WELL TEST ANALYSIS FOR WELLS PRODUCED AT A CONSTANT PRESSURE

By

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ΘΑΡΣΕΙΝ ΧΡΗ ΤΑΧ’ΑΥΡΙΟΝ ΕϹϹΕΤΑΙ ΑΜΕΙΝΟΝ

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ABSTRACT

Conventional well test analysis has been developed primarily for constant flow rate production. Constant pressure production results in a transient rate response. Pressure buildup after constant pressure flow is complicated by the transient rate prior to shut-in. Thus, the methods of drawdown and buildup analysis designed for constant rate production are not valid for constant pressure production.

Some transient rate analysis methods are outlined in the literature but a thorough study is lacking. The necessary analytical solutions for determination of reservoir permeability and porosity and wellbore skin factor are provided in this study. Reservoir limit testing and interference analysis are also discussed. In addition, analysis of flow at constant wellhead pressure is shown to be a simple extension of the existing theory for constant wellbore pressure production.

Most of the existing methods for pressure buildup analysis for wells with a constant pressure flow history are empirical. In this work, the method of superposition in time of continuously changing rates is used to generate an exact solution for pressure buildup following constant pressure

flow. The method is general. Wellbore storage and skin effects are incorporated into the theory, and both bounded and unbounded reservoirs are considered. Buildup solutions are graphed using conventional techniques for analysis. Horner's[10] method for plotting buildup after variable rate flow is found to be accurate in a majority of cases. Curves for determination of static reservoir pressure similar to those developed by Matthews, Brons, and Hazebroek[18] are provided for closed bounded reservoirs. Additional applications of the method of superposition in time of continuously changing rates are also included.

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SECTION 1

INTRODUCTION

Although constant-rate production is usually assumed in the development of well test analysis methods, several common reservoir production conditions result in flow at a constant pressure instead. Reservoir fluids are often produced into a constant pressure separator or pipeline; and constant pressure flow is also maintained during the rate decline period of reservoir depletion. Wells in low permeability reservoirs are often by necessity produced at constant pressure. In geothermal reservoirs, produced fluids may drive a back-pressured turbine. Finally, open wells, including artesian water wells, flow at constant atmospheric pressure.

Fundamental considerations instruct that conventional pressure drawdown and buildup analysis methods should not be appropriate for wells produced at constant pressure. However, analogous well test methods have been proposed. The purpose of this study is to review the existing methods for transient rate decline and pressure buildup analysis and to contribute new solutions where needed in order to produce a comprehensive well test analysis package for wells produced at constant pressure. The remainder of this section is a discussion of the methods available in the literature and the objectives of this work.

Many of the basic analytical solutions for transient rate decline have been available for some time. The first solutions were published by Moore, et al. (1933) and Hurst (1934). Results were presented in graphical form for bounded and unbounded reservoirs in which the flow was radial and the single phase fluid was slightly compressible. These solutions were not tabulated, however. Tables of dimensionless flow rate vs dimensionless time were provided later by Ferris, et al. (1962) for the unbounded system and by Tsarevich and Kuranov (1956) for the closed bounded circular reservoir. Tsarevich and Kuranov also provided tabulated solutions for the cumulative production from a closed bounded reservoir. Fetkovich (1973) developed the type curves for transient rate vs time in the closed bounded circular reservoir. Fetkovich was the first to determine the exponential form of the final rate decline for constant pressure production., Type curves for rate decline in closed bounded reservoirs with pressure sensitive rock and fluid properties were developed by Samaniego and Cinco (1978). A method for determining the skin effect was given by Earlougher (1977). Type curves for analysis of the transient rate response when the well penetrates a fracture were developed by Prats, et al. (1962) and by Locke and Sawyer (1975). Kucuk (1978) developed type curves for the transient rate and cumulative production for constant pressure production with elliptical flow.

Although the rate decline solutions present in the literature provide a fairly comprehensive list, certain problems have not been discussed. One such problem is the effect of production with constant pressure at the wellhead rather than the wellbore. Constant wellhead pressure production causes a variable wellbore pressure because the pressure drop due to friction in the wellbore is dependent on the transient rate. A second subject not found in the literature is interference analysis. Finally, a solution for the early transient rate response which allows for a more realistic finite initial rate has not been determined. These problems are discussed in Section 2 of this work.

Another subject which has not received a thorough treatment in the literature is the analysis of pressure buildup after constant pressure production. Hornar (1951) suggested two methods for dealing with variable rate production prior to shut-in. The first method was exact, but required long calculations. The second method was to assume approximate constant rate production by using the last established rate in conjunction with a corrected flow time determined by dividing the cumulative production by the last established flow rate. The latter method was not theoretically justified at the 'time and has been questioned in other studies. Investigators who have found fault with the Horner approximate pressure buildup analysis method for variable rate production prior to shut-in include Odeh and Selig (1963), Sandrea (1971), and Clegg (1967). Their objections will be discussed in Section 3. Jacob and Lohman (1952) analyzed pressure buildup after constant pressure production for a number of wells for which transmissivity had already been determined by type curve analysis of the rate response. Their graph of residual drawdown versus the log of the total time divided by the shut-in time produced a semi-log straight line. Transmissivities calculated from the slope of the line and the average flow rate during the flow period agreed with the values determined from type curve matching.

In Section 3 of this study a solution for pressure buildup after constant pressure production is derived based on superposition in time of continuously varying rates. The resulting solution is general and can be used to justify the modified Horner method theoretically. The Jacob and Lohman method is shown to be of somewhat limited :accuracy. In addition, methods for determination of wellbore storage and skin effect and the static reservoir pressure from the pressure buildup data are shown to be analogous to the constant rate case. Limitations of the methods for analysis of pressure buildup are also considered.

The method of superposition in time of continuously varying rates has many applications. In the last part of Section 3, three applications of the theory are presented: a constant initial rate followed by constant pressure production 1) during the early period of production, 2) after the onset of pseudo-steady state, and 3) interference among flowing wells produced at constant rate or constant pressure.

SECTION 2

ANALYTICAL SOLUTIONS FOR TRANSIENT RATE DECLINE

Although many of the basic solutions for transient rate decline for wells produced at constant pressure have been published, no comprehensive analysis has been offered. In this section the problem of constant pressure production from the center of a circular reservoir is examined. In Section 2.1, equations which define the basic problem and the assumptions required for their derivation are given. In Section 2.2, the method used in this work for obtaining solutions to the equations is outlined. In Section 2.3 the analytical solutions in real space for the unbounded circular reservoir are presented. Included in this section are discussions of the application of the solutions to well test analysis.

Three important extensions of the basic solutions are derived in the final three sections. The solutions given in the first three sections apply €or production at a constant wellbore pressure. Because the pressure is normally controlled at the wellhead, the effect of changing the inner boundary condition to include frictional pressure drop in the wellbore is examined in Section 2.1. An apparent advantage of constant pressure testing is the absence of wellbore storage effects. This is discussed in Section 2.5. Finally, Section 2.6 contains a discussion of interference analysis for wells produced at constant pressure.

2.1 FUNDAMENTAL PARTIAL DIFFERENTIAL EQUATIONS

The fundamental partial differential equation representing idealized flow through porous media is the diffusivity equation. The diffusivity equation in radial geometry is given by:

$$\frac{\partial^2 p}{\partial r^2} + \frac{1}{r}\frac{\partial p}{\partial r} = \frac{\phi\mu c_t}{k}\frac{\partial p}{\partial t} \qquad (2.1)$$

The porous medium is contained in the region between the finite wellbore raduis, r_w, and the reservoir radius, r_e, which may be infinite or finite. Implicit in the use of this equation are the following assumptions:

1. Flow through the porous medium is strictly radial with negligible gravity effects.

2. The porous medium is homogeneous and isotropic, with constant thickness, h, porosity, ϕ, and permeability, k.

3. The fluid viscosity, μ, is constant, and the total compressibility, c_t, of the fluid and the porous medium is small in magnitude and constant.

4. Pressure gradients are small everywhere such that gradient squared terms may be neglected.

The last two assumptions are essentially satisfied for a liquid saturated, one phase, isothermal reservoir.

A complete mathematical definition of the problem of constant pressure production from a circular reservoir requires additional equations which represent the appropriate initial and boundary conditions. For a reservoir initially at a constant pressure, p_i, the initial condition is given by:

$$p(r,0) = p_i \tag{2.2}$$

The inner boundary condition is:

$$p(r_w,t) = p_{wf} + s \left(r \frac{\partial p}{\partial r} \right)_{r=r_w^+} \tag{2.3}$$

where s is the wellbore skin factor, and p_{wf} is the flowing bottomhole pressure. Three different outer boundary conditions are often considered: an infinitely large reservoir, a closed outer boundary, and a constant-pressure outer boundary. The condition for an infinitely large reservoir is:

$$\lim_{r\to\infty} p(r,t) = p_i \tag{2.4}$$

For the closed outer boundary the condition is:

$$\frac{\partial p}{\partial r}(r_e,t) = 0 \tag{2.5}$$

and for the constant pressure outer boundary, the condition is:

$$p(r_e,t) = p_i \tag{2.6}$$

Fig. 2.1 is a schematic diagram of the system described by Eqs. 2.1-2.6. The flow into the wellbore is given by:

$$q(t) = \frac{-2\pi kh}{\mu}\left(r\,\frac{\partial p}{\partial r}\right)_{r=r_w^+} \tag{2.7}$$

In order to provide general solutions, dimensionless variables may be defined as follows:

$$r_D = r/r_w \tag{2.8}$$

$$t_D = kt/\phi\mu c_t r_w^2 \tag{2.9}$$

$$p_D(r_D,t_D) = \frac{p_i - p(r,t)}{p_i - p_{wf}} \tag{2.10}$$

$$q_D(t_D) = q(t)\ \mu/[2\pi kh(p_i - p_w \tag{2.11}$$

The resulting equations in dimensionless variables are

$$\frac{\partial^2 p_D}{\partial r_D^2} + \frac{1}{r_D}\frac{\partial p_D}{\partial r_D} = \tag{2.12}$$

$$p_D(r_D,0) = \tag{2.13}$$

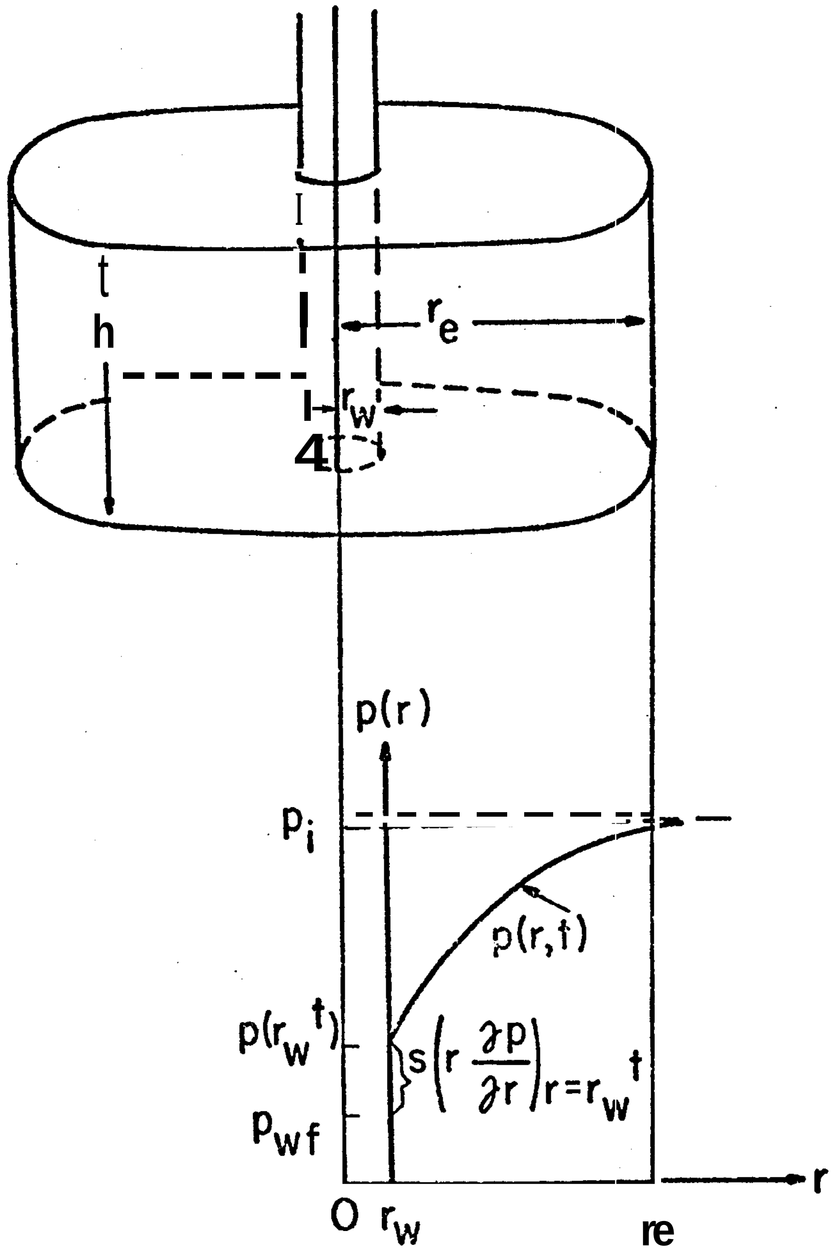

Figure 2.1: Schematic Diagram of a Well Producing at a Constant Wellbore Pressure from a Circular Reservoir

$$p_D(1,t_D) = 1 + s \left(\frac{\partial p_D}{\partial r_D}\right)_{r_D=1^+} \quad (2.14)$$

with outer boundary condition one of the following:

$$\lim_{r_D \to \infty} p_D(r_D,t_D) = 0 \quad (2.15)$$

$$\frac{\partial p_D}{\partial r_D}(r_{eD},t_D) = 0 \quad (2.16)$$

$$p_D(r_{eD},t_D) = 0 \quad (2.17)$$

The flow rate is determined from:

$$q_D(t_D) = \left(\frac{\partial p_D}{\partial r_D}\right)_{r_D=1^+} \quad (2.18)$$

Eqs. 2.12-2.14 and one of Eqs. 2.15, 2.16, or 2.17 completely describe the problem of a well producing at a constant wellbore pressure from the center of a circular reservoir under the assumptions listed in this section. In the next section, the method of solution used in this work is described.

