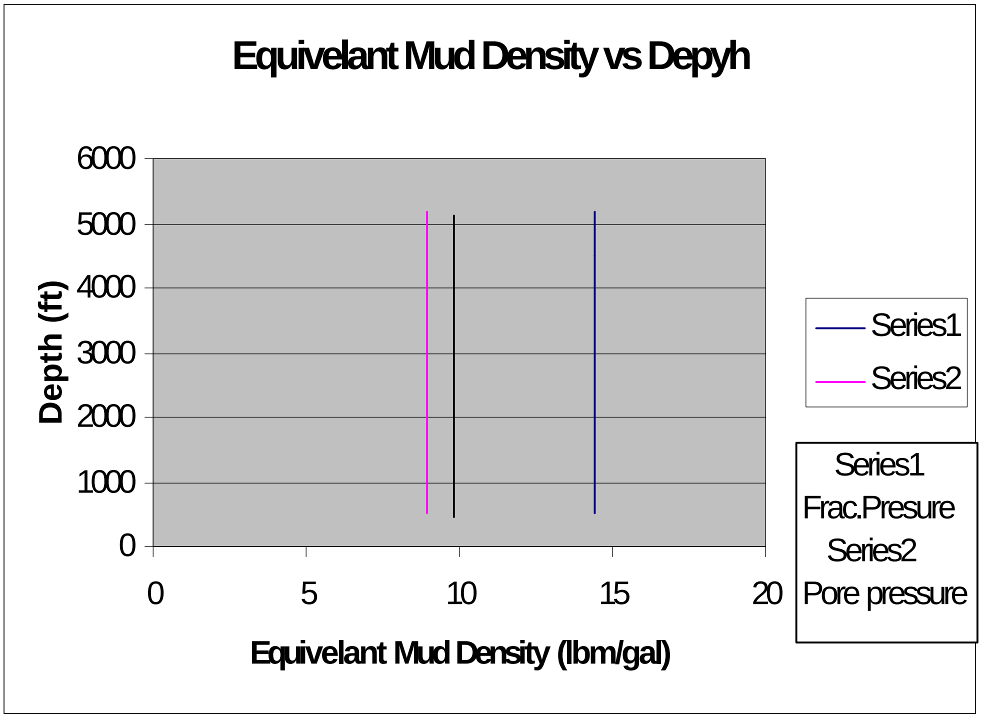
Calculations and Results:

In the casing design, assuming that there is a pore pressure gradient of 0.465 psi/ft, Fracture gradient of 0.75 psi/ft and considering the depth of well number 1, One casing would be enough to cover the well. However, There are several fresh and salt water formations and coal formations that need to be protected. Therefore, four casing strings (Conductor, surface, Intermediate, Production) are recommended for this well are seated at depth of 30’,1133’, 2432’, and 5987’ respectively.

SELECTION OF CASING SETTING DEPTHS

Well # 1

Depth(ft)	Pore Pressure(psi)	Fracture Pressure(psi)	Pore Press.(lbm/gal)	Frac. Pressure(lbm/gal)
500	232.5	375	8.942307692	14.42307692
1000	465	750	8.942307692	14.42307692
1500	697.5	1125	8.942307692	14.42307692
2000	930	1500	8.942307692	14.42307692
2500	1162.5	1875	8.942307692	14.42307692
3000	1395	2250	8.942307692	14.42307692
3500	1627.5	2625	8.942307692	14.42307692
4000	1860	3000	8.942307692	14.42307692
4500	2092.5	3375	8.942307692	14.42307692
5000	2325	3750	8.942307692	14.42307692
5185	2411.025	3888.75	8.942307692	14.42307692



Selection of casing sizes

Well # 1

A 4.5 inches production casing is desired for the first well. Using table 7.8 and 7.9 in the applied Drilling Engineering book a 6 ¼ inches bit is needed to drill the bottom section of the bore hole. This bit will pass through 3 of the 7 inches casings available(The required maximum weight per foot will be determined in the next section). According to table 7.7, a 8 5/8 inches bit will pass through a 9 5/8 inches casing. A 12 ¼ inches bit is needed to drill to the depth of the surface casing (9 5/8"). Finally, as shown in table 7.8 a 12 ¼ inches bit will pass through 13 3/8 casing, which will need a 17 ½ inches bit to start the drilling.

Casing	Casing sizes (inches)	Bit sizes (inches)
Conductor	13 3/8	17 ½
Surface	9 5/8	12 ¼
Intermediate	7	8 5/8
Production	4 ¼	6 ¼

Selection of grades and weight

Well # 1

Surface casing:

Design- loading conditions for surface casing are illustrated in Appendix A for burst, collapse, and tension considerations. The high-internal-pressure loading condition used for the burst design is based on a well-control condition assumed to occur while circulating out a large kick. The high-external-pressure loading condition used for the collapse design is based on a severe lost-circulation problem. The high-axial-tension loading condition is based on an assumption of stuck casing while the casing ran into the hole before cementing operations.

Calculation for surface casing:

The surface casing selected has an OD of 9 5/8-in and is to set at 1133.05 feet. The first step is the selection of the casing grade, wall thickness, and connectors are to eliminate the casing that will not meet the burst-design load (see appendix A). The fracture gradient at 1133.05 feet is equals to 0.75 psi/ft (assumed) which is equivalent to the following mud density:

$\rho mud = \{P/(0.052 * h)]$

$P = 0.75 * 1133.05 = 849.8$ psi
$\rho mud = [849.8 \text{ psi} / (0.052 * 1133.05)]$
$\rho mud = 14.4$ lbm/gal.

<u>Assumptions:</u> for burst considerations, use an injection pressure that is equivalent to a mud density 0.3 lbm/gal greater than the fracture gradient and a safety factor of 1.1.

And kick is composed of methane (molecular weight = 16) assume ideal gas behavior.

Formation temperature gradient = 1°f/100 feet.

Tx = surface temperature Ts°f + 0.01 * depth

Tx + 460 = T(°R)

T1133.05 = 65 + (0.01* 1133.05) = 78.3 °f = 538.3 °R

Injection-pressure pressure calculation at 1133.05 ft

Pi = 0.052(14.4+0.3)*1133.05 = 866.1 psig

The gas gradient for methane is given by the following equation:

ρgas = [PM / (80.3 * Z * T)]

0.052*ρgas = {[0.052 * (866.1+15)*16]/ (80.3 * 1 * 538.3)} = 0.017 psi/ft

To ensure that casing rupture will not occur at the surface, (endangering the lives of the drilling personal) the casing resistant to **burst** at the surface will be:

866.1 – 0.017 (1133.05) = **846.84 psig**

The external pressure is zero at the surface.

A normal formation pore pressure was assumed to be 0.465psi/ft. then, the external pressure at the casing seat is:

0.465 * 1133.05 = 526.9 psig

Finally, the pressure differential that tends to burst the casing is 846.84 psig at surface (846.84 – 526.9) = 318.94 at the casing seat.

These pressures will be multiplied by the safety factor: assumed 1.1

At casing surface = 1.1 * 846.84 = 931.524 psig

At casing seat = 1.1 * 318.94 = 350.83 psig

A graphical representation is shown:

Now, using table 7.6 (Applied Drilling Engineering) for 9 5/8-in casing the H-40 casing 32.3 lb/ft is the less expansive 95/8-in available and it meets the burst requirements.

The **collapse-design** load is based on the mud density in the hole when the casing is run (see appendix B).

The planned mud density is 9.44 lbm/gal and the external pressure at 1133.05feet is:

0.052 * 9.44 * 1133.05 = **556.2 psig**

For internal pressure for the collapse-design is controlled by the maximum loss if fluid level that could occur if a severe lost-circulation problem is encountered. The maximum depth of the mud level is calculated with the following equation:

$$Dm = [(\rho max - gp) / \rho max] * Dlc$$

Where:

Dlc: depth of the lost-circulation zone, feet.

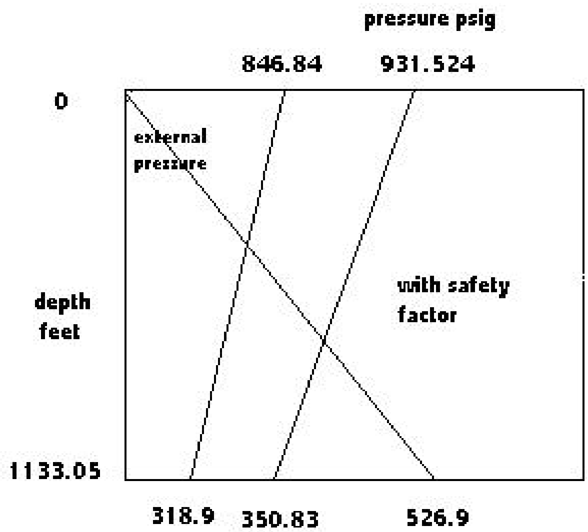
gp : pore pressure gradient of the lost-circulation zone.

ρmax: maximum mud density anticipated in drilling to Dlc.

Dm: depth to which the mud level will fall.

$$Dm = [(9.44 – 0.465/0.052) / 9.44] * 1665$$

$$Dm = 87.78 \text{ feet}$$



For these conditions, then, the mud level could fall to within (1133.05 ft – 87.78 ft) = 1045.27 feet of the casing bottom.

The internal pressure is assumed to be **zero** to a depth at 87.78 feet and:

0.052 * 9.44 * 1045.27 = 513.1 psig at the bottom of the casing.

The pressure differential that tends to collapse the casing is **zero** at the surface.

0.052 * 9.44 * 87.78 = 43.08 psig at 87.78 feet

43.08 * safety factor (1.1) = 47.39 psi

And

556.2 – 513.1 = 43.1 psig at 1133.05 feet.

43.1 * 1.1 = 47.41psi

Then, using table 7.6 (Applied Drilling Engineering) again: the collapse resistance for 9 5/8-in casing is 1370 psi, which excess the design requirements.

Intermediate casing for well # 1:

OD = 7-in

Bit size = 8 5/8

Depth = 2432.9 feet

Fracture gradient = 0.75 psi/ft assumed.

Mud density:

$\rho mud = \{P/(0.052 * h)]\}$

$p = 0.75 * 2432.9 = 1824.675$ psi

$\rho mud = 1824.675 / (0.052 * 2432.9) = 14.42$ lbm/gal

pressure equivalent to a mud density = 0.3 lbm/gal

safety factor = 1.1

Temperature gradient = 1 °f / 100 ft.

Tx = surface temperature Ts°f + 0.01 * depth

Tx + 460 = T(°R)

$T2432.9 = 65 + (0.01* 2432.9) = 89.33$ °f = 549.33 °R

$Pi = 0.052 (14.42 + 0.3) * 2432.9$

Pi = 1862.24 psig

Gas gradient of methane:

$\rho gas = [PM / (80.3 * Z * T)]$

$0.052*\rho gas = \{[0.052 * (1862.24 +15)*16]/ (80.3 * 1 * 549.33)\}$

$0.052*\rho gas = 0.0354$ psi/ft

To ensure that casing rupture will not occur at the surface.

The casing resistant to **burst** at the surface will be:

1862.24 – 0.0354 (2432.9) = **1776.1 psig**

Normal formation pore pressure = 0.465 psi/ft (assumed).

The external pressure of the casing seat is:

0.465 * 2432.9 = 1131.3 psig

Pressure differential that tend to burst the casing is 1776.1 psig and

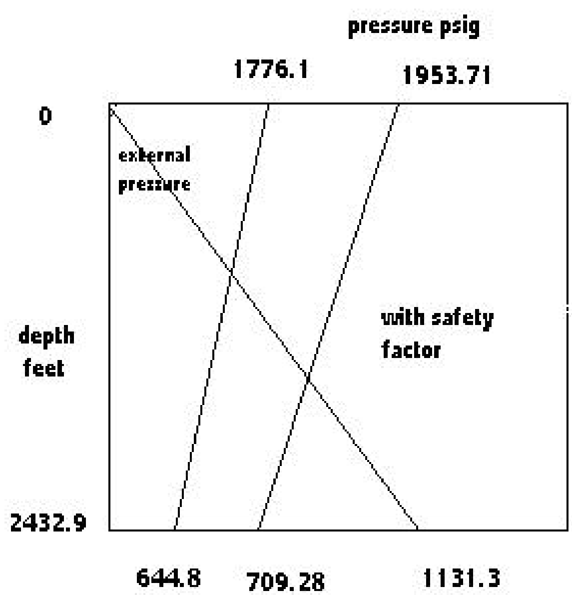
(1776.1 – 1131.3) = 644.8 psig.

These pressures will be multiply by safety factor = 1.1 (assumed) then:

At casing surface = 1953.71 psig

At casing seat = 709.28 psig

A graphical representation is shown:



Now, table 7.6 (Applied Drilling Engineering) for 7-in casing the H-40, 17 lb/ft is the less expensive 7-in available and it meets the burst design.

<u>Collapse design</u>:

The planned mud density is 9.44 lbm/gal and the external pressure at 2432.9 feet is:

0.052 * 9.44 * 2432.9 = 1194.3 psig.

The maximum mud density anticipated in drilling to depth of the lost circulation zone.

Dm = [(ρmax - gp) / ρmax]* Dlc

Dm = [(9.44 – 0.465/0.052) / 9.44] * 2432.9

Dm = 128.26 feet

For these conditions, then, the mud level could fall to within (2432.9 – 128.26) = 2304.64 feet of casing bottom.

The internal pressure is assumed to be zero to a depth at 128.26 feet and

0.052 * 9.44 * 2304.64 = 1131.3 psig at the bottom of the casing.

The pressure differential that tends to collapse the casing is zero at the surface.

0.052 * 9.44 * 128.26 = 62.96 psig at 128.26 feet.

62.96 * 1.1 = 69.256 psi

And

(1194.3 – 1131.3) = 63 psig at 2432.9

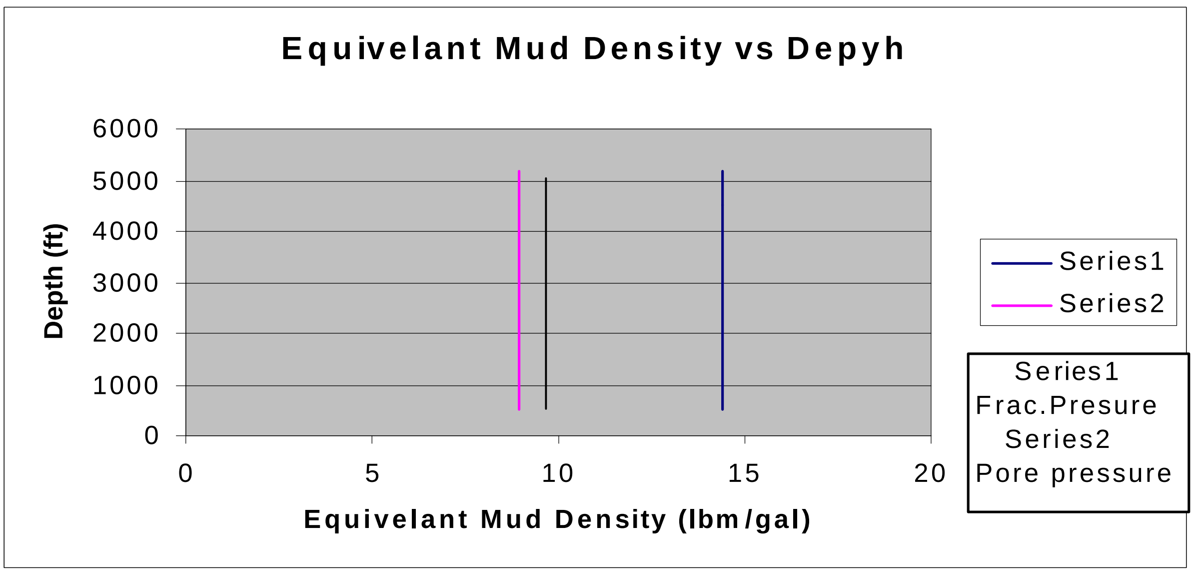
63 * 1.1 = 69.3 psi

then, using table 7.6 (Applied Drilling Engineering): the collapse resistance for 7-in casing is 1420 psi which excess the design requirements.

SELECTION OF CASING SETTING DEPTHS

Well # 2

Depth(ft)	Pore Pressure(psi)	Fracture Pressure(psi)	Pore Press.(lbm/gal)	Frac. Pressure(lbm/gal)
500	232.5	375	8.942307692	14.42307692
1000	465	750	8.942307692	14.42307692
1500	697.5	1125	8.942307692	14.42307692
2000	930	1500	8.942307692	14.42307692
2500	1162.5	1875	8.942307692	14.42307692
3000	1395	2250	8.942307692	14.42307692
3500	1627.5	2625	8.942307692	14.42307692
4000	1860	3000	8.942307692	14.42307692
4500	2092.5	3375	8.942307692	14.42307692
5000	2325	3750	8.942307692	14.42307692
5185	2411.025	3888.75	8.942307692	14.42307692



Assuming that there is a pore pressure gradient of 0.465 psi/ft, Fracture gradient of 0.75 psi/ft and considering the depth of well number 2, One casing would be enough to cover the well. However, There are several fresh and salt water formations and coal formations that need to be protected. Therefore, four casing strings (Conductor, surface, Intermediate, Production) are recommended for this well are seated at depth of 36',786', 2211', and 5077' respectively.

Selection of casing sizes

Well # 2

A 4.5 inches production casing is desired for the first well. Using table 7.8 and 7.9 in the applied Drilling Engineering book a 6 ¼ inches bit is needed to drill the bottom section of the bore hole. This bit will pass through 3 of the 7 inches casings available (the required maximum weight per foot will be determined in the next section). According to table 7.7, a 8 5/8 inches bit will pass through a 9 5/8 inches casing. A 12 ¼ inches bit is needed to drill to the depth of the surface casing (9 5/8”). Finally, as shown in table 7.8 a 12 ¼ inches bit will pass through 13 3/8 casing, which will need a 17 ½ inches bit to start the drilling.

Casing	Casing sizes (inches)	Bit sizes (inches)
Conductor	13 3/8	17 ½
Surface	9 5/8	12 ¼
Intermediate	7	8 5/8
Production	4 ¼	6 ¼

Selection of grades and weight

Calculation for surface casing well # 2:

The surface casing selected has an OD of 9 5/8-in and is to set at 786.55 feet.

Bit size = 12 ¼-in

Mud density:

ρmud = {P/(0.052 * h)]}

p = 0.75 * 786.55 = 589.91 psi

ρmud = 589.91 / (0.052 *786.55) = 14.42 lbm/gal

Pressure equivalent to a mud density = 0.3 lbm/gal

Safety factor = 1.1

Tmperature gradient = 1 °f / 100 ft.

Tx = surface temperature Ts°f + 0.01 * depth

Tx + 460 = T(°R)

T786.55 = 65 + (0.01*786.55) = 72.86 °f = 532.86 °R

Pi = 0.052 (14.42 + 0.3) * 786.55

Pi = 602.05 psig

Gas gradient of methane:

ρgas = [PM / (80.3 * Z * T)]

0.052*ρgas = {[0.052 * (602.05+15)*16]/ (80.3 * 1 * 532.86)}

0.052*ρgas = 0.01199 psi/ft

To ensure that casing rupture will not occur at the surface.

The casing resistant to **burst** at the surface will be:

602.05 – 0.01199 (786.55) = **592.62 psig**

Normal formation pore pressure = 0.465 psi/ft (assumed).

The external pressure of the casing seat is:

0.465 * 786.55 = 365.74 psig

Pressure differential that tend to burst the casing is 592.62 psig and

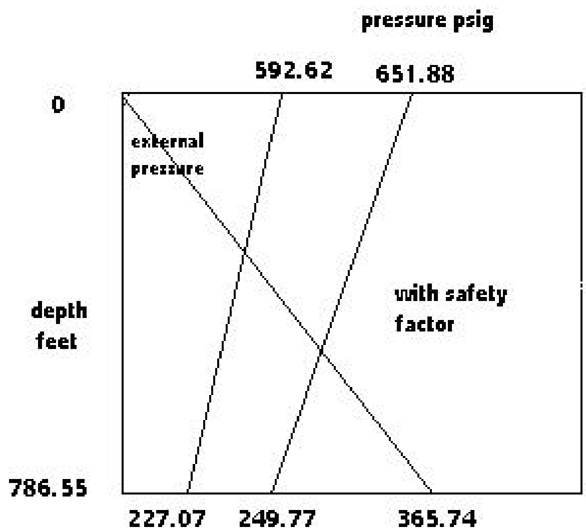
(592.62 – 365.55) = 227.07 psig.

These pressures will be multiply by safety factor = 1.1 (assumed) then:

At casing surface = 651.882 psig

At casing seat = 249.77 psig

A graphical representation is shown:



Now, table 7.6 (Applied Drilling Engineering) for 7-in casing the H-40, 17 lb/ft is the less expensive 7-in available and it meets the burst design.

Collapse design:

The planned mud density is 9.44 lbm/gal and the external pressure at 786.55 feet is:

0.052 * 9.44 * 786.55 = 386.1 psig.

The maximum mud density anticipated in drilling to depth of the lost circulation zone.

$D_m = [(\rho_{max} - g_p) / \rho_{max}] * D_{lc}$

$D_m = [(9.44 - 0.465/0.052) / 9.44] * 1415$

$D_m = 74.6$ feet

For these conditions, then, the mud level could fall to within (786.55 – 74.6) = 711.95 feet of casing bottom.

The internal pressure is assumed to be zero to a depth at 74.6 feet and

0.052 * 9.44 * 711.95 = 349.48 psig at the bottom of the casing.

The pressure differential that tends to collapse the casing is zero at the surface.

0.052 * 9.44 * 74.6 = 36.619 psig at 74.6 feet.

36.619 * 1.1 = 40.28 psi

And

(386.1 – 349.48) = 36.62 psig at 2432.9

36.62 * 1.1 = 40.282 psi

then, using table 7.6 (Applied Drilling Engineering): the collapse resistance for 9 5/8-in casing is 1370 psi which excess the design requirements.

Intermediate casing for well # 2:

OD = 7-in

Bit size = 8 5/8

Depth = 2211 feet

Fracture gradient = 0.75 psi/ft assumed.

Mud density:

ρmud = {P/(0.052 * h)]}

p = 0.75 * 2211 = 1658.25 psi

ρmud = 1658.25 / (0.052 * 2211) = 14.42 lbm/gal

Pressure equivalent to a mud density = 0.3 lbm/gal

Safety factor = 1.1

Temperature gradient = 1 °f / 100 ft.

Tx = surface temperature Ts°f + 0.01 * depth

Tx + 460 = T(°R)

T2432.9 = 65 + (0.01* 2211) = 87.11 °f = 547.11 °R

Pi = 0.052 (14.42 + 0.3) * 2211

Pi = 1692.38 psig

Gas gradient of methane:

ρgas = [PM / (80.3 * Z * T)]

0.052*ρgas = {[0.052 * (1692.38 +15)*16]/ (80.3 * 1 * 547.11)}

0.052*ρgas = 0.03233 psi/ft

To ensure that casing rupture will not occur at the surface.

The casing resistant to **burst** at the surface will be:

1692.38 – 0.03233 (2211) = **1620.9 psig**

Normal formation pore pressure = 0.465 psi/ft (assumed).

The external pressure of the casing seat is:

0.465 * 2211 = 1028.115 psig

Pressure differential that tend to burst the casing is 1620.9 psig and

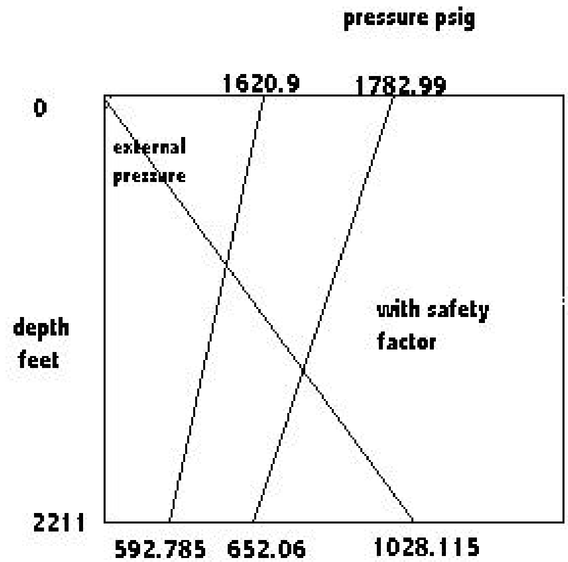
(1620.9 – 1028.115) = 592.785 psig.

These pressures will be multiply by safety factor = 1.1 (assumed) then:

At casing surface = 1782.99 psig

At casing seat = 652.06 psig

A graphical representation is shown:



Now, table 7.6 (Applied Drilling Engineering) for 7-in casing the H-40, 17 lb/ft is the less expensive 7-in available

and it meets the burst design.

Collapse design:

The planned mud density is 9.44 lbm/gal and the external pressure at 2211 feet is:

0.052 * 9.44 * 2211 = 1085.33 psig.

The maximum mud density anticipated in drilling to depth of the lost circulation zone.

Dm = [(ρmax - gp) / ρmax]* Dlc

Dm = [(9.44 – 0.465/0.052) / 9.44] * 2211

Dm = 116.56 feet

For these conditions, then, the mud level could fall to within (2211 – 116.56) = 2094.44 feet of casing bottom.

The internal pressure is assumed to be zero to a depth at 116.56 feet and

0.052 * 9.44 * 2094.44 = 1028.11 psig at the bottom of the casing.

The pressure differential that tends to collapse the casing is zero at the surface.

0.052 * 9.44 * 116.56 = 57.217 psig at 116.56 feet.

57.217 * 1.1 = 62.938 psi

And

(1085.33 – 1028.11) = 57.22 psig at 2211

57.22 * 1.1 = 62.942 psi

then, using table 7.6 (Applied Drilling Engineering): the collapse resistance for 7-in casing is 1420 psi which excess the design requirements.

Production casing:

The 4 ½-in casing is designed in account appendix A (production casing design loads for burst and collapse.)

Burst design: (see appendix A)

Internal pressures = (formation pressure + completion fluid pressure) at top and bottom of the casing.

External forces = mud hydrostatic pressure (9.44 ppg) at top and bottom.

Collapse design: external forces: mud hydrostatic pressure. Internal forces: none.

Final assumption: the casing was landed "as cemented" the axial tension results only from the hanging weight of the casing under prevailing borehole conditions.

Casing Design

Well # 1

casing	setting depth (ft)	Size(in)	Grade	Wt(lb/ft)	Cement
Conductor	30	13 5/8	H-40	48	
Surface	1133	9 5/8	H-40	32.3	365 sxs
Intermediate	2432	7	H-40	17	230 sxs
Production	5987	4 1/2	J-55	10.5	290 sxs

well#2

casing	setting depth (ft)	Size(in)	Grade	Wt(lb/ft)	Cenent
Conductor	36.5	13 5/8	H-40	48	
Surface	786.5	9 5/8	H-40	32.3	240 sxs
Intermediate	2211	7	H-40	17	260 sxs
Production	5077.9	4 1/2	J-55	10.5	235 sxs

Well Completion

Bottom hole Completions:

The bottom of the well is completed with either an open hole or cased hole completion. A cased hole completion is made by drilling though the producing formation, then cased, A open hole completion is made by drilling down to the top of the producing formation. The wall is cased and then drilled though the producing formation, leaving the bottom of the well open. This completion is used primarily in developing a field with a known reservoir and reduces the cost of casing. It, however, cannot be used in soft formations that might cave in to the well and doesn't isolate selective zones in the producing formation. Because the casing "**set in the dark**" before the pay is drilled, the casing can't be salvaged if the pay proves to be unproductive.

One well can produce from two or more producing zones in a multiple completion. If, there are two producing zones is used in a dual completion (fig 4). Sometimes only one packer and tubing strings is used in a dual completion, and the production from one zone is brought up the casing-tubing annulus. If it is a flowing well, there will be a double wing tree. If beam pumping is used, there will be two beam pumpers and sucker-rod string per well. The most common completion is a triple completion.

Casing that has been cemented into the producing zone in a set through completion is perforated by shooting holes called perforation through it (fig 5). The perforation is done by a perforation gun run into the well on a wireline, or tubing string. The original perforation guns used steel bullets, but jet perforations that use shaped explosive charges are more commonly used today. The perforations are described in shots per foot (**density**) and angular separation (**phasing**). Perforation completion can be used where there is a sand control problem and are used for multiple completions.