2.2 METHOD OF SOLUTION

A straight-foreward method for solving Eqs. 2.12-2.17 involves use of the Laplace transformation. Carslaw and Jaeger (1947) used the Laplace transformation to solve the diffusivity equation. By this method, the equations are transformed into a system of ordinary differential equations which can be solved analytically. The resulting solution for the Laplace transform of the pressure, $\bar{p}_D$, is a function of the Laplace variable, ℓ, and the spacial variable, r_D. To determine the pressure, p_D, as a function of r_D and t_D, the Laplace space solutions must be inverted using the inverse Laplace transformation.

Application of the Laplace transformation to Eqs. 2.12-2.18 results in:

$$\frac{d^2\bar{p}_D}{dr_D^2} + \frac{1}{r_D}\frac{d\bar{p}_D}{dr_D} = \ell\bar{p}_D \tag{2.19}$$

$$p_D(1,\ell) = \frac{1}{\ell} + s\left(\frac{dp_D}{dr_D}\right)_{r_D=1^+} \tag{2.20}$$

$$\lim_{r_D\to\infty} \bar{p}_D(r_D,\ell) = 0 \tag{2.21}$$

$$\frac{d\bar{p}_D}{dr_D}(r_{eD},\ell) = 0 \tag{2.22}$$

$$\bar{p}_D(r_{eD},\ell) = 0 \tag{2.23}$$

$$q_D(\ell) = \left(\frac{d\bar{p}_D}{dr_D}\right)_{r_D=1^+} \tag{2.24}$$

The solutions in Laplace space for all three boundary cases are given in Table 2.1.

A relationship exists between the Laplace transformed solutions for the constant pressure and constant rate problems which was indicated by van Everdingen and Hurst (1949). De-

Table 2.1: Laplace Space Solutions for a Well Producing at a Constant Pressure from the Center of a Circular Reservoir

INFINITE OUTEP BOUNDARY

$$\bar{p}_D(r_D,\ell) = K_0(r_D\sqrt{\ell}) \;/\; \{\ell[K_0(\sqrt{\ell}) + s\sqrt{\ell}\; K_1(\sqrt{\ell})]\}$$

$$\bar{q}_D(\ell) = K_1(\sqrt{\ell}) \;/\; \{\sqrt{\ell}[K_0(\sqrt{\ell}) + s\sqrt{\ell}\; K_1(\sqrt{\ell})]\}$$

CLOSED OUTER BOUNDARY

$$\bar{p}_D(r_D,\ell) = [K_1(r_{eD}\sqrt{\ell})I_0(r_D\sqrt{\ell}) + K_0(r_D\sqrt{\ell})I_1(r_{eD}\sqrt{\ell})] \;/\; D_1$$

$$\bar{q}_D(\ell) = [K_1(\sqrt{\ell})I_1(r_{eD}\sqrt{\ell}) - K_1(r_{eD}\sqrt{\ell})I_1(\sqrt{\ell})] \;/\; D_1$$

$$D_1 = \ell\cdot\{[K_1(r_{eD}\sqrt{\ell})I_0(\sqrt{\ell}) + K_0(\sqrt{\ell})I_1(r_{eD}\sqrt{\ell})]$$
$$- [s\sqrt{\ell}\; K_1(r_{eD}\sqrt{\ell})I_1(\sqrt{\ell}) - K_1(\sqrt{\ell})I_1(r_{eD}\sqrt{\ell})]\}$$

CONSTANT PRESSURE OUTER BOUNDARY

$$\bar{p}_D(r_D,\ell) = [K_0(r_D\sqrt{\ell})I_0(r_{eD}\sqrt{\ell}) - K_0(r_{eD}\sqrt{\ell})I_0(r_D\sqrt{\ell})] \;/\; D_2$$

$$\bar{q}_D(\ell) = [K_1(\sqrt{\ell})I_0(r_{eD}\sqrt{\ell}) + K_0(r_{eD}\sqrt{\ell})I_1(\sqrt{\ell})] \;/\; D_2$$

$$D_2 = \sqrt{\ell}\cdot\{[K_0(\sqrt{\ell})I_0(r_{eD}\sqrt{\ell}) - K_0(r_{eD}\sqrt{\ell})I_0(\sqrt{\ell})]$$
$$+ s\sqrt{\ell}[K_0(r_{eD}\sqrt{\ell})I_1(\sqrt{\ell}) - K_1(\sqrt{\ell})I_0(r_{eD}\sqrt{\ell})]\}$$

noting the dimensionless wellbore pressure under constant rate production by p_{wD}, and the dimensionless cumulative production under constant pressure production by Q_D, this relation is given by:

$$\ell \bar{p}_{wD}(\ell)\ \bar{Q}_D(\ell) = \frac{1}{\ell^2} \tag{2.25}$$

where Q_D is defined by:

$$Q_D(t_D) = Q(t)/[2\pi\phi c_t h r_w^2 (p_i - p_{wf})] \tag{2.26}$$

This result can be derived from the principle of superposition. The cumulative production is related to the transient rate by:

$$\bar{Q}_D(\ell) = \bar{q}_D(\ell)/\ell \tag{2.27}$$

This is easily verified from basic properties of the Laplace transformation. Finally, by combining Eqs. 2.25 and 2.27,

$$q_D(\ell) = \frac{1}{\ell^2 \bar{p}_{wD}(\ell)} \tag{2.28}$$

Thus, any solution for $\bar{p}_{wD}(\ell)$ for constant rate production has an analog solution, $\bar{q}_D(\ell)$ for constant pressure production.

Unfortunately, the inverse Laplace transformation of the solutions in Table 2.1 can only be obtained through use of the Mellin inversion integral, and the resulting integrals cannot be reduced to simple functions. The solutions tabulated in the literature were obtained from numerical integrations of the inversion intregrals. In this work, the solutions are determined using an algorithm for approximate numerical inversion of the Laplace space solutions. The tabulated solutions in the literature serve as a check of the "approximate" solutions determined herein. In general almost exact agreement was found with solutions obtained by numerical integration.

The algorithm for numerical inversion of the transformed solutions was presented by Stehfest (1970). This algorithm provides tabular solutions for a wide variety of problems of interest in well test analysis. The algorithm is based on the following formula given by Stehfest:

$$F(t) \approx \frac{\ln 2}{t} \sum_{i=1}^{N} V_i \, f\left(\frac{\ln 2}{t} i \right) \tag{2.29}$$

where $f(s)$ is the Laplace transformation of $F(t)$, and the V_i are:

$$V_i = (-1)^{[(N/2)+i]} \sum_{k=\frac{i+1}{2}}^{\min\{i,N/2\}} \frac{k^{N/2}(2k)!}{[(N/2)-k]!\,k!\,(k-1)!\,(i-k)!\,(2k-i)!} \tag{2.30}$$

N, the number of terms in the sum, may be determined by comparison with known analytical solutions. Stehfest observed that theoretically, the greater N is, the more accurate is the value computed for $F(t)$; but in practice roundoff errors increase with increasing N. Thus, there is an optimum value for N which can only be determined by comparing values for F(t) with known values.

The Stehfest algorithm provides a convenient method for obtaining real space solutions from the Laplace space solutions given in Table 2.1. Solutions calculated from the Stehfest algorithm are tabulated in Appendix B. The solutions tabulated in this work have been checked against existing solutions whenever possible. Generally, the solutions agree for at least three or, in most cases, four significant figures.

An alternative method for obtaining solutions for constant pressure flow was used by Juan (1977). He developed an algorithm for deriving the constant pressure solutions from the constant rate solutions using superposition. This derivation did not require Laplace transformations.

In the next section graphs of the solutions are presented along with a discussion of their use in well test analysis.

2.3 BASIC TRANSIENT RATE SOLUTIONS

Portions of the analytical solutions for transient rate decline discussed in this section have appeared elsewhere in the literature. A complete study of how they may be applied in well test analysis has been lacking. Three types of reservoirs are considered: the unbounded reservoir; the closed, bounded reservoir; and the constant pressure bounded reservoir. For each type of reservoir, analogies with the analysis of pressure drawdown for the corresponding constant rate case are indicated.

2.3.1 Unbounded Reservoir

As in the case of constant rate production, the transient rate solutions for an unbounded reservoir represent the transient behavior before boundary effects become evident. The transient rate solution by Jacob and Lohman (1952), ignores the skin effect and assigns unrealistically high values to the flow rates during the early flow period. A log-log graph of this solution is shown in Fig. 2.2. Also shown in the figure is a graph of $1/p_{wD}$ where p_{wD} is the wellbore pressure drop determined from the finite wellbore radius solution for constant rate production.

The close similarity between the two solutions which are related exactly in Laplace space by Eq. 2.28 may be seen in Fig. 2.2. Earlougher (1977) determined that for $t_D > 8\times10^4$, p_{wD} and $1/q_D$ agree within 1%. Because the period when $1/q_D$ and p_{wD} coincide is in the semi-log straight portion of the p_{wD} function, a graph of $1/q_D$ vs log t_D produces a straight line if the flow period is long enough. Earlougher described the method for determining reservoir permeability from the slope, m_q, of the semi-log straight line:

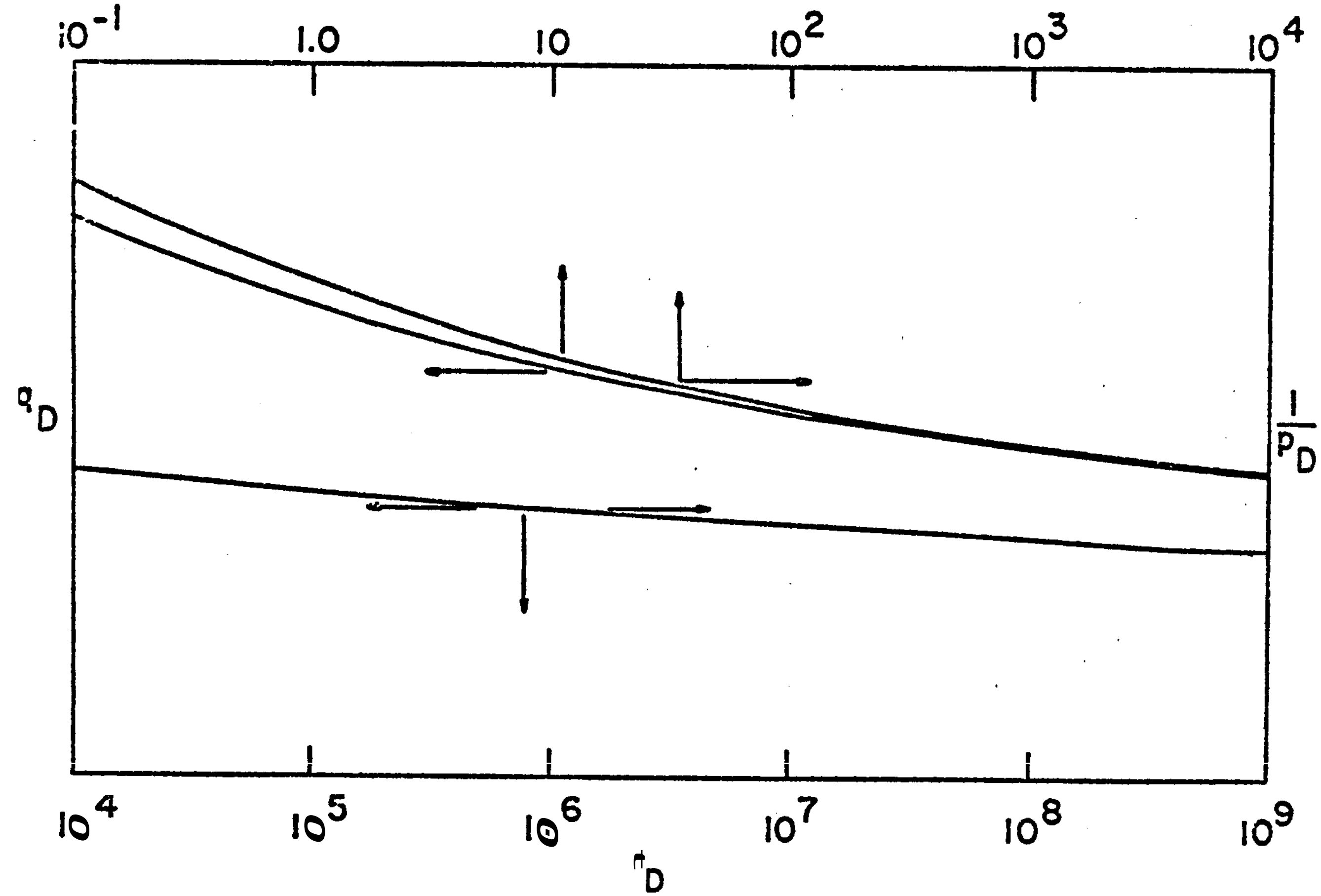

Figure 2.2: Dimensionless Flow Rate for Constant-Pressure Production and Dimensionless Pressure Drop for Constant-Rate Production from an Unbounded Reservoir with a Finite Wellbore Radius and Zero Skin

$$k = \frac{\mu \cdot \ell n\ 10}{4\pi m_q h(p_i - p_{wf})} \quad (2.31)$$

In addition, Earlougher indicated that the wellbore skin factor could be estimated from:

$$s = \frac{\ell n\ 10}{2}\left[\frac{(\frac{1}{q})_{1\ hr}}{m_q} - \log\frac{k}{\phi\mu c_t r_w^2} - 0.80907\right] \quad (2.32)$$

where $(1/q)_{1\ hr}$ is the extrapolated value of the semi-log straight line at a flow time of one hour.

A second method for determining the reservoir permeability is by type curve matching with a graph of log q_D vs log t_D. This method was described by Jacob and Lohman (1952). If q_{DM} is the value for q_D which coincides with the value q on the graph of log q vs log t overlaying the type curve, the permeability can be determined from:

$$k = q_M\mu/[2\pi h q_{DM}(p_i - p_{wf})] \quad (2.33)$$

Likewise, the porosity can be determined from the time match points:

$$\phi = k t_M/(\mu c_t r_w^2 t_{DM}) \quad (2.34)$$

The type curve for q_D vs t_D does not take the skin effect into account. If a non-zero skin factor is present, the estimate for k by type curve matching will be accurate, but the estimate for ϕ will be in error. For positive skin factors, the following approximation can often be used:

$$\phi e^{-2s} \cong kt_M/(\mu c_t r_w^2 t_{DM}) \tag{2.35}$$

The methods described thus far for transient rate analysis of an unbounded reservoir are exactly analogous to the pressure transient analysis techniques. Still other analogous techniques can be derived. For instance, multiple rate testing is analogous to analysis of the rate response to multiple changes of the producing pressure. Fetkovich (1973) applied the ideas of Hurst (1943) to determine the rate response to a change in producing pressure. In a similar fashion, a step change in the flowing bottomhole pressure from p_{wf_1} to p_{wf_2} at time t_1 results in:

$$q(t) = 2\pi kh[(p_i-p_{wf_1})\ q_D(t) + (p_{wf_1}-p_{wf_2})\ q_D(t-t_1)] \tag{2.36}$$

For $t - t_1 << t_1$, $q(t) \cong q(t_1)$. A rearrangement of Eq. 2.36 results in:

$$q(t) - q(t_1) = \frac{2\pi kh}{\mu}\ (p_{wf_1}-p_{wf_2})\ q_D(t-t_1) \tag{2.37}$$

Hence, a graph of log $[q(t)-q(t_1)]$ vs log $(t-t_1)$ can be matched with the q_D vs t_D type curve. Furthermore, a graph of $1/[q(t)-q(t_1)]$ vs log $(t-t_1)$ can be examined for a semi-log straight line.

One difficulty with the analytical solutions for constant pressure (transient rate) production is that computed production rates very early in time may be unrealistically large. A realistic assumption might be that the initial flow rate for an instantaneous drop in the wellbore pressure must be equal to or less than some rate q_c possibly due to the critical flow phenomenon. Critical flow is the maximum possible rate of flow for a particular orifice, and is independent of the pressure drop across the orifice. The maximum rate is established when the flow velocity reaches the velocity of sound in the flowing fluid. Downstream changes in pressure will not propagate upstream, and the flowrate is a function of the upstream pressure only. For ideal gases, it is often shown that a pressure drop approximately half the upstream pressure will cause critical flow. Poettmann and Beck (1963) have shown that similar results may be obtained for multiphase flow of gas and oil. The existence of a critical orifice or flow restriction anywhere between the sand face and the surface could control the initial flow rate, and could prevent instantaneous establishment of an arbitrary constant bottomhole flowing pressure. If a particular bottomhole production pressure is specified, the result could be constant rate flow until the reservoir pressure at the sand face dropped to the desired value, and perhaps for a longer period of time depending upon the location of the critical choke. Then the rate would begin to decline as the pressure is held constant. The mathematics needed to provide a solution for the rate decline after the initial constant flow is analogous to the mathematical solution of pressure buildup after constant pressure production presented in Section 3. Hence, this solution is discussed in Section 3.5.1.

2.3.2 Closed Bounded Reservoir

Fetkovich (1973) showed that one important effect of a closed boundary on constant pressure production is the generation of an exponential decline in the production rate at long times. This state was termed "exponential depletion". It is important in that this state must be the terminal state for any production condition.

The exponential depletion state can be derived from the dimensionless wellbore pressure function for constant-rate production after the onset of pseudo-steady state by use of Eq. 2.28. For pseudo-steady state for closed reservoirs produced at a constant rate Ramey and Cobb (1971) showed that:

$$p_{wD}(t_D) = 2\pi t_{DA} + \frac{1}{2} \ell n \frac{4A}{\gamma C_A r_w^2} \tag{2.38}$$

Thus:

$$\bar{q}_D(\ell) = \frac{1}{\ell^2 \bar{p}_{wD}(\ell)} \tag{2.28}$$

$$= \frac{1}{\ell^2}\left(L\left\{2\pi t_{DA} + \frac{1}{2}\ln\frac{4A}{\gamma C_A r_w^2}\right\}\right)^{-1}$$

$$= \frac{1}{\ell^2}\left[\frac{2\pi}{\ell^2} + \left(\frac{1}{2}\ln\frac{4A}{\gamma C_A r_w^2}\right)\Big/\ell\right]^{-1}$$

$$\bar{q}_D(\ell) = \frac{2}{\ln\frac{4A}{\gamma C_A r_w^2}}\left[\frac{4\pi}{\ln\frac{4A}{\gamma C_A r_w^2}} + \ell\right]^{-1}$$

and

$$q_D(t_D) = \frac{2}{\ln\frac{4A}{\gamma C_A r_w^2}}\left[\exp\frac{-4\pi}{\ln\frac{4A}{\gamma C_A r_w^2}}\right] \tag{2.40}$$

for $t_{DA} > (t_{pss})_D$.

where $(t_{pss})_D$ is the time required for development of true pseudo-steady state at the producing well for the constant rate case, and is dependent on the reservoir shape. See Earlougher and Ramey (1968). To allow for a skin factor, the effective wellbore radius $r_w' = r_w e^{-s}$ should be substituted for r_w.

For closed bounded circular reservoirs after the onset of exponential decline:

$$p_{wD} = 2\pi t_{DA} + \ln r_{eD} - 3/4 \tag{2.41}$$

Following the same procedure as that used to demonstrate exponential decline for other reservoir shapes, for circular reservoirs:

$$q_D(t_D) = \frac{1}{\ell n r_{eD} - \frac{3}{4}} \exp\left[-2\pi t_{DA}/(\ell n r_{eD} - 3/4)\right] \quad (2.42)$$

for $t_{DA} \geq 0.1$

Fetkovich (1973) drew type curves for rate decline in closed bounded circular reservoirs which contained a slight error due to substitution of 1/2 for the correct value of 3/4 in Eq. 2.42. The Fetkovich type curves are reproduced in Fig. 2.3. Again, wellbore skin effects may be included by the substitution of $r_w' = r_w e^{-s}$ for r_w.

In the final depletion of an oil field, flow which has been at a constant rate eventually declines exponentially while the wellbore or wellhead pressure remains constant. This type of decline following constant rate production is slightly different, and is treated in Section 3.5.2.

An analogy for reservoir limit testing from constant rate production data exists for exponential rate decline. From Eqs. 2.40 and 2.11:

$$\ell n\ q = \frac{-4\pi t_{DA}}{\ell n \frac{4A}{\gamma C_A r_w^2}} + \ell n \left[\frac{4\pi kh(p_i - p_{wf})}{\mu \ell n \frac{4A}{\gamma C_A r_w^2}}\right] \quad (2.43)$$

Thus, a graph of log q vs t will have an intercept, q_{int}, and a slope, m^*, given by:

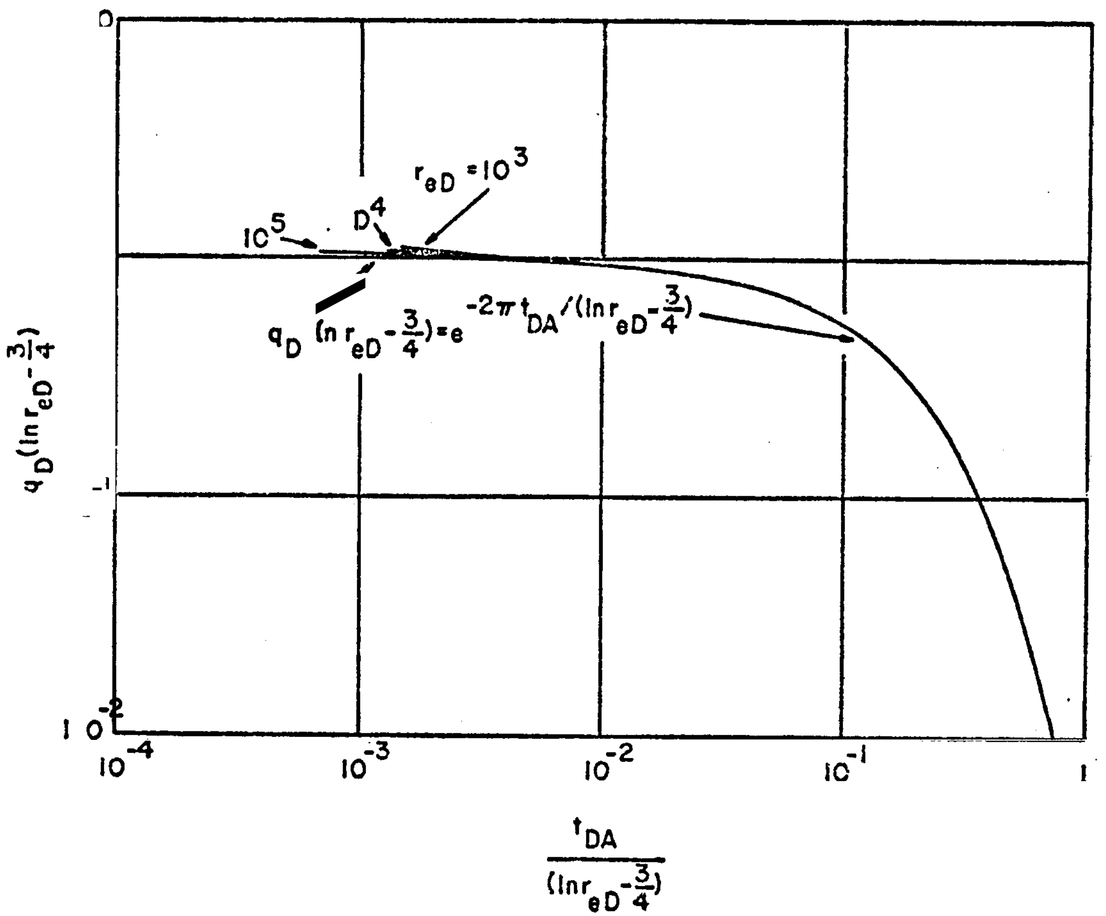

Figure 2 3: Dimensionless Flow Rate Functions for a Well Produced at a Constant Pressure from the Center of a Closed, Bounded, Circular Reservoir

$$q_{INT} = \frac{4\pi kh(p_i - p_{wf})}{\mu \ell n \dfrac{4A}{\gamma C_A r_w^2}} \tag{2.44}$$

and :

$$m^* = \frac{4\pi k}{\phi \mu c_t A \ell n \dfrac{4A}{\gamma C_A r_w^2}} \tag{2.45}$$

Solving for ln $(4A/\gamma C_A r_w^2)$ in both equations and equating the resulting expressions:

$$A = \frac{q_{INT}\mu}{m^* \phi c_t h(p_i - p_{wf})} \tag{2.46}$$

Then C_A can be estimated from either Eq. **2.44 or 2.45:**

$$C_A = \frac{4A}{\gamma r_w^2} \exp[-4\pi kh(p_i - p_{wf})/q_{INT}\mu] \tag{2.47}$$

$$C_A = \frac{4A}{\gamma r_w^2} \exp[-4\pi kh/m^* \phi \mu c_t A] \tag{2.48}$$

The Laplace space solution for cumulative production during the exponential rate decline period is determined from Eq. **2.25.** The derivation **is** similar to the derivation of Eq. **2.40,** and the result is that for closed, bounded reservoirs:

$$Q_D(t_D) = \frac{A}{2\pi r_w^2} \left[1 - \exp \left(-4\pi t_{DA} / \ell n \frac{A}{\gamma C_A r_w^2} \right. \right. \tag{2.49}$$

for $t_{DA} \geq t_{pssD}$. For circular reservoirs:

$$Q_D(t_D) = \frac{r_{eD}^2}{2}[1 - \exp(-2\pi t_{DA}/(\ell n\, r_{eD} - 3/4))] \tag{2.50}$$

for $t_{DA} \geq 0.1$. A type curve graph of log (Q_D/r_{eD}^2) vs log $t_D/(\ln r_{eD} - 3/4)$ for circular reservoirs is shown in Fig. 2.4.

2.3.3 Constant Pressure Bounded Circular- Reservoir

The solution for constant pressure production from a circular reservoir with constant pressure boundary involves the transition from the infinite acting rate function to true steady-state. The final value for the rate may be written immediately from the steady state rate equation for radial flow:[5]

$$q_o = \frac{1}{\ell n r_{eD} + S} \tag{2.51}$$

Steady state flow occurs for $t_{DA} \geq \gamma/4 = 1/2.2458\pi$. This value was determined by equating the right hand side of Eq. 2.51 with the semi-log approximate solution for $1/q_D$, and solving for t_D. Fig. 2.5 is a graph of the solution for a constant pressure outer boundary.