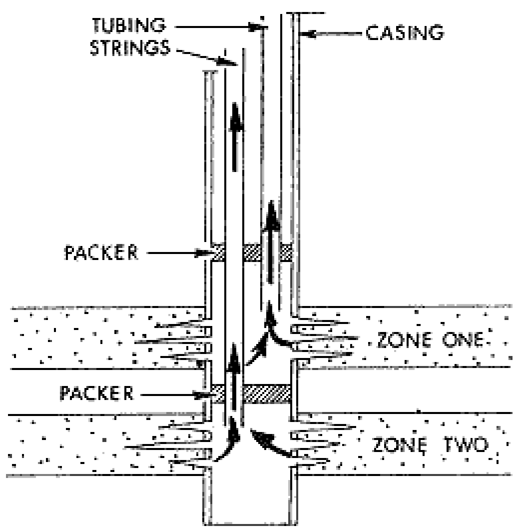


Fig.4 Dual completion

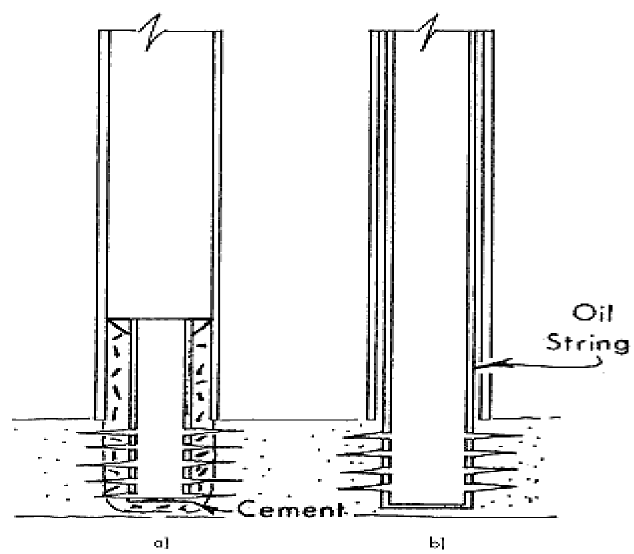


Fig.5 a) cased hole completion
b) Open hole completion

The bottom hole for the first well is completed by using open cased completion. Since there are two pay zones, dual completion is used. The first pay zone (4780' – 5280) is perforated with 38 shots. The second pay zone (5710'- 5994') is perforated with 40 holes. The bottom hole for the second well is completed by using open cased completion. The pay zone (4419' – 5018') is perforated with 40 holes.

Log analysis calculation

ρ_B, Φ_N, R_{ID} values are read from the logs every two feet for the entire targeted formation for both wells. Then porosity is calculating by using equation (B3).

The value of ρ_B for the formation is read from the log to be 2.71 g/cc for both wells.

Then by using the porosity values, the water saturation is determined by using the equations (B3) to (B8) that were explained in the theory. The value of Rwa is assumed for both wells to be 0.0125. The gas formation factor is then calculated by using equation (B2):

Bgi = 0.0283 z T / P.

Where Z-factor is calculated by assuming gas gravity of 0.6 and using chart(2) in appendix B to determine Ppc, Tpc. Then Ppr and Tpr.

Tpr = T/Tpc **Eq. (B9)**

Ppr = P/Ppc **Eq.(B10)**

And then using chart(1) in appendix B, Z-factor is determined. Finally, the original gas in place is determined by the following equation:

G = (43560) (A) (h) (ϕ) (1 – Sw) (1/ Bgi).

Where:

G1= average original gas in place obtained by averaging the entire pay zone thickness.

G2= the average original gas in place obtained by averaging the parameter involved in the calculation (Sw, ϕ**).**

The following table presents the results in details for both wells:

Table 2.1

well #	T (R)	P (psi)	Specific gravity	Tpc	Ppc	Tpr	Ppr	Z	Bg
well#1	597.67	739.7	0.6	350	678	1.707	1.09	0.93	0.0212
well#2	574.37	739.7	0.6	350	678	1.641	1.09	0.92	0.0202

Table 2.2

Well # 1(first pay zone) sample calculation:

Depth	bulk Dens.	Porosity N	Porosity	Rt	F	Rw	I	Sw	G
(feet)	(g/cc)	(%)	(%)	(ohm-m)		(ohm-m)		(fraction)	(scf/ac-ft)
4780	2.68	15	5.546125	23	325.103	0.07075	7.0747	0.375964	7179064
4782	2.725	14.8	5.45572	22	335.966	0.06548	6.5483	0.390784	6894329
4784	2.72	15	5.531365	22	326.84	0.06731	6.7311	0.38544	7051240
4786	2.656	14.8	5.481181	28	332.852	0.08412	8.4121	0.344784	7449504
4788	2.65	16	5.926199	32	284.739	0.11238	11.238	0.298297	8625777
4790	2.649	16.5	6.11107	31	267.772	0.11577	11.577	0.293902	8950578
4792	2.651	15	5.556827	30	323.852	0.09263	9.2635	0.328558	7739336
4794	2.648	15	5.557934	34	323.723	0.10503	10.503	0.308565	7971372
4796	2.65	14	5.188192	35	371.508	0.09421	9.4211	0.325799	7255610

avg G1	avg Porosit	avg Sw	avg G2
(scf/ac-ft)	(%)	(fraction)	(scf/ac-ft)
6545199	5.2306361	0.400142	6508363

To view the entire calculation for the first pay zone, (see table 2.2 appendix BII)

Well #1 (second pay zone)sample calculation:

Depth	bulk Dens.	porosity N	Porosity	Rt	F	Rw	I	Sw	G
(feet)	(g/cc)	(%)	(%)	(ohm-m)		(ohm-m)		(fraction)	(scf/ac-ft)
5710	2.56	16.4	6.10701	22	268.128	0.08205	8.20503	0.34911	8245294
5712	2.62	17	6.30627	22	251.452	0.087492	8.7492	0.33808	8658620
5714	2.56	16.8	6.25461	22	255.623	0.086064	8.60644	0.34087	8551461
5716	2.57	17	6.32472	24	249.987	0.096005	9.60051	0.32274	8885165
5718	2.62	16	5.93727	23	283.679	0.081078	8.10777	0.3512	7990408
5720	2.7	15	5.53875	18	325.97	0.05522	5.52199	0.42555	6599802
5722	2.725	15.9	5.86162	14	291.048	0.048102	4.81021	0.45595	6614920
5724	2.74	16	5.89299	15	287.958	0.052091	5.2091	0.43815	6867960
5726	2.75	16	5.8893	16	288.319	0.055494	5.54941	0.4245	7030374

Avg G1	avg Porosity	avg Sw	avg G2
(scf/ac-ft)	(%)	(fraction)	(scf/ac-ft)
6701346	5.6786102	0.43221	6687986

To view the entire calculation for the second pay zone, (see table 2.3 appendix BII)

Well#2:

Depth	bulk Dens.	porosity N	Porosity	Rt	F	Rwa	I	Sw	Sw	Gi
(feet)	(g/cc)	(%)	(%)	(ohm-m)		(omh-m)		(fraction)	(%)	(scf/ac-ft)
4420	2.7	12	4.43173	23	509.16	0.0452	4.517	0.4705	47.05	5060271
4422	2.659	11	4.07786	25	601.36	0.0416	4.157	0.4905	49.045	4480771
4424	2.659	11.9	4.40996	25	514.2	0.0486	4.862	0.4535	45.352	5196930
4426	2.659	13	4.81587	24	431.17	0.0557	5.566	0.4239	42.386	5983302
4428	2.7	13	4.80074	21	433.89	0.0484	4.84	0.4546	45.455	5646754
4430	2.658	10	3.70923	24	726.83	0.033	3.302	0.5503	55.031	3596899
4432	2.7	11.8	4.35793	26	526.55	0.0494	4.938	0.45	45.002	5168485
4434	2.659	12.1	4.48376	25	497.41	0.0503	5.026	0.4461	44.605	5356077
4436	2.658	11.2	4.15203	30	580.07	0.0517	5.172	0.4397	43.972	5016490
4438	2.657	12.3	4.5583	31	481.28	0.0644	6.441	0.394	39.402	5956613

Avg G1	avg G2	avg porosity	avg Sw
(scf/ac-ft)	(scf/ac-ft)	(%)	(fraction)

5702171	5685646	4.751262	0.44507

To view the entire calculation for the second well, (see table 2.4 appendix BII)

	G1 scf/acre-ft	Sw%	porosity %	G2 scf/acre-ft
well #1 first pay zone	6545199	40.014	5.23	6508363
well #1 second pay zone	6701346	43.221	5.678	6687986
Well # 2	5702171	44.507	4.715	5685646

Buildup Test Data Analysis

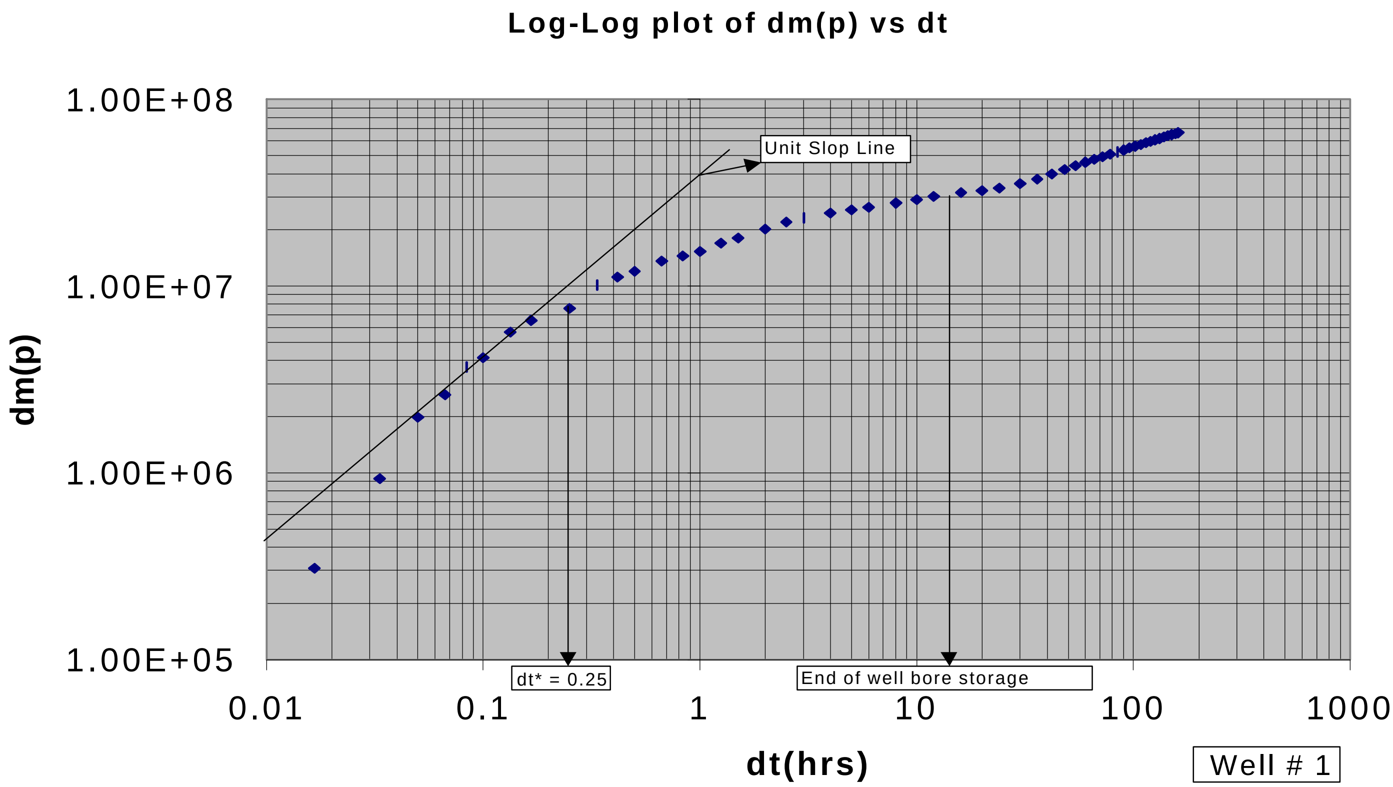
Sample of the computer program results of well number 1.

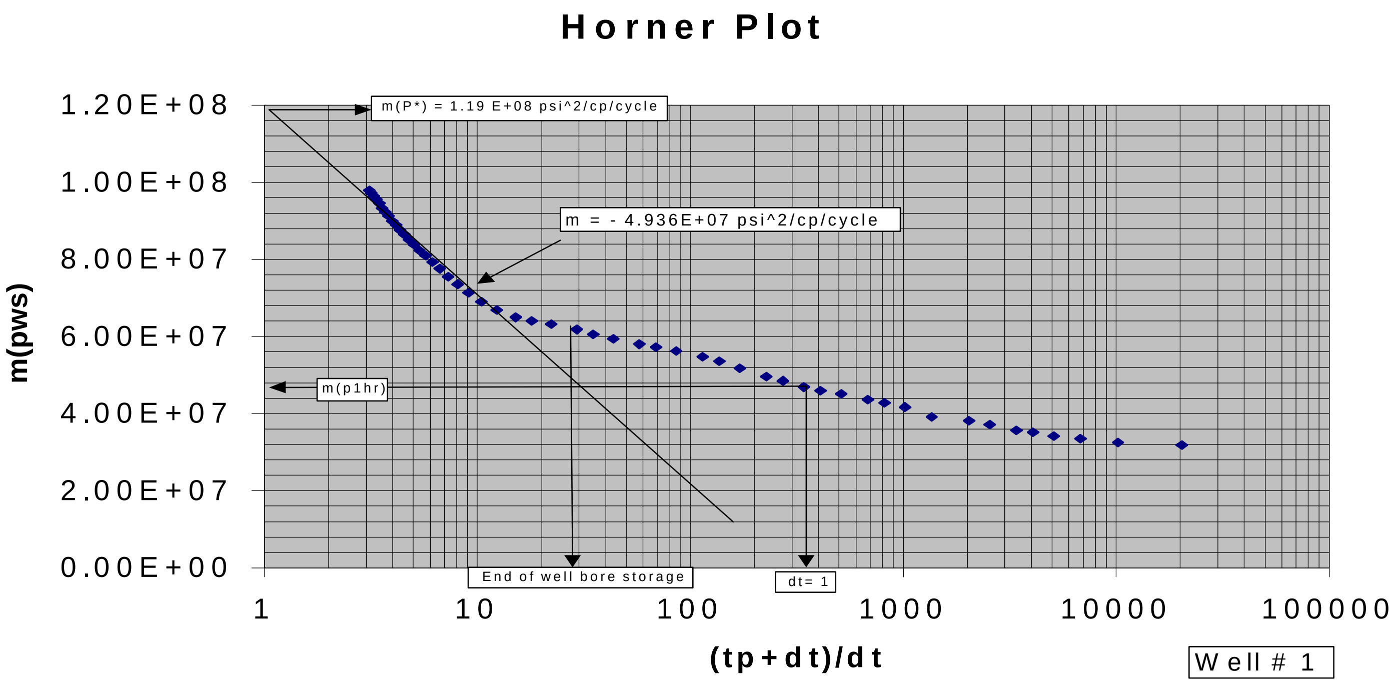
Well # 1

tp = 339.749 hrs T=137 F Gas gravity=0.6

Shut-in time(Min.)	Pressure (Psia)	Shut-in Time(hrs)	(dt+tp)/dt	**Z**	**Vis, cp**	**m(p)** psi^2/cp	dm(p)
0	620	0		0.8764	0.013791	3.15E+07	
1	623	0.0166667	20385.94	0.8761	0.013797	3.18E+07	3.09E+05
2	629	0.0333333	10193.47	0.8754	0.013808	3.25E+07	9.31E+05
3	639	0.05	6795.98	0.8737	0.013839	3.35E+07	1.98E+06
4	645	0.0666667	5097.235	0.8727	0.013859	3.42E+07	2.62E+06
5	655	0.0833333	4077.988	0.8723	0.013867	3.52E+07	3.69E+06
6	659	0.1	3398.49	0.8709	0.013894	3.57E+07	4.13E+06
8	673	0.1333333	2549.1175	0.8702	0.01391	3.72E+07	5.67E+06
10	681	0.1666667	2039.494	0.8693	0.013928	3.81E+07	6.57E+06

To view the entire calculation, (see table 3.1 appendix C)


Log-Log plot of dm(p) vs dt
1.00E+08
1.00E+07
1.00E+06
1.00E+05
dm(p)
Unit Slop Line
dt* = 0.25
End of well bore storage
0.01
0.1
1
10
100
1000
dt(hrs)
Well # 1


Horner Plot
1.20E+08
1.00E+08
8.00E+07
6.00E+07
4.00E+07
2.00E+07
0.00E+00
m(pws)
m(P*) = 1.19 E+08 psi^2/cp/cycle
m = - 4.936E+07 psi^2/cp/cycle
m(p1hr)
End of well bore storage
dt= 1
1
10
100
1000
10000
100000
(tp+dt)/dt
Well # 1

Calculation Well # 1

$$tp = \left[\frac{3026.6 \text{ Mscf}}{213.8 \text{ Mscf/d}} \right] \left[\frac{24 \text{ hrs}}{1 \text{ day}} \right] = 339.75 \text{ hrs}$$

From figure 1:

Ät* = 0.25 hrs

End of well bore storage effect = (Ät*) (50) = 0.25 *50 = 12.50

From figure 2:

$$m = \left[\frac{8.51 \text{ E} +07 - 7.31 \text{ E}+07}{\log(4.77498)-\log(9.08926)} \right] = - 4.936 \text{ E} +07 \text{ psi}^2\text{/cp/cycle}$$

$$k = \left[\frac{- 1637 \; qT}{mh} \right] = \left[\frac{-1637 * 213.7 * 596.67}{- 4.936 \text{ E}+07 * 20} \right] = 0.2115 \text{ md}$$

$$S` = 1.151 \left[\frac{m(pws) - m(p1hr)}{m} - \log \frac{k}{\text{ö Ì} * Ct * rw\text{^}2} + 3.23 \right]$$

$$= 1.151 \left[\frac{3.15 \text{ E}+07 - 4.76 \text{ E}+07}{-4.936 \text{ E}+07} - \log \frac{0.215}{0.054* 0.015*0.00115* 0.167^2} + 3.23 \right]$$

$$= -3.861$$

Äm(p)s = -0.87 m s = -0.87 * -4.936 E+07 * -3.861 = - 1.66 E + 08 psi^2 / cp

From figure 2: m(p*) = 1.19 E+08

$$E = \left[\frac{m(p^*) - m(pws) - \text{Ä}m(p)s}{m(p^*) - m(pws)} \right] = \left[\frac{1.19 \text{ E}+08 - 3.15 \text{ E}+07 - 1.19 \text{ E}+08}{1.19 \text{ E}+08 - 3.15 \text{ E}+07} \right]$$

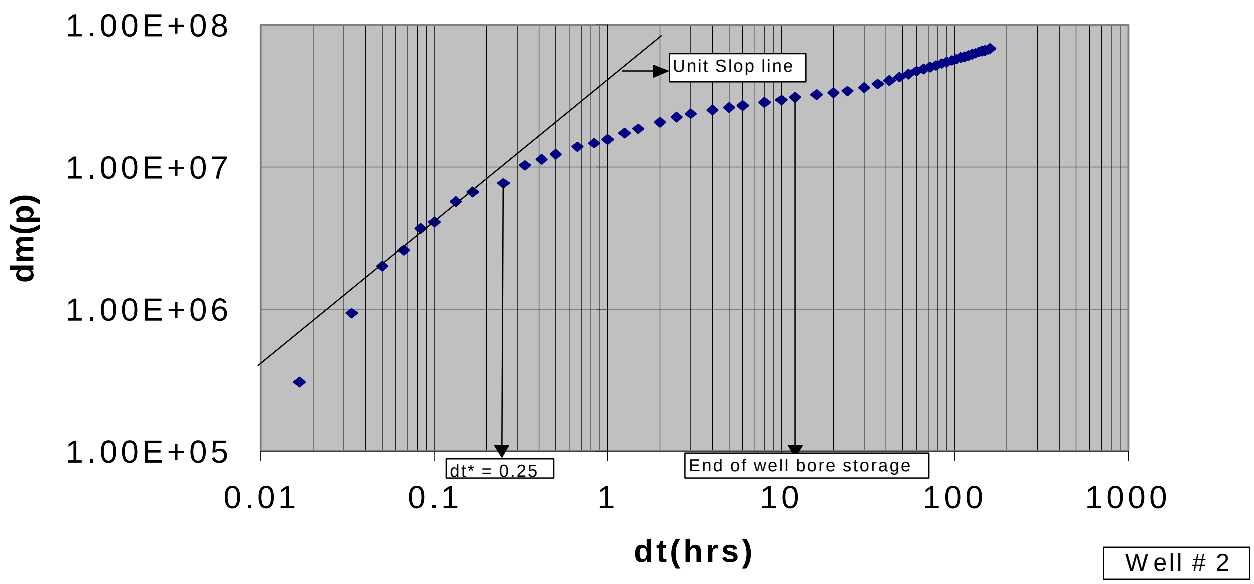
$$= 2.894$$

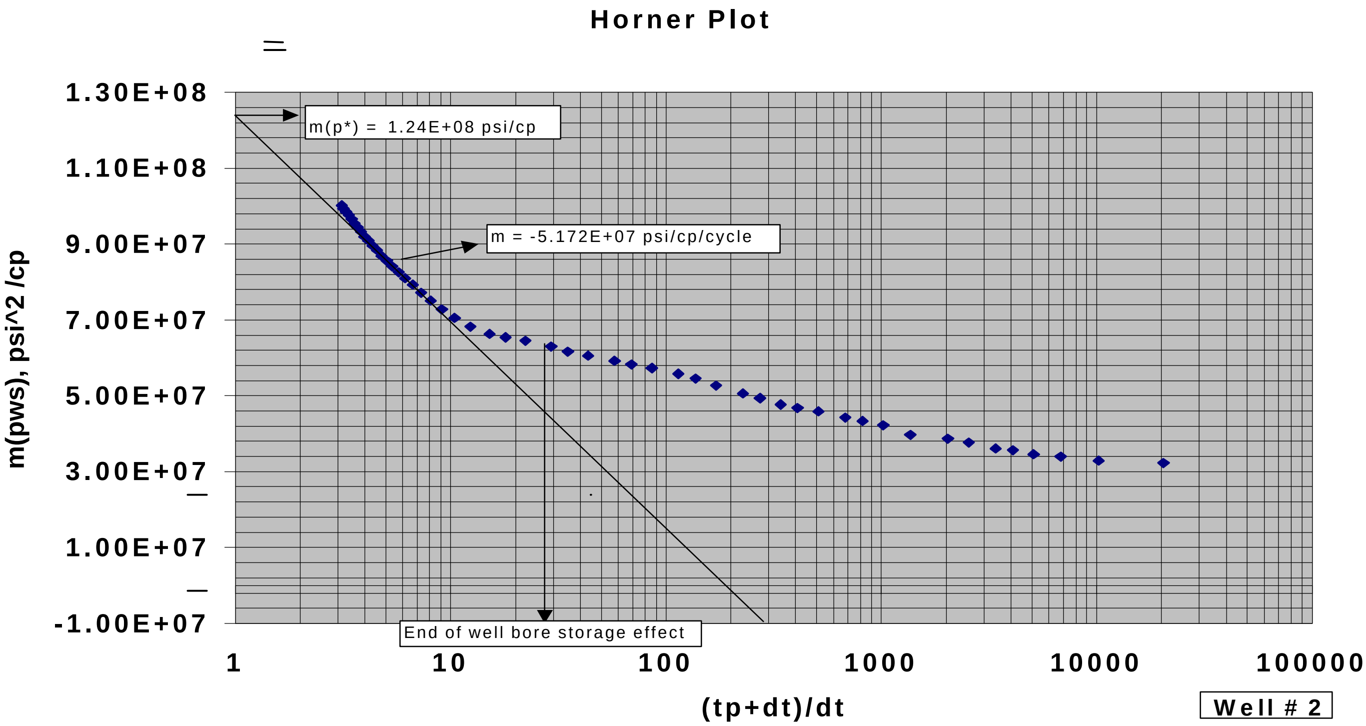
Well # 2 T= 114 F G=0.6

Shut-in time(Min.)	Pressure (Psia)	Shut-in time(hrs)	(dt+tp)/dt	Z	Ug cp	M(P) psi^2/cp	**dM(p)**
0	620	0		0.8638	0.01377	3.20E+07	
1	623	0.016667	20385.94	0.8633	0.01377	3.23E+07	3.06E+05
2	629	0.033333	10193.47	0.8625	0.01379	3.29E+07	9.36E+05
3	639	0.05	6795.98	0.8612	0.01381	3.40E+07	2.01E+06
4	645	0.066667	5097.235	0.8604	0.01383	3.46E+07	2.62E+06
5	655	0.083333	4077.988	0.8458	0.01387	3.57E+07	3.72E+06
6	659	0.1	3398.49	0.8453	0.01388	3.61E+07	4.12E+06
8	673	0.133333	2549.118	0.8436	0.01391	3.77E+07	5.72E+06
10	681	0.166667	2039.494	0.8427	0.01393	3.87E+07	6.72E+06
15	690	0.25	1359.996	0.8417	0.01395	3.97E+07	7.72E+06

To view the entire calculation, (see table 3.2 appendix C)

Log- Log Plot of dm(p) vs dt





Well # 2

$$tp = \left[\frac{3026.6 \text{ Mscf}}{213.8 \text{ Mscf/d}}\right]\left[\frac{24 \text{ hrs}}{1 \text{ day}}\right] = 339.75 \text{ hrs}$$

From figure 3:

Ät* = 0.25 hrs

End of well bore storage = (Ät*) (50) = 0.25 *50 = 12.50

From figure 4:

$$m = \left[\frac{8.84 \text{ E} +07 - 7.28 \text{ E}+07}{\log(4.5390)-\log(9.08926)}\right] = -5.172 \text{ E} +07 \ \text{psi}^2\text{/cp/cycle}$$

$$k = \left[\frac{-1637 \ qT}{mh}\right] = \left[\frac{-1637 * 213.7 * 574}{-5.172 \text{ E}+07 * 10}\right] = 0.3885 \text{ md}$$

$$S` = 1.151\left[\frac{m(pws) - m(p1hr)}{m} - \log\frac{k}{ö \ ì * Ct * rw^2} + 3.23\right]$$

$$= 1.151 \left[\frac{3.15\ E{+}07 - 4.77\ E{+}07}{-5.172\ E{+}07} - \log \frac{0.215}{0.047 * 0.015 * 0.00111 * 0.167^2} + 3.23 \right]$$

$= -4.265$

Äm(p)s = -0.87 m s = -0.87 * -517 E+07 * -4.2665 = - 1.92 E + 08 psi^2 / cp

From figure 4: m(p*) = 1.24 E+08 psi^2 /cp

$$E = \left[\frac{m(p^*) - m(pws) - Äm(p)s}{m(p^*) - m(pws)} \right] = \left[\frac{1.24\ E{+}08 - 3.15\ E{+}07 - 1.92\ E{+}08}{1.24\ E{+}08 - 3.15\ E{+}07} \right]$$

$= 3.074$

Results

The initial formation pressure could not be calculated since both wells are assumed not to be a new reservoir. The permeability, skin factor and flow effiency values for both wells are tabulated in table 3.3.

Table 3.3

	K (md)	**S`**	**E**
Well # 1	0.2115	-3.861	2.894
Well # 2	0.3885	-4.265	3.074

Prediction of reservoir performance

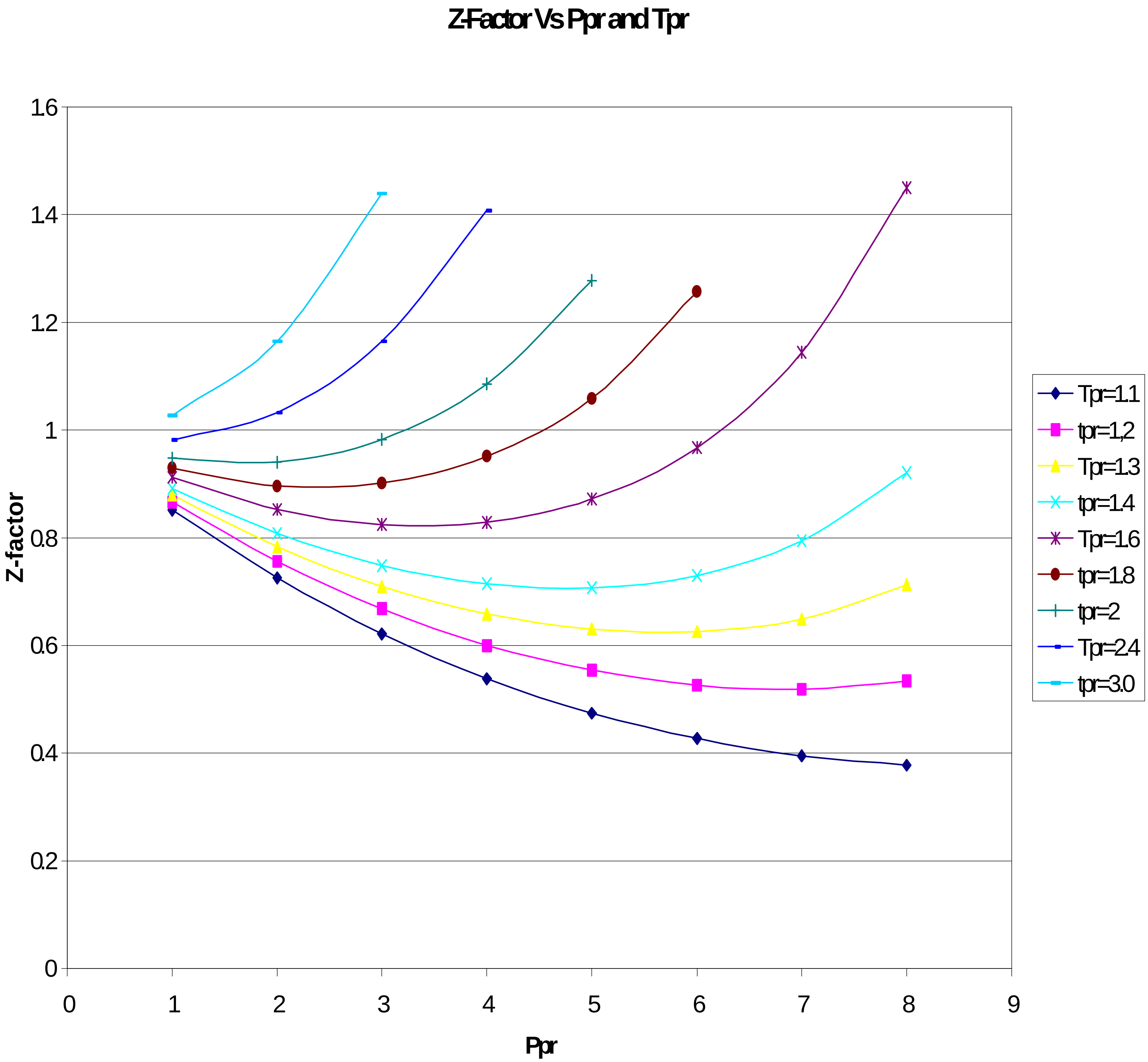
The computer program results of Z factor.

Z-Factor

	Tpr	1.1	1.2	1.3	1.4	1.5	1.6	1.7
Ppr	1	0.852	0.867	0.88	0.892	0.902	0.912	0.921
	2	0.726	0.756	0.783	0.808	0.831	0.853	0.875
	3	0.622	0.668	0.709	0.748	0.786	0.824	0.862
	4	0.538	0.6	0.658	0.715	0.771	0.829	0.888
	5	0.474	0.554	0.63	0.707	0.787	0.872	0.962
	6	0.427	0.526	0.626	0.73	0.843	0.968	1.105
	7	0.395	0.518	0.649	0.794	0.958	1.144	1.357
	8	0.377	0.534	0.713	0.921	1.165	1.45	1.221

	Tpr	1.8	1.9	2	2.1	2.2	2.3	2.4
Ppr	1	0.93	0.939	0.948	0.956	0.965	0.973	0.982
	2	0.896	0.918	0.94	0.963	0.986	1.009	1.033
	3	0.901	0.941	0.983	1.025	1.07	1.116	1.165
	4	0.951	1.017	1.086	1.16	1.238	1.321	1.408
	5	1.059	1.164	1.278	1.401	1.261	1.448	1.412
	6	1.257	1.425	1.215	1.112	1.476	1.332	1.147
	7	1.054	1.01	1.286	1.01	1.466	1.376	1.313
	8	1.1	1.474	1.316	1.23	1.178	1.145	1.122

	Tpr	2.5	2.6	2.7	2.8	2.9
Ppr	1	0.991	1	1.009	1.018	1.027
	2	1.058	1.084	1.11	1.137	1.165
	3	1.215	1.268	1.323	1.38	1.44
	4	1.361	1.468	1.427	1.418	1.35
	5	1.17	1.311	1.47	1.334	1.242
	6	1.07	1.036	1.443	1.396	1.357
	7	1.267	1.233	1.206	1.184	1.165
	8	1.106	1.094	1.085	1.077	1.071

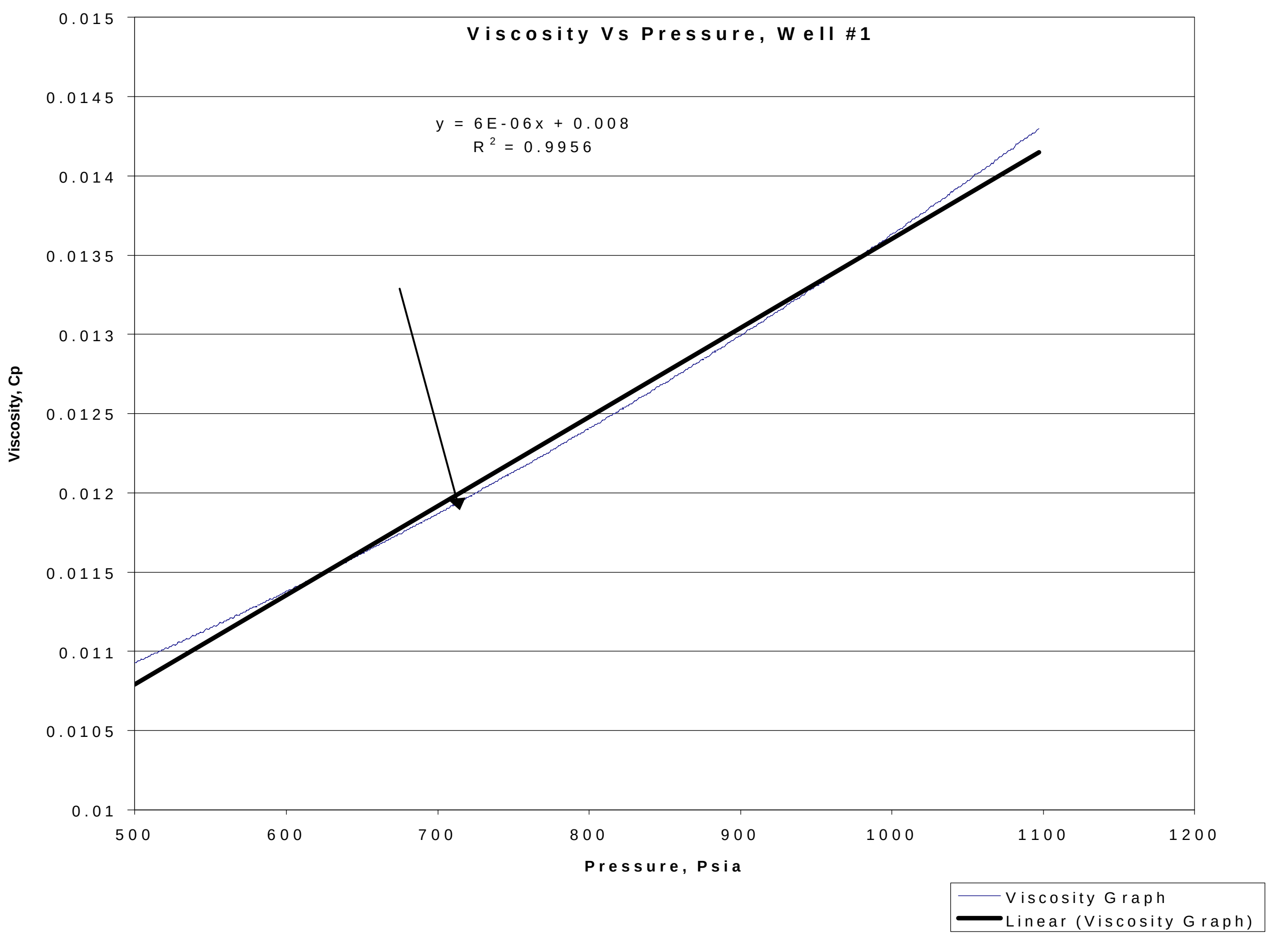

Z-Factor Vs Ppr and Tpr
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Z-factor
0
1
2
3
4
5
6
7
8
9
Ppr
Tpr=1.1
tpr=1,2
Tpr=1.3
tpr=1.4
Tpr=1.6
tpr=1.8
tpr=2
Tpr=2.4
tpr=3.0

Sample of the computer results of viscosity vs pressure

Viscosity Graph for Well #1
with Temp. = 137.67 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
500	0.01093	546	0.01113	592	0.01134
501	0.01093	547	0.01114	593	0.01134
502	0.01094	548	0.01114	594	0.01135
503	0.01094	549	0.01114	595	0.01135
504	0.01095	550	0.01115	596	0.01136
505	0.01095	551	0.01115	597	0.01136
506	0.01095	552	0.01116	598	0.01137
507	0.01096	553	0.01116	599	0.01137
508	0.01096	554	0.01116	600	0.01138
509	0.01097	555	0.01117	601	0.01138

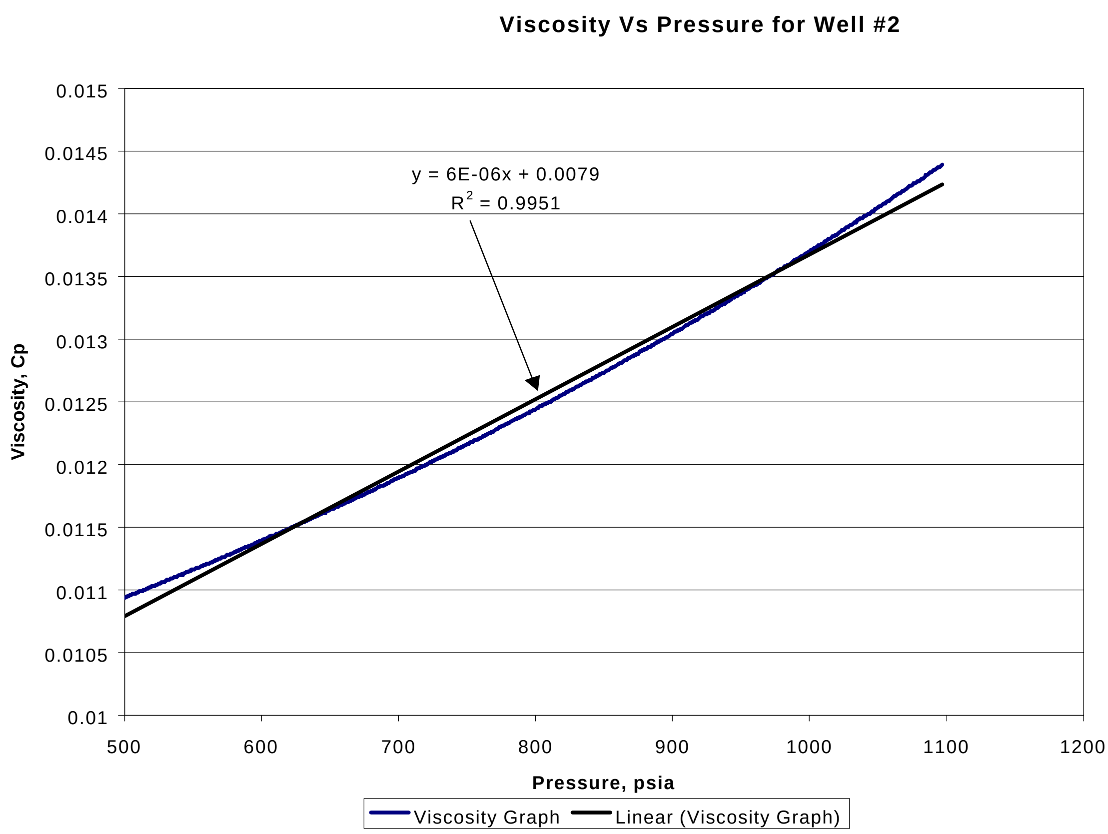
To view the entire calculation, (see table 4.1 appendix D)



Viscosity Vs Pressure For Well # 2 with Temp. = 114.37 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
500	0.01094	546	0.01114	592	0.01135
501	0.01094	547	0.01115	593	0.01136
502	0.01095	548	0.01115	594	0.01136
503	0.01095	549	0.01116	595	0.01137
504	0.01096	550	0.01116	596	0.01137
505	0.01096	551	0.01116	597	0.01138
506	0.01097	552	0.01117	598	0.01138
507	0.01097	553	0.01117	599	0.01139
508	0.01097	554	0.01118	600	0.01139

To view the entire calculation, (see table 4.2 appendix D)



Data for Pressure Profile

Well # 1
Porosity, (fraction) = 0.054
Viscosity at Pi = 0.015 cp
Compressibility at Pi = 0.00102 $psia^{-1}$
Wellbore Radius = 0 .167 ft
Permeability = 0.2115md
Reservoir Temperature = 137 ºF
Formation Thickness = 20 ft
Skin Factor = -3.861
Initial Pressure = 1097 psia Pseudo-Pressure = 204e9 $psia^2/cp$

Abandonment pressure = 500 psia Pseudo-Pressure = 9.78e9 $psia^2/cp$

Optimum Flow rate for seven years = 6837 Mscf/D

Well # 2
Porosity, (fraction) = 0.047
Viscosity at Pi = 0.014 cp
Compressibility at Pi = 0.0011 $psia^{-1}$
Wellbore Radius = 0 .167 ft
Permeability = 0.388577 md
Reservoir Temperature = 114 ºF
Formation Thickness = 10 ft
Skin Factor = -4.26
Initial Pressure = 1097 psia Pseudo-Pressure = 204e9 $psia^2/cp$

Abandonment pressure = 500 psia Pseudo-Pressure = 9.78e9 $psia^2/cp$

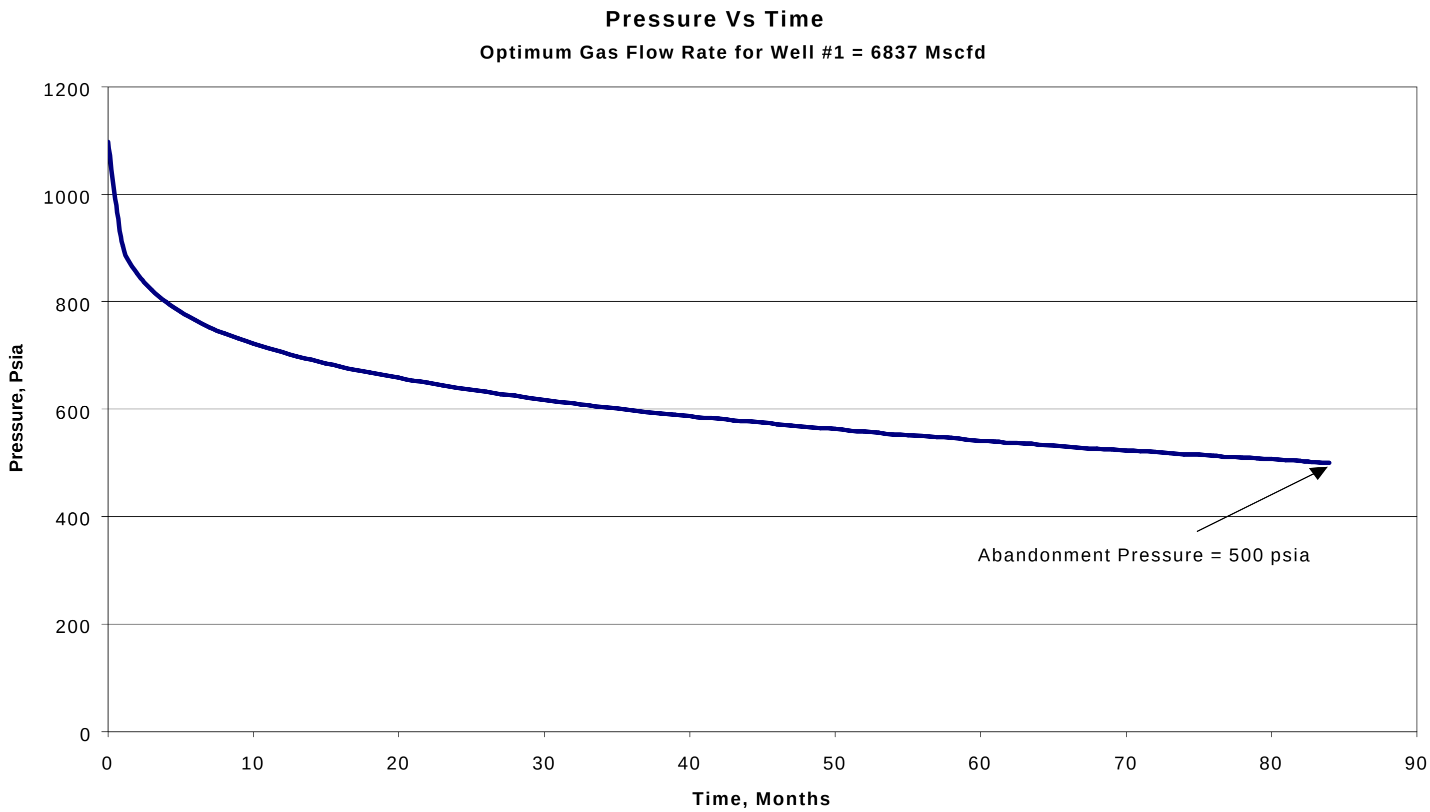
Optimum Flow rate for seven years = 6608 Mscf/D

<u>**Sample of the computer program results for Pressure Profile**</u>

PseudoPressure and Pressure Profile For WELL #1
Optimum Flow Rate for this well (MMscfD) =6837

Time,(Month)	Mpwf, (psia^2/cp)	Pressure,Psia	Time,(Month)	Mpwf, (psia^2/cp)	Pressure,Psia
0	9.78E+09	1097	45	2.70E+09	575
1	6.70E+09	904	46	2.67E+09	572
2	5.97E+09	853	47	2.65E+09	569
3	5.55E+09	822	48	2.63E+09	567
4	5.24E+09	799	49	2.61E+09	565
5	5.01E+09	781	50	2.59E+09	563
6	4.82E+09	766	51	2.56E+09	560
7	4.65E+09	752	52	2.54E+09	558
8	4.51E+09	741	53	2.52E+09	556
9	4.39E+09	731	54	2.50E+09	553
10	4.28E+09	722	55	2.49E+09	552

To view the entire calculation, (see table 4.31 appendix D)

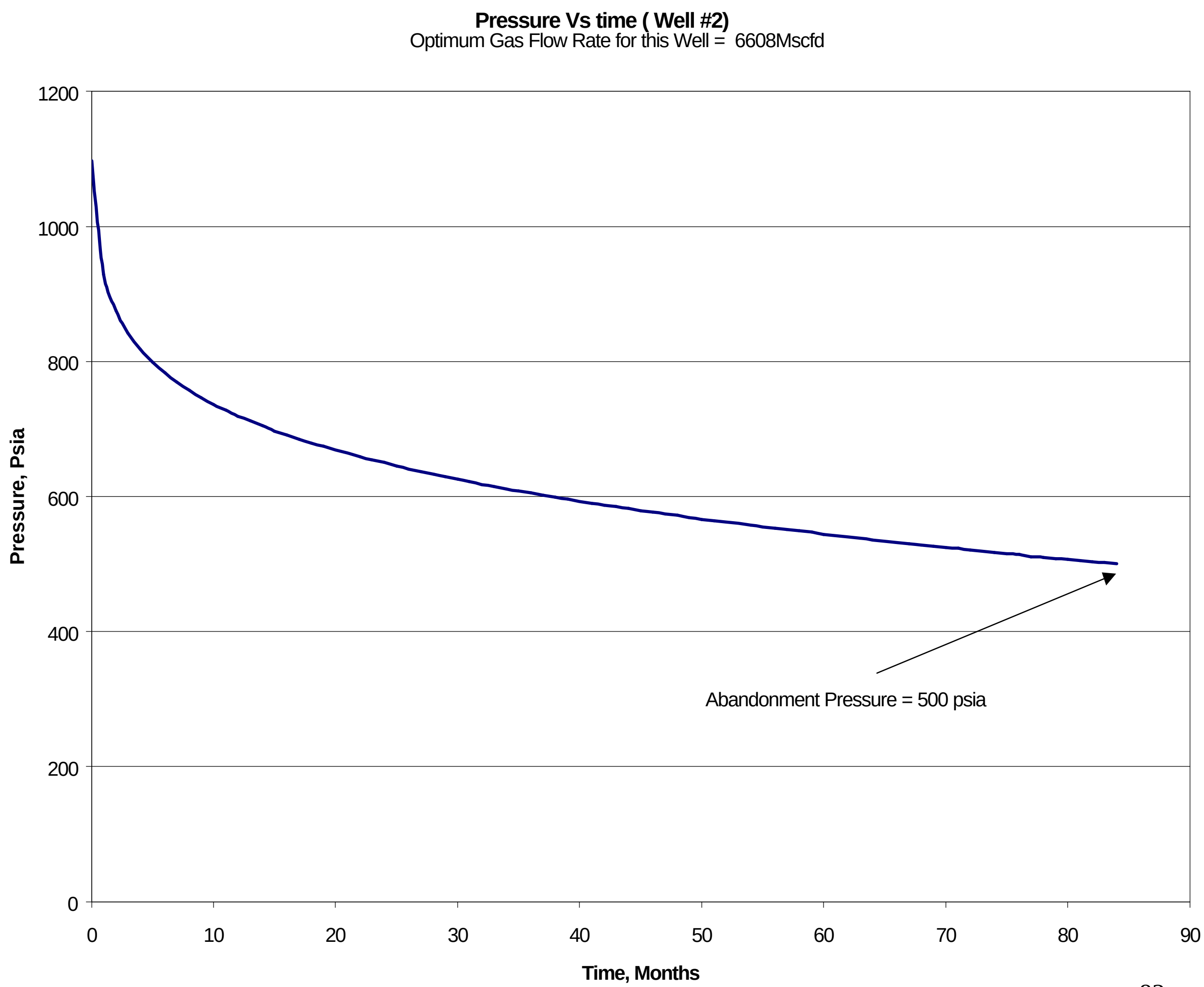


Ppseudo-Pressure and Pressure Profile for Well #2

Optimum Gas Flow Rate for this well: 6608 Mscfd

Time,(Month)	Mpwf, (psia^2/cp)	Pressure, Psia	Time,(Month)	Mpwf, (psia^2/cp)	Pressure, Psia
0	9.78E+09	1097	43	2.801E+09	585
1	7.076E+09	929	44	2.774E+09	582
2	6.288E+09	875	45	2.749E+09	579
3	5.827E+09	842	46	2.724E+09	577
4	5.500E+09	818	47	2.699E+09	574
5	5.246E+09	799	48	2.676E+09	572
6	5.039E+09	783	49	2.652E+09	569
7	4.864E+09	769	50	2.629E+09	566
8	4.712E+09	757	51	2.607E+09	564

To view the entire calculation, (see table 4.4 appendix D)



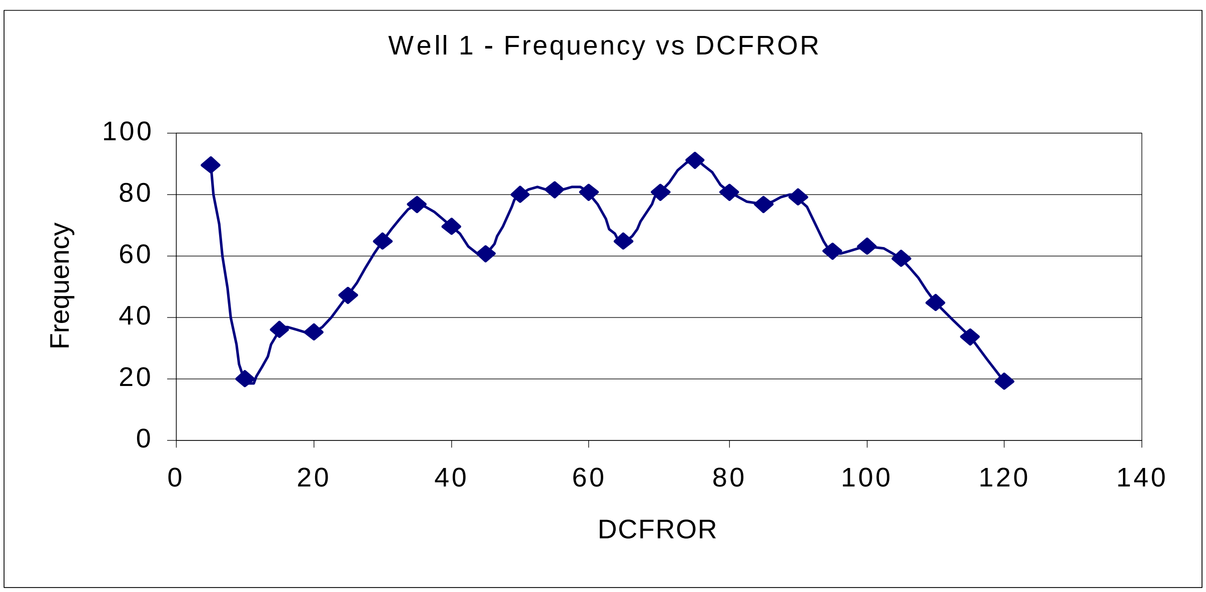
Economical Analysis Calculation

	Parameter	Distribution	Min. Value	Max. Value	Mean value
Well # 1	Porosity	Uniform	0.01	0.1	
	Thickness	Triangular	10	20	15
	Sw	Uniform	0.35	0.55	
Well # 2	Parameter	Distribution	Min. Value	Max. Value	Mean value
	Porosity	Uniform	0.01	0.1	
	Thickness	Triangular	10	15	12.5
	Sw	Uniform	0.35	0.55	

Sample Results of the computer Program

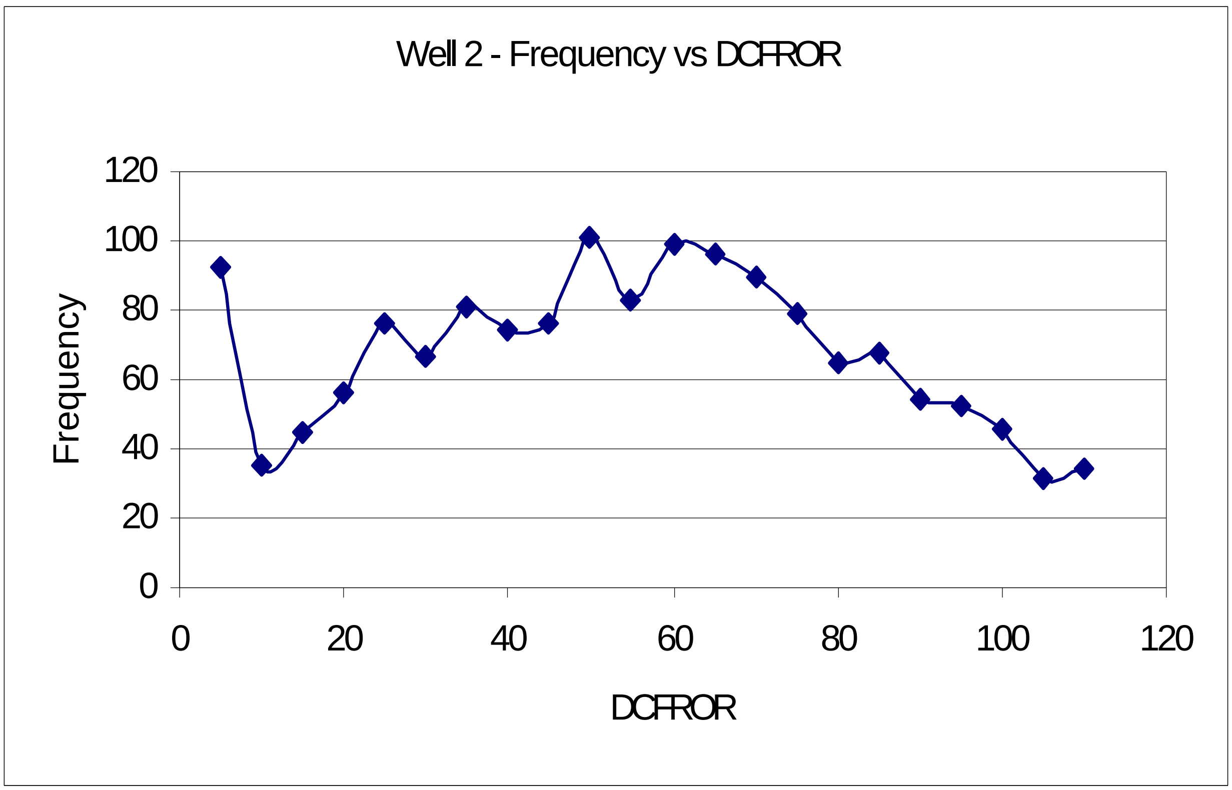
Well # 1 1

Porosity	Thickness (ft)	Sw	Gi	RF	EUR(scf)	DCFROR
7.35E-02	12.22041924	0.443315	5.39E+09	0.301948	1.63E+09	0.4694
7.97E-02	14.14547192	0.547196	5.51E+09	0.709038	3.9E+09	0.8592
1.41E-02	14.04382681	0.467193	1.14E+09	0.373536	4.24E+08	0.1481
9.66E-02	17.24721792	0.375711	1.12E+10	0.364019	4.08E+09	0.8772
5.72E-02	18.38910529	0.396578	6.85E+09	0.4687	3.21E+09	0.6798
3.68E-02	12.13804392	0.425461	2.77E+09	0.279342	7.74E+08	0.2809
8.47E-02	14.93094271	0.38508	8.38E+09	0.910964	7.64E+09	1.1595
3.04E-02	12.07513834	0.410977	2.33E+09	0.533873	1.25E+09	0.3973



Well # 2

Pososity	Thickness (ft)	Sw	Gi	RF	EUR	DCFROR
7.35E-02	10.09990425	0.4433152	2238935108	0.301948	676042002	0.25
7.97E-02	11.700341	0.54719647	2288460584	0.7090379	1622605287	0.5481
1.41E-02	11.61060484	0.46719346	471968251	0.3735362	176297213	0.0002
9.66E-02	13.70959348	0.37571083	4478271750	0.3640187	1630174565	0.5495
5.72E-02	14.76324929	0.39657767	2762617814	0.4687001	1294839276	0.4075
3.68E-02	10.03460206	0.42546066	1150564899	0.2793421	321401164	8.73E-02
8.47E-02	12.43140682	0.38507957	3507218912	0.9109643	3194951256	0.7809
3.04E-02	9.984851331	0.4109769	969249445	0.5338731	517456188	0.1909



Discussion of Results and Conclusion

The casing program and the completion design were successful designed to withstand the most sever loading conditions anticipated during casing placement and the life of the well.