This concludes the discussion of the solution for constant wellbore pressure procudtion from a circular reser-

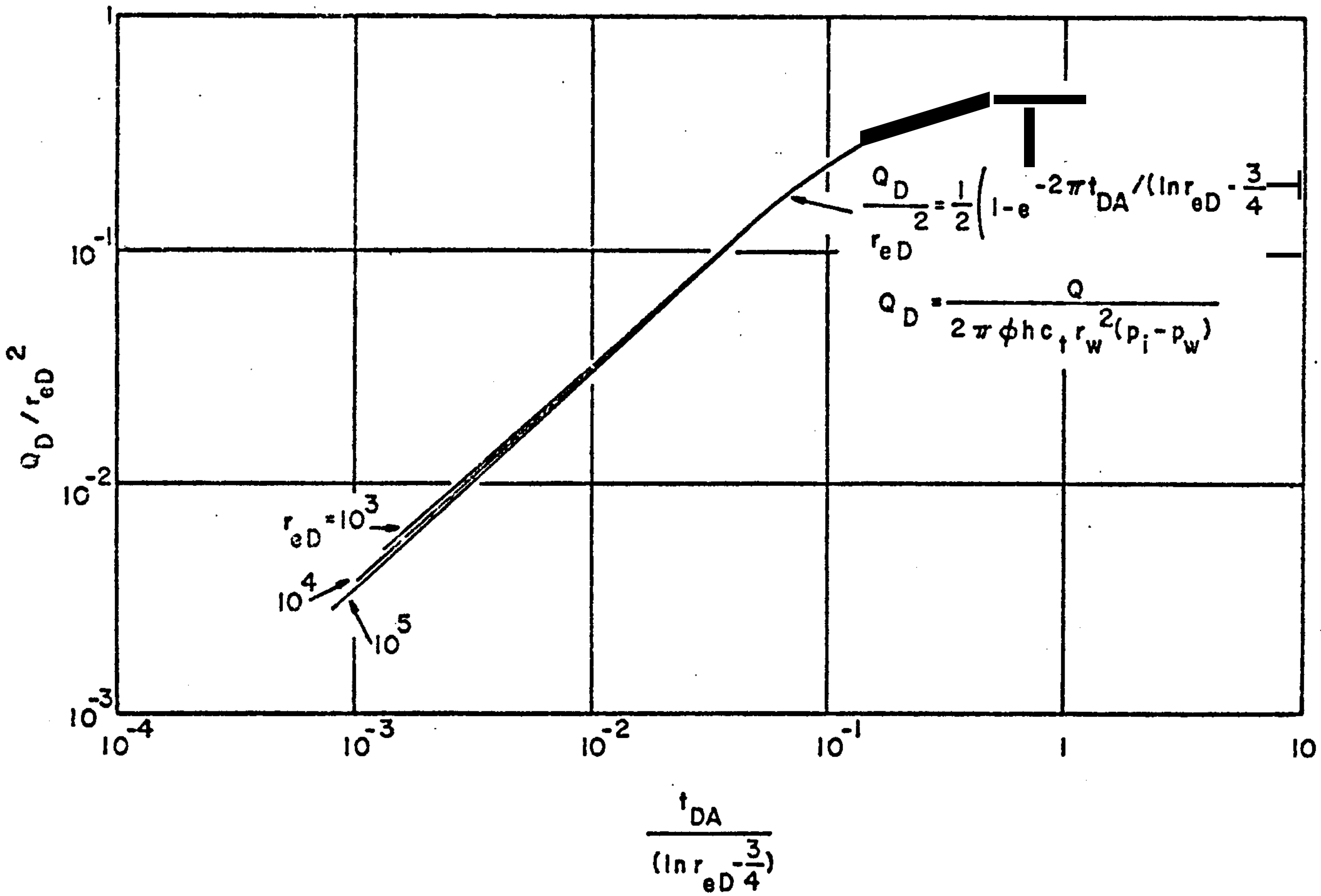

Figure 2.4: Dimensionless Cumulative Production for a Well Produced at a Constant Pressure from the Center of a Closed Bounded Circular Reservoir

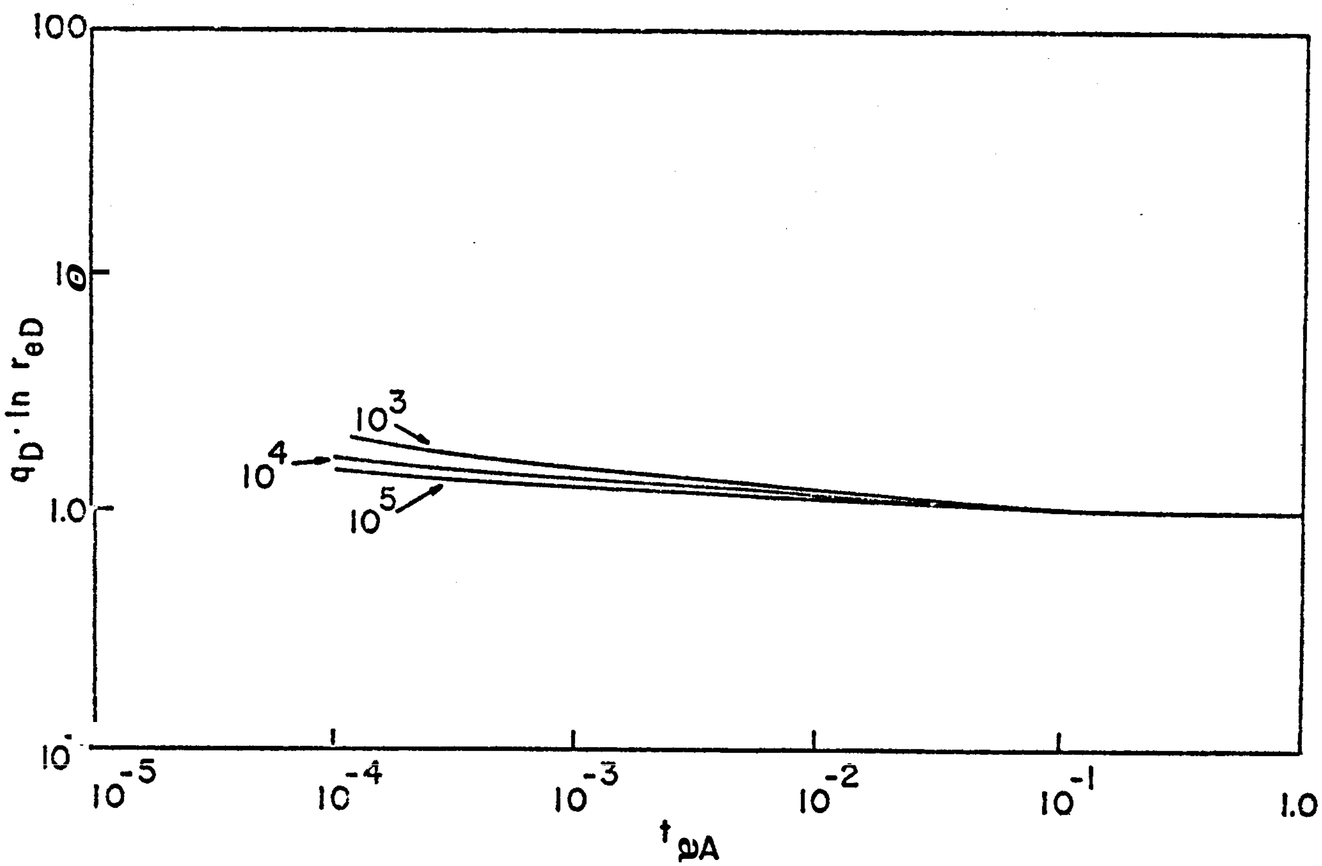

Figure 2.5: Dimensionless Flow Rate for a Well Produced at a Constant Pressure from the Center of a Constant Pressure Bounded Circular Reservoir

voir. In the next section, the theory is extended to solutions for constant pressure at the wellhead instead of at the sand face in the wellbore. The constant wellhead pressure problem is a simple extension of the constant wellbore pressure problem if the flow up the wellbore is laminar.

2.4 PRODUCTION AT CONSTANT WELLHEAD PRESSURE

Frequently reservoir fluids are produced with a constant pressure at the wellhead. Examples are production of fluids into a constant pressure separator and production of gas into a constant pressure pipeline. When the wellhead pressure is constant, the pressure drop in the wellbore due to flowing friction varies as a function of the flow rate, and hence, the wellbore sandface pressure is not constant. The solutions previously discussed are not directly valid for wells produced at constant wellhead pressure. In this section the solution for constant wellhead pressure production when the flow up the wellbore is laminar is derived. The resulting solution is a simple extension of the existing solutions.

Assuming negligible heat loss the mechanical energy balance in differential form for the flowing fluid in the wellbore is given by:

$$vdp + dH + \frac{UdU}{q_c} + dW_f = - dW_s \qquad (2.52)$$

where v is specific volume, H is vertical distance, U is fluid velocity, W_f is frictional energy loss, and W_s is shaft work. Assuming in addition that the shaft work term and the kinetic energy term may be neglected, Eq. 2.52 becomes:

$$vdp = - dW_f - dH \tag{2.53}$$

The frictional energy loss is given by:

$$dW_f = \frac{4f_M U2dL}{2g_c D} \tag{2.54}$$

where L is the tubing length and D is the tubing diameter. For one phase liquid flow in the tubing:

$$U = \frac{4q}{\pi D^2} \tag{2.55}$$

and the density, ρ, is approximatly constant. Hence, the equation for the pressure drop in the wellbore for flowing liquid is given by:

$$p_{wf} - p_{tf} = \frac{4^2 f_M L\bar{\rho} q^2}{2g_c \pi^2 D^5} + H\bar{\rho} \tag{2.56}$$

where p_{wf} is the wellbore flowing pressure, $\bar{\rho}$ is the average density in the wellbore, and p_{tf} is the wellhead flowing pressure. For laminar flow in the wellbore, the Moody friction factor is given by:

$$4f_M = 64/N_{RE} \tag{2.57}$$

where $N_{RE} = 4q\rho/\pi\mu D$ is the Reynolds number. Thus, Eq. 2.56 becomes:

$$p_{wf} - p_{tf} = \frac{64Lq\mu}{2g_c\pi D^4} \tag{2.58}$$

The inner boundary condition is:

$$p(r_w,t) = p_{wf} + s\left(r\frac{\partial p}{\partial r}\right)_{r=r_w} \tag{2.3}$$

Combining Eqs. 2.58 and 2.3:

$$p(r_w,t) = p_{tf} + \frac{64Lq\mu}{2g_c\pi D^4} + H\bar{\rho} + s\left(r\frac{\partial p}{\partial r}\right)_{r=r_w^+} \tag{2.59}$$

Redefine the following dimensionless groups:

$$p_D(r_D,t_D) = \frac{[p_i - p(r,t_D)]}{(p_i - p_{tf} - b)} \tag{2.60}$$

and:

$$q_D(t_D) = \frac{q(t)\mu}{2\pi kh(p_i - p_{tf} - b)} \tag{2.61}$$

where $b = H\bar{\rho}$. Finally let:

$$a = \frac{64khL}{q_c D^4} \tag{2.62}$$

Substitution of Eqs. 2.60-2.62 in 2.59 yields:

$$p(r_w,t) = p_{tf} + a(p_i - p_{tf} - b)q_D + b + s\left(r\frac{\partial p}{\partial r}\right)_{r=r_w^+} \tag{2.63}$$

Rearranging yields:

$$p_D(1,t_D) = 1 + (s+a)\left(\frac{\partial p_D}{\partial r_D}\right)_{r_D=1^+} \quad (2.64)$$

Eq. 2.64 is exactly like Eq. 2.14, the dimensionless form of the inner boundary condition used previously. The solutions discussed in this chapter are therefore valid for constant wellhead pressure production with laminar flow in the well-bore, if the dimensionless variables are redefined as in the preceding. In particular, the transient rate response is identical except for an increase in the effective skin factor. Furthermore, substitution of typical values for the parameters in a indicates that a is typically less than 0.01; and hence, $s+a \cong s$.

In the case of fully turbulent flow in the wellbore, the friction factor depends only upon the relative roughness of the well pipe and would be a constant for a given case. In this case Eq. 2.53 applies with the friction factor constant.

$$p_{wf} - p_{tf} = a' q_D^2 (p_i - p_{tf} - b) + b \quad (2.65)$$

where:

$$a' = \frac{32\, L\bar{\rho}\ f_M (kh)^2 (p_i - p_{tf} - b)}{\mu g_c D^5} \quad (2.66)$$

The inner boundary condition, Eq. 2.3, becomes:

$$p(r_w,t) = p_{tf} + a'q_D^2\,(p_i - p_{tf} - b) + b + s\left(r\,\frac{\partial p}{\partial r}\right)_{r=r_w^+} \qquad (2.67)$$

Redefining dimensionless groups as before and rearranging yields:

$$p_D(1,t_D) = 1 + a'\left(\frac{\partial p_D}{\partial r_D}\right)^2_{r_D=1^+} + s\left(\frac{\partial p_D}{\partial r_D}\right)_{r_D=1^+} \qquad (2.68)$$

Although the problem could be resolved using this condition, it was beyond the objectives of this study to do so. The condition was one finding of the study and poses an interesting problem for future investigation. In the next section, the effect of wellbore storage is examined as a further extension of the constant wellhead pressure solution.

2.5 EFFECT OF WELLBORE STORAGE

A drop in the wellhead pressure, whether due to constant rate or constant pressure flow can cause fluid production from the wellbore itself independent of the formation. When the surface rate is constant, variable fluid production from the wellbore causes a variable rate at the sand face. For the constant rate case, the effect of wellbore storage is incorporated into the inner boundary condition through a material balance on the wellbore. The same procedure can be used to include wellbore storage for the case of constant pressure production. The derivation follows.

The isothermal compressibility of the wellbore fluid is defined by:

$$c_w = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T \tag{2.69}$$

By the chain rule for differentiation:

$$c_w = -\frac{1}{V}\left(\frac{\partial V}{\partial t}\right)_T \Big/ \left(\frac{\partial p}{\partial t}\right)_T \tag{2.70}$$

Thus, the rate of fluid production from the well'bore volume, V_w, is:

$$q_w = \left(\frac{\partial V_w}{\partial t}\right)_T = -c_w V_w \frac{\partial p_{wf}}{\partial t} \tag{2.71}$$

V_w includes the volume of the wellbore, the annulus, and any additional volume of fluid connected with the wellbore which may be produced without changing the sand face pressure. The total surface fluid production rate, q_t, is the sum of the production rate from the wellbore volume, q_w, and the production rate from the sand face, q. Thus:

$$q_t = V_w c_w \frac{\partial p_{wf}}{\partial t} + \frac{2\pi kh}{\mu}\left(r\frac{\partial p}{\partial r}\right)_{r=r_w^+} \tag{2.72}$$

From Eq. 2.3:

$$p_{wf}(t) = p(r_w,t) - s\left(r\frac{\partial p}{\partial r}\right)_{r=r_w^+} \tag{2.3}$$

and :

$$\frac{dp_{wf}}{dt} = \left(\frac{\partial p}{\partial t}\right)_{r=r_w^+} - s\frac{\partial}{\partial t}\left(r\frac{\partial p}{\partial r}\right)_{r=r_w^+} \tag{2.73}$$

Defining p_D and q_D as in Section 2.4, and defining the dimensionless storage by:

$$C_D = \frac{V_w c_w}{2\pi\phi c_t h r_w^2} \tag{2.74}$$

the total dimensionless surface rate is:

$$q_{tD} = C_D \left[\left(\frac{\partial p_D}{\partial t_D}\right)_{r_D=1^+} + s \frac{\partial}{\partial t_D} \left(\frac{\partial p_D}{\partial r_D}\right)_{r_D=1^+} \right] + \left(\frac{\partial p_D}{\partial r_D}\right)_{r_D=1} \tag{2.75}$$

Taking the Laplace tranformation of q_{tD} results in:

$$\bar{q}_{tD}(\ell) = \left[C_D\, \ell \bar{p}_D(1,\ell) + s \left(\frac{\partial \bar{p}_D}{\partial r_D}\right)_{r_D=1^+} \right] + \frac{\partial \bar{p}_D}{\partial r_D}\bigg|_{r_D=1^+} \tag{2.76}$$

Substituting the solution for $\bar{p}_D$ and $\left(\frac{\partial \bar{p}_D}{\partial r_D}\right)_{r_D=1^+}$ for the infinite system given in Table 2.1 with the skin factor adjusted to include wellbore friction pressure loss and rearranging results in:

$$\bar{q}_{tD}(\ell) = C_D \left[\frac{K_o(\sqrt{\ell}) + S\sqrt{\ell}\, K_1(\sqrt{\ell})}{K_o(\sqrt{\ell}) + (s+a)\sqrt{\ell}\, K_1(\sqrt{\ell})} \right] + \frac{K_1(\sqrt{\ell})}{\sqrt{\ell}[K_o(\sqrt{\ell}) + (s+a)\sqrt{\ell}\, K_1(\sqrt{\ell})]} \tag{2.77}$$

In the preceding section, comparison of s and s+a indicated that they are approximately equal. Thus Eq. 2.77 reduces to:

$$\bar{q}_{tD}(\ ) = C_D \frac{K_1(\sqrt{\ell})}{\sqrt{\ell}[K_o(\sqrt{\ell}) + s\sqrt{\ell}K_1(\sqrt{\ell})]} \qquad (2.78)$$

This expression can be derived from the van Everdingen and Hurst (1949) equation discussed in Section 2.2 (Eq. 2.28).

The inverse transformation of the constant term in Eq. 2.78 is C_D multiplied by the Dirac delta, function, $\delta(t)$. (See Abramowitz and Stegun (1972), page 1029.) Thus, the theory implies an immediate unloading of the wellbore, and subsequent flow rates are unaffected by the wellbore storage effect. The lack of prolonged wellbore storage effects may be an advantage of constant pressure testing. However, if the initial flow rate is limited by a critical flow restriction, the wellbore storage effect may last for a longer period of time.

The final aspect of the problem of constant pressure production to be considered in this chapter is interference analysis. This topic is examined in the next section.

2.6 INTERFERENCE ANALYSIS

The well test analysis methods presented thus far in this work have concentrated on the behavior of the solutions at the producing well. This section deals with the pressure variation in the reservoir away from the well. Interference analysis is a method for determining reservoir parameters by observing the pressure response or interference at a nearby non-producing well. For the constant rate case, Mueller and Witherspoon (1965) showed that the line source solution can be used to determine the pressure drop in the reservoir for $r_D > 25$, and that for $t_D/r_D^2 > 25$, the log approximation holds:

$$p_D(r_D,t_D) = \frac{1}{2}\left(\ln \frac{t_D}{r_D^2} + 0.80907\right) \qquad (2.79)^*$$

For zero storage, these approximations are valid even if a nonzero skin factor is present.

Interference analysis is more complicated when the production is at a constant pressure. The most obvious difficulties are shown in Fig. 2.6, a graph of p_D vs t_D/r_D^2. The figure indicates that a different solution results for each value of r_D. Unlike the constant rate solution, the pressure distribution for constant pressure production does not correlate with the line source solution. Although the graph of p_D/q_D vs t_D/r_D^2 shown in Fig. 2.7 shows that for $t_D/r_D^2 \gtrsim 10^4$ the log approximation holds, this is not particularly useful. In order to make use of this property in well test analysis, the production rate must be known during the entire interference test. If the rate versus time data is

* In Eq. (2.79) p_D refers to the dimensionless pressure drop for constant rate production.

available, it can be analyzed directly, and the interference data does not, in general, produce additional information about the reservoir. Furthermore, for every nonzero skin factor, another family of curves results, as shown in Fig. 2.8.

Interference between flowing wells is also more complicated for constant pressure production. The method of imaging used to generate linear boundaries near a well requires superposition in time of constant rate solutions. When the rates are continuously varying, the derivation requires superposition in time and space. The method of superposition in time of continuously varying rate solutions is explained in Section 3. Hence, the topic of interference between flowing wells is revisited in Section 3.4.3.

This concludes the discussion of transient rate analysis for wells produced at constant pressure. In the next section pressure buildup solutions for wells produced at constant pressure are derived.

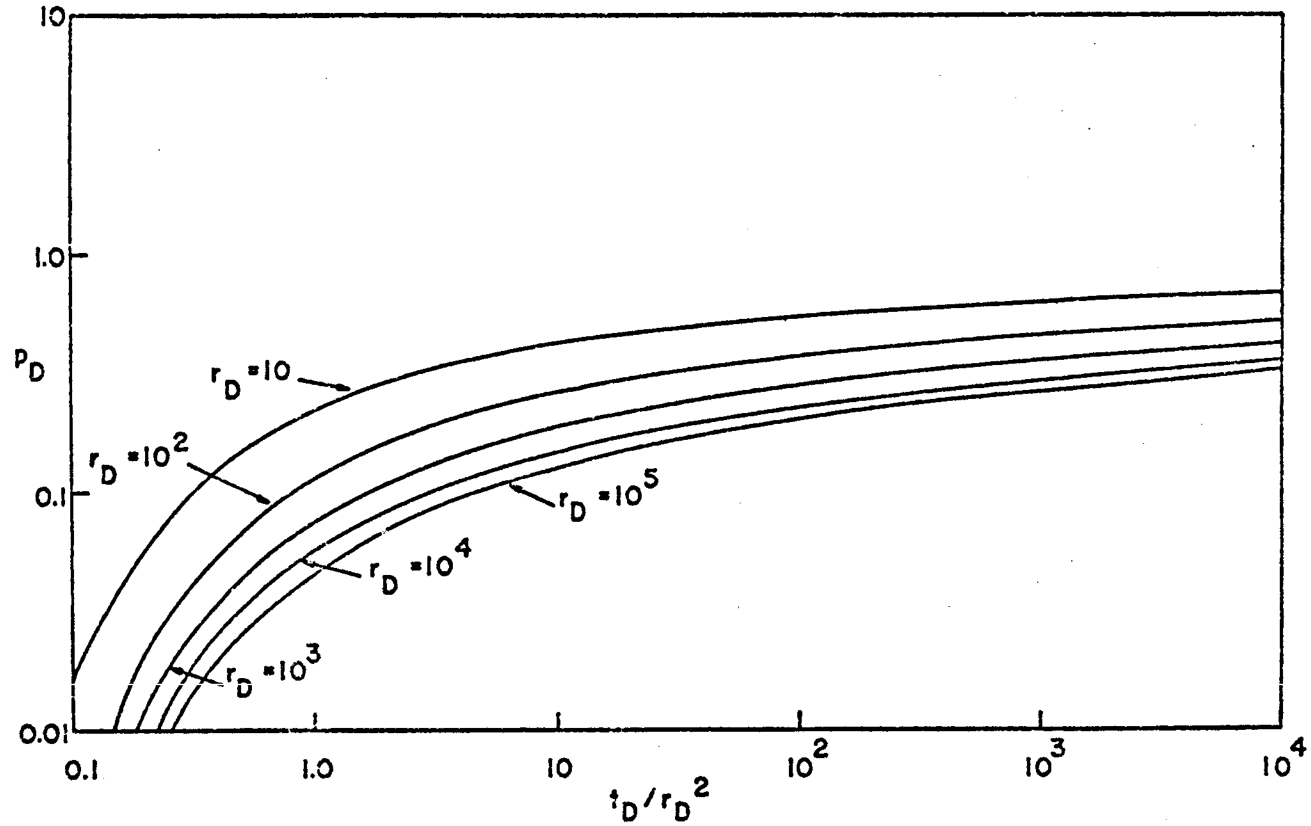

Figure 2.6: Dimensionless Pressure for Various Observation Well Locations for a Well Produced at Constant Pressure from an Unbounded Reservoir with Zero Skin

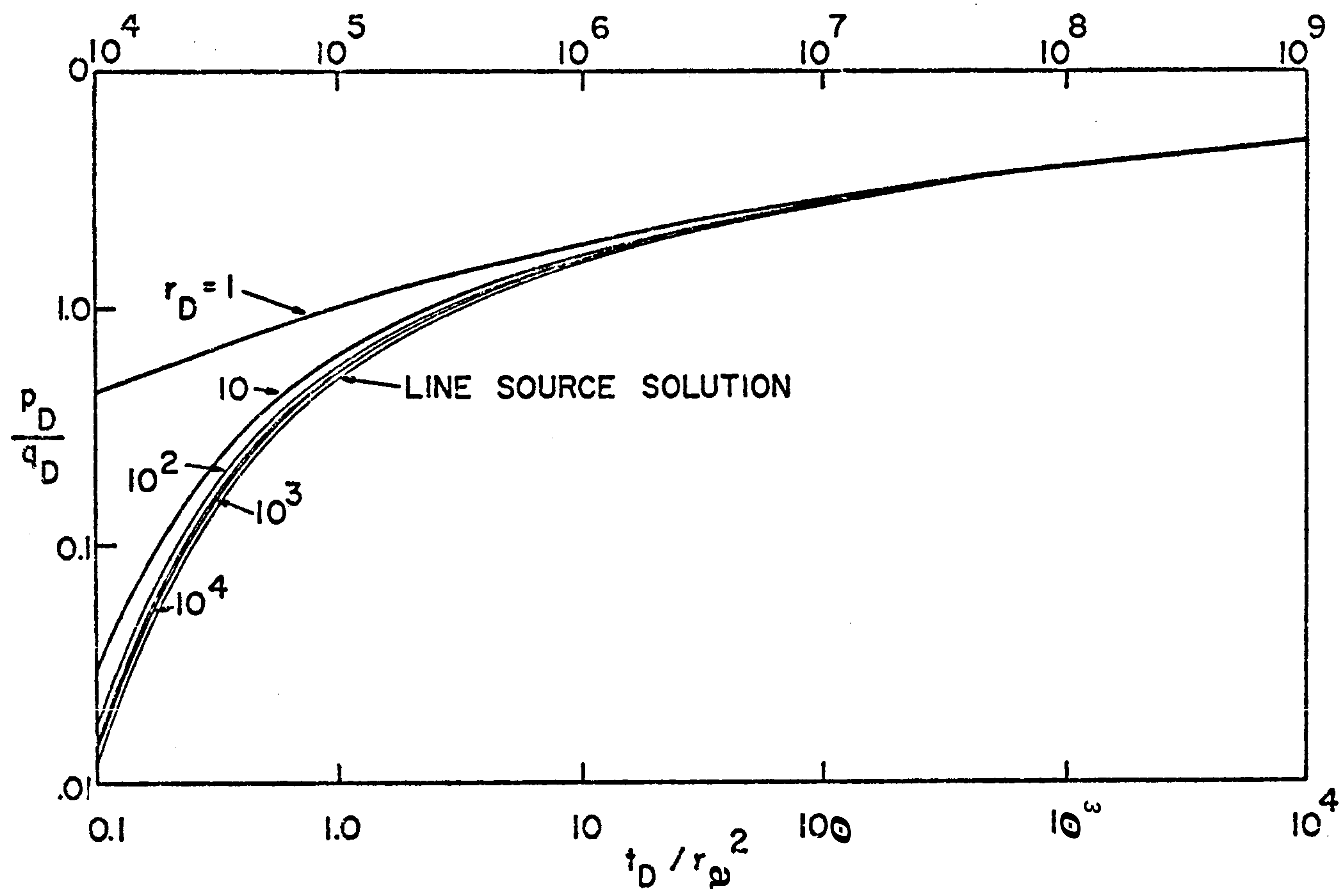

Figure 2.7: Normalized Graph of Dimensionless Pressure for Various Observation Well Locations for a Well Produced at a Constant Pressure from an Unbounded Reservoir with Zero Skin

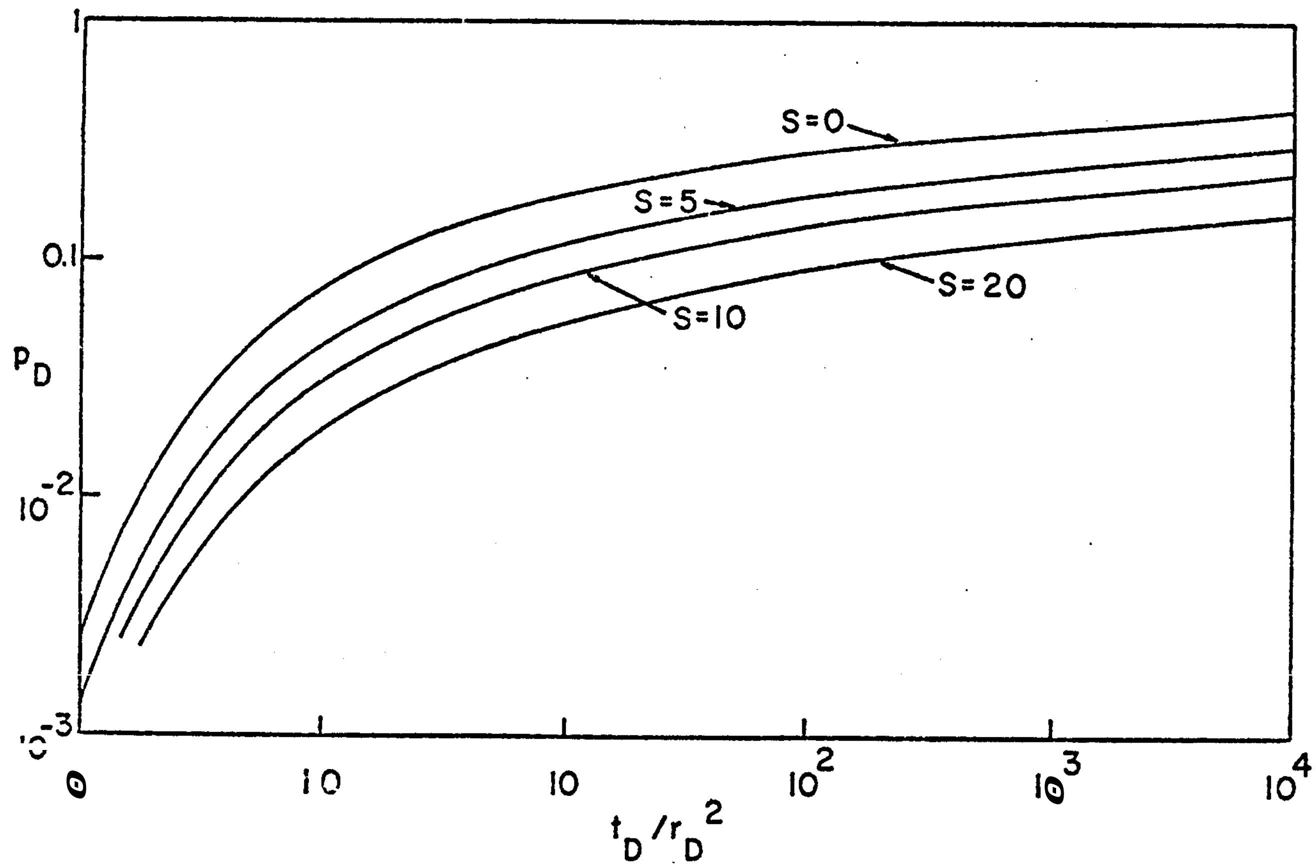

Figure 2 8: Dimensionless Pressure for an Observation Well Located at $r_D=10^3$ for a Well Produced at a Constant Pressure from an Unbounded Reservoir with Various Nonzero Skin Values

SECTION 3

PRESSURE BUILDUP AFTER CONSTANT PRESSURE PRODUCTION

In Section 2 the transient rate response and pressure distributions for constant pressure production were discussed. Methods analogous to pressure drawdown analysis for constant rate well tests were provided. In this section, pressure buildup following constant pressure production is examined. Pressure buildup after constant rate production is a simpler problem to handle analytically, but through use of superposition in time of constant rate solutions, an integral expression for the pressure buildup after constant pressure production can be written. This method is explained in the Section 3.1. Section 3.2 reveals the solution for pressure buildup and how to apply conventional methods of pressure buildup analysis to wells produced at constant pressure. Methods are discussed for determination of wellbore storage and skin effect by type curve matching, Horner buildup analysis, and determination of average reservoir pressure. Section 3.3 discusses the practical limitations of the theory. Finally, three additional applications of the method of superposition in time of constant rate solutions are discussed in Section 3.4.