Reserve is calculated by averaging the original gas in place for the entire formation. The first well has two pay zones, the first pay zone with original gas in place of 6545199 scf/acre-ft, average porosity of 5.23% and average water saturation of 40.014%. While, the second pay zone has an initial gas in place equals to 6701346 scf/acre-ft, average porosity of 5.678% and average water saturation of 43.221%. The second well has an initial gas in place of 5702171 scf/acre-ft, average porosity of 4.715% and, water saturation of 44.507%. There were slight differences between the two methods. The first one which is calculating the reserve by averaging the whole formation thickness is more accurate than the second one which is averaging the parameters involved then calculating the original gas in place.

Gulf Gas Company developed a computer program (see appendix C II) to convert pressure to pseudo-pressure in order to evaluate the buildup test data that were obtained from the instructor. The computer program calculate the following parameters: Deviation factor, Gas viscosity and gas compressibility, which are function of pressure, in order to calculate the pseudo-pressure. Then using Horner method, permeability, skin factor and flow efficiency were evaluated and the results are tabulated in table 3.3.

Reservoir Engineering definitely plays an important role in Petroleum Engineering. We realized this by mean of the three important aspects of reservoir engineering that we dealt with in this part of the project.

The first aspect was concerned with the generation of gas deviation factor as a function of pseudo-reduced pressure for different pseudo-reduced temperatures. The method used in this project to generate the z-factor values did not quite fix the standing-katz correlation for pseudo-reduced temperatures greater than 2 and lower than 1.3. This means that the eight-coefficient equation used is not accurate enough in all the range of pseudo-reduced temperatures covered by the standing Katz correlation.

The viscosity versus pressure plots for our wells were accurately fixed with a polynomial of first degree (straight line) with a regression coefficient greater than 99%.

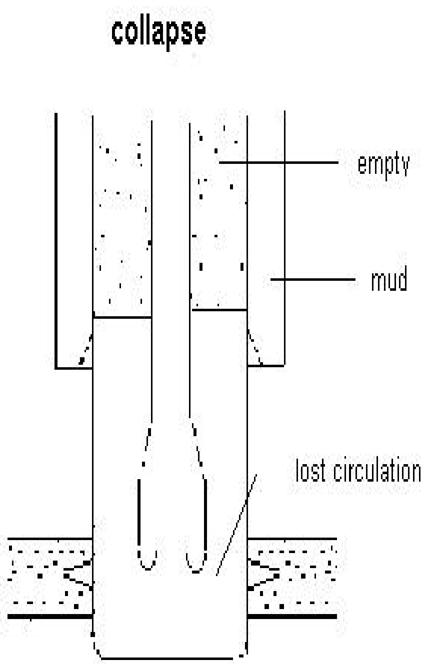
The pressure profile was generated using the line-source solution for the diffusivity equation with a constant flow rate that had to be maximized for seven years. The maximum flow rates for well # 1 was determined to be 6837 Mscf/d where the maximum flow rate for well # 2 is 6608 Mscf/d. These results seem too high for Shale formation. This is because prediction of pressure profile for shale formation has special method to be evaluated and in this project conventional method was used.

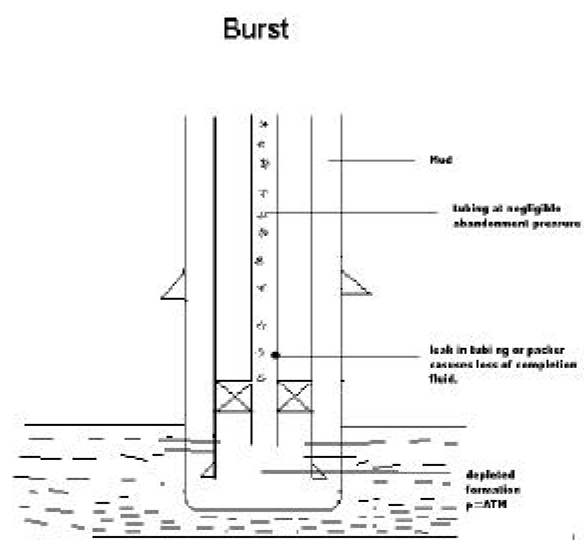
For the economical analysis of the two wells, a computer program was developed in visual basic (see Appendix E) to calculate the Discount Cash Flow Rate Of Return. The DCFROR for the

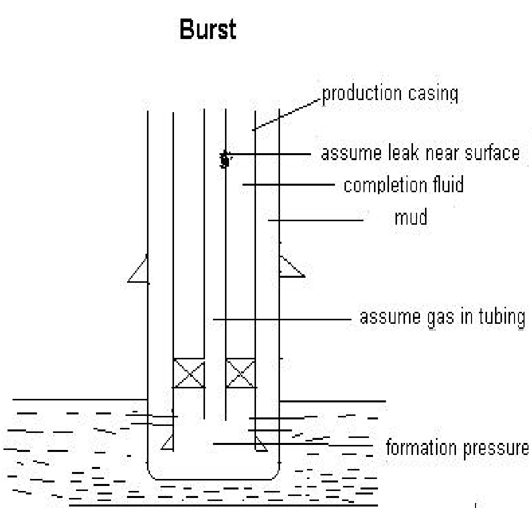
first well was determined to be 75% where DCFROR for the second well was determined to be 50%. Thus, Gulf Gas Company decided to invest in the frist well.

APPENDIXES

Appendix A

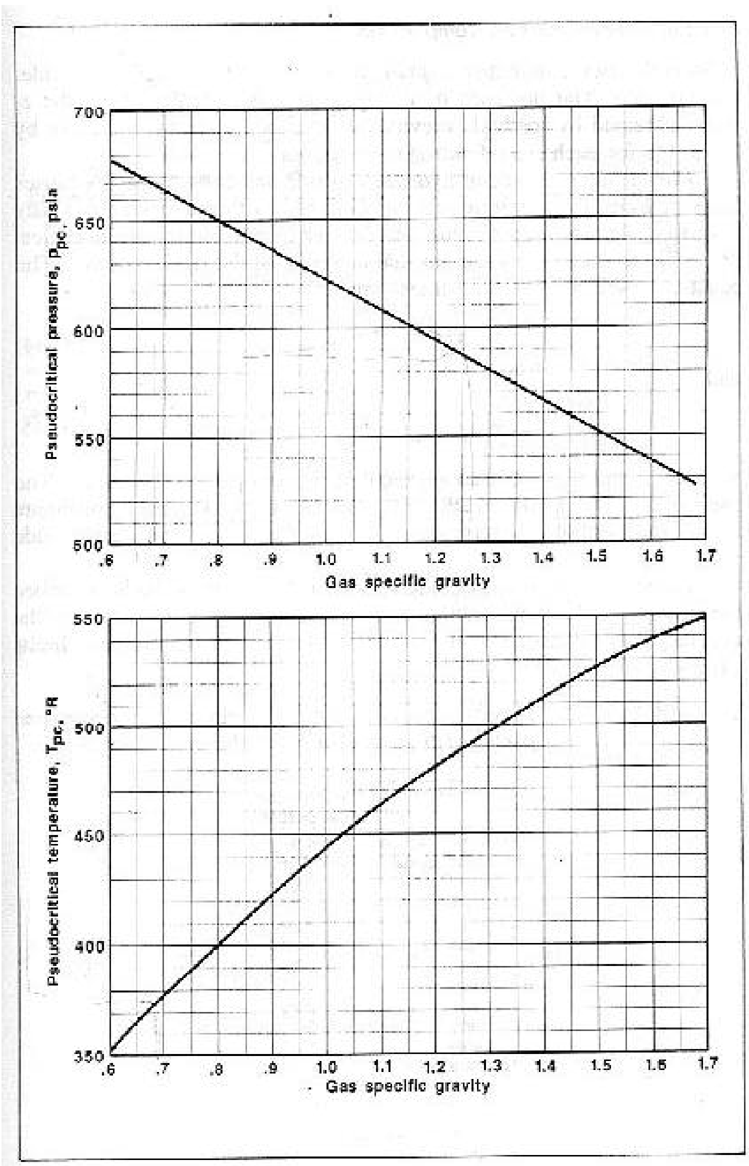

collapse
empty
mud
lost circulation

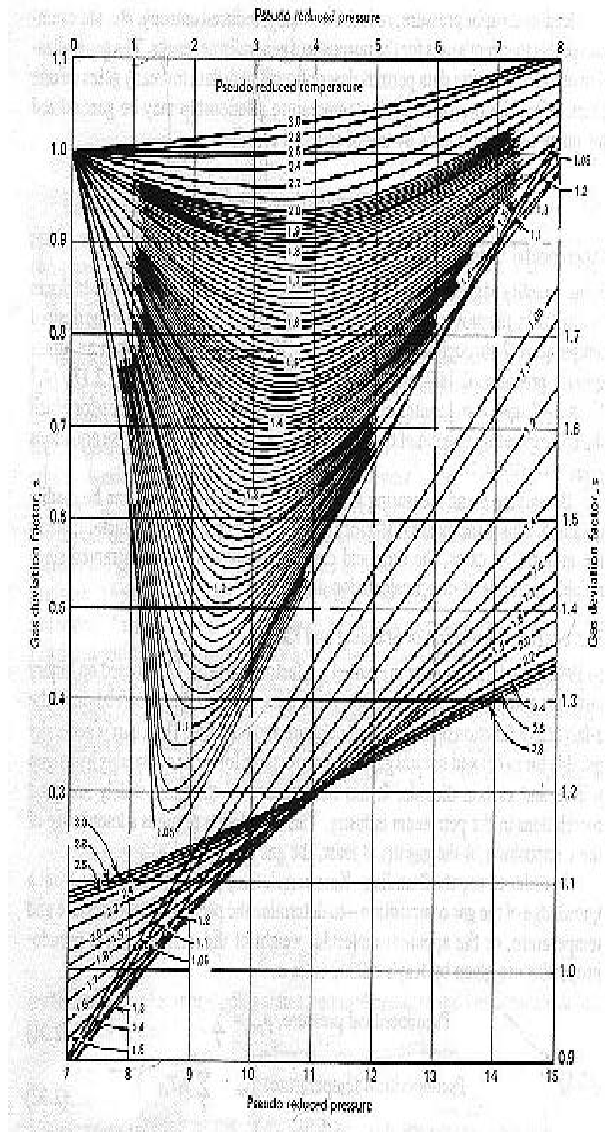

Burst
Mud
tubing at negligible abandonment pressure
leak in tubi ng or packer causes loss of completion fluid.
depleted formation p=ATM


Burst
production casing
assume leak near surface
completion fluid
mud
assume gas in tubing
formation pressure

Appendix B

(1) Z-chart
(2) Psudocritical properties of natural gas chart.





(2) **(1)**

Appendix B II

Table 2.1

Well #1(first pay zone):

Depth	bulk Dens.	Porosity N	Porosity	Rt	F	Rw	I	Sw	G
(feet)	(g/cc)	(%)	(%)	(ohm-m)		(ohm-m)		(fraction)	(scf/ac-ft)
4780	2.68	15	5.546125	23	325.103	0.07075	7.0747	0.375964	7179064
4782	2.725	14.8	5.45572	22	335.966	0.06548	6.5483	0.390784	6894329
4784	2.72	15	5.531365	22	326.84	0.06731	6.7311	0.38544	7051240
4786	2.656	14.8	5.481181	28	332.852	0.08412	8.4121	0.344784	7449504
4788	2.65	16	5.926199	32	284.739	0.11238	11.238	0.298297	8625777
4790	2.649	16.5	6.11107	31	267.772	0.11577	11.577	0.293902	8950578
4792	2.651	15	5.556827	30	323.852	0.09263	9.2635	0.328558	7739336
4794	2.648	15	5.557934	34	323.723	0.10503	10.503	0.308565	7971372
4796	2.65	14	5.188192	35	371.508	0.09421	9.4211	0.325799	7255610
4798	2.655	14	5.186347	29	371.772	0.078	7.8005	0.358047	6906113
4800	2.656	14	5.185978	25	371.825	0.06724	6.7236	0.385655	6608628
4802	2.725	10	3.684502	30	736.618	0.04073	4.0727	0.495519	3855599
4804	2.7	10	3.693727	35	732.943	0.04775	4.7753	0.457616	4155662
4806	2.72	16	5.900369	30	287.238	0.10444	10.444	0.309428	8451941
4808	2.73	15	5.527675	21	327.277	0.06417	6.4166	0.394773	6939515
4810	2.73	15	5.527675	20	327.277	0.06111	6.111	0.404522	6827734
4812	2.74	14.4	5.302583	22	355.652	0.06186	6.1858	0.40207	6576680
4814	2.72	14.4	5.309963	22	354.664	0.06203	6.2031	0.401511	6591989
4816	2.695	15	5.54059	21	325.753	0.06447	6.4466	0.393853	6966305
4818	2.73	14	5.158672	21	375.772	0.05588	5.5885	0.423012	6174096
4820	2.735	14	5.156827	22	376.041	0.0585	5.8504	0.413434	6274340
4822	2.745	13.9	5.116236	23	382.031	0.0602	6.0205	0.407554	6287351
4824	2.7	14	5.169742	24	374.164	0.06414	6.4143	0.394844	6489403
4826	2.7	15	5.538745	23	325.97	0.07056	7.0559	0.376465	7163756
4828	2.7	13	4.800738	22	433.894	0.0507	5.0704	0.4441	5535710
4830	2.705	14	5.167897	21	374.431	0.05609	5.6085	0.422257	6193232
4832	2.71	14.8	5.461255	21	335.286	0.06263	6.2633	0.399575	6801740
4834	2.685	15.2	5.618081	25	316.828	0.07891	7.8907	0.355993	7504934
4836	2.67	16	5.918819	30	285.45	0.1051	10.51	0.308464	8490212
4838	2.7	14.4	5.317343	30	353.68	0.08482	8.4822	0.343356	7242579
4840	2.7	14	5.169742	29.9	374.164	0.07991	7.9911	0.353749	6930083
4842	2.725	12.5	4.607011	29.9	471.152	0.06346	6.3461	0.396959	5762819
4844	2.73	14	5.158672	27	375.772	0.07185	7.1852	0.373061	6708594
4846	2.71	14	5.166052	25	374.699	0.06672	6.672	0.387143	6567296
4848	2.69	14	5.173432	25	373.631	0.06691	6.6911	0.386591	6582604
4850	2.72	14.5	5.346863	24	349.786	0.06861	6.8613	0.381764	6856805

4852	2.71	14	5.166052	22	374.699	0.05871	5.8714	0.412696	6293475
4854	2.71	13	4.797048	22	434.562	0.05063	5.0626	0.444441	5528056
4856	2.725	13	4.791513	24	435.567	0.0551	5.5101	0.426012	5704849
4858	2.72	14	5.162362	23	375.235	0.06129	6.1295	0.403913	6383028
4860	2.74	15	5.523985	20	327.714	0.06103	6.1029	0.404793	6820080
4862	2.74	14.9	5.487085	20	332.137	0.06022	6.0216	0.407515	6743538
4864	2.735	15	5.52583	22	327.495	0.06718	6.7177	0.385826	7039759
4866	2.73	16	5.896679	24	287.597	0.08345	8.345	0.346168	7997279
4868	2.74	16	5.892989	24	287.958	0.08335	8.3346	0.346385	7989625
4870	2.745	15	5.52214	23	327.933	0.07014	7.0136	0.377597	7129312
4872	2.747	15	5.521402	22	328.021	0.06707	6.7069	0.386135	7030574
4874	2.7	14.6	5.391144	20	344.063	0.05813	5.8129	0.414767	6544529
4876	2.69	14	5.173432	20	373.631	0.05353	5.3529	0.432221	6092932
4878	2.69	14	5.173432	21	373.631	0.05621	5.6205	0.421805	6204713
4880	2.73	14	5.158672	22	375.772	0.05855	5.8546	0.413286	6278167
4882	2.7	14.5	5.354244	22	348.822	0.06307	6.3069	0.39819	6683839
4884	2.71	14.5	5.350554	22	349.303	0.06298	6.2983	0.398465	6676185
4886	2.72	14	5.162362	26	375.235	0.06929	6.929	0.379896	6640204
4888	2.7	14.5	5.354244	29	348.822	0.08314	8.3137	0.346819	7254379
4890	2.725	15	5.52952	25	327.058	0.07644	7.6439	0.361695	7321234
4892	2.7	15	5.538745	24.5	325.97	0.07516	7.516	0.364759	7298250
4894	2.65	12	4.450185	26	504.945	0.05149	5.1491	0.440692	5162945
4896	2.7	12.6	4.653137	25	461.858	0.05413	5.4129	0.429818	5503363
4898	2.665	14	5.182657	21	372.302	0.05641	5.6406	0.421054	6223848
4900	2.71	15.6	5.756458	21.5	301.779	0.07124	7.1244	0.37465	7467018
4902	2.7	15.7	5.797048	23	297.568	0.07729	7.7293	0.359691	7699549
4904	2.65	14	5.188192	26	371.508	0.06999	6.9985	0.378005	6693783
4906	2.71	15.3	5.645756	26.5	313.73	0.08447	8.4468	0.344076	7681463
4908	2.657	15	5.554613	25	324.11	0.07713	7.7134	0.360061	7373282
4910	2.71	14	5.166052	25	374.699	0.06672	6.672	0.387143	6567296
4912	2.7	16	5.907749	26	286.521	0.09074	9.0744	0.331964	8186351
4914	2.65	16	5.926199	29.9	284.739	0.10501	10.501	0.308594	8499193
4916	2.71	14.8	5.461255	28	335.286	0.08351	8.3511	0.346042	7408171
4918	2.655	15.8	5.850554	27	292.15	0.09242	9.2418	0.328943	8143755
4920	2.658	15.8	5.849446	27	292.261	0.09238	9.2383	0.329006	8141459
4922	2.7	14	5.169742	27	374.164	0.07216	7.2161	0.372262	6731557
4924	2.72	13.8	5.088561	27	386.198	0.06991	6.9912	0.378201	6563164
4926	2.7	13.6	5.02214	26	396.481	0.06558	6.5577	0.390503	6349345
4928	2.7	14	5.169742	27	374.164	0.07216	7.2161	0.372262	6731557
4930	2.72	15	5.531365	26.5	326.84	0.08108	8.1079	0.351192	7444183
4932	2.725	12	4.422509	26.5	511.284	0.05183	5.183	0.439247	5144099
4934	2.7	11	4.062731	27	605.848	0.04457	4.4566	0.473696	4435299
4936	2.69	12	4.435424	30	508.311	0.05902	5.9019	0.411627	5413227
4938	2.67	14	5.180812	34	372.567	0.09126	9.1259	0.331026	7189113
4940	2.653	16	5.925092	35	284.846	0.12287	12.287	0.28528	8784151
4942	2.65	14.3	5.298893	33	356.147	0.09266	9.2658	0.328517	7380550
4944	2.65	16	5.926199	32	284.739	0.11238	11.238	0.298297	8625777

4946	2.65	16	5.926199	33	284.739	0.1159	11.59	0.293742	8681763
4948	2.65	15	5.557196	32	323.809	0.09882	9.8824	0.318104	7860358
4950	2.657	15	5.554613	29	324.11	0.08948	8.9476	0.334308	7670002
4952	2.7	15	5.538745	28	325.97	0.0859	8.5898	0.3412	7568909
4954	2.65	15.5	5.741697	30	303.333	0.0989	9.8901	0.317979	8122811
4956	2.65	15.5	5.741697	32	303.333	0.10549	10.549	0.307882	8243067
4958	2.65	16	5.926199	33	284.739	0.1159	11.59	0.293742	8681763
4960	2.65	15	5.557196	33	323.809	0.10191	10.191	0.313247	7916343
4962	2.71	13.4	4.944649	34	409.005	0.08313	8.3128	0.346837	6699245
4964	2.68	14	5.177122	32	373.098	0.08577	8.5768	0.341457	7071976
4966	2.71	13.6	5.01845	31	397.064	0.07807	7.8073	0.35789	6684172
4968	2.65	16	5.926199	33	284.739	0.1159	11.59	0.293742	8681763
4970	2.59	16.6	6.169742	37	262.704	0.14084	14.084	0.26646	9387702
4972	2.59	15	5.579336	40	321.244	0.12452	12.452	0.283392	8293403
4974	2.6	14.5	5.391144	38	344.063	0.11044	11.044	0.300904	7817837
4976	2.6	14	5.206642	30	368.88	0.08133	8.1327	0.350656	7012953
4978	2.625	14	5.197417	24	370.19	0.06483	6.4832	0.392742	6546810
4980	2.63	14	5.195572	23.5	370.453	0.06344	6.3436	0.397039	6498176
4982	2.7	13.8	5.095941	26	385.08	0.06752	6.7518	0.384848	6502429
4984	2.71	15	5.535055	30	326.404	0.09191	9.1911	0.329851	7694176
4986	2.72	14	5.162362	29	375.235	0.07728	7.7285	0.35971	6856361
4988	2.73	15	5.527675	27	327.277	0.0825	8.2499	0.348157	7474013
4990	2.7	14	5.169742	27	374.164	0.07216	7.2161	0.372262	6731557
4992	2.7	14	5.169742	29	374.164	0.07751	7.7506	0.359197	6871669
4994	2.68	15	5.546125	30	325.103	0.09228	9.2279	0.329192	7717139
4996	2.65	15	5.557196	27	323.809	0.08338	8.3383	0.346308	7535247
4998	2.69	14	5.173432	26	373.631	0.06959	6.9587	0.379083	6663167
5000	2.68	14.5	5.361624	25	347.862	0.07187	7.1868	0.373021	6972968
5002	2.72	14	5.162362	22	375.235	0.05863	5.863	0.412991	6285821
5004	2.7	14	5.169742	20.5	374.164	0.05479	5.4789	0.427223	6142191
5006	2.69	14	5.173432	22	373.631	0.05888	5.8882	0.412107	6308784
5008	2.7	14	5.169742	25	374.164	0.06682	6.6816	0.386867	6574950
5010	2.65	12	4.450185	28	504.945	0.05545	5.5452	0.424662	5310923
5012	2.7	14	5.169742	30	374.164	0.08018	8.0179	0.353159	6936411
5014	2.68	14	5.177122	29	373.098	0.07773	7.7728	0.358685	6886978
5016	2.72	15	5.531365	24	326.84	0.07343	7.343	0.36903	7239514
5018	2.74	14	5.154982	20	376.31	0.05315	5.3148	0.433768	6054661
5020	2.72	12	4.424354	21	510.858	0.04111	4.1107	0.49322	4650912
5022	2.7	14	5.169742	23	374.164	0.06147	6.147	0.403336	6398337
5024	2.71	13.8	5.092251	23	385.639	0.05964	5.9641	0.409474	6237599
5026	2.72	14	5.162362	20	375.235	0.0533	5.33	0.433148	6069969
5028	2.72	14	5.162362	21	375.235	0.05596	5.5965	0.422709	6181750
5030	2.75	13	4.782288	22	437.249	0.05031	5.0315	0.445813	5497439
5032	2.7	13.2	4.874539	22	420.855	0.05227	5.2274	0.437376	5688794
5034	2.65	14	5.188192	22	371.508	0.05922	5.9218	0.410935	6339400
5036	2.65	14.4	5.335793	25	351.238	0.07118	7.1177	0.374827	6919389
5038	2.67	14	5.180812	30	372.567	0.08052	8.0522	0.352405	6959374

5040	2.66	14	5.184502	31	372.037	0.08333	8.3325	0.346427	7028611
5042	2.65	12	4.450185	28.5	504.945	0.05644	5.6442	0.42092	5345461
5044	2.7	13	4.800738	24	433.894	0.05531	5.5313	0.425193	5723984
5046	2.7	12	4.431734	23	509.158	0.04517	4.5173	0.470503	4867498
5048	2.65	16	5.926199	23	284.739	0.08078	8.0776	0.351852	7967446
5050	2.65	16	5.926199	24	284.739	0.08429	8.4288	0.344444	8058512
5052	2.67	15	5.549815	23	324.671	0.07084	7.0841	0.375714	7186718
5054	2.67	15	5.549815	20	324.671	0.0616	6.1601	0.402909	6873659
5056	2.55	16	5.9631	18	281.226	0.06401	6.4005	0.395268	7480034
5058	2.65	16	5.926199	21	284.739	0.07375	7.3752	0.368226	7766168
5060	2.67	15.9	5.881919	22	289.043	0.07611	7.6113	0.362468	7778388
5062	2.68	14.8	5.472325	18	333.931	0.0539	5.3903	0.430717	6462027
5064	2.65	14.8	5.483395	17	332.584	0.05111	5.1115	0.442309	6343246
5066	2.6	8	2.99262	21	1116.6	0.01881	1.8807	0.729187	1681086
5068	2.7	12	4.431734	37	509.158	0.07267	7.2669	0.370959	5782578
5070	2.72	13	4.793358	30	435.231	0.06893	6.8929	0.38089	6155684
5072	2.7	12.5	4.616236	24	469.271	0.05114	5.1143	0.442187	5341275
5074	2.7	12	4.431734	24	509.158	0.04714	4.7137	0.460597	4958565
5076	2.71	13	4.797048	25	434.562	0.05753	5.7529	0.416923	5801877
5078	2.725	12	4.422509	24	511.284	0.04694	4.6941	0.461557	4939430
5080	2.725	11.9	4.385609	23.5	519.924	0.0452	4.5199	0.470366	4818081
5082	2.69	12	4.435424	24	508.311	0.04722	4.7215	0.460213	4966219
5084	2.7	13	4.800738	25	433.894	0.05762	5.7618	0.416603	5809531
5086	2.7	13	4.800738	24	433.894	0.05531	5.5313	0.425193	5723984
5088	2.68	12.9	4.771218	22	439.28	0.05008	5.0082	0.446848	5474477
5090	2.7	12	4.431734	22	509.158	0.04321	4.3209	0.481077	4770291
5092	2.73	13.5	4.97417	22	404.165	0.05443	5.4433	0.428616	5895457
5094	2.73	14	5.158672	21	375.772	0.05588	5.5885	0.423012	6174096
5096	2.74	15	5.523985	20	327.714	0.06103	6.1029	0.404793	6820080
5098	2.79	14.4	5.284133	19	358.14	0.05305	5.3052	0.43416	6202063
5100	2.71	14	5.166052	19	374.699	0.05071	5.0707	0.444083	5957129
5102	2.72	13.4	4.940959	20.5	409.616	0.05005	5.0047	0.447004	5667631
5104	2.71	13	4.797048	21	434.562	0.04832	4.8325	0.4549	5423986
5106	2.715	12.8	4.721402	22	448.599	0.04904	4.9042	0.451562	5371145
5108	2.7	13	4.800738	22	433.894	0.0507	5.0704	0.4441	5535710
5110	2.7	14	5.169742	20	374.164	0.05345	5.3452	0.43253	6085277
5112	2.7	15	5.538745	19.5	325.97	0.05982	5.9822	0.408857	6791608
5114	2.7	14	5.169742	20	374.164	0.05345	5.3452	0.43253	6085277
5116	2.71	14	5.166052	20	374.699	0.05338	5.3376	0.432839	6077623
5118	2.7	14.8	5.464945	19.5	334.833	0.05824	5.8238	0.414378	6638524
5120	2.71	14	5.166052	19	374.699	0.05071	5.0707	0.444083	5957129
5122	2.725	15	5.52952	19	327.058	0.05809	5.8094	0.414893	6711067
5124	2.7	14.8	5.464945	18	334.833	0.05376	5.3758	0.431299	6446718
5126	2.75	14.2	5.225092	19	366.279	0.05187	5.1873	0.439065	6079596
5128	2.75	14	5.151292	20	376.849	0.05307	5.3072	0.434079	6047007
5130	2.75	14	5.151292	20	376.849	0.05307	5.3072	0.434079	6047007
5132	2.74	14	5.154982	20	376.31	0.05315	5.3148	0.433768	6054661