3.1 THEORETICAL EXPRESSION FOR PRESSURE BUILDUP

For a finite number of changes in production rate with each rate constant over a finite period in time, the pressure at the wellbore is given by

$$p_{wf}(t) = p_i - \frac{\mu}{2\pi kh} [q_o p_{wD}(t) + (q_1 - q_o) p_{wD}(t - t_1)$$

$$+ \cdots + (q_N - q_{N-1}) p_{wD}(t - t_N)] \qquad (3.1)$$

where p_{wD} is the dimensionless pressure drop at the wellbore for unit constant rate production. This equation can be rewritten as the following:

$$p_{wf}(t) = p_i - \frac{\mu}{2\pi kh} \Big\{ q_o [p_{wD}(t) - p_{wD}(t - t_1)]$$

$$+ q_1 [p_{wD}(t - t_1) - p_{wD}(t - t_2)]$$

$$+ \cdots$$

$$+ q_N [p_{wD}(t - t_{N-1}) - p_{wD}(t - t_N)]$$

$$+ q_N p_{wD}(t - t_N) \Big\} \qquad (3.2)$$

From Eq. 3.2 it is easily seen that for a continuously changing rate, $q(t)$,

$$p_{wf}(t) = p_i + \frac{\mu}{2\pi kh} \int_o^t q(\tau) p_{wD}' (t - \tau) d\tau \qquad (3.3)$$

where the prime indicates the derivative with respect to time. If production is at constant pressure p_{wf}, Eq. 3.3 becomes:

$$1 = -\int_{o}^{t_D} q_D(\tau)\, p_{wD}'(t_D - \tau)d\tau \tag{3.4}$$

where q_D is the dimensionless flowrate defined by Eq. 2.11 in the preceding section, and t_D is dimensionless time. Referring again to Eq. 3.3, if production at constant pressure is changed to constant rate production after time t_p, the wellbore pressure at time t is given by:

$$p_{wf}(t) = p_i + \frac{\mu}{2\pi kh}\int_{o}^{t_p} q(\tau)p_{wD}'(t - \tau)d\tau - q_D(t_D)p_{wD}(t - t_p) \tag{3.5}$$

If the well is shut in, pressure buildup is exactly determined from:

$$p_{wf}(\Delta t) = p_i + \frac{\mu}{2\pi kh}\int_{o}^{t_p} q(\tau)p_{wD}'(t - \tau)d\tau \tag{3.6}$$

where Δt is the elapsed time after shut-in. The integral in Eq. 3.6 is difficult to evaluate because $q_D(0)$ is infinite. However, the equation can be written in a more easily evaluated form by using Eq. 3.4:

$$\frac{p_i - p_{ws}(\Delta t_D)}{p_i - p_{wf}} = -\int_{o}^{t_{pD}+\Delta t_D} q_D(\tau)p_{wD}'(t_{pD} + \Delta t_D - \tau)d\tau + \int_{t_{pD}}^{t_{pD}+\Delta t_D} q_D(\tau)p_{wD}'(t_{pD} + \Delta t_D - \tau)d\tau \tag{3.7}$$

or:

$$\frac{p_i - p_{ws}(\Delta t_D)}{p_i - p_{wf}} = 1 + \int_{t_{pD}}^{t_{pD}+\Delta t_D} q_D(\tau)p_{wD}'(t_{pD} + \Delta t_D - \tau)d\tau \tag{3.8}$$

Eq. 3.8 is general. The functions to be used for q_D and p_D can be chosen for any set of inner and outer boundary conditions. Examination of the integration limits reveals that q_D is evaluated for late times $(t > t_p)$ and p_{wD}' is evaluated beginning with time zero. Thus, phemonema such as wellbore storage, skin effect, or a fracture penetrated by the well-bore, should be included in the pressure function, while boundary effects will affect the rate function and, later in shut-in time, the pressure function as well.

Although the integral in Eq. 3.8 is similar to a convolution integral, it cannot be solved easily by Laplace transformation. However, Eq. 3.8 can be integrated numerically. Numerical evaluation of the integral is discussed in Appendix C.

3.2 ANALYSIS OF PRESSURE BUILDUP

The problem of pressure buildup after constant pressure production has received only limited attention in the literature. Methods of analysis have been suggested in both the petroleum and the groundwater literature,, but theoretical justification of the methods is almost nonexistent. Evaluation of the expression for pressure buildup given by Eq. 3.8 provides an exact solution which is used to determine methods of analysis which are theoretically valid.

Three periods of shut-in time are discussed: the early shut-in period, when wellbore effects dominate, the period when Horner buildup analysis applies, and the late time when outer boundary effects are evident.

3.2.1 Early Shut-in Time

For small shut-in periods, the rate function $q_D(\tau)$ is essentially constant for $t_{pD} < \tau < t_{pD} + \Delta t_D$. Hence, examination of Eq. 3.8 reveals that pressure recovery can be approximated accurately by:

$$\frac{p_i - p_{ws}(\Delta t)}{p_i - p_{wf}} \cong 1 - q_D(t_{pD})p_{wD}(\Delta t_D) \tag{3.9}$$

whenever $q_D(t_{pD}) \cong q_D(t_{pD}+\Delta t_D)$. Dividing by $q_D(t_{pD})$ and rearranging results in:

$$\frac{p_{ws}(\Delta t) - p_{wf}}{q(t_p)\mu/2\pi kh} = p_{wD}(\Delta t) \tag{3.10}$$

Thus, a log-log graph of $p_{ws}(\Delta t) - p_{wf}$ vs time can be compared to type curves of pressure drawdown for constant flow rate production. Effects of early transient behavior such as wellbore storage and skin effects, partial penetration, or the evidence of a fracture, can be analyzed using conventional type curve matching techniques.

3.2.2 Horner Buildup Analysis

According to the method by Horner (19511, buildup pressures may be graphed vs log [(t + Δt)/Δt] in order to produce a semilog straight line. The slope of the line is used to determine permeability from the equation:

$$k = \frac{q\mu \cdot \ln 10}{4\pi mh} \qquad (3.11)$$

Horner suggested that for variable rate production prior to shut-in, the permeability should be calculated using Eq. 3.11 with q equal to the last established flow rate, q_f, and m determined from the slope of a graph of $p_{ws}(\Delta t)$ vs log $[(t_p^* + \Delta t)/\Delta t]$, where $t_p^* = Q(t_p)/q(t_p)$. Jacob and Lohman (1952) graphed $p_{ws}(\Delta t)$ vs log $[(t_p + \Delta t)/\Delta t]$ and calculated permeability from Eq. 3.17 with q equal to the average flow rate, instead of the last flow rate.

In the present work, several cases involving pressure buildup after constant pressure production for infinite, closed bounded, and constant-pressure bounded circular reservoirs were computed by numerical integration of Eq. 3.8. In every case, if there was a period of time when the pressure buildup was not dominated by boundary effects, the semilog straight line was present, and the slope produced the correct value for the permeability when the data were graphed according to Horner's method.

The following derivation shows that the Horner method of graphing buildup data will always result in the correct straight line, provided that early transient effects and late boundary effects are separated in time. Referring again to Eq. 3.9, we divide by $q_D(t_{pD} + \Delta t_D)$:

$$\frac{p_i - p_{wf}(\Delta t_D)}{(p_i - p_{wf})q_D(t_{pD} + \Delta t_D)} = \frac{1}{q_D(t_{pD} + \Delta t_D)} - p_{wD}(\Delta t_D) \qquad (3.12)$$

When $10^4 \lesssim t_p \lesssim t_{pss}$, this can be written as:

$$\frac{p_i - p_{ws}(\Delta t_D)}{(p_i - p_{wf})q_D(t_{pD} + \Delta t_D)} \cong \frac{1}{2}\left[\ell n(t_{pD} + \Delta t_D) + 0.80907\right] - p_{wD}(\Delta t_D) \qquad (3.13)$$

For $\Delta t_D \gtrsim 5$, the log approximation is valid for p_{wD}, and:

$$\frac{p_i - p_{wf}(\Delta t_D)}{(p_i - p_{wf})q_D(t_{pD} + \Delta t_D)} \cong \frac{1}{2}\,\ell n[(t_{pD} + \Delta t_D)/\Delta t_D] \qquad (3.14)$$

or:

$$p_{ws}(\Delta t) \cong p_i - \frac{q(t \;\; + \Delta t)}{4\pi kh}\,\ell n[(t_p + \Delta t)/\Delta t] \qquad (3.15)$$

Noting that $q(t_p) = q(t_p + \Delta t)$ for $\Delta t \ll t_p$, this expression is identical to the result for constant rate flow, except that if $q(t_p)$ were constant, t would be equal to the Horner corrected flow time, t_p^*. Hence, to produce the correct slope, t_p^* must be used.

At infinite shut-in time, the extrapolated pressure for Eq. 3.15 is p_i. Thus, the behavior of the Horner pressure buildup curve following constant pressure production that has not shown a boundary influence is identical to the constant rate case.

The Jacob and Lohman (1952) method of using the average rate prior to shut-in is justified by the following arguments. If the variation in q_D is small for $0 < t_D < t_{pD}$, then Eq. 3.6 may be approximated by the following:

For $\Delta t_D \gtrsim 5$, the log approximation is valid for p_{wD}, and:

$$\frac{p_i - p_{ws}(\Delta t_D)}{p_i - p_{wf}} \cong \bar{q}_D(t_{pD}) \ \frac{1}{2} \ln[(t_{pD} + \Delta t_D)/\Delta t_D] \qquad (3.16)$$

or:

$$p_{ws}(\Delta t) = p_i - \frac{\bar{q}\mu}{4\pi kh} \ln[(t_p + \Delta t)/\Delta t] \qquad (3.17)$$

The last expression is identical to the result for constant rate flow except that $\bar{q}$ is computed from $Q(t_p)/t_p$. This method is equivalent to the Horner method as long as $t <$ t_{pss} Once exponential decline has begun, the approximation in Eq. 3.22 is no longer valid.

In the next section, boundary effects are considered. The Horner method is shown to be an effective means of analysis, even when boundary effects are evident prior to shut-in.

3.2.3 Outer Boundary Effects

When $t_p > t_{pss}$, the Horner method still produces a semi-log straight line for Δt sufficiently small, because $q_D(t_{pD})$ may be assumed to be constant. However, unlike in Eq. 3.15, the extrapolated pressure is not p_i, but, to use the conventional notation, p^*.

The equation for p^* is derived as follows. For the closed bounded reservoir, early enough in shut-in time that $t_p >> \Delta t$ but late enough that $\Delta t_D > 100$:

$$\frac{p_i - p_{ws}(\Delta t_D)}{(p_i - p_{wf})q_D(t_{pD})} \cong \frac{1}{q_D(t_{pD})} - \frac{1}{2}(\ln \Delta t_D + 0.80907) \quad (3.18)$$

Adding and subtracting $\frac{1}{2}[\ln(t_{pD}^* + \Delta t_D) + 0.80907]$,

$$\frac{p_i - p_{ws}(\Delta t_D)}{(p_i - p_{wf})q_D(t_{pD})} \cong \frac{1}{q_D(t_{pD})} - \frac{1}{2}[\ln(t_{pD}^* + \Delta t_D) + 0.80907]$$

$$+ \frac{1}{2}\ln[(t_{pD}^* + \Delta t_D)/\Delta t_D]$$

$$\cong \frac{1}{q_D(t_{pD})} = \frac{1}{2}(\ln t_{pD}^* + 0.80907)$$

$$+ \frac{1}{2}\ln[(t_{pD}^* + \Delta t_D)/\Delta t_D] \quad (3.19)$$

Rearranging:

$$p_{ws}(\Delta t) = p^* - \frac{q(t_p)\mu}{4\pi kh}\ln[(t_p^* + \Delta t)/\Delta t] \quad (3.20)$$

where:

$$\frac{p_i - p^*}{(p_i - p_{wf})q_D(t_{pD})} = \frac{1}{q_D(t_{pD})} - \frac{1}{2}(\ln t_{pD}^* + 0.80907) \quad (3.21)$$

Eq. 3.21 can be used to determine static pressure correction curves analogous to those derived by Matthews, Brons, and Hazebroek (1954) for pressure buildup after constant rate production. Referring to the definition of $q_D(t_D)$ in

Eq. 2.26, the average reservoir pressurer pressure at shut-in for a circular reservoir is given by:

$$\frac{p_i - \bar{p}(t_{pD})}{p_i - p_{wf}} = \frac{Q(t_{pD})\pi\phi c_t h r_e^2}{p_i - p_{wf}}$$

$$= 2Q_D(t_{pD})/r_{eD}^2 \qquad (3.22)$$

Hence, the departure of the extrapolated pressure, p^*, **from** the actual average reservoir pressure, $\bar{p}$, is given by:

$$\frac{2\pi kh(p^* - \bar{p})}{q_t} \quad \frac{2Q_D(t_{pD})}{q_D(t_{pD})r_{eD}^2} \quad \overline{\quad} \quad q_D(t_{pD})$$

$$+ \frac{1}{2}(\ln t_{pD}^* + 0.80907) \qquad (3.23)$$

Substituting the exponential decline functions for Q_D and q_D, and recalling that $t_{pD}^* = Q_D(t_{pD})/q(t_{pD})$, results in:

$$\frac{4\pi kh(p^* - \bar{p})}{q_{t_p}\mu} = [\ln t_{pDA}^* + 3.45381 \qquad (3.24)$$

This result is identical to the equation for the Mathews, Brons, and Hazebroek curves for determining the average pressure in a closed bounded circular, reservoir produced at **a** constant rate for $t_{DA} > 0.1$. Fig. **3.1** is **a** graph of $4\pi kh(p^* - \bar{p})/q_{t_p}\mu$ vs t_{pDA}^*.