5134	2.74	14.9	5.487085	20	332.137	0.06022	6.0216	0.407515	6743538
5136	2.71	14	5.166052	20	374.699	0.05338	5.3376	0.432839	6077623
5138	2.72	14	5.162362	20	375.235	0.0533	5.33	0.433148	6069969
5140	2.72	14	5.162362	20	375.235	0.0533	5.33	0.433148	6069969
5142	2.72	13.7	5.051661	20	391.861	0.05104	5.1039	0.44264	5840343
5144	2.72	14.4	5.309963	20	354.664	0.05639	5.6391	0.421108	6376137
5146	2.73	14.2	5.232472	20	365.247	0.05476	5.4758	0.427344	6215399
5148	2.75	14	5.151292	19	376.849	0.05042	5.0418	0.445356	5926513
5150	2.75	13.9	5.114391	19	382.307	0.0497	4.9698	0.448569	5849971
5152	2.74	14	5.154982	19	376.31	0.05049	5.049	0.445037	5934167
5154	2.75	15	5.520295	17	328.152	0.05181	5.1805	0.439353	6419788
5156	2.73	16	5.896679	16	287.597	0.05563	5.5633	0.423967	7045683
5158	2.75	14	5.151292	17	376.849	0.04511	4.5111	0.470825	5654369
5160	2.74	14	5.154982	18	376.31	0.04783	4.7833	0.457232	5803766
5162	2.75	14	5.151292	19	376.849	0.05042	5.0418	0.445356	5926513
5164	2.74	14.9	5.487085	19.5	332.137	0.05871	5.8711	0.412706	6684450
5166	2.75	15	5.520295	20	328.152	0.06095	6.0947	0.405063	6812426
5168	2.752	16	5.888561	19	288.391	0.06588	6.5883	0.389596	7455820
5170	2.75	15	5.520295	18	328.152	0.05485	5.4853	0.426974	6561531
5172	2.73	14	5.158672	18	375.772	0.0479	4.7901	0.456905	5811420
5174	2.73	14	5.158672	17.5	375.772	0.04657	4.6571	0.463386	5742068
5176	2.7	15	5.538745	17	325.97	0.05215	5.2152	0.437889	6458059
5178	2.725	16	5.898524	16	287.418	0.05567	5.5668	0.423835	7049510
5180	2.75	15	5.520295	17	328.152	0.05181	5.1805	0.439353	6419788
5182	2.73	14.8	5.453875	17.5	336.194	0.05205	5.2053	0.438304	6354403
5184	2.74	14	5.154982	18	376.31	0.04783	4.7833	0.457232	5803766
5186	2.74	15	5.523985	19	327.714	0.05798	5.7977	0.415308	6699586
5188	2.74	15	5.523985	19.2	327.714	0.05859	5.8588	0.41314	6724436
5190	2.74	14	5.154982	19	376.31	0.05049	5.049	0.445037	5934167
5192	2.75	13.8	5.077491	20	387.884	0.05156	5.1562	0.440388	5893923
5194	2.75	13	4.782288	20	437.249	0.04574	4.5741	0.467573	5281587
5196	2.725	12.6	4.643911	20	463.695	0.04313	4.3132	0.481505	4994555
5198	2.74	12	4.416974	20.5	512.567	0.03999	3.9995	0.500032	4580736
5200	2.71	14	5.166052	20	374.699	0.05338	5.3376	0.432839	6077623
5202	2.7	14	5.169742	18	374.164	0.04811	4.8107	0.455927	5834383
5204	2.71	14.5	5.350554	18	349.303	0.05153	5.1531	0.440519	6209438
5206	2.7	14	5.169742	19.5	374.164	0.05212	5.2116	0.43804	6026189
5208	2.67	13	4.811808	20	431.9	0.04631	4.6307	0.464704	5342821
5210	2.65	14	5.188192	20	371.508	0.05383	5.3835	0.430992	6123548
5212	2.7	13	4.800738	20	433.894	0.04609	4.6094	0.465776	5319858
5214	2.73	12	4.420664	20	511.711	0.03908	3.9085	0.505822	4531477
5216	2.73	13	4.789668	20	435.902	0.04588	4.5882	0.466852	5296896
5218	2.7	14	5.169742	20	374.164	0.05345	5.3452	0.43253	6085277
5220	2.7	14.6	5.391144	20	344.063	0.05813	5.8129	0.414767	6544529
5222	2.73	13.8	5.084871	20	386.759	0.05171	5.1712	0.439749	5909231
5224	2.72	14	5.162362	18.5	375.235	0.0493	4.9302	0.450366	5885597
5226	2.74	14	5.154982	17.5	376.31	0.0465	4.6504	0.463718	5734413

5228	2.74	14.8	5.450185	16	336.649	0.04753	4.7527	0.4587	6119526
5230	2.73	15	5.527675	16	327.277	0.04889	4.8888	0.45227	6280264
5232	2.73	15.2	5.601476	17	318.71	0.05334	5.334	0.432985	6588180
5234	2.71	16	5.904059	20	286.879	0.06972	6.9716	0.378734	7608461
5236	2.65	17	6.295203	23	252.337	0.09115	9.1148	0.331227	8732865
5238	2.55	17	6.332103	35	249.404	0.14033	14.033	0.266943	9628409
5240	2.5	17.8	6.645756	47	226.418	0.20758	20.758	0.219486	10759541
5242	2.5	14	5.243542	57	363.706	0.15672	15.672	0.252603	8129147
5244	2.53	14	5.232472	45	365.247	0.1232	12.32	0.284896	7761480
5246	2.55	12.8	4.782288	23	437.249	0.0526	5.2602	0.436014	5594647
5248	2.6	12.8	4.763838	20	440.642	0.04539	4.5388	0.469384	5243316
5250	2.68	12.8	4.734317	23	446.154	0.05155	5.1552	0.440432	5495142
5252	2.7	12.4	4.579336	23	476.865	0.04823	4.8232	0.455338	5173666
5254	2.7	13	4.800738	22	433.894	0.0507	5.0704	0.4441	5535710
5256	2.7	14	5.169742	22	374.164	0.0588	5.8798	0.412401	6301129
5258	2.67	14	5.180812	20	372.567	0.05368	5.3682	0.431606	6108240
5260	2.7	13.8	5.095941	20	385.08	0.05194	5.1937	0.438794	5932194
5262	2.71	14	5.166052	20	374.699	0.05338	5.3376	0.432839	6077623
5264	2.71	13.6	5.01845	20	397.064	0.05037	5.037	0.445569	5771456
5266	2.72	13.8	5.088561	20	386.198	0.05179	5.1787	0.43943	5916885
5268	2.7	14	5.169742	20	374.164	0.05345	5.3452	0.43253	6085277
5270	2.71	12.8	4.723247	20	448.248	0.04462	4.4618	0.473418	5159120
5272	2.7	13	4.800738	22	433.894	0.0507	5.0704	0.4441	5535710
5274	2.66	13.4	4.9631	23	405.97	0.05665	5.6654	0.420129	5969702
5276	2.6	13.4	4.98524	30	402.372	0.07456	7.4558	0.366229	6553702
5278	2.45	12.8	4.819188	34	430.578	0.07896	7.8964	0.355866	6439003
5280	2.35	12.6	4.782288	30	437.249	0.06861	6.8611	0.381772	6132721

Table 2.3

Well#1 (second pay zone):

Depth	bulk Dens.	porosityN	Porosity	Rt	F	Rw	I	Sw	G
(feet)	(g/cc)	(%)	(%)	(ohm-m)		(ohm-m)		(fraction)	(scf/ac-ft)
5710	2.56	16.4	6.10701	22	268.128	0.08205	8.20503	0.34911	8245294
5712	2.62	17	6.30627	22	251.452	0.087492	8.7492	0.33808	8658620
5714	2.56	16.8	6.25461	22	255.623	0.086064	8.60644	0.34087	8551461
5716	2.57	17	6.32472	24	249.987	0.096005	9.60051	0.32274	8885165
5718	2.62	16	5.93727	23	283.679	0.081078	8.10777	0.3512	7990408
5720	2.7	15	5.53875	18	325.97	0.05522	5.52199	0.42555	6599802
5722	2.725	15.9	5.86162	14	291.048	0.048102	4.81021	0.45595	6614920
5724	2.74	16	5.89299	15	287.958	0.052091	5.2091	0.43815	6867960
5726	2.75	16	5.8893	16	288.319	0.055494	5.54941	0.4245	7030374
5728	2.725	15.8	5.82472	16	294.747	0.054284	5.42838	0.4292	6896426

5730	2.72	16	5.90037	16	287.238	0.055703	5.5703	0.4237	7053337
5732	2.7	15	5.53875	16	325.97	0.049084	4.90843	0.45137	6303226
5734	2.69	16	5.91144	18	286.163	0.062901	6.29012	0.39872	7372875
5736	2.65	16	5.9262	21	284.739	0.073752	7.37517	0.36823	7766168
5738	2.6	15.8	5.87085	23	290.134	0.079274	7.92738	0.35517	7852633
5740	2.55	16	5.9631	25	281.226	0.088896	8.88964	0.3354	8220601
5742	2.6	16.4	6.09225	26	269.429	0.0965	9.65004	0.32191	8569060
5744	2.6	17	6.31365	25	250.864	0.099656	9.96555	0.31677	8947749
5746	2.6	17	6.31365	26	250.864	0.103642	10.3642	0.31062	9028312
5748	2.67	16	5.91882	27	285.45	0.094588	9.45875	0.32515	8285357
5750	2.71	16	5.90406	25	286.879	0.087145	8.71448	0.33875	8098134
5752	2.67	15.6	5.77122	23	300.238	0.076606	7.6606	0.3613	7645970
5754	2.65	15	5.5572	21	323.809	0.064853	6.48531	0.39268	7000749
5756	2.68	14.8	5.47232	22	333.931	0.065882	6.58819	0.3896	6928773
5758	2.65	14	5.18819	23	371.508	0.06191	6.19099	0.4019	6436608
5760	2.61	14	5.20295	20	369.403	0.054141	5.41414	0.42977	6154165
5762	2.64	14.8	5.48708	16	332.137	0.048173	4.8173	0.45562	6196067
5764	2.65	15.8	5.8524	14	291.966	0.047951	4.79508	0.45667	6595785
5766	2.65	15	5.5572	15	323.809	0.046324	4.63236	0.46462	6171429
5768	2.68	15	5.54613	16	325.103	0.049215	4.92152	0.45077	6318535
5770	2.68	14.8	5.47232	15	333.931	0.04492	4.49195	0.47183	5995382
5772	2.6	15.6	5.79705	15	297.568	0.050409	5.04086	0.4454	6668951
5774	2.68	15	5.54613	17	325.103	0.052291	5.22912	0.43731	6473367
5776	2.69	15.8	5.83764	19	293.444	0.064748	6.47482	0.39299	7350192
5778	2.65	14	5.18819	19.5	371.508	0.052489	5.24888	0.43648	6064460
5780	2.68	13	4.80812	20	432.563	0.046236	4.6236	0.46506	5335167
5782	2.68	14	5.17712	20	373.098	0.053605	5.36052	0.43191	6100586
5784	2.65	15	5.5572	19	323.809	0.058677	5.86766	0.41283	6768474
5786	2.6	14	5.20664	20	368.88	0.054218	5.42182	0.42946	6161819
5788	2.55	13.9	5.18819	25	371.508	0.067293	6.72933	0.38549	6613221
5790	2.6	14	5.20664	25	368.88	0.067773	6.77728	0.38412	6651492
5792	2.64	14.8	5.48708	19	332.137	0.057205	5.72054	0.4181	6623044
5794	2.64	16	5.92989	19	284.385	0.066811	6.68108	0.38688	7541547
5796	2.67	15	5.54982	24	324.671	0.073921	7.39211	0.3678	7277785
5798	2.65	15	5.5572	24	323.809	0.074118	7.41178	0.36732	7293093
5800	2.63	15.8	5.85978	25	291.231	0.085843	8.58425	0.34131	8006284
5802	2.62	15.4	5.71587	25	306.081	0.081678	8.16778	0.3499	7707770
5804	2.6	16	5.94465	22	282.975	0.077745	7.77455	0.35864	7908509
5806	2.65	14	5.18819	23	371.508	0.06191	6.19099	0.4019	6436608
5808	2.68	15	5.54613	24	325.103	0.073823	7.38228	0.36805	7270131
5810	2.69	15	5.54244	21	325.536	0.064509	6.4509	0.39372	6970132
5812	2.67	15.4	5.69742	20	308.066	0.064921	6.49211	0.39247	7179827
5814	2.65	16	5.9262	18	284.739	0.063216	6.32157	0.39773	7403492
5816	2.7	14.4	5.31734	17	353.68	0.048066	4.8066	0.45612	5998807
5818	2.7	15.2	5.61255	17	317.454	0.053551	5.35511	0.43213	6611142
5820	2.72	15.8	5.82657	20	294.56	0.067898	6.78978	0.38377	7447723
5822	2.735	14	5.15683	20	376.041	0.053186	5.31857	0.43361	6058488

5824	2.7	15	5.53875	18	325.97	0.05522	5.52199	0.42555	6599802
5826	2.65	14.4	5.33579	17	351.238	0.0484	4.84002	0.45454	6037078
5828	2.7	15.9	5.87085	18	290.134	0.06204	6.20404	0.40148	7288679
5830	2.74	14	5.15498	18	376.31	0.047833	4.78329	0.45723	5803766
5832	2.75	15	5.5203	16	328.152	0.048758	4.87579	0.45287	6264955
5834	2.67	16	5.91882	16	285.45	0.056052	5.60519	0.42238	7091608
5836	2.89	15.8	5.76384	16	301.007	0.053155	5.31549	0.43374	6770132
5838	2.65	15.7	5.8155	16	295.683	0.054112	5.4112	0.42989	6877290
5840	2.67	15.7	5.80812	14	296.435	0.047228	4.72279	0.46015	6503935
5842	2.65	16	5.9262	13	284.739	0.045656	4.56558	0.46801	6539597
5844	2.7	16	5.90775	13	286.521	0.045372	4.53719	0.46947	6501326
5846	2.7	16	5.90775	13	286.521	0.045372	4.53719	0.46947	6501326
5848	2.67	15	5.54982	14	324.671	0.043121	4.31206	0.48157	5968141
5850	2.68	15.2	5.61993	13	316.62	0.041059	4.10586	0.49351	5904299
5852	2.65	15.6	5.7786	13	299.471	0.04341	4.34099	0.47996	6233429
5854	2.57	16	5.95572	14	281.924	0.049659	4.96588	0.44875	6810102
5856	2.7	15.9	5.87085	15	290.134	0.0517	5.17003	0.4398	6822035
5858	2.7	15.6	5.76015	17	301.393	0.056405	5.64048	0.42106	6917310
5860	2.73	15	5.52768	18	327.277	0.054999	5.49993	0.4264	6576840
5862	2.71	15.9	5.86716	17	290.499	0.05852	5.852	0.41338	7139282
5864	2.7	16	5.90775	17	286.521	0.059333	5.93325	0.41054	7223478
5866	2.68	16	5.91513	18	285.806	0.06298	6.29798	0.39847	7380530
5868	2.7	15	5.53875	16	325.97	0.049084	4.90843	0.45137	6303226
5870	2.65	15	5.5572	14	323.809	0.043235	4.32354	0.48093	5983450
5872	2.68	16	5.91513	13	285.806	0.045485	4.54854	0.46888	6516634
5874	2.65	16.5	6.1107	12	267.805	0.044809	4.48088	0.47241	6687393
5876	2.65	14	5.18819	13	371.508	0.034993	3.49925	0.53458	5008759
5878	2.6	14.4	5.35424	16	348.822	0.045869	4.58687	0.46692	5920517
5880	2.65	14.6	5.40959	20	341.72	0.058527	5.85274	0.41335	6582800
5882	2.7	14	5.16974	18	374.164	0.048107	4.81072	0.45593	5834383
5884	2.71	14.6	5.38745	16	344.535	0.046439	4.64395	0.46404	5989404
5886	2.72	14.8	5.45756	16	335.739	0.047656	4.7656	0.45808	6134834
5888	2.72	15	5.53137	14	326.84	0.042834	4.28344	0.48317	5929870
5890	2.71	15	5.53506	14	326.404	0.042892	4.28916	0.48285	5937524
5892	2.72	14.8	5.45756	14.5	335.739	0.043188	4.31883	0.48119	5873207
5894	2.71	14	5.16605	16	374.699	0.042701	4.27009	0.48393	5530153
5896	2.71	14.8	5.46125	16	335.286	0.04772	4.77205	0.45777	6142488
5898	2.7	15.4	5.68635	16	309.267	0.051735	5.17353	0.43965	6609394
5900	2.7	15	5.53875	16	325.97	0.049084	4.90843	0.45137	6303226
5902	2.7	14.6	5.39114	15	344.063	0.043597	4.35966	0.47893	5826990
5904	2.7	14.6	5.39114	15	344.063	0.043597	4.35966	0.47893	5826990
5906	2.71	14.6	5.38745	15	344.535	0.043537	4.3537	0.47926	5819336
5908	2.7	16	5.90775	14	286.521	0.048862	4.88621	0.45239	6710598
5910	2.73	16	5.89668	14	287.597	0.048679	4.86792	0.45324	6687635
5912	2.73	16	5.89668	14	287.597	0.048679	4.86792	0.45324	6687635
5914	2.7	15.2	5.61255	14	317.454	0.044101	4.41009	0.47619	6098262
5916	2.65	15	5.5572	14	323.809	0.043235	4.32354	0.48093	5983450

5918	2.67	15.4	5.69742	17	308.066	0.055183	5.5183	0.42569	6787189
5920	2.5	15	5.61255	18	317.454	0.056701	5.67012	0.41996	6752886
5922	2.6	15	5.57565	15	321.669	0.046632	4.66317	0.46308	6209700
5924	2.68	15.2	5.61993	14	316.62	0.044217	4.4217	0.47556	6113571
5926	2.7	15.8	5.83395	13	293.816	0.044245	4.42454	0.47541	6348242
5928	2.7	16	5.90775	12	286.521	0.041882	4.18818	0.48864	6266412
5930	2.71	16	5.90406	11	286.879	0.038344	3.83437	0.51068	5992499
5932	2.68	16	5.91513	10	285.806	0.034989	3.49888	0.53461	5710201
5934	2.72	16	5.90037	10	287.238	0.034814	3.48144	0.53595	5679584
5936	2.68	15.9	5.87823	10	289.406	0.034554	3.45536	0.53796	5633659
5938	2.69	15.9	5.87454	11	289.769	0.037961	3.79612	0.51325	5931265
5940	2.69	14.4	5.32103	10	353.19	0.028313	2.83134	0.5943	4477876
5942	2.67	14.5	5.36531	10	347.384	0.028787	2.87866	0.58939	4569726
5944	2.6	16	5.94465	13	282.975	0.045941	4.59405	0.46655	6577868
5946	2.6	17.8	6.60886	16	228.954	0.069883	6.98832	0.37828	8522941

Table 2.4

Well # 2:

Depth	bulk Dens.	porosity N	Porosity	Rt	F	Rwa	I	Sw	Sw	Gi
(feet)	(g/cc)	(%)	(%)	(ohm-m)		(omh-m)		(fraction)	(%)	(scf/ac-ft)
4420	2.7	12	4.43173	23	509.16	0.0452	4.517	0.4705	47.05	5060271
4422	2.659	11	4.07786	25	601.36	0.0416	4.157	0.4905	49.045	4480771
4424	2.659	11.9	4.40996	25	514.2	0.0486	4.862	0.4535	45.352	5196930
4426	2.659	13	4.81587	24	431.17	0.0557	5.566	0.4239	42.386	5983302
4428	2.7	13	4.80074	21	433.89	0.0484	4.84	0.4546	45.455	5646754
4430	2.658	10	3.70923	24	726.83	0.033	3.302	0.5503	55.031	3596899
4432	2.7	11.8	4.35793	26	526.55	0.0494	4.938	0.45	45.002	5168485
4434	2.659	12.1	4.48376	25	497.41	0.0503	5.026	0.4461	44.605	5356077
4436	2.658	11.2	4.15203	30	580.07	0.0517	5.172	0.4397	43.972	5016490
4438	2.657	12.3	4.5583	31	481.28	0.0644	6.441	0.394	39.402	5956613
4440	2.7	12.2	4.50554	29	492.61	0.0589	5.887	0.4121	41.215	5711496
4442	2.71	12.2	4.50185	24	493.42	0.0486	4.864	0.4534	45.342	5306133
4444	2.73	11.8	4.34686	24	529.23	0.0453	4.535	0.4696	46.959	4971925
4446	2.7	12	4.43173	27	509.16	0.053	5.303	0.4343	43.425	5406688
4448	2.7	11.5	4.24723	25	554.35	0.0451	4.51	0.4709	47.089	4846012
4450	2.7	12	4.43173	25	509.16	0.0491	4.91	0.4513	45.129	5243879
4452	2.7	11.8	4.35793	25	526.55	0.0475	4.748	0.4589	45.893	5084732
4454	2.659	12	4.44686	23	505.7	0.0455	4.548	0.4689	46.89	5092896
4456	2.659	12.2	4.52066	25	489.32	0.0511	5.109	0.4424	44.241	5435650
4458	2.695	9.9	3.65867	30	747.06	0.0402	4.016	0.499	49.902	3952595
4460	2.7	11	4.06273	30	605.85	0.0495	4.952	0.4494	44.939	4823922
4462	2.659	10	3.70886	32	726.98	0.044	4.402	0.4766	47.663	4185834
4464	2.7	8.8	3.25092	36	946.21	0.038	3.805	0.5127	51.267	3416346

4466	2.7	11.2	4.13653	30	584.42	0.0513	5.133	0.4414	44.137	4983069
4468	2.659	12.2	4.52066	25	489.32	0.0511	5.109	0.4424	44.241	5435650
4470	2.7	12	4.43173	23	509.16	0.0452	4.517	0.4705	47.05	5060271
4472	2.657	12	4.4476	23	505.53	0.0455	4.55	0.4688	46.882	5094487
4474	2.7	12	4.43173	22	509.16	0.0432	4.321	0.4811	48.108	4959214
4476	2.71	12.1	4.46494	22	501.61	0.0439	4.386	0.4775	47.75	5030830
4478	2.659	12	4.44686	25	505.7	0.0494	4.944	0.4498	44.976	5276504
4480	2.7	10.8	3.98893	26	628.47	0.0414	4.137	0.4917	49.165	4372752
4482	2.72	12	4.42435	25	510.86	0.0489	4.894	0.452	45.204	5227964
4484	2.7	10.2	3.76753	25	704.51	0.0355	3.549	0.5309	53.085	3811560
4486	2.72	12	4.42435	22	510.86	0.0431	4.306	0.4819	48.188	4943299
4488	2.71	12	4.42804	20	510.01	0.0392	3.922	0.505	50.498	4726856
4490	2.7	13	4.80074	25	433.89	0.0576	5.762	0.4166	41.66	6039611
4492	2.655	11.8	4.37454	30	522.56	0.0574	5.741	0.4174	41.736	5496316
4494	2.658	12.4	4.59483	33	473.65	0.0697	6.967	0.3789	37.886	6154591
4496	2.658	12.4	4.59483	28	473.65	0.0591	5.911	0.4113	41.129	5833183
4498	2.71	12.4	4.57565	25	477.63	0.0523	5.234	0.4371	43.71	5554214
4500	2.71	12.5	4.61255	22	470.02	0.0468	4.681	0.4622	46.222	5349123
4502	2.7	11.3	4.17343	22	574.13	0.0383	3.832	0.5109	51.085	4402201
4504	2.658	12.4	4.59483	23	473.65	0.0486	4.856	0.4538	45.38	5411985
4506	2.71	12.2	4.50185	22	493.42	0.0446	4.459	0.4736	47.359	5110403
4508	2.7	12	4.43173	23	509.16	0.0452	4.517	0.4705	47.05	5060271
4510	2.657	11.2	4.1524	22	579.97	0.0379	3.793	0.5134	51.344	4356844
4512	2.7	12	4.43173	25	509.16	0.0491	4.91	0.4513	45.129	5243879
4514	2.7	11.8	4.35793	26	526.55	0.0494	4.938	0.45	45.002	5168485
4516	2.73	12.4	4.56827	25	479.18	0.0522	5.217	0.4378	43.78	5538300
4518	2.7	12.4	4.57934	22	476.86	0.0461	4.613	0.4656	46.557	5277507
4520	2.7	12.4	4.57934	22	476.86	0.0461	4.613	0.4656	46.557	5277507
4522	2.657	12.4	4.5952	22	473.58	0.0465	4.645	0.464	46.396	5311723
4524	2.7	12.3	4.54244	22	484.64	0.0454	4.539	0.4694	46.935	5197933
4526	2.654	12.5	4.63321	23	465.84	0.0494	4.937	0.45	45.004	5494741
4528	2.655	14	5.18635	24	371.77	0.0646	6.456	0.3936	39.358	6782217
4530	2.655	12	4.44834	23	505.36	0.0455	4.551	0.4687	46.875	5096079
4532	2.658	12.2	4.52103	23	489.24	0.047	4.701	0.4612	46.121	5252838
4534	2.7	14.1	5.20664	24	368.88	0.0651	6.506	0.392	39.205	6825983
4536	2.71	12.6	4.64945	25	462.59	0.054	5.404	0.4302	43.016	5713361
4538	2.71	12.4	4.57565	25	477.63	0.0523	5.234	0.4371	43.71	5554214
4540	2.7	12	4.43173	25	509.16	0.0491	4.91	0.4513	45.129	5243879
4542	2.72	13.9	5.12546	26	380.66	0.0683	6.83	0.3826	38.263	6823609
4544	2.654	12.6	4.67011	28	458.51	0.0611	6.107	0.4047	40.466	5995513
4546	2.658	12	4.44723	27	505.62	0.0534	5.34	0.4327	43.274	5440108
4548	2.71	12	4.42804	24	510.01	0.0471	4.706	0.461	46.098	5146987
4550	2.656	13.2	4.89077	25	418.07	0.0598	5.98	0.4089	40.893	6233770
4552	2.657	13	4.81661	23	431.04	0.0534	5.336	0.4329	43.291	5890220
4554	2.7	12	4.43173	22	509.16	0.0432	4.321	0.4811	48.108	4959214
4556	2.7	13	4.80074	23	433.89	0.053	5.301	0.4343	43.434	5856003
4558	2.659	12	4.44686	25	505.7	0.0494	4.944	0.4498	44.976	5276504

4560	2.659	12	4.44686	26	505.7	0.0514	5.141	0.441	44.102	5360257
4562	2.65	12.1	4.48708	30	496.67	0.0604	6.04	0.4069	40.689	5739015
4564	2.63	13.2	4.90037	31	416.43	0.0744	7.444	0.3665	36.651	6694258
4566	2.65	13	4.81919	30	430.58	0.0697	6.967	0.3788	37.885	6455174
4568	2.65	13	4.81919	24	430.58	0.0557	5.574	0.4236	42.357	5990463
4570	2.653	13	4.81808	25	430.78	0.058	5.803	0.4151	41.51	6077011
4572	2.653	11.8	4.37528	30	522.38	0.0574	5.743	0.4173	41.729	5497908
4574	2.652	12	4.44945	32	505.11	0.0634	6.335	0.3973	39.73	5782869
4576	2.655	13.5	5.00185	27	399.7	0.0675	6.755	0.3848	38.476	6636095
4578	2.7	12	4.43173	30	509.16	0.0589	5.892	0.412	41.197	5619655
4580	2.658	12	4.44723	30	505.62	0.0593	5.933	0.4105	41.053	5653076
4582	2.655	12.8	4.74354	25	444.42	0.0563	5.625	0.4216	42.163	5916273
4584	2.7	13	4.80074	22	433.89	0.0507	5.07	0.4441	44.41	5754946
4586	2.73	12	4.42066	22	511.71	0.043	4.299	0.4823	48.228	4935342
4588	2.7	12.8	4.72694	22	447.55	0.0492	4.916	0.451	45.103	5595800
4590	2.7	12.5	4.61624	22	469.27	0.0469	4.688	0.4618	46.185	5357080
4592	2.7	12.4	4.57934	22	476.86	0.0461	4.613	0.4656	46.557	5277507
4594	2.7	12.7	4.69004	23	454.62	0.0506	5.059	0.4446	44.459	5617284
4596	2.7	12.2	4.50554	24	492.61	0.0487	4.872	0.4531	45.305	5314091
4598	2.7	12.7	4.69004	24	454.62	0.0528	5.279	0.4352	43.523	5711957
4600	2.7	13	4.80074	24	433.89	0.0553	5.531	0.4252	42.519	5950677
4602	2.71	12.5	4.61255	23	470.02	0.0489	4.893	0.4521	45.206	5450180
4604	2.72	12	4.42435	25	510.86	0.0489	4.894	0.452	45.204	5227964
4606	2.73	9	3.31365	29	910.72	0.0318	3.184	0.5604	56.039	3141279
4608	2.659	10	3.70886	25	726.98	0.0344	3.439	0.5392	53.925	3685038
4610	2.657	13	4.81661	25	431.04	0.058	5.8	0.4152	41.523	6073828
4612	2.654	12	4.44871	29	505.28	0.0574	5.739	0.4174	41.741	5588953
4614	2.657	14	5.18561	29	371.88	0.078	7.798	0.3581	35.81	7178031
4616	2.658	12	4.44723	26	505.62	0.0514	5.142	0.441	44.098	5361052
4618	2.7	13	4.80074	30	433.89	0.0691	6.914	0.3803	38.03	6415388
4620	2.7	11.8	4.35793	28	526.55	0.0532	5.318	0.4337	43.365	5322323
4622	2.7	11	4.06273	21	605.85	0.0347	3.466	0.5371	53.712	4055289
4624	2.658	13.8	5.11144	21	382.75	0.0549	5.487	0.4269	42.692	6316761
4626	2.658	12	4.44723	26	505.62	0.0514	5.142	0.441	44.098	5361052
4628	2.657	11.7	4.3369	25	531.67	0.047	4.702	0.4612	46.116	5039375
4630	2.659	12	4.44686	22	505.7	0.0435	4.35	0.4794	47.944	4991839
4632	2.657	13.8	5.11181	21	382.69	0.0549	5.487	0.4269	42.689	6317557
4634	2.658	12	4.44723	22	505.62	0.0435	4.351	0.4794	47.94	4992634
4636	2.71	12.4	4.57565	21	477.63	0.044	4.397	0.4769	47.691	5161357
4638	2.7	12.4	4.57934	20	476.86	0.0419	4.194	0.4883	48.83	5053106
4640	2.659	13	4.81587	20	431.17	0.0464	4.639	0.4643	46.431	5563171
4642	2.7	13.8	5.09594	23	385.08	0.0597	5.973	0.4092	40.918	6492590
4644	2.658	13	4.81624	20	431.11	0.0464	4.639	0.4643	46.428	5563967
4646	2.7	13	4.80074	20	433.89	0.0461	4.609	0.4658	46.578	5530546
4648	2.74	13	4.78598	21	436.57	0.0481	4.81	0.456	45.595	5614925
4650	2.74	12.4	4.56458	20	479.95	0.0417	4.167	0.4899	48.987	5021277
4652	2.74	12.4	4.56458	20	479.95	0.0417	4.167	0.4899	48.987	5021277

4654	2.7	13	4.80074	20	433.89	0.0461	4.609	0.4658	46.578	5530546
4656	2.72	13.8	5.08856	21	386.2	0.0544	5.438	0.4288	42.884	6267426
4658	2.7	13	4.80074	23	433.89	0.053	5.301	0.4343	43.434	5856003
4660	2.7	13	4.80074	22	433.89	0.0507	5.07	0.4441	44.41	5754946
4662	2.71	12.4	4.57565	20	477.63	0.0419	4.187	0.4887	48.869	5045149
4664	2.658	12.6	4.66863	22	458.8	0.048	4.795	0.4567	45.667	5470074
4666	2.654	13.8	5.11292	26	382.53	0.068	6.797	0.3836	38.357	6796554
4668	2.658	13.8	5.11144	29	382.75	0.0758	7.577	0.3633	36.329	7018089
4670	2.658	13	4.81624	25	431.11	0.058	5.799	0.4153	41.526	6073032
4672	2.658	13	4.81624	25	431.11	0.058	5.799	0.4153	41.526	6073032
4674	2.7	11.4	4.21033	27	564.11	0.0479	4.786	0.4571	45.709	4929248
4676	2.7	12	4.43173	25	509.16	0.0491	4.91	0.4513	45.129	5243879
4678	2.71	13	4.79705	23	434.56	0.0529	5.293	0.4347	43.467	5848046
4680	2.71	12.6	4.64945	21	462.59	0.0454	4.54	0.4693	46.934	5320504
4682	2.7	13	4.80074	24	433.89	0.0553	5.531	0.4252	42.519	5950677
4684	2.655	13	4.81734	25	430.91	0.058	5.802	0.4152	41.517	6075419
4686	2.657	12	4.4476	25	505.53	0.0495	4.945	0.4497	44.968	5278095
4688	2.656	14	5.18598	25	371.83	0.0672	6.724	0.3857	38.566	6870356
4690	2.656	13	4.81697	24	430.97	0.0557	5.569	0.4238	42.376	5985689
4692	2.658	14	5.18524	25	371.93	0.0672	6.722	0.3857	38.571	6868765
4694	2.65	14	5.18819	28	371.51	0.0754	7.537	0.3643	36.425	7112722
4696	2.7	13	4.80074	27	433.89	0.0622	6.223	0.4009	40.088	6202420
4698	2.652	13	4.81845	25	430.71	0.058	5.804	0.4151	41.507	6077806
4700	2.655	12.6	4.66974	25	458.58	0.0545	5.452	0.4283	42.829	5757126
4702	2.657	13.6	5.03801	25	393.99	0.0635	6.345	0.397	39.698	6551267
4704	2.657	11.8	4.3738	26	522.74	0.0497	4.974	0.4484	44.839	5202702
4706	2.7	12.2	4.50554	26	492.61	0.0528	5.278	0.4353	43.528	5486778
4708	2.657	11.4	4.2262	26	559.89	0.0464	4.644	0.464	46.405	4884408
4710	2.657	12.4	4.5952	25	473.58	0.0528	5.279	0.4352	43.524	5596388
4712	2.657	12.2	4.5214	26	489.16	0.0532	5.315	0.4338	43.375	5520995
4714	2.65	14	5.18819	31	371.51	0.0834	8.344	0.3462	34.618	7314929
4716	2.63	14	5.19557	35	370.45	0.0945	9.448	0.3253	32.534	7558875
4718	2.63	13	4.82657	33	429.26	0.0769	7.688	0.3607	36.067	6654311
4720	2.65	13	4.81919	30	430.58	0.0697	6.967	0.3788	37.885	6455174
4722	2.65	12	4.45018	27	504.94	0.0535	5.347	0.4325	43.245	5446474
4724	2.63	13	4.82657	28	429.26	0.0652	6.523	0.3915	39.155	6332904
4726	2.63	13.8	5.12177	28	381.21	0.0735	7.345	0.369	36.898	6969490
4728	2.652	12.4	4.59705	25	473.2	0.0528	5.283	0.4351	43.506	5600367
4730	2.653	12.6	4.67048	23	458.43	0.0502	5.017	0.4465	44.645	5575110
4732	2.65	13	4.81919	25	430.58	0.0581	5.806	0.415	41.501	6079398
4734	2.65	13.4	4.96679	26	405.37	0.0641	6.414	0.3949	39.485	6481444
4736	2.653	14	5.18708	30	371.67	0.0807	8.072	0.352	35.198	7248520
4738	2.651	13	4.81882	33	430.64	0.0766	7.663	0.3612	36.125	6637601
4740	2.654	14	5.18672	32	371.72	0.0861	8.609	0.3408	34.083	7372743
4742	2.7	12	4.43173	30	509.16	0.0589	5.892	0.412	41.197	5619655
4744	2.7	12.8	4.72694	27	447.55	0.0603	6.033	0.4071	40.713	6043274
4746	2.65	13.8	5.11439	28	382.31	0.0732	7.324	0.3695	36.951	6953575

4748	2.6	13.8	5.13284	38	379.56	0.1001	10.01	0.316	31.605	7570441
4750	2.558	14.2	5.29594	40	356.54	0.1122	11.22	0.2986	29.856	8010732
4752	2.657	13.6	5.03801	26	393.99	0.066	6.599	0.3893	38.927	6635020
4754	2.657	13	4.81661	22	431.04	0.051	5.104	0.4426	44.264	5789163
4756	2.655	13	4.81734	25	430.91	0.058	5.802	0.4152	41.517	6075419
4758	2.659	13	4.81587	30	431.17	0.0696	6.958	0.3791	37.911	6448013
4760	2.656	14	5.18598	30	371.83	0.0807	8.068	0.3521	35.205	7246133
4762	2.655	13.8	5.11255	27	382.58	0.0706	7.057	0.3764	37.643	6874814
4764	2.659	12	4.44686	25	505.7	0.0494	4.944	0.4498	44.976	5276504
4766	2.7	13.9	5.13284	25	379.56	0.0659	6.587	0.3896	38.965	6755771
4768	2.652	13	4.81845	26	430.71	0.0604	6.037	0.407	40.701	6161559
4770	2.65	14	5.18819	28	371.51	0.0754	7.537	0.3643	36.425	7112722
4772	2.651	14	5.18782	24	371.56	0.0646	6.459	0.3935	39.347	6785400
4774	2.658	13	4.81624	20	431.11	0.0464	4.639	0.4643	46.428	5563967
4776	2.655	13	4.81734	21	430.91	0.0487	4.873	0.453	45.298	5682562
4778	2.653	13	4.81808	20	430.78	0.0464	4.643	0.4641	46.41	5567945
4780	2.7	13.4	4.94834	19	408.4	0.0465	4.652	0.4636	46.362	5723573
4782	2.65	14	5.18819	19	371.51	0.0511	5.114	0.4422	44.219	6240799
4784	2.55	13.8	5.15129	20	376.85	0.0531	5.307	0.4341	43.408	6286492
4786	2.655	12.4	4.59594	24	473.42	0.0507	5.069	0.4441	44.414	5509045
4788	2.657	13.6	5.03801	30	393.99	0.0761	7.614	0.3624	36.239	6927044
4790	2.7	11.8	4.35793	25	526.55	0.0475	4.748	0.4589	45.893	5084732
4792	2.7	14	5.16974	20	374.16	0.0535	5.345	0.4325	43.253	6326279
4794	2.659	13	4.81587	19	431.17	0.0441	4.407	0.4764	47.637	5437905
4796	2.71	12	4.42804	20	510.01	0.0392	3.922	0.505	50.498	4726856
4798	2.659	14	5.18487	19	371.98	0.0511	5.108	0.4425	44.247	6233638
4800	2.7	14.2	5.24354	18	363.71	0.0495	4.949	0.4495	44.951	6224594
4802	2.725	13	4.79151	19	435.57	0.0436	4.362	0.4788	47.88	5385387
4804	2.7	13	4.80074	20	433.89	0.0461	4.609	0.4658	46.578	5530546
4806	2.658	13	4.81624	20	431.11	0.0464	4.639	0.4643	46.428	5563967
4808	2.7	13	4.80074	19	433.89	0.0438	4.379	0.4779	47.788	5405280
4810	2.7	13.6	5.02214	20	396.48	0.0504	5.044	0.4452	44.524	6007985
4812	2.657	13.8	5.11181	26	382.69	0.0679	6.794	0.3837	38.365	6794167
4814	2.652	13	4.81845	26	430.71	0.0604	6.037	0.407	40.701	6161559
4816	2.658	13	4.81624	25	431.11	0.058	5.799	0.4153	41.526	6073032
4818	2.652	14	5.18745	23	371.61	0.0619	6.189	0.402	40.196	6689931
4820	2.655	14.2	5.26015	20	361.41	0.0553	5.534	0.4251	42.51	6521233
4822	2.656	13.8	5.11218	20	382.64	0.0523	5.227	0.4374	43.74	6202144
4824	2.7	12	4.43173	20	509.16	0.0393	3.928	0.5046	50.456	4734813
4826	2.65	14	5.18819	22	371.51	0.0592	5.922	0.4109	41.093	6590466
4828	2.62	14.2	5.27306	21	359.65	0.0584	5.839	0.4138	41.384	6665292
4830	2.654	13	4.81771	19	430.84	0.0441	4.41	0.4762	47.619	5441884
4832	2.659	13	4.81587	15	431.17	0.0348	3.479	0.5361	53.614	4817215
4834	2.559	14	5.22177	20	366.75	0.0545	5.453	0.4282	42.822	6438477
4836	2.65	13.8	5.11439	21	382.31	0.0549	5.493	0.4267	42.667	6323127
4838	2.655	14	5.18635	18	371.77	0.0484	4.842	0.4545	45.447	6101256
4840	2.5583	13	4.85303	15	424.59	0.0353	3.533	0.532	53.204	4897345

4842	2.558	16	5.96015	19	281.5	0.0675	6.749	0.3849	38.492	7905472
4844	2.65	14	5.18819	30	371.51	0.0808	8.075	0.3519	35.19	7250907
4846	2.658	10	3.70923	39	726.83	0.0537	5.366	0.4317	43.17	4545645
4848	2.657	12	4.4476	30	505.53	0.0593	5.934	0.4105	41.05	5653872
4850	2.657	13	4.81661	27	431.04	0.0626	6.264	0.3996	39.956	6236637
4852	2.7	12	4.43173	29	509.16	0.057	5.696	0.419	41.901	5552349
4854	2.7	11	4.06273	27	605.85	0.0446	4.457	0.4737	47.37	4610955
4856	2.7	12	4.43173	26	509.16	0.0511	5.106	0.4425	44.253	5327632
4858	2.7	11.8	4.35793	25	526.55	0.0475	4.748	0.4589	45.893	5084732
4860	2.657	12	4.4476	27	505.53	0.0534	5.341	0.4327	43.271	5440904
4862	2.658	12.4	4.59483	25	473.65	0.0528	5.278	0.4353	43.527	5595592
4864	2.659	13.6	5.03727	23	394.1	0.0584	5.836	0.4139	41.394	6366068
4866	2.658	12	4.44723	24	505.62	0.0475	4.747	0.459	45.899	5188365
4868	2.658	12	4.44723	24	505.62	0.0475	4.747	0.459	45.899	5188365
4870	2.658	12.4	4.59483	22	473.65	0.0464	4.645	0.464	46.4	5310927
4872	2.659	13.8	5.11107	19	382.8	0.0496	4.963	0.4489	44.886	6074491
4874	2.7	13.7	5.05904	18	390.72	0.0461	4.607	0.4659	46.59	5826728
4876	2.7	14	5.16974	19	374.16	0.0508	5.078	0.4438	44.377	6201013
4878	2.658	13.6	5.03764	20	394.05	0.0508	5.076	0.4439	44.387	6041406
4880	2.656	13	4.81697	20	430.97	0.0464	4.641	0.4642	46.421	5565558
4882	2.7	13	4.80074	20	433.89	0.0461	4.609	0.4658	46.578	5530546
4884	2.658	12	4.44723	20	505.62	0.0396	3.956	0.5028	50.28	4768234
4886	2.659	12	4.44686	20	505.7	0.0395	3.955	0.5028	50.284	4767438
4888	2.658	13.2	4.89004	19	418.19	0.0454	4.543	0.4691	46.915	5597847
4890	2.656	14	5.18598	18	371.83	0.0484	4.841	0.4545	45.45	6100460
4892	2.657	13	4.81661	19	431.04	0.0441	4.408	0.4763	47.63	5439496
4894	2.658	14	5.18524	18	371.93	0.0484	4.84	0.4546	45.456	6098868
4896	2.658	13	4.81624	18	431.11	0.0418	4.175	0.4894	48.939	5303136
4898	2.7	13	4.80074	18	433.89	0.0415	4.148	0.491	49.097	5269715
4900	2.657	13.4	4.96421	18	405.79	0.0444	4.436	0.4748	47.48	5622225
4902	2.659	13	4.81587	18	431.17	0.0417	4.175	0.4894	48.943	5302340
4904	2.71	14	5.16605	18	374.7	0.048	4.804	0.4563	45.625	6057490
4906	2.7	14	5.16974	17	374.16	0.0454	4.543	0.4691	46.914	5918091
4908	2.71	14	5.16605	17	374.7	0.0454	4.537	0.4695	46.948	5910133
4910	2.71	13.6	5.01845	19	397.06	0.0479	4.785	0.4571	45.714	5874762
4912	2.7	12.4	4.57934	20	476.86	0.0419	4.194	0.4883	48.83	5053106
4914	2.7	12.4	4.57934	19	476.86	0.0398	3.984	0.501	50.098	4927840
4916	2.7	13	4.80074	19	433.89	0.0438	4.379	0.4779	47.788	5405280
4918	2.657	12	4.4476	19	505.53	0.0376	3.758	0.5158	51.582	4643764
4920	2.656	14	5.18598	19	371.83	0.0511	5.11	0.4424	44.238	6236025
4922	2.7	13.8	5.09594	18	385.08	0.0467	4.674	0.4625	46.253	5906301
4924	2.71	14	5.16605	18	374.7	0.048	4.804	0.4563	45.625	6057490
4926	2.71	13.8	5.09225	18	385.64	0.0467	4.668	0.4629	46.286	5898344
4928	2.71	14	5.16605	18	374.7	0.048	4.804	0.4563	45.625	6057490
4930	2.71	14	5.16605	16	374.7	0.0427	4.27	0.4839	48.393	5749169
4932	2.72	14	5.16236	15	375.23	0.04	3.997	0.5002	50.016	5564408
4934	2.7	14.5	5.35424	16	348.82	0.0459	4.587	0.4669	46.692	6154993

4936	2.71	14	5.16605	17	374.7	0.0454	4.537	0.4695	46.948	5910133
4938	2.71	14	5.16605	17	374.7	0.0454	4.537	0.4695	46.948	5910133
4940	2.72	13	4.79336	18	435.23	0.0414	4.136	0.4917	49.173	5253800
4942	2.5	13	4.87454	18	420.86	0.0428	4.277	0.4835	48.354	5428862
4944	2.72	13.8	5.08856	16	386.2	0.0414	4.143	0.4913	49.13	5582065
4946	2.72	14	5.16236	15	375.23	0.04	3.997	0.5002	50.016	5564408
4948	2.72	14	5.16236	16	375.23	0.0426	4.264	0.4843	48.427	5741212
4950	2.7	13	4.80074	15	433.89	0.0346	3.457	0.5378	53.783	4784590
4952	2.657	13	4.81661	15	431.04	0.0348	3.48	0.5361	53.606	4818806
4954	2.659	14	5.18487	14	371.98	0.0376	3.764	0.5155	51.546	5417524
4956	2.7	14.2	5.24354	15	363.71	0.0412	4.124	0.4924	49.241	5739469
4958	2.7	14	5.16974	15	374.16	0.0401	4.009	0.4994	49.944	5580322
4960	2.7	14	5.16974	15	374.16	0.0401	4.009	0.4994	49.944	5580322
4962	2.7	14	5.16974	16	374.16	0.0428	4.276	0.4836	48.358	5757126
4964	2.7	14	5.16974	17	374.16	0.0454	4.543	0.4691	46.914	5918091
4966	2.7	14.3	5.28044	17	358.64	0.0474	4.74	0.4593	45.931	6156810
4968	2.7	12.4	4.57934	18	476.86	0.0377	3.775	0.5147	51.471	4792275
4970	2.73	13	4.78967	18	435.9	0.0413	4.129	0.4921	49.211	5245843
4972	2.75	12.7	4.67159	20	458.22	0.0436	4.365	0.4787	47.865	5252039
4974	2.72	12	4.42435	19	510.86	0.0372	3.719	0.5185	51.853	4593633
4976	2.7	12.8	4.72694	17	447.55	0.038	3.798	0.5131	51.309	4963211
4978	2.658	13	4.81624	15	431.11	0.0348	3.479	0.5361	53.61	4818010
4980	2.658	13.8	5.11144	17	382.75	0.0444	4.442	0.4745	47.45	5792365
4982	2.656	13.9	5.14908	18	377.17	0.0477	4.772	0.4578	45.776	6020887
4984	2.657	13	4.81661	18	431.04	0.0418	4.176	0.4894	48.935	5303932
4986	2.657	12.4	4.5952	18	473.58	0.038	3.801	0.5129	51.293	4826492
4988	2.7	14	5.16974	19	374.16	0.0508	5.078	0.4438	44.377	6201013
4990	2.7	13	4.80074	19	433.89	0.0438	4.379	0.4779	47.788	5405280
4992	2.7	12	4.43173	19	509.16	0.0373	3.732	0.5177	51.767	4609547
4994	2.656	14	5.18598	18	371.83	0.0484	4.841	0.4545	45.45	6100460
4996	2.7	14.2	5.24354	17	363.71	0.0467	4.674	0.4625	46.254	6077237
4998	2.658	13	4.81624	17	431.11	0.0394	3.943	0.5036	50.358	5155779
5000	2.7	14.2	5.24354	17	363.71	0.0467	4.674	0.4625	46.254	6077237
5002	2.72	13	4.79336	15	435.23	0.0345	3.446	0.5387	53.866	4768675
5004	2.657	14	5.18561	14	371.88	0.0376	3.765	0.5154	51.539	5419115
5006	2.658	14	5.18524	14	371.93	0.0376	3.764	0.5154	51.543	5418319
5008	2.655	14	5.18635	15	371.77	0.0403	4.035	0.4978	49.784	5616130
5010	2.651	14	5.18782	17	371.56	0.0458	4.575	0.4675	46.751	5957082
5012	2.62	15	5.56827	21	322.52	0.0651	6.511	0.3919	39.19	7301878
5014	2.552	15	5.59336	31	319.64	0.097	9.699	0.3211	32.11	8188644
5016	2.53	14.5	5.41697	50	340.79	0.1467	14.67	0.2611	26.107	8631696
5018	2.53	14	5.23247	60	365.25	0.1643	16.43	0.2467	24.673	8499543
5020	2.52	14.2	5.30996	60	354.66	0.1692	16.92	0.2431	24.313	8666647

Appendix C

Table 3.1

Well # 1

tp = 339.749 hrs T=137 F Gas gravity=0.6

Shut-in time(Min.)	Pressure (Psia)	Shut-in time(hrs)	(dt+tp)/dt	Z	Vis, cp	m(p) psi^2/cp	dm(p)
0	620	0		0.8764	0.013791	3.15E+07	
1	623	0.0166667	20385.94	0.8761	0.013797	3.18E+07	3.09E+05
2	629	0.0333333	10193.47	0.8754	0.013808	3.25E+07	9.31E+05
3	639	0.05	6795.98	0.8737	0.013839	3.35E+07	1.98E+06
4	645	0.0666667	5097.235	0.8727	0.013859	3.42E+07	2.62E+06
5	655	0.0833333	4077.988	0.8723	0.013867	3.52E+07	3.69E+06
6	659	0.1	3398.49	0.8709	0.013894	3.57E+07	4.13E+06
8	673	0.1333333	2549.1175	0.8702	0.01391	3.72E+07	5.67E+06
10	681	0.1666667	2039.494	0.8693	0.013928	3.81E+07	6.57E+06
15	690	0.25	1359.996	0.8674	0.013973	3.91E+07	7.59E+06
20	712	0.3333333	1020.247	0.8666	0.013991	4.17E+07	1.01E+07
25	721	0.4166667	816.3976	0.8661	0.014005	4.27E+07	1.12E+07
30	728	0.5	680.498	0.865	0.014032	4.36E+07	1.20E+07
40	741	0.6666667	510.6235	0.8645	0.014046	4.51E+07	1.36E+07
50	748	0.8333333	408.6988	0.864	0.014061	4.60E+07	1.45E+07
60	755	1	340.749	0.8631	0.014088	4.69E+07	1.53E+07
75	768	1.25	272.7992	0.8625	0.014106	4.85E+07	1.70E+07
90	777	1.5	227.49933	0.8615	0.01414	4.96E+07	1.81E+07
120	793	2	170.8745	0.8607	0.014169	5.17E+07	2.02E+07
150	807	2.5	136.8996	0.8602	0.014188	5.35E+07	2.20E+07
180	816	3	114.24967	0.8555	0.01422	5.47E+07	2.32E+07
240	827	4	85.93725	0.8555	0.014234	5.62E+07	2.47E+07
300	834	5	68.9498	0.8555	0.014247	5.72E+07	2.57E+07
360	840	6	57.624833	0.8555	0.014267	5.80E+07	2.65E+07
480	850	8	43.468625	0.8555	0.014284	5.94E+07	2.79E+07
600	858	10	34.9749	0.8555	0.014302	6.05E+07	2.90E+07
720	867	12	29.312417	0.8557	0.014323	6.18E+07	3.03E+07
960	877	16	22.234313	0.8557	0.014335	6.32E+07	3.17E+07
1200	883	20	17.98745	0.8559	0.014348	6.41E+07	3.25E+07
1440	889	24	15.156208	0.8561	0.014374	6.49E+07	3.34E+07
1800	902	30	12.324967	0.8566	0.014405	6.68E+07	3.53E+07
2160	917	36	10.437472	0.8571	0.014436	6.91E+07	3.75E+07
2520	932	42	9.0892619	0.8577	0.014467	7.13E+07	3.98E+07
2880	947	48	8.0781042	0.8584	0.014493	7.36E+07	4.20E+07
3240	960	54	7.2916481	0.8589	0.01452	7.56E+07	4.40E+07
3600	973	60	6.6624833	0.8595	0.014543	7.76E+07	4.61E+07
3960	984	66	6.1477121	0.8604	0.014562	7.93E+07	4.78E+07
4320	994	72	5.7187361	0.861	0.01458	8.09E+07	4.94E+07
4680	1003	78	5.3557564	0.8617	0.014598	8.23E+07	5.08E+07

5040	1012	84	5.044631	0.8623	0.014614	8.38E+07	5.22E+07
5400	1020	90	4.7749889	0.863	0.014632	8.51E+07	5.35E+07
5760	1029	96	4.5390521	0.8636	0.014646	8.65E+07	5.50E+07
6120	1036	102	4.3308725	0.8643	0.014662	8.77E+07	5.61E+07
6480	1044	108	4.1458241	0.8649	0.014674	8.90E+07	5.75E+07
6840	1050	114	3.9802544	0.8656	0.01469	9.00E+07	5.84E+07
7200	1058	120	3.8312417	0.8662	0.014701	9.13E+07	5.98E+07
7560	1064	126	3.6964206	0.8668	0.014713	9.23E+07	6.08E+07
7920	1070	132	3.5738561	0.8675	0.014727	9.33E+07	6.18E+07
8280	1077	138	3.4619493	0.8681	0.014738	9.45E+07	6.30E+07
8640	1083	144	3.3593681	0.8687	0.014748	9.55E+07	6.40E+07
9000	1088	150	3.2649933	0.8692	0.014758	9.64E+07	6.48E+07
9360	1093	156	3.1778782	0.8697	0.014766	9.72E+07	6.57E+07
9640	1097	160.66667	3.1146203	0.87	0.015	9.79E+07	6.63E+07

Table 3.2

Well # 2 T= 114 F G=0.6

Shut-in time(Min.)	Pressure (Psia)	Shut-in time(hrs)	(dt+tp)/dt	Z	Ug cp	M(P) psi^2/cp	**dM(p)**
0	620	0		0.8638	0.01377	3.20E+07	
1	623	0.016667	20385.94	0.8633	0.01377	3.23E+07	3.06E+05
2	629	0.033333	10193.47	0.8625	0.01379	3.29E+07	9.36E+05
3	639	0.05	6795.98	0.8612	0.01381	3.40E+07	2.01E+06
4	645	0.066667	5097.235	0.8604	0.01383	3.46E+07	2.62E+06
5	655	0.083333	4077.988	0.8458	0.01387	3.57E+07	3.72E+06
6	659	0.1	3398.49	0.8453	0.01388	3.61E+07	4.12E+06
8	673	0.133333	2549.118	0.8436	0.01391	3.77E+07	5.72E+06
10	681	0.166667	2039.494	0.8427	0.01393	3.87E+07	6.72E+06
15	690	0.25	1359.996	0.8417	0.01395	3.97E+07	7.72E+06
20	712	0.333333	1020.247	0.8394	0.014	4.23E+07	1.03E+07
25	721	0.416667	816.3976	0.8386	0.01402	4.34E+07	1.14E+07
30	728	0.5	680.498	0.8379	0.01404	4.43E+07	1.23E+07
40	741	0.666667	510.6235	0.8368	0.01407	4.59E+07	1.39E+07
50	748	0.833333	408.6988	0.8362	0.01409	4.68E+07	1.48E+07
60	755	1	340.749	0.8357	0.0141	4.77E+07	1.57E+07
75	768	1.25	272.7992	0.8347	0.01413	4.94E+07	1.74E+07
90	777	1.5	227.4993	0.8341	0.01416	5.06E+07	1.86E+07
120	793	2	170.8745	0.8331	0.01419	5.27E+07	2.07E+07
150	807	2.5	136.8996	0.8323	0.01423	5.46E+07	2.26E+07
180	816	3	114.2497	0.8319	0.01425	5.58E+07	2.38E+07
240	827	4	85.93725	0.8314	0.01428	5.73E+07	2.53E+07
300	834	5	68.9498	0.8311	0.01429	5.83E+07	2.63E+07
360	840	6	57.62483	0.8309	0.01431	5.92E+07	2.72E+07
480	850	8	43.46863	0.8306	0.01433	6.06E+07	2.86E+07
600	858	10	34.9749	0.8303	0.01435	6.17E+07	2.97E+07