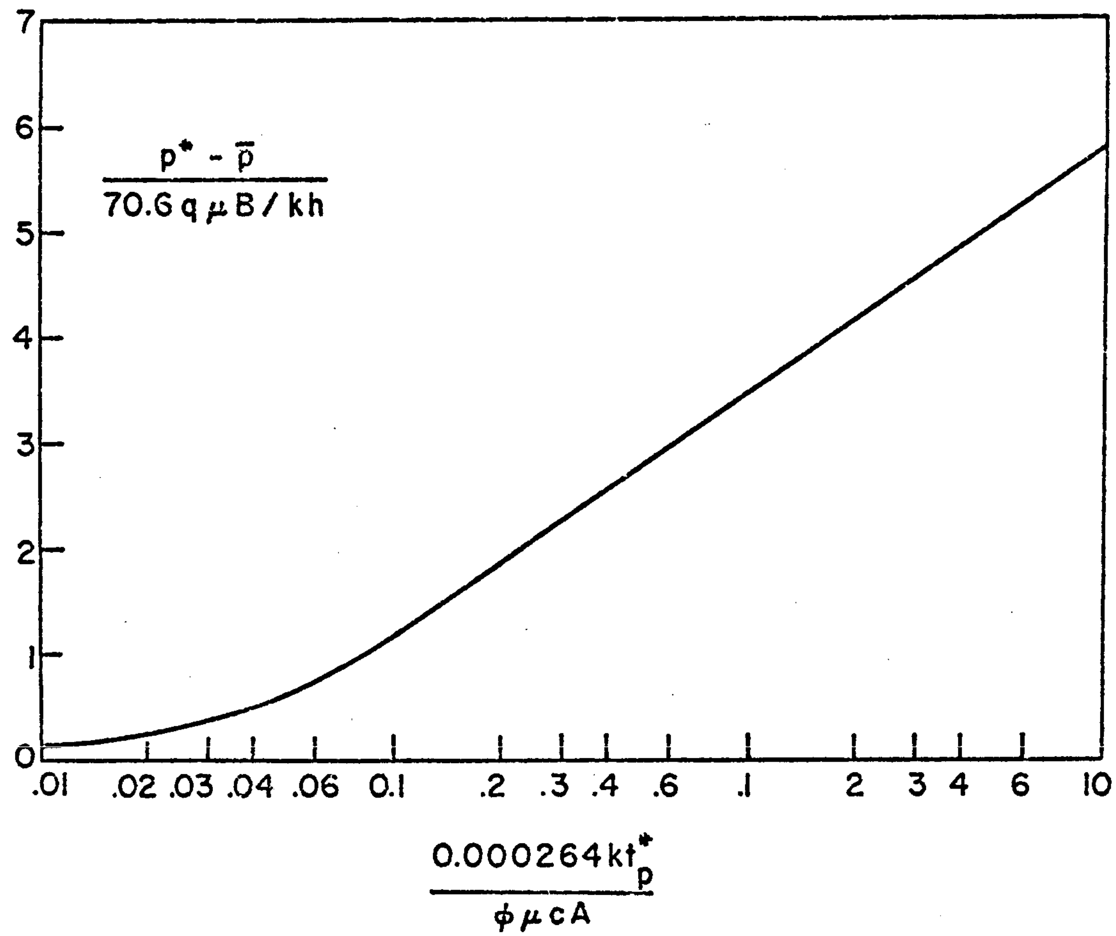

Figure 3.1: Graph of Matthews-Brons-Hazebroek Static Pressure for a Well Produced at a Constant Pressure from a Closed, Bounded Circular Reservoir

3.3 PRACTICAL LIMITATIONS OF THE THEORY

In general, pressure buildup for wells produced at constant pressure can be analyzed as effectively as pressure buildup for wells produced at constant rate. Hence, specific limitations in the theory to be discussed in this section affect pressure buildup analysis after both constant pressure and constant rate flow. Nonetheless, to alert the reader to possible pitfalls in the analysis, three problems are discussed: a short flow time before shut-in, wellbore effects, and outer boundary effects. To avoid errors in the analysis of pressure buildup, the engineer needs to be aware of the approximate ranges of time for which the various methods apply.

Limitations in the application of the Horner method with adjusted flow time have been discussed by previous investigators including Clegg (19671, Odeh and Selig (19631, and Sandrea (1971). The reasons for differences between their conclusions and the results herein are considered in Section 3.4.4.

3.3.1 Short Flow Time Before Shut-in

If the production time before shut-in is very short, the wellbore pressure may return essentially to the initial reservoir pressure before the semi-log straight line develops. Such cases are shown in Fig. 3.2. For each of the three

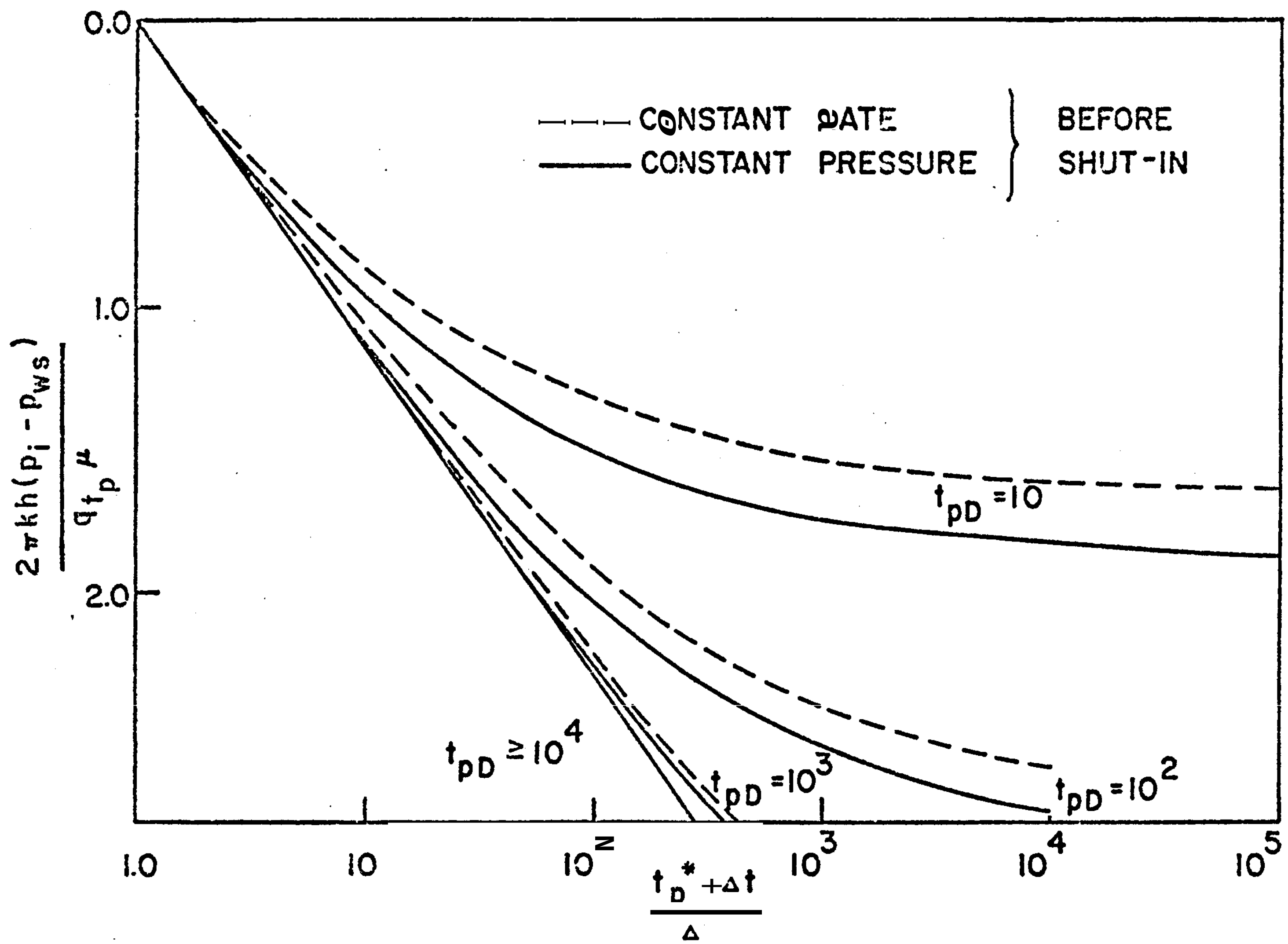

Figure 3.2: Examples of Horner Buildup Graphs for Very Short Flow Times for a Well Produced at a Constant Rate or a Constant Pressure Before Shut-In

flow times indicated, the Horner buildup graph failed to develop a semi-log straight line. However, as the dashed lines indicate, the problem also exists for each of these times for wells produced at constant rate. If the dimensionless flow time exceeds 10^4, the correct semi-log straight line will develop for wells produced at constant rate or at constant pressure, provided that the semi-log straight line portion is not masked by wellbore and/or outer boundary effects.

3.3.2 Wellbore Effects

Earlougher (1977) showed schematically the effects on pressure buildup data of inner boundary effects such as wellbore storage, skin effect, and fracture effects for wells produced at constant rate. The same curves apply for wells produced at constant pressure, as long as $\Delta t << t_p$ for the duration of the effect. Such effects can greatly prolong the length of shut-in time required for the correct semi-log straight line to develop. For example, Chen and Brigham (1974) demonstrated that wellbore storage effects do not vanish until $\Delta t_D > 50 C_D e^{.14s}$; and Earlougher estimated that the semilog straight line begins for $\Delta t_D > (60+3.5s) C_D$. Similarly, Earlougher indicated that effects of a fracture exist until the shut-in time exceeds a dimensionless fracture time, t_{xf_D}, of 3 for the infinite conductivity case, and 2 for the uniform flux case. Inner boundary effects should be analyzed by type curve matching in accordance with Eq. 3.16.

3.3.3 Outer Boundary Effects

As mentioned in Section 3.3, if exponential rate decline, or constant rate production develops during the flow period, then the buildup curve will show the effects of an outer boundary, if the shut-in time is long enough. If there is a period of time between the end of the inner boundary effects and the start of the outer boundary effects, however, the correct semi-log straight line will develop, no matter how long the rate may have been declining exponentially, if $r_D > 10^3$. Care must be taken to choose the semi-log straight line from the correct portion of the buildup graph.

3.3.4 Comparison with Previous Studies

Results of this study indicate that the correct semi-log straight line will develop during the course of the pressure buildup after constant pressure production, provided that inner and outer boundary effects are separated in time. This conclusion is not in agreement with certain previous studies. In this section, we will attempt to explain the different results.

One such study was published by Clegg (1967). In his analytical solution, an approximation of the pressure distribution at the time of shut-in was used as an initial condition in the solution of Eq. 2.1. The inner boundary condition was specified as a zero flow rate; and the outer boundary was assumed to be infinite. The error in the initial condition is shown in Fig. 3.3. This error explains the qualitative differences between the Clegg approximate solution for pressure buildup and the solution herein.

Other pertinent studies are those by Odeh and Selig (1963), and Sandrea (19711. These investigators concluded that the correct semi-log straight line would not develop when shut-in follows an exponentially declining production rate, particularly when the reservoir has undergone considerable depletion. Sandrea attributed differences between the results of Horner and Odeh and Selig for new wells to the method used by Odeh and Selig to discretize and interpret the data. For old wells, Sandrea concluded that the reservoir permeability would be underestimated and the static pressure overestimated by the Horner method. However, Sandrea's model assumes exponential decline from the beginning of production with a finite initial rate. For a large reservoir radius, there is a long period of rate decline before the exponential decline period. Hence, the behavior of the old wells discussed by Sandrea is not directly comparable with the results of the present study.

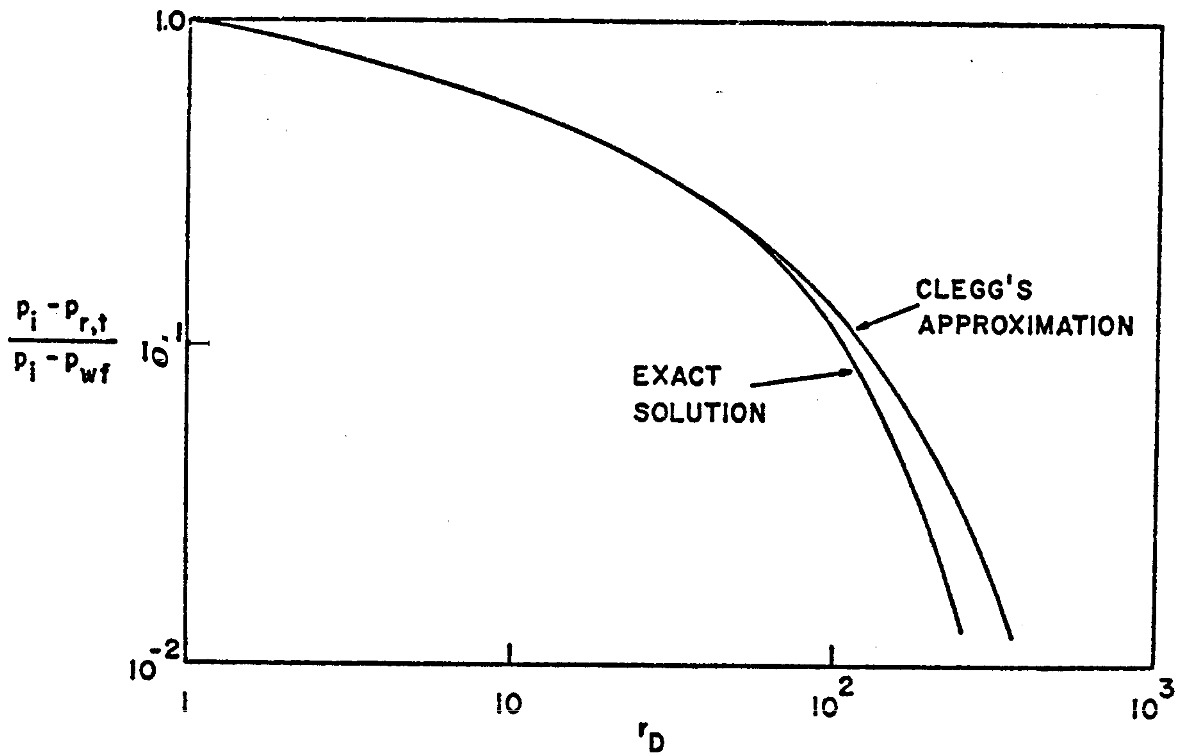

Figure [illegible]: Graph of Clegg's Approximation and the Exact Solution for the Pressure Distribution for a Well Produced at a Constant Pressure from an Unbounded Circular Reservoir

3.4 FURTHER APPLICATIONS OF THE SOLUTION TECHNIQUE

In this section the method of superposition in time is applied to three problems other than pressure buildup.