720	867	12	29.31242	0.8301	0.01438	6.30E+07	3.10E+07
960	877	16	22.23431	0.8299	0.0144	6.45E+07	3.25E+07
1200	883	20	17.98745	0.8298	0.01441	6.54E+07	3.34E+07
1440	889	24	15.15621	0.8279	0.01443	6.63E+07	3.43E+07
1800	902	30	12.32497	0.8296	0.01446	6.82E+07	3.62E+07
2160	917	36	10.43747	0.8295	0.0145	7.05E+07	3.85E+07
2520	932	42	9.089262	0.8296	0.01453	7.28E+07	4.08E+07
2880	947	48	8.078104	0.8297	0.01457	7.51E+07	4.31E+07
3240	960	54	7.291648	0.8299	0.0146	7.72E+07	4.52E+07
3600	973	60	6.662483	0.8301	0.01464	7.93E+07	4.73E+07
3960	984	66	6.147712	0.8304	0.01466	8.10E+07	4.90E+07
4320	994	72	5.718736	0.8308	0.01469	8.26E+07	5.06E+07
4680	1003	78	5.355756	0.8311	0.01471	8.41E+07	5.21E+07
5040	1012	84	5.044631	0.8315	0.01473	8.56E+07	5.36E+07
5400	1020	90	4.774989	0.8318	0.01475	8.69E+07	5.49E+07
5760	1029	96	4.539052	0.8323	0.01477	8.84E+07	5.64E+07
6120	1036	102	4.330873	0.8326	0.01479	8.96E+07	5.76E+07
6480	1044	108	4.145824	0.8329	0.01481	9.10E+07	5.90E+07
6840	1050	114	3.980254	0.8332	0.01482	9.20E+07	6.00E+07
7200	1058	120	3.831242	0.8336	0.01484	9.33E+07	6.13E+07
7560	1064	126	3.696421	0.834	0.01486	9.44E+07	6.24E+07
7920	1070	132	3.573856	0.8344	0.01487	9.54E+07	6.34E+07
8280	1077	138	3.461949	0.8348	0.01489	9.66E+07	6.46E+07
8640	1083	144	3.359368	0.8352	0.0149	9.77E+07	6.57E+07
9000	1088	150	3.264993	0.8355	0.01491	9.85E+07	6.65E+07
9360	1093	156	3.177878	0.8358	0.01492	9.94E+07	6.74E+07
9640	1097	160.6667	3.11462	0.8361	0.01493	1.00E+08	6.82E+07

Appendix C II

```
THIS PROGRAM CALCULATES PSEUDO PRESSURE AND Ip=(1/Ug*Ct) VALUE
*    WITH INCREMENTS OF 1 (IN PRESSURE).
      real n
      OPEN(UNIT=9,STATUS='NEW',FILE='sedo3.txt')
      WRITE(6,30)
   30 FORMAT(5X,2(/),'ENTER RESERVOIR TEMPERATURE  VALUE :'$)
      READ(*,*)T
      WRITE(6,31)
   31 FORMAT(5X,2(/),'ENTER GAS GRAVITY VALUE :'$)
      READ(*,*)GG
      WRITE(6,32)
   32 FORMAT(3X,'UNTIL WHAT PRESSURE IS THE INTEGRAL?'$)
      READ(*,*)N

*    -------PSEUDO-CRITICAL AND PSEUDO- REDUCED CONDITIONS------------

      A1=0.3265
      A2=-1.0700
      A3=-0.5339
      A4=0.01569
      A5=-0.05165
      A6=0.5475
      A7=-0.7361
      A8=0.1844
      A9=0.1056
      A10=0.6134
      A11=0.7210

      PPC=709.604-(58.718*GG)
      TPC=170.491+(307.344*GG)

      SUMA=0
      DO P =1,N,1


      PPR=P/PPC
      TPR=(T+460)/TPC
```

```
*     ----------------Z-FACTOR DETERMINATION---------------------------


      ZFS=1
    1 DPR=0.27*((PPR/ZFS*TPR))
      ZFC=1+ (A1+(A2/TPR)+(A3/TPR**3)+(A4/TPR**4)+(A5/TPR**5))*DPR
     *+(A6+(A7/TPR)+(A8/TPR**2))*DPR**2-A9*((A7/TPR)+(A8/TPR**2))*
     *DPR**5+A10*(1+A11*DPR**2)*((DPR**2/TPR**3))*EXP(-A11*DPR**2)
      IF(ZFC.GE.0.86.AND.ZFC.LE.1.11)THEN
      GO TO 3
      ENDIF
      IF(ABS(ZFS-ZFC).LT.0.003)THEN
      CONTINUE
      ELSE
      ZFS=ZFC
      GOTO 1
    3 ENDIF

*      -------------GAS COMPRESSIBILITY DETERMINATION------------------


      DZDD=A1+(A2/TPR)+(A3/TPR**3)+(A4/TPR**4)+(A5/TPR**5)+2*DPR*(A6+
     *(A7/TPR)+(A8/TPR**2))-5*DPR**4*A9*((A7/TPR)+(A8/TPR**2)+(2*A10
     **DPR/TPR**3)*(1+A11*(DPR**2)-(A11**2)*DPR**4))*EXP(-A11*DPR**2)
      CPR=(1/PPR)-(0.27/(ZFC**2)*TPR)*(DZDD/(1+(DPR/ZFC)*DZDD))
      COMPG=CPR/PPC




*     --------------GAS VISCOSITY AT HIGHER PRESSURES------------------

      DG=(2.703*GG*P)/(ZFC*(T+460))
      DG1=DG*0.01603
      AU=(9.379+0.01607*(GG*29)*(T+460)**1.5/(209.2+19.26*(GG*29)+(T+4
     *60)))
      BU=3.448+(986.4/(T+460))+0.01009*(GG*29)
      CU=2.447-0.2224*BU
      UGHP=AU*EXP(BU*DG1**CU)*1E-3


*  ----- PROCEDURE TO CALCULATE PSEUDO PRESSURE  AND (1/Ug*Ct)
VALUE----
```

```
      P1=2*P/(UGHP*ZFC)
      T1=1/(UGHP*COMPG)
      SUMA=SUMA+P1
      SUMA2=SUMA2+T1
*       if(p.ge.870)then
      WRITE(6,71)P,ZFC,UGHP,SUMA
      WRITE(9,71)P,ZFC,UGHP,SUMA
*       endif
      if(p.eq.n)then
      write(6,72)ughp,compg
      endif
      ENDDO
   71 FORMAT(2(/),'P='F8.3,2X,'Z='F8.4,2X,'Ug='F8.6,2X,'M(P)='E14.7)
*      *,2X,'(1/C*U)='E14.7)
   72 format(2x,2(/),'Ui='f9.4,2x,'Ci='f9.5)
   74 FORMAT(2X,F7.2,5X,E14.7)
      STOP
      END
```

Appendix D

Table 4.1

Viscosity Graph for Well #1
with Temp. = 137.67 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
500	0.01093	546	0.01113	592	0.01134
501	0.01093	547	0.01114	593	0.01134
502	0.01094	548	0.01114	594	0.01135
503	0.01094	549	0.01114	595	0.01135
504	0.01095	550	0.01115	596	0.01136
505	0.01095	551	0.01115	597	0.01136
506	0.01095	552	0.01116	598	0.01137
507	0.01096	553	0.01116	599	0.01137
508	0.01096	554	0.01116	600	0.01138
509	0.01097	555	0.01117	601	0.01138
510	0.01097	556	0.01118	602	0.01139
511	0.01098	557	0.01118	603	0.01139
512	0.01098	558	0.01118	604	0.01139
513	0.01099	559	0.01119	605	0.0114
514	0.01099	560	0.01119	606	0.01141
515	0.01099	561	0.0112	607	0.01141
516	0.011	562	0.0112	608	0.01141
517	0.011	563	0.01121	609	0.01142
518	0.01101	564	0.01121	610	0.01142
519	0.01101	565	0.01121	611	0.01143
520	0.01102	566	0.01122	612	0.01143
521	0.01102	567	0.01123	613	0.01144
522	0.01102	568	0.01123	614	0.01144
523	0.01103	569	0.01123	615	0.01145
524	0.01103	570	0.01124	616	0.01145
525	0.01104	571	0.01124	617	0.01146
526	0.01104	572	0.01125	618	0.01146
527	0.01104	573	0.01125	619	0.01147
528	0.01105	574	0.01126	620	0.01147
529	0.01106	575	0.01126	621	0.01148
530	0.01106	576	0.01127	622	0.01148
531	0.01106	577	0.01127	623	0.01148
532	0.01107	578	0.01128	624	0.01149
533	0.01107	579	0.01128	625	0.0115
534	0.01108	580	0.01128	626	0.0115
535	0.01108	581	0.01129	627	0.01151

536	0.01108	582	0.01129	628	0.01151
537	0.01109	583	0.0113	629	0.01151
538	0.0111	584	0.0113	630	0.01152
539	0.0111	585	0.01131	631	0.01152
540	0.0111	586	0.01131	632	0.01153
541	0.01111	587	0.01132	633	0.01153
542	0.01111	588	0.01132	634	0.01154
543	0.01112	589	0.01133	635	0.01155
544	0.01112	590	0.01133	636	0.01155
545	0.01112	591	0.01133	637	0.01155

Viscosity Graph for Well #1
with Temp. = 137.67 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
638	0.01156	682	0.01178	726	0.012
639	0.01156	683	0.01178	727	0.01201
640	0.01157	684	0.01179	728	0.01201
641	0.01157	685	0.01179	729	0.01202
642	0.01158	686	0.0118	730	0.01203
643	0.01158	687	0.0118	731	0.01203
644	0.01159	688	0.01181	732	0.01204
645	0.01159	689	0.01181	733	0.01204
646	0.0116	690	0.01182	734	0.01205
647	0.0116	691	0.01182	735	0.01205
648	0.01161	692	0.01183	736	0.01206
649	0.01161	693	0.01183	737	0.01206
650	0.01162	694	0.01184	738	0.01207
651	0.01162	695	0.01184	739	0.01207
652	0.01163	696	0.01185	740	0.01208
653	0.01163	697	0.01185	741	0.01209
654	0.01164	698	0.01186	742	0.01209
655	0.01164	699	0.01186	743	0.0121
656	0.01165	700	0.01187	744	0.0121
657	0.01165	701	0.01187	745	0.01211
658	0.01166	702	0.01188	746	0.01211
659	0.01166	703	0.01188	747	0.01212
660	0.01167	704	0.01189	748	0.01212
661	0.01167	705	0.01189	749	0.01213
662	0.01168	706	0.0119	750	0.01213
663	0.01168	707	0.0119	751	0.01214
664	0.01169	708	0.01191	752	0.01214
665	0.01169	709	0.01192	753	0.01215
666	0.0117	710	0.01192	754	0.01215
667	0.0117	711	0.01193	755	0.01216
668	0.01171	712	0.01193	756	0.01216

669	0.01171	713	0.01194	757	0.01217
670	0.01172	714	0.01194	758	0.01217
671	0.01172	715	0.01195	759	0.01218
672	0.01173	716	0.01195	760	0.01218
673	0.01173	717	0.01196	761	0.01219
674	0.01174	718	0.01196	762	0.01219
675	0.01174	719	0.01197	763	0.0122
676	0.01174	720	0.01197	764	0.01221
677	0.01175	721	0.01198	765	0.01221
678	0.01176	722	0.01198	766	0.01222
679	0.01176	723	0.01199	767	0.01222
680	0.01177	724	0.01199	768	0.01223
681	0.01177	725	0.012	737	0.01206

Viscosity Graph for Well #1
with Temp. = 137.67 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
737	0.01206	781	0.0123	825	0.01255
738	0.01207	782	0.01231	826	0.01255
739	0.01207	783	0.01231	827	0.01256
740	0.01208	784	0.01232	828	0.01256
741	0.01209	785	0.01232	829	0.01257
742	0.01209	786	0.01233	830	0.01258
743	0.0121	787	0.01234	831	0.01258
744	0.0121	788	0.01234	832	0.01259
745	0.01211	789	0.01235	833	0.0126
746	0.01211	790	0.01235	834	0.0126
747	0.01212	791	0.01236	835	0.01261
748	0.01212	792	0.01236	836	0.01261
749	0.01213	793	0.01237	837	0.01262
750	0.01213	794	0.01237	838	0.01262
751	0.01214	795	0.01238	839	0.01263
752	0.01214	796	0.01238	840	0.01263
753	0.01215	797	0.01239	841	0.01264
754	0.01215	798	0.0124	842	0.01265
755	0.01216	799	0.0124	843	0.01265
756	0.01216	800	0.01241	844	0.01266
757	0.01217	801	0.01241	845	0.01267
758	0.01217	802	0.01242	846	0.01267
759	0.01218	803	0.01242	847	0.01268
760	0.01218	804	0.01243	848	0.01268
761	0.01219	805	0.01243	849	0.01269
762	0.01219	806	0.01244	850	0.01269
763	0.0122	807	0.01244	851	0.0127
764	0.01221	808	0.01245	852	0.0127

765	0.01221	809	0.01246	853	0.01271
766	0.01222	810	0.01246	854	0.01272
767	0.01222	811	0.01247	855	0.01272
768	0.01223	812	0.01248	856	0.01273
769	0.01223	813	0.01248	857	0.01274
770	0.01224	814	0.01249	858	0.01274
771	0.01224	815	0.01249	859	0.01275
772	0.01225	816	0.0125	860	0.01275
773	0.01225	817	0.0125	861	0.01276
774	0.01226	818	0.01251	862	0.01276
775	0.01227	819	0.01251	863	0.01277
776	0.01227	820	0.01252	864	0.01278
777	0.01228	821	0.01253	865	0.01278
778	0.01228	822	0.01253	866	0.01279
779	0.01229	823	0.01254	867	0.01279
780	0.0123	824	0.01254	868	0.0128

Viscosity Graph for Well #1
with Temp. = 137.67 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
869	0.01281	914	0.01308	959	0.01336
870	0.01281	915	0.01308	960	0.01337
871	0.01282	916	0.01309	961	0.01338
872	0.01282	917	0.0131	962	0.01338
873	0.01283	918	0.01311	963	0.01339
874	0.01284	919	0.01311	964	0.01339
875	0.01284	920	0.01312	965	0.0134
876	0.01285	921	0.01312	966	0.01341
877	0.01285	922	0.01313	967	0.01341
878	0.01286	923	0.01314	968	0.01342
879	0.01286	924	0.01314	969	0.01342
880	0.01287	925	0.01315	970	0.01344
881	0.01288	926	0.01315	971	0.01344
882	0.01289	927	0.01316	972	0.01345
883	0.01289	928	0.01316	973	0.01345
884	0.0129	929	0.01317	974	0.01346
885	0.0129	930	0.01318	975	0.01347
886	0.01291	931	0.01319	976	0.01347
887	0.01291	932	0.01319	977	0.01348
888	0.01292	933	0.0132	978	0.01348
889	0.01292	934	0.01321	979	0.01349
890	0.01293	935	0.01321	980	0.0135
891	0.01294	936	0.01322	981	0.0135
892	0.01295	937	0.01322	982	0.01351
893	0.01295	938	0.01323	983	0.01352
894	0.01296	939	0.01323	984	0.01353

895	0.01296	940	0.01324	985	0.01353
896	0.01297	941	0.01325	986	0.01354
897	0.01298	942	0.01325	987	0.01355
898	0.01298	943	0.01326	988	0.01355
899	0.01299	944	0.01327	989	0.01356
900	0.01299	945	0.01328	990	0.01356
901	0.013	946	0.01328	991	0.01357
902	0.013	947	0.01329	992	0.01358
903	0.01301	948	0.01329	993	0.01358
904	0.01302	949	0.0133	994	0.01359
905	0.01303	950	0.01331	995	0.01359
906	0.01303	951	0.01331	996	0.0136
907	0.01304	952	0.01332	997	0.01361
908	0.01304	953	0.01332	998	0.01362
909	0.01305	954	0.01333	999	0.01363
910	0.01305	955	0.01333	1000	0.01363
911	0.01306	956	0.01335	1001	0.01364
912	0.01307	957	0.01335	1002	0.01364
913	0.01307	958	0.01336	1003	0.01365

Viscosity Graph for Well #1
with Temp. = 137.67 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
1004	0.01366	1048	0.01395	1092	0.01426
1005	0.01366	1049	0.01396	1093	0.01427
1006	0.01367	1050	0.01397	1094	0.01427
1007	0.01367	1051	0.01397	1095	0.01428
1008	0.01368	1052	0.01398	1096	0.01429
1009	0.01369	1053	0.01399	1097	0.0143
1010	0.0137	1054	0.014	1098	0.01431
1011	0.01371	1055	0.01401	1099	0.01432
1012	0.01371	1056	0.01401	1100	0.01432
1013	0.01372	1057	0.01402		
1014	0.01373	1058	0.01402		
1015	0.01373	1059	0.01403		
1016	0.01374	1060	0.01404		
1017	0.01374	1061	0.01404		
1018	0.01375	1062	0.01405		
1019	0.01376	1063	0.01406		
1020	0.01376	1064	0.01406		
1021	0.01377	1065	0.01407		
1022	0.01377	1066	0.01408		
1023	0.01378	1067	0.01408		
1024	0.01379	1068	0.0141		
1025	0.0138	1069	0.0141		

1026	0.01381	1070	0.01411		
1027	0.01381	1071	0.01412		
1028	0.01382	1072	0.01412		
1029	0.01383	1073	0.01413		
1030	0.01383	1074	0.01414		
1031	0.01384	1075	0.01414		
1032	0.01384	1076	0.01415		
1033	0.01385	1077	0.01416		
1034	0.01386	1078	0.01416		
1035	0.01386	1079	0.01417		
1036	0.01387	1080	0.01417		
1037	0.01388	1081	0.01418		
1038	0.01388	1082	0.0142		
1039	0.0139	1083	0.0142		
1040	0.0139	1084	0.01421		
1041	0.01391	1085	0.01422		
1042	0.01392	1086	0.01422		
1043	0.01392	1087	0.01423		
1044	0.01393	1088	0.01424		
1045	0.01393	1089	0.01424		
1046	0.01394	1090	0.01425		
1047	0.01395	1091	0.01426		

Table 4.2

Viscosity Vs Pressure For Well # 2 with Temp. = 114.37 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
500	0.01094	546	0.01114	592	0.01135
501	0.01094	547	0.01115	593	0.01136
502	0.01095	548	0.01115	594	0.01136
503	0.01095	549	0.01116	595	0.01137
504	0.01096	550	0.01116	596	0.01137
505	0.01096	551	0.01116	597	0.01138
506	0.01097	552	0.01117	598	0.01138
507	0.01097	553	0.01117	599	0.01139
508	0.01097	554	0.01118	600	0.01139
509	0.01098	555	0.01118	601	0.0114
510	0.01098	556	0.01119	602	0.0114
511	0.01099	557	0.01119	603	0.01141
512	0.01099	558	0.0112	604	0.01141
513	0.01099	559	0.0112	605	0.01142
514	0.011	560	0.01121	606	0.01142
515	0.011	561	0.01121	607	0.01143

516	0.01101	562	0.01121	608	0.01143
517	0.01101	563	0.01122	609	0.01143
518	0.01102	564	0.01122	610	0.01144
519	0.01102	565	0.01123	611	0.01145
520	0.01103	566	0.01123	612	0.01145
521	0.01103	567	0.01124	613	0.01145
522	0.01103	568	0.01124	614	0.01146
523	0.01104	569	0.01125	615	0.01146
524	0.01104	570	0.01125	616	0.01147
525	0.01105	571	0.01126	617	0.01147
526	0.01105	572	0.01126	618	0.01148
527	0.01106	573	0.01126	619	0.01148
528	0.01106	574	0.01127	620	0.01149
529	0.01106	575	0.01128	621	0.01149
530	0.01107	576	0.01128	622	0.0115
531	0.01108	577	0.01128	623	0.0115
532	0.01108	578	0.01129	624	0.01151
533	0.01108	579	0.01129	625	0.01151
534	0.01109	580	0.0113	626	0.01152
535	0.01109	581	0.0113	627	0.01152
536	0.0111	582	0.01131	628	0.01153
537	0.0111	583	0.01131	629	0.01153
538	0.0111	584	0.01132	630	0.01154
539	0.01111	585	0.01132	631	0.01154
540	0.01112	586	0.01133	632	0.01155
541	0.01112	587	0.01133	633	0.01155
542	0.01112	588	0.01134	634	0.01156
543	0.01113	589	0.01134	635	0.01156
544	0.01113	590	0.01134	636	0.01157
545	0.01114	591	0.01135	637	0.01157

Viscosity Vs Pressure For Well # 2 with Temp. = 114.37 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
638	0.01158	683	0.0118	728	0.01204
639	0.01158	684	0.01181	729	0.01205
640	0.01159	685	0.01182	730	0.01205
641	0.01159	686	0.01182	731	0.01206
642	0.0116	687	0.01183	732	0.01206
643	0.0116	688	0.01183	733	0.01207
644	0.01161	689	0.01183	734	0.01207
645	0.01161	690	0.01184	735	0.01208
646	0.01161	691	0.01184	736	0.01208
647	0.01162	692	0.01185	737	0.01209
648	0.01163	693	0.01185	738	0.01209
649	0.01163	694	0.01186	739	0.0121

650	0.01164	695	0.01187	740	0.0121
651	0.01164	696	0.01187	741	0.01211
652	0.01165	697	0.01188	742	0.01211
653	0.01165	698	0.01188	743	0.01212
654	0.01166	699	0.01189	744	0.01213
655	0.01166	700	0.01189	745	0.01213
656	0.01166	701	0.0119	746	0.01214
657	0.01167	702	0.0119	747	0.01214
658	0.01168	703	0.01191	748	0.01215
659	0.01168	704	0.01191	749	0.01215
660	0.01169	705	0.01192	750	0.01216
661	0.01169	706	0.01192	751	0.01216
662	0.0117	707	0.01193	752	0.01217
663	0.0117	708	0.01193	753	0.01218
664	0.01171	709	0.01194	754	0.01218
665	0.01171	710	0.01194	755	0.01219
666	0.01172	711	0.01195	756	0.01219
667	0.01172	712	0.01195	757	0.0122
668	0.01173	713	0.01196	758	0.0122
669	0.01173	714	0.01197	759	0.01221
670	0.01174	715	0.01197	760	0.01221
671	0.01174	716	0.01198	761	0.01222
672	0.01175	717	0.01198	762	0.01223
673	0.01175	718	0.01199	763	0.01223
674	0.01176	719	0.01199	764	0.01224
675	0.01176	720	0.012	765	0.01224
676	0.01177	721	0.012	766	0.01225
677	0.01177	722	0.01201	767	0.01225
678	0.01178	723	0.01202	768	0.01226
679	0.01178	724	0.01202	769	0.01226
680	0.01179	725	0.01203	770	0.01227
681	0.01179	726	0.01203	771	0.01228
682	0.0118	727	0.01204	772	0.01228

Viscosity Vs Pressure For Well # 2 with Temp. = 114.37 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
773	0.01229	818	0.01255	863	0.01281
774	0.0123	819	0.01255	864	0.01282
775	0.0123	820	0.01256	865	0.01283
776	0.01231	821	0.01256	866	0.01283
777	0.01231	822	0.01257	867	0.01284
778	0.01232	823	0.01258	868	0.01285
779	0.01232	824	0.01258	869	0.01285
780	0.01233	825	0.01259	870	0.01286
781	0.01233	826	0.01259	871	0.01286

782	0.01234	827	0.0126	872	0.01287
783	0.01235	828	0.0126	873	0.01287
784	0.01235	829	0.01261	874	0.01288
785	0.01236	830	0.01262	875	0.01288
786	0.01236	831	0.01262	876	0.0129
787	0.01237	832	0.01263	877	0.0129
788	0.01237	833	0.01263	878	0.01291
789	0.01238	834	0.01264	879	0.01291
790	0.01238	835	0.01265	880	0.01292
791	0.01239	836	0.01265	881	0.01292
792	0.01239	837	0.01266	882	0.01293
793	0.0124	838	0.01266	883	0.01294
794	0.01241	839	0.01267	884	0.01294
795	0.01241	840	0.01267	885	0.01295
796	0.01242	841	0.01268	886	0.01295
797	0.01242	842	0.01269	887	0.01296
798	0.01243	843	0.01269	888	0.01297
799	0.01243	844	0.0127	889	0.01298
800	0.01244	845	0.01271	890	0.01298
801	0.01245	846	0.01271	891	0.01299
802	0.01245	847	0.01272	892	0.01299
803	0.01246	848	0.01272	893	0.013
804	0.01247	849	0.01273	894	0.013
805	0.01247	850	0.01273	895	0.01301
806	0.01248	851	0.01274	896	0.01302
807	0.01248	852	0.01275	897	0.01302
808	0.01249	853	0.01275	898	0.01303
809	0.01249	854	0.01276	899	0.01304
810	0.0125	855	0.01277	900	0.01304
811	0.0125	856	0.01277	901	0.01305
812	0.01251	857	0.01278	902	0.01306
813	0.01252	858	0.01278	903	0.01306
814	0.01252	859	0.01279	904	0.01307
815	0.01253	860	0.0128	905	0.01307
816	0.01253	861	0.0128	906	0.01308
817	0.01254	862	0.01281	907	0.01308

Viscosity Vs Pressure For Well # 2 with Temp. = 114.37 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
908	0.01309	953	0.01339	998	0.01368
909	0.0131	954	0.01339	999	0.01369
910	0.01311	955	0.0134	1000	0.0137
911	0.01311	956	0.0134	1001	0.01371
912	0.01312	957	0.01341	1002	0.01371
913	0.01313	958	0.01342	1003	0.01372

914	0.01313	959	0.01342	1004	0.01373
915	0.01314	960	0.01343	1005	0.01373
916	0.01314	961	0.01343	1006	0.01374
917	0.01315	962	0.01344	1007	0.01375
918	0.01315	963	0.01345	1008	0.01375
919	0.01316	964	0.01345	1009	0.01376
920	0.01317	965	0.01347	1010	0.01376
921	0.01318	966	0.01347	1011	0.01378
922	0.01318	967	0.01348	1012	0.01378
923	0.01319	968	0.01348	1013	0.01379
924	0.0132	969	0.01349	1014	0.0138
925	0.0132	970	0.0135	1015	0.0138
926	0.01321	971	0.0135	1016	0.01381
927	0.01321	972	0.01351	1017	0.01382
928	0.01322	973	0.01351	1018	0.01382
929	0.01322	974	0.01352	1019	0.01383
930	0.01323	975	0.01353	1020	0.01383
931	0.01324	976	0.01354	1021	0.01384
932	0.01325	977	0.01355	1022	0.01385
933	0.01325	978	0.01355	1023	0.01386
934	0.01326	979	0.01356	1024	0.01387
935	0.01327	980	0.01356	1025	0.01387
936	0.01327	981	0.01357	1026	0.01388
937	0.01328	982	0.01358	1027	0.01389
938	0.01328	983	0.01358	1028	0.01389
939	0.01329	984	0.01359	1029	0.0139
940	0.0133	985	0.01359	1030	0.01391
941	0.0133	986	0.0136	1031	0.01391
942	0.01331	987	0.01361	1032	0.01392
943	0.01332	988	0.01362	1033	0.01393
944	0.01333	989	0.01363	1034	0.01393
945	0.01333	990	0.01363	1035	0.01395
946	0.01334	991	0.01364	1036	0.01395
947	0.01334	992	0.01364	1037	0.01396
948	0.01335	993	0.01365	1038	0.01396
949	0.01336	994	0.01366	1039	0.01397
950	0.01336	995	0.01366	1040	0.01398
951	0.01337	996	0.01367	1041	0.01398
952	0.01337	997	0.01368	1042	0.01399

Viscosity Vs Pressure For Well # 2 with Temp. = 114.37 F

Pressure,Psia	Viscosity, cp	Pressure,Psia	Viscosity, cp
1043	0.014	1088	0.01433
1044	0.014	1089	0.01433
1045	0.01401	1090	0.01434

1046	0.01402	1091	0.01435
1047	0.01402	1092	0.01435
1048	0.01404	1093	0.01436
1049	0.01404	1094	0.01437
1050	0.01405	1095	0.01437
1051	0.01406	1096	0.01438
1052	0.01406	1097	0.01439
1053	0.01407	1098	0.0144
1054	0.01408	1099	0.01441
1055	0.01408	1100	0.01441
1056	0.01409		
1057	0.0141		
1058	0.0141		
1059	0.01411		
1060	0.01412		
1061	0.01413		
1062	0.01414		
1063	0.01414		
1064	0.01415		
1065	0.01416		
1066	0.01416		
1067	0.01417		
1068	0.01418		
1069	0.01418		
1070	0.01419		
1071	0.0142		
1072	0.01421		
1073	0.01422		
1074	0.01422		
1075	0.01423		
1076	0.01424		
1077	0.01424		
1078	0.01425		
1079	0.01426		
1080	0.01426		
1081	0.01427		
1082	0.01428		
1083	0.01428		
1084	0.01429		
1085	0.01431		
1086	0.01431		
1087	0.01432		

Table 4.3

PseudoPressure and Pressure Profile For WELL #1
Optimum Flow Rate for this well (MMscfD) =6837

Time,(Month)	Mpwf, (psia^2/cp)	Pressure,Psia	Time,(Month)	Mpwf, (psia^2/cp)	Pressure,Psia
0	9.78E+09	1097	45	2.70E+09	575
1	6.70E+09	904	46	2.67E+09	572
2	5.97E+09	853	47	2.65E+09	569
3	5.55E+09	822	48	2.63E+09	567
4	5.24E+09	799	49	2.61E+09	565
5	5.01E+09	781	50	2.59E+09	563
6	4.82E+09	766	51	2.56E+09	560
7	4.65E+09	752	52	2.54E+09	558
8	4.51E+09	741	53	2.52E+09	556
9	4.39E+09	731	54	2.50E+09	553
10	4.28E+09	722	55	2.49E+09	552
11	4.18E+09	714	56	2.47E+09	550
12	4.09E+09	706	57	2.45E+09	548
13	4.00E+09	698	58	2.43E+09	546
14	3.93E+09	692	59	2.41E+09	543
15	3.85E+09	685	60	2.39E+09	541
16	3.78E+09	679	61	2.38E+09	540
17	3.72E+09	673	62	2.36E+09	537
18	3.66E+09	668	63	2.34E+09	536
19	3.60E+09	663	64	2.33E+09	534
20	3.55E+09	658	65	2.31E+09	532
21	3.50E+09	653	66	2.29E+09	530
22	3.45E+09	649	67	2.28E+09	528
23	3.40E+09	644	68	2.26E+09	526
24	3.36E+09	640	69	2.25E+09	525
25	3.31E+09	636	70	2.23E+09	523
26	3.27E+09	632	71	2.22E+09	522
27	3.23E+09	628	72	2.20E+09	520
28	3.20E+09	625	73	2.19E+09	518
29	3.16E+09	621	74	2.17E+09	516
30	3.12E+09	617	75	2.16E+09	515
31	3.09E+09	614	76	2.15E+09	514
32	3.06E+09	611	77	2.13E+09	511
33	3.02E+09	607	78	2.12E+09	510

34	2.99E+09	604	79	2.10E+09	508
35	2.96E+09	601	80	2.09E+09	507
36	2.93E+09	598	81	2.08E+09	505
37	2.90E+09	595	82	2.07E+09	504
38	2.87E+09	592	83	2.05E+09	501
39	2.85E+09	590	84	2.04E+09	500
40	2.82E+09	587			
41	2.79E+09	584			
42	2.77E+09	582			
43	2.74E+09	579			
44	2.72E+09	577			

Table 4.4

Ppseudo-Pressure and Pressure Profile for Well #2

Optimum Gas Flow Rate for this well: 6608 Mscfd

Time,(Month)	Mpwf, (psia^2/cp)	Pressure, Psia	Time,(Month)	Mpwf, (psia^2/cp)	Pressure, Psia
0	9.78E+09	1097	43	2.801E+09	585
1	7.076E+09	929	44	2.774E+09	582
2	6.288E+09	875	45	2.749E+09	579
3	5.827E+09	842	46	2.724E+09	577
4	5.500E+09	818	47	2.699E+09	574
5	5.246E+09	799	48	2.676E+09	572
6	5.039E+09	783	49	2.652E+09	569
7	4.864E+09	769	50	2.629E+09	566
8	4.712E+09	757	51	2.607E+09	564
9	4.578E+09	746	52	2.585E+09	562
10	4.458E+09	736	53	2.563E+09	560
11	4.350E+09	728	54	2.542E+09	558
12	4.251E+09	719	55	2.521E+09	555
13	4.160E+09	712	56	2.500E+09	553
14	4.076E+09	705	57	2.480E+09	551
15	3.998E+09	697	58	2.460E+09	549
16	3.924E+09	691	59	2.441E+09	547
17	3.855E+09	685	60	2.422E+09	544
18	3.790E+09	679	61	2.403E+09	542
19	3.729E+09	674	62	2.385E+09	540
20	3.671E+09	669	63	2.366E+09	538
21	3.615E+09	664	64	2.349E+09	536
22	3.562E+09	659	65	2.331E+09	534
23	3.512E+09	654	66	2.314E+09	532

24	3.463E+09	650	67	2.296E+09	530
25	3.417E+09	645	68	2.280E+09	528
26	3.372E+09	641	69	2.263E+09	526
27	3.330E+09	637	70	2.247E+09	524
28	3.288E+09	633	71	2.231E+09	523
29	3.248E+09	629	72	2.215E+09	521
30	3.210E+09	626	73	2.199E+09	519
31	3.173E+09	622	74	2.184E+09	517
32	3.136E+09	618	75	2.168E+09	515
33	3.101E+09	615	76	2.153E+09	514
34	3.068E+09	611	77	2.138E+09	511
35	3.035E+09	608	78	2.124E+09	510
36	3.003E+09	605	79	2.109E+09	508
37	2.971E+09	602	80	2.095E+09	507
38	2.941E+09	599	81	2.081E+09	505
39	2.912E+09	596	82	2.067E+09	503
40	2.883E+09	593	83	2.053E+09	502
41	2.855E+09	590	84	2.039E+09	500
42	2.827E+09	587			

Appendix D II

Program Code

```
Private Sub cmdGe2_Click()
Dim Zfs!
Dim Zfc!
Dim Zfc1!
Dim Zfc2!
Dim Zfct!
Dim Dg, Dg1, Au, Bu, Cu, Gv As Single
Dim Ppc, Tpc, Ppr, Tpr, Dpr, Gravity, Pressure, Temp
Dim a1, a2, a3, a4, a5, a6, a7, a8, a9, a10, a11
Label14.Caption = ""
Label14.Refresh

Open App.Path + "/" + "ViscosityGraph.txt" For Output As 1
Print #1, "Pressure,Psia", " Viscosity, cp"
a1 = 0.3265
a2 = -1.07
a3 = -0.5339
a4 = 0.01569
a5 = -0.05165
a6 = 0.5475
a7 = -0.7361
a8 = 0.1844
a9 = 0.1056
a10 = 0.6134
a11 = 0.721
Ppc = 709.604 - 58.719 * Val(txtGra.Text)
Tpc = 170.491 + 307.344 * Val(txtGra.Text)
Tpr = (Val(txtTemp.Text) + 460) / Tpc

'Iterating with Pressure
j = 0

For Pressure = 500 To 1100
Grid3.Col = 0
j = j + 1
Grid3.Row = j
Grid3.Text = Pressure
Ppr = Pressure / Ppc
```

```
'Z-factor calculation
'-------------------------------------------------------------------------------
Zfs = 1
Zfct = 2
Do While DoEvents()
Zfs = Zfct
Dpr = 0.27 * ((Ppr / Zfs * Tpr))
Zfc = 1 + (a1 + (a2 / Tpr) + (a3 / Tpr ^ 3) + (a4 / Tpr ^ 4) + (a5 / Tpr ^ 5)) * Dpr
Zfc1 = (a6 + (a7 / Tpr) + (a8 / Tpr ^ 2)) * Dpr ^ 2 - a9 * ((a7 / Tpr) + (a8 / Tpr ^ 2)) *
Dpr ^ 5
Zfc2 = a10 * (1 + a11 * Dpr ^ 2) * ((Dpr ^ 2 / Tpr ^ 3)) * (Exp(-a11 * Dpr ^ 2))
Zfct = Zfc + Zfc1 + Zfc2
Zfct = Format(Zfct, "0.000")

If (Zfct > 0.7 And Zfct < 1.1) Then
GoTo 1
End If
If Abs(Zfs - Zfct) <= 0.0001 Then

GoTo 1
End If
Zfs = Zfct
Loop

'------------------------------------------------------------------------------------
'Viscosity Calculation
1:
'---------------------
Grid3.Col = 1
Dg = 2.703 * Pressure / (Zfct * (Temp + 460))
Dg1 = Dg * 0.01603
Au = (9.379 + 0.01607 * (Gravity * 29) * (Temp + 460) ^ 1.5 / (209.2 + 19.26 * (Gravity
* 29) + (Temp + 460)))
Bu = 3.448 + (986.4 / (Temp + 460)) + 0.01009 * (Gravity * 29)
Cu = 2.447 - 0.2224 * Bu
Gv = Au * Exp(Bu * Dg1 ^ Cu) * 0.001
Gv = Format(Gv, "0.00000")
Grid3.Row = j
Grid3.Text = Gv
Print #1, Pressure, Gv
Next Pressure
Close #1

'Graph Generator
```

```
Dim i3, j3 As Integer
Dim Aux(700, 700) As Double
Chart.chartType = VtChChartType2dXY
With Chart.Plot.Axis(VtChAxisIdX)
.AxisScale.Type = VtChScaleTypeLinear
'.AxisGrid.MinorPen.Style = VtPenStyleDitted
'.CategoryScale.Auto = False
.AxisGrid.MinorPen.Join = VtPenJoinRound
.ValueScale.Minimum = 500
.ValueScale.Maximum = 1100
End With
With Chart.Plot.Axis(VtChAxisIdY)
.AxisScale.Type = VtChScaleTypeLinear
'.AxisGrid.MinorPen.Style = VtPenStyleDitted
'.CategoryScale.Auto = False
.ValueScale.Minimum = 0.01
.ValueScale.Maximum = 1000

End With
Chart.ColumnCount = 2
Chart.RowCount = Grid3.Rows - 1

For j3 = 0 To 1
For i3 = 1 To Grid3.Rows - 1
Chart.Column = j3 + 1
Chart.Row = i3
Grid3.Col = j3
Grid3.Row = i3
Aux(i3, j3) = Grid3.Text
Chart.Data = Aux(i3, j3)
If j3 = 1 Then
Chart.Data = Chart.Data * 100000
End If
Next i3
Next j3
Close #1
Label14.Caption = "This Number is really (1)one!!"
End Sub

Private Sub cmdGen3_Click()
Label10.Visible = True
txtOptimum.Text = ""
Dim MPwf(1 To 64000), Qgas As Double
Dim Time As Double
Dim i As Double
Dim A, B, C As Double
```

```
If Optime(1) = False And Optime(2) = False Then
MsgBox "Please choose an ELAPSED time..(Each Month...Each Year)", vbInformation
Exit Sub
End If

Open App.Path + "/" + "PpressureProfile.txt" For Output As 1
Label10.Caption = "Processing...Processing...it may take several minutes!"
Label10.Refresh

For Qgas = Val(txtRange(0).Text) To Val(txtRange(1).Text) Step 1
For Time = 1 To 84
A = (1637 * Qgas * (Val(txtReData(5)) + 460) / (Val(txtReData(4)) *
Val(txtReData(6))))
B = Log((Val(txtReData(4)) * Time / (730 * Val(txtReData(0)) * Val(txtReData(1)) *
Val(txtReData(2)) * Val(txtReData(3) ^ 2))))
C = -3.23 + 0.87 * Val(txtReData(7))
MPwf(Time) = Val(TxtSe.Text) - A * (B + C)
If MPwf(Time) < Val(txtPe.Text) And Time < 84 Then
Label10.Caption = " the flow rate Range you chose is too high, PLEASE decrease the
range."
Label10.Refresh
Close #1
Exit Sub
End If
If MPwf(84) <= Val(txtPe.Text) And MPwf(84) <> Empty Then
txtOptimum.Text = Str(Qgas)
Label10.Caption = "READY!!..Check your output file called PpressureProfile.txt"
GoTo 1
End If
Next Time
Next Qgas
Label10.Caption = "Optimum flow rate not found..(choose another range for
Qg..(Greater))!!"
'Printing the OUTPUT file
1:

If Optime(1) = True Then
Print #1, "Time,(Month)", "  Mpwf, (psia^2/cp)"
For i = 1 To 84
Print #1, i, MPwf(i)
Next i
ElseIf Optime(2) = True Then
Print #1, "Time,(Year)", "  Mpwf, (psia^2/cp)"
For i = 1 To 7
Print #1, i, MPwf(i)
Next i
```

```
End If
Close #1
End Sub

Private Sub cmdGenerate_Click()
Dim Zfs!
Dim Zfc!
Dim Zfc1!
Dim Zfc2!
Dim Zfct!
Dim Ppc, Tpc, Ppr, Tpr, Dpr, Gravity, Pressure, Temp, Tpr1, Tpr2, j
Dim a1, a2, a3, a4, a5, a6, a7, a8, a9, a10, a11
Open App.Path + "/" + "Z-Factor(Ppr,Tpr).txt" For Output As 1
Label13.Caption = ""
Label13.Refresh
Print #1, "Tpr", " Z-Factor"
Print #1, "Ppr"
FrmOut.Visible = True

Grid2.Row = 0

a1 = 0.3265
a2 = -1.07
a3 = -0.5339
a4 = 0.01569
a5 = -0.05165
a6 = 0.5475
a7 = -0.7361
a8 = 0.1844
a9 = 0.1056
a10 = 0.6134
a11 = 0.721

k = 0
Grid2.Row = 0
' Starting the loops

For Tpr = 1.1 To 3 Step 0.1
Print #1, Tpr
   j = 1
   k = k + 1


   For Ppr = 1 To 8 Step 1

   'Z-factor calculation
```

```
   '--------------------------------------------------------------------------------
   Zfs = 1
   Zfct = 2
   Do While DoEvents()
   Zfs = Zfct
   Dpr = 0.27 * ((Ppr / Zfs * Tpr))
   Zfc = 1 + (a1 + (a2 / Tpr) + (a3 / Tpr ^ 3) + (a4 / Tpr ^ 4) + (a5 / Tpr ^ 5)) * Dpr
   Zfc1 = (a6 + (a7 / Tpr) + (a8 / Tpr ^ 2)) * Dpr ^ 2 - a9 * ((a7 / Tpr) + (a8 / Tpr ^ 2)) *
Dpr ^ 5
   Zfc2 = a10 * (1 + a11 * Dpr ^ 2) * ((Dpr ^ 2 / Tpr ^ 3)) * (Exp(-a11 * Dpr ^ 2))
   Zfct = Zfc + Zfc1 + Zfc2
   Zfct = Format(Zfct, "0.000")
   If (Zfct >= 0.86 And Zfct <= 1.5) Then
   j = j + 1
   Grid2.Col = k
   Grid2.Row = j
   Grid2.Text = Val(Zfct)
    Print #1, Ppr, Zfct
   GoTo 1
   End If
   If (Zfct >= 0.3 And Zfct <= 0.859) Then
   j = j + 1
   Grid2.Col = k
   Grid2.Row = j
   Grid2.Text = Val(Zfct)
    Print #1, Ppr, Zfct
   GoTo 1
   End If

   If Abs(Zfs - Zfct) <= 0.0001 Then
   j = j + 1
   Grid2.Col = 1
   Grid2.Row = j
   Grid2.Text = Val(Zfct)
   Print #1, Ppr, Zfct
   GoTo 1
   End If
   Zfs = Zfct
   Loop
1:
   Next Ppr
Next Tpr
Label13.Caption = "Your OUTPUT file called Z-factor(Ppr,Tpr).txt is ready!!!"
Close #1
End Sub
```

```
Private Sub Form_Load()
Dim T
Dim i As Integer
Label10.Visible = False
Grid2.Col = 0
For i = 2 To Grid2.Rows - 1
Grid2.Row = i
Grid2.Text = i - 1
Next i
Grid2.Row = 1
For i = 1 To Grid2.Rows - 2
Grid2.Col = i
Grid2.Text = "Z-factor"
Next i
Grid2.Row = 0
i = 0
For T = 1.1 To 3 Step 0.1
i = i + 1
Grid2.Col = i
Grid2.Text = T
Next T

FrmOut.Visible = False

Grid2.Col = 0
Grid2.Row = 0
Grid2.Text = "Tpr-->"
Grid2.Col = 0
Grid2.Row = 1
Grid2.Text = "Ppr"
Grid3.Col = 0
Grid3.Row = 0
Grid3.Text = "Pressure, psia"
Grid3.Col = 1
Grid3.Row = 0
Grid3.Text = "Viscosity, cp"
Grid3.ColWidth(0) = 1200
Grid3.ColWidth(1) = 1200

End Sub

Private Sub Grid1_KeyPress(KeyAscii As Integer)
If KeyAscii > 65 Then
Exit Sub
End If
```

```
If KeyAscii > 26 Then
grid1.Text = grid1.Text + Chr(KeyAscii)
End If
If KeyAscii = 13 Then
grid1.Text = ""
End If

End Sub



Private Sub mnuExit_Click()
End
End Sub

Private Sub txtValues_Change()
grid1.Rows = Val(txtValues.Text) + 1
End Sub
```

Appendix E

Monte Carlo Simulation Computer Program Code

```
 Option Explicit
Dim por(5000) As Double
Dim sw(5000) As Double
Dim h(5000) As Double
Dim eur(5000) As Double
Dim i As Integer
Dim initial_cost, operating_cost, tax
Dim revenue(20) As Double, taxes(20), gp(20)
Dim p1(25), p2(25), p3(25), p4(25)
Dim gg(5000) As Double

Private Sub Command2_Click()
Dim const1 As Double
Dim flag As Integer, j As Integer
Dim rf(5000) As Double, random_no, ncf(25)
Dim counterf, interest, npv1, inter(5000), fq(100)

prgbar.Min = 1
prgbar.Max = 1500
For i = 1 To 1500 Step 1
por(i) = Val(txtminpor.Text) + Rnd() * (Val(txtmaxpor.Text) - Val(txtminpor.Text))
sw(i) = Val(txtminsat.Text) + Rnd() * (Val(txtmaxsat.Text) - Val(txtminsat.Text))
const1 = (Val(txtlikeh.Text) - Val(txtminh.Text)) / (Val(txtmaxh.Text) -
Val(txtminh.Text))
If Rnd() < const1 Then
   h(i) = Val(txtminh.Text) + ((Val(txtlikeh.Text) - Val(txtminh.Text)) *
(Val(txtmaxh.Text) - Val(txtminh.Text) * Rnd())) ^ 0.5
Else
   h(i) = Val(txtmaxh.Text) - ((Val(txtmaxh.Text) - Val(txtlikeh.Text)) *
(Val(txtlikeh.Text) - Val(txtminh.Text) * Rnd())) ^ 0.5
End If
gg(i) = 43560 * Val(txtarea.Text) * por(i) * h(i) * (1 - sw(i)) / Val(txtbgi.Text)
prgbar.Value = i
rf(i) = Rnd()
eur(i) = gg(i) * rf(i)
Next
scenario
Open "d:\295param.txt" For Output As #2
prgbar.Min = 1
prgbar.Max = 1500
```

```
For j = 1 To 1500
random_no = Rnd()
If random_no <= 0.25 Then
   For i = 1 To 12 Step 1
      If i = 1 Then
         gp(i) = p1(i) * eur(j)
         revenue(i) = gp(i) * 2 / 1000
         taxes(i) = tax * revenue(i)
         ncf(i) = revenue(i) - operating_cost - taxes(i) - initial_cost
      Else
         gp(i) = p1(i) * eur(j)
         revenue(i) = gp(i) * 2 / 1000
         taxes(i) = tax * revenue(i)
         ncf(i) = revenue(i) - operating_cost - taxes(i)
       End If
      If i > 4 Then
         gp(i) = (p1(i) - p1(i - 1)) * eur(j)
         revenue(i) = gp(i) * 2 / 1000
         taxes(i) = tax * revenue(i)
         ncf(i) = revenue(i) - operating_cost - taxes(i)
      End If
   Next
   flag = 1
ElseIf (0.25 < random_no) And (random_no <= 0.5) Then
   For i = 1 To 14 Step 1
      If i = 1 Then
         gp(i) = p2(i) * eur(j)
         revenue(i) = gp(i) * 2 / 1000
         taxes(i) = tax * revenue(i)
         ncf(i) = revenue(i) - operating_cost - taxes(i) - initial_cost
      Else
         gp(i) = p2(i) * eur(j)
         revenue(i) = gp(i) * 2 / 1000
         taxes(i) = tax * revenue(i)
         ncf(i) = revenue(i) - operating_cost - taxes(i)
       End If
      If i > 4 Then
         gp(i) = (p2(i) - p2(i - 1)) * eur(j)
         revenue(i) = gp(i) * 2 / 1000
         taxes(i) = tax * revenue(i)
         ncf(i) = revenue(i) - operating_cost - taxes(i)
      End If
   Next
   flag = 2
ElseIf (0.5 < random_no) And (random_no <= 0.75) Then
   For i = 1 To 16 Step 1
```

```
        If i = 1 Then
            gp(i) = p3(i) * eur(j)
            revenue(i) = gp(i) * 2 / 1000
            taxes(i) = tax * revenue(i)
            ncf(i) = revenue(i) - operating_cost - taxes(i) - initial_cost
        Else
            gp(i) = p3(i) * eur(j)
            revenue(i) = gp(i) * 2 / 1000
            taxes(i) = tax * revenue(i)
            ncf(i) = revenue(i) - operating_cost - taxes(i)
        End If
        If i > 4 Then
            gp(i) = (p3(i) - p3(i - 1)) * eur(j)
            revenue(i) = gp(i) * 2 / 1000
            taxes(i) = tax * revenue(i)
            ncf(i) = revenue(i) - operating_cost - taxes(i)
        End If
    Next
    flag = 3
Else
        For i = 1 To 18 Step 1
            If i = 1 Then
            gp(i) = p4(i) * eur(j)
            revenue(i) = gp(i) * 2 / 1000
            taxes(i) = tax * revenue(i)
            ncf(i) = revenue(i) - operating_cost - taxes(i) - initial_cost
        Else
            gp(i) = p4(i) * eur(j)
            revenue(i) = gp(i) * 2 / 1000
            taxes(i) = tax * revenue(i)
            ncf(i) = revenue(i) - operating_cost - taxes(i)
          End If
        If i > 4 Then
            gp(i) = (p4(i) - p4(i - 1)) * eur(j)
            revenue(i) = gp(i) * 2 / 1000
            taxes(i) = tax * revenue(i)
            ncf(i) = revenue(i) - operating_cost - taxes(i)
        End If
    Next
    flag = 4
End If

If flag = 1 Then counterf = 12
If flag = 2 Then counterf = 14
If flag = 3 Then counterf = 16
If flag = 4 Then counterf = 18
```

```
interest = 0.0001
    Do
        npv1 = 0
    For i = 1 To counterf Step 1
        npv1 = npv1 + ncf(i) / (1 + interest) ^ (i - 1)
    Next
    interest = interest + 0.0001

    Loop Until npv1 < 0
    inter(j) = interest
    prgbar.Value = j
grdres.Row = j:
grdres.Col = 1:  grdres.Text = Format(por(j), " #0.0####")
grdres.Col = 2:  grdres.Text = Format(h(j), " #0.0#  ")
grdres.Col = 3:  grdres.Text = Format(sw(j), "#0.0####")
grdres.Col = 4:  grdres.Text = Format(gg(j), "#0.#")
grdres.Col = 5:  grdres.Text = Format(rf(j), "#0.0###")
grdres.Col = 6:  grdres.Text = Format(eur(j), "#0.#")
grdres.Col = 7:  grdres.Text = Format(inter(j), "#0.0####")
Print #2, por(j), h(j), sw(j), gg(j), rf(j), eur(j), inter(j)
Next j
Close #2

For i = 1 To 1500 Step 1
    If (0.05 > inter(i)) Then
    fq(1) = fq(1) + 1
    ElseIf (0.05 < inter(i)) And (inter(i) <= 0.1) Then
    fq(2) = fq(2) + 1
    ElseIf (0.1 < inter(i)) And (inter(i) <= 0.15) Then
    fq(3) = fq(3) + 1
    ElseIf (0.15 < inter(i)) And (inter(i) <= 0.2) Then
    fq(4) = fq(4) + 1
    ElseIf (0.2 < inter(i)) And (inter(i) <= 0.25) Then
    fq(5) = fq(5) + 1
    ElseIf (0.25 < inter(i)) And (inter(i) <= 0.3) Then
    fq(6) = fq(6) + 1
    ElseIf (0.3 < inter(i)) And (inter(i) <= 0.35) Then
    fq(7) = fq(7) + 1
    ElseIf (0.35 < inter(i)) And (inter(i) <= 0.4) Then
    fq(8) = fq(8) + 1
    ElseIf (0.4 < inter(i)) And (inter(i) <= 0.45) Then
    fq(9) = fq(9) + 1
    ElseIf (0.45 < inter(i)) And (inter(i) <= 0.5) Then
    fq(10) = fq(10) + 1
    ElseIf (0.5 < inter(i)) And (inter(i) <= 0.55) Then
```

```
    fq(11) = fq(11) + 1
    ElseIf (0.55 < inter(i)) And (inter(i) <= 0.6) Then
    fq(12) = fq(12) + 1
    ElseIf (0.6 < inter(i)) And (inter(i) <= 0.65) Then
    fq(13) = fq(13) + 1
     ElseIf (0.65 < inter(i)) And (inter(i) <= 0.7) Then
    fq(14) = fq(14) + 1
     ElseIf (0.7 < inter(i)) And (inter(i) <= 0.75) Then
    fq(15) = fq(15) + 1
     ElseIf (0.75 < inter(i)) And (inter(i) <= 0.8) Then
    fq(16) = fq(16) + 1
     ElseIf (0.8 < inter(i)) And (inter(i) <= 0.85) Then
    fq(17) = fq(17) + 1
     ElseIf (0.85 < inter(i)) And (inter(i) <= 0.9) Then
    fq(18) = fq(18) + 1
     ElseIf (0.9 < inter(i)) And (inter(i) <= 0.95) Then
    fq(19) = fq(19) + 1
     ElseIf (0.95 < inter(i)) And (inter(i) <= 1) Then
    fq(20) = fq(20) + 1
   '  ElseIf (0.19 < inter(i)) And (inter(i) <= 0.2) Then
   ' fq(20) = fq(20) + 1
   '  ElseIf (0.2 < inter(i)) And (inter(i) <= 0.21) Then
   ' fq(21) = fq(21) + 1
   '  ElseIf (0.21 < inter(i)) And (inter(i) <= 0.22) Then
   ' fq(22) = fq(22) + 1
   ' ElseIf (0.22 < inter(i)) And (inter(i) <= 0.23) Then
   ' fq(23) = fq(23) + 1
    ElseIf (1 < inter(i)) Then
    fq(21) = fq(21) + 1
    Else
    End If
Next

Open "a:\saeed.txt" For Output As #1
For i = 1 To 21
Print #1, fq(i)
Next
Close #1

End Sub

Public Sub scenario()

initial_cost = Val(txtic.Text)
operating_cost = Val(txtoc.Text)
tax = Val(txttc.Text)
```

```
p1(1) = 0: p1(2) = 0: p1(3) = 0
p1(4) = 0.04: p1(5) = 0.17: p1(6) = 0.35: p1(7) = 0.56: p1(8) = 0.73
p1(9) = 0.85: p1(10) = 0.94: p1(11) = 0.99: p1(12) = 1

p2(1) = 0: p2(2) = 0: p2(3) = 0
p2(4) = 0.04: p2(5) = 0.13: p2(6) = 0.24: p2(7) = 0.42: p2(8) = 0.6
p2(9) = 0.73: p2(10) = 0.84: p2(11) = 0.91: p2(12) = 0.96: p2(13) = 0.99
p2(14) = 1

p3(1) = 0: p3(2) = 0: p3(3) = 0
p3(4) = 0.03: p3(5) = 0.12: p3(6) = 0.22: p3(7) = 0.35: p3(8) = 0.5
p3(9) = 0.62: p3(10) = 0.73: p3(11) = 0.82: p3(12) = 0.89: p3(13) = 0.94
p3(14) = 0.97: p3(15) = 0.99: p3(16) = 1

p4(4) = 0.03: p4(5) = 0.1: p4(6) = 0.19: p4(7) = 0.29: p4(8) = 0.42
p4(9) = 0.53: p4(10) = 0.64: p4(11) = 0.73: p4(12) = 0.82: p4(13) = 0.87
p4(14) = 0.92: p4(15) = 0.95: p4(16) = 0.98: p4(17) = 0.99: p4(18) = 1

End Sub
Private Sub Command1_Click()
End
End Sub

Private Sub Form_Load()
grdres.Row = 0
grdres.Col = 0: grdres.Text = "Number"
grdres.Col = 1: grdres.Text = "Porosity"
grdres.Col = 2: grdres.Text = "Thickness"
grdres.Col = 3: grdres.Text = "Water Saturation"
grdres.Col = 4: grdres.Text = "Initial Gas In Place"
grdres.Col = 5: grdres.Text = "Recovery Factor"
grdres.Col = 6: grdres.Text = "Estimate Recovery"
grdres.Col = 7: grdres.Text = " DCFROR"
grdres.Col = 0
For i = 1 To 1000 Step 1
   grdres.Row = i
   grdres.Text = i
Next
End Sub
```

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