3.4.1 The Critical Flow Phenomenon

In Section 2.3.1 the possibility of a critical flow limited initial rate in the transient solution for wells produced at constant pressure was discussed. Using the superposition in time of solutions for step changes in the wellbore pressure, the rate as a function of time is given by:

$$q(t) = \frac{2\pi kh}{\mu} [(p_i - p_{wf_1})q_D(t) + (p_{wf_1} - p_{wf_2})q_D(t - t_1) + \cdots + (p_{wf_{N-1}} - p_{wf_N})q_D(t - t_N)] \quad (3.25)$$

For a continuously changing pressure:

$$q(t) = \frac{-2\pi kh}{\mu} \int_0^t q_D(t - \tau) \frac{dp_{wf}}{d} (\tau) d\tau \quad (3.26)$$

or:

$$\frac{q(t)}{q_i} = \int_0^t q_D(t - \tau) p_{wD}'(\tau) d\tau \quad (3.27)$$

If the initial rate is constant at q_c until the wellbore pressure reaches the pressure p_{wf}, then the rate as a function of the time after the onset of constant-pressure production is given by:

$$q(\Delta t) = \frac{-2\pi kh}{\mu} \int_0^{t_c} q_D(t - \tau) \frac{dp_{wf}}{d\tau}(\tau) d\tau \qquad (3.28)$$

where t_c is the time elapsed during the constant rate production. Since q, and p_{wf} are specified conditions, the quantity $\frac{2\pi kh}{q_c \mu}(p_i - p_{wf}) = p_{wfD}$ is specified, although the value of p_{wf} is not, in general, known. The value of t_c is the time when $p_D = p_{wfD}$ determined from the p_D solution for constant rate production. If nonzero storage and/or skin are present, this will affect the value for t_c.

The initial value for q (t) where $0 < t < t_c$ is given by $1/p_{wfD}$. When t is sufficiently large, $q(t-t_c) \cong q(t)$, and the following approximation holds:

$$q(\Delta t) = q_D(t) \cdot \frac{2\pi kh}{\mu}(p_i - p_{wf}) \qquad (3.29)$$

or:

$$q_D(\Delta t_D) = \frac{q(\Delta t_D)}{2\pi kh(p_i - p_{wf})}$$

$$= q_D(t_D) \qquad (3.30)$$

Thus, the effect of the initial constant rate on the solution dies out in time, and hence, the analysis techniques already discussed become valid. Approximate solutions can be determined from Eq. 3.30 for specified p_{wf}, C_D, and s. Some solutions are graphed in Fig. 3.4.

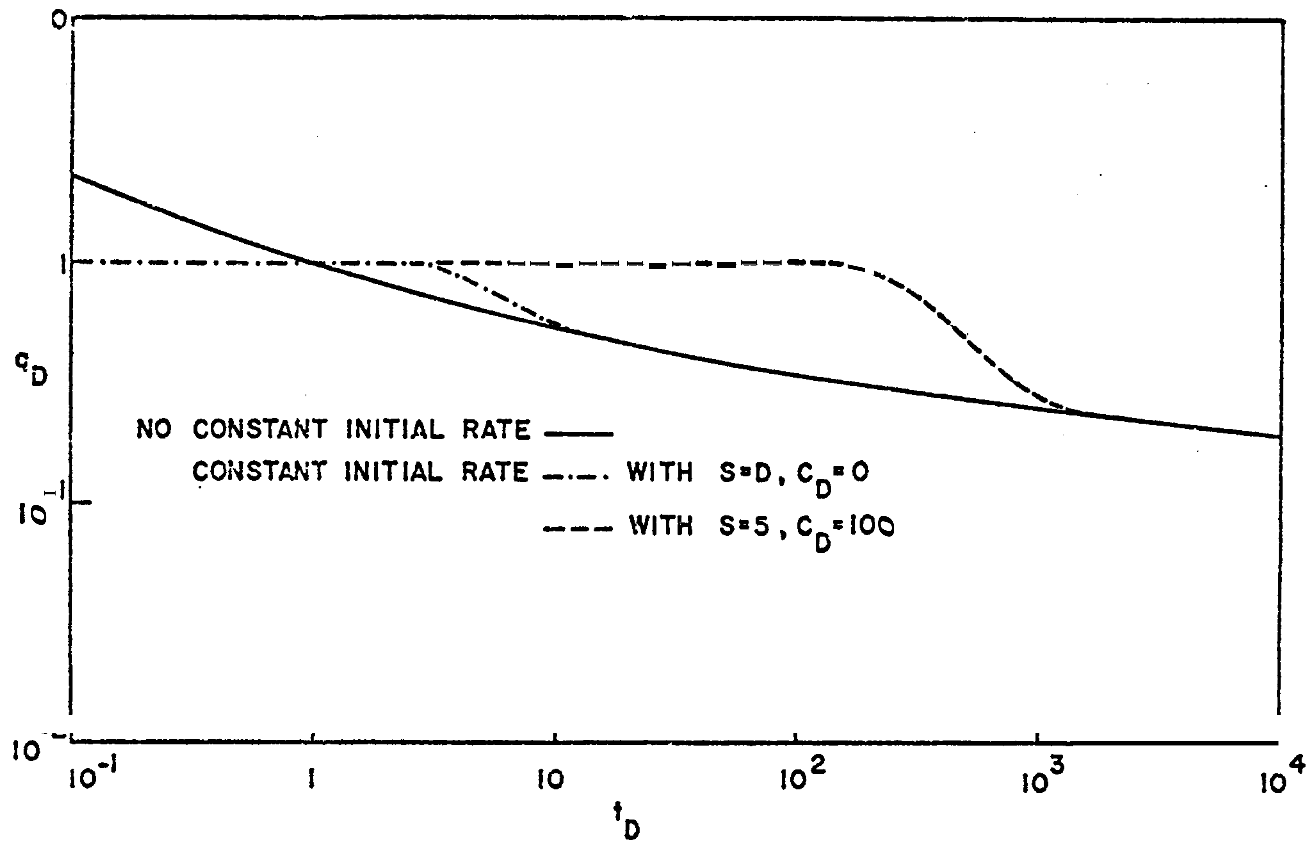

Figure 3.4: Approximate Transient Rate Solutions for Critical Flow Rate-Limited Production

3.4.2 Exponential Decline After Constant Rate Production

Often a well is produced at a constant rate until the reservoir has been nearly depleted, and the constant rate can no longer be maintained economically. Then the well is produced at the final pressure until it declines to some minimum allowable value. Assuming that the pressure decline has reached pseudo-steady state when constant pressure Production begins, the expression for p_{wD} is given by Eq. 2.38. Hence:

$$\frac{dp_{wD}}{dt_D} = 2\pi r_w^2/A \tag{3.31}$$

Refering to Eqs. 3.37 and 3.38:

$$\frac{q(\Delta t)}{q_c} = \int_o^{t_c} q_D(t-\tau)p_{wD}'(\tau)d\tau$$

$$= 1 - \int_{t_c}^{t} q_D(t-\tau)p_{wD}'(\tau)d\tau \tag{3.32}$$

Substitution of Eq. 3.31 and the definition of q into the integral results in:

$$\frac{q(\Delta t)}{q_c} = 1 - 2\pi r_w^2/A \cdot \frac{\mu}{2\pi kh(p_i - p_{wf})} \cdot \frac{k}{\phi\mu C_t r_w^2}$$

$$\cdot \int_{t_c}^{t} q(t-\tau)d\tau$$

$$= 1 - 2\pi \frac{r_w^2}{A} \cdot \frac{1}{2\pi\phi c_t h r_w^2 (p_i - p_{wf})} \int_o^{t-t_c} q(\tau)d\tau \tag{3.33}$$

or:

$$\frac{q(\Delta t)}{q_c} = 1 - 2\pi Q_D(t - t_c) r_w^2 / A \qquad (3.34)$$

For $(t-t_c)_{DA} > 0.1$, Eq. 2.50 may be substituted for $Q_D(t-t_c)$:

$$\frac{q}{q_c} = 1 - \frac{2\pi r_w^2}{\pi r_e^2} \left[r_{eD}^2 \left(1 - e^{-2\pi(t-t_c)_{DA}/(\ell n r_{eD} - 3/4)}\right) \right]$$

$$= e^{-2\pi(t-t_c)_{DA}/(\ell n r_{eD} - 3/4)} \qquad (3.35)$$

As noted before $q_C = 1/p_{wf}$ where p_{wf} is the final production pressure. Examination of Eq. 2.42 indicates that unlike the case in the last section in which the rate decline for a constant finite initial flow rate eventually matches the decline for constant pressure production for all time, in this case the rates are different for all time.

An example of two rate histories is shown in Fig 3.5. For a closed bounded circular reservoir of dimensionless radius $r_{eD} = 10^5$, curve A represents the production rates at a constant pressure p_{wf} for the entire production time. Curve B represents the production rates for constant-rate production, at $(q_c)_D = .025$, until the pressure in the wellbore declines to p_{wf}, and constant pressure production thereafter. Fig. 3.6 shows the cumulative production for the two rate histories. For this example, the skin factor was taken to be zero. Figures 3.7 and 3.8 show results for a positive

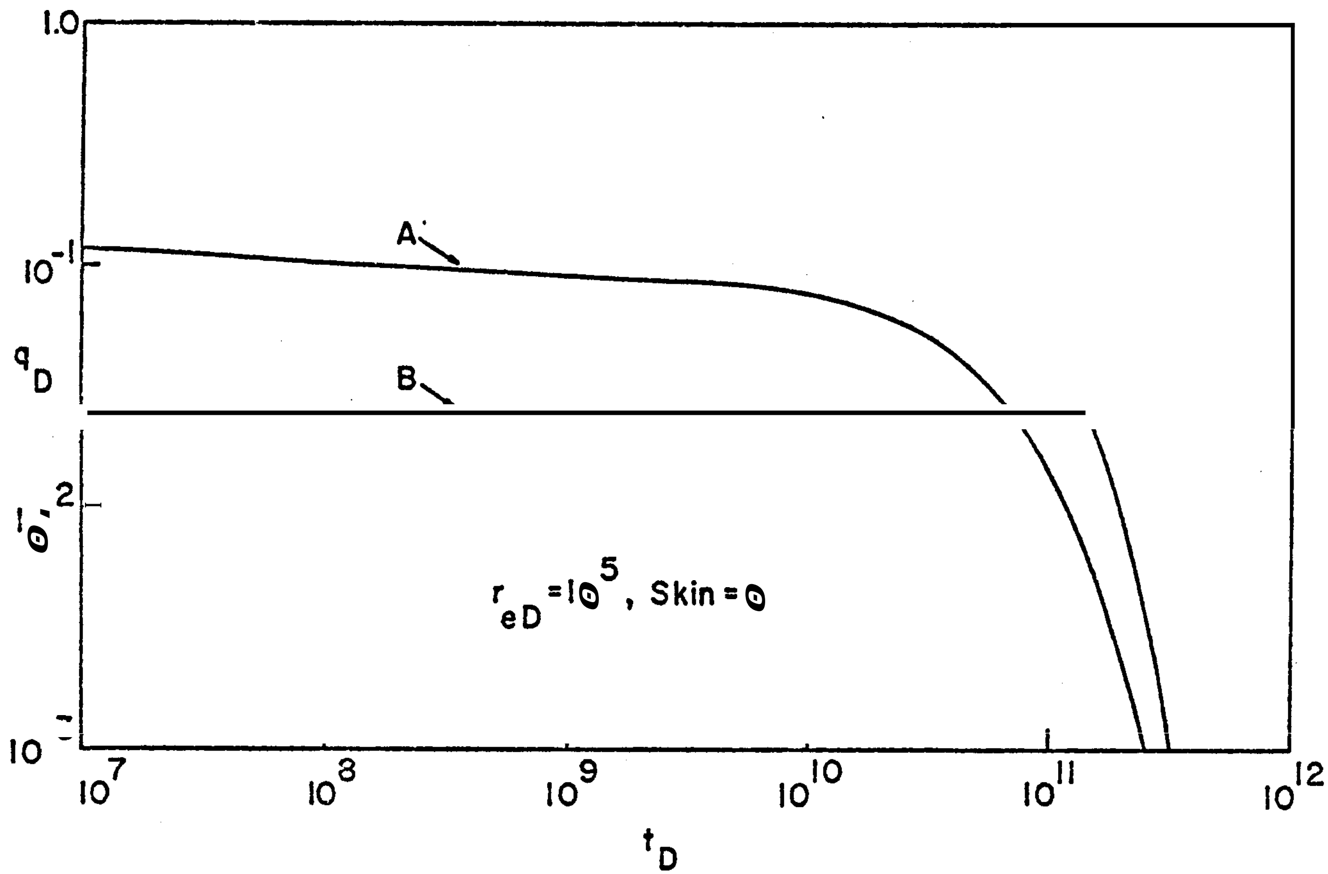

Figure 3.5: Two Rate Histories with Zero Skin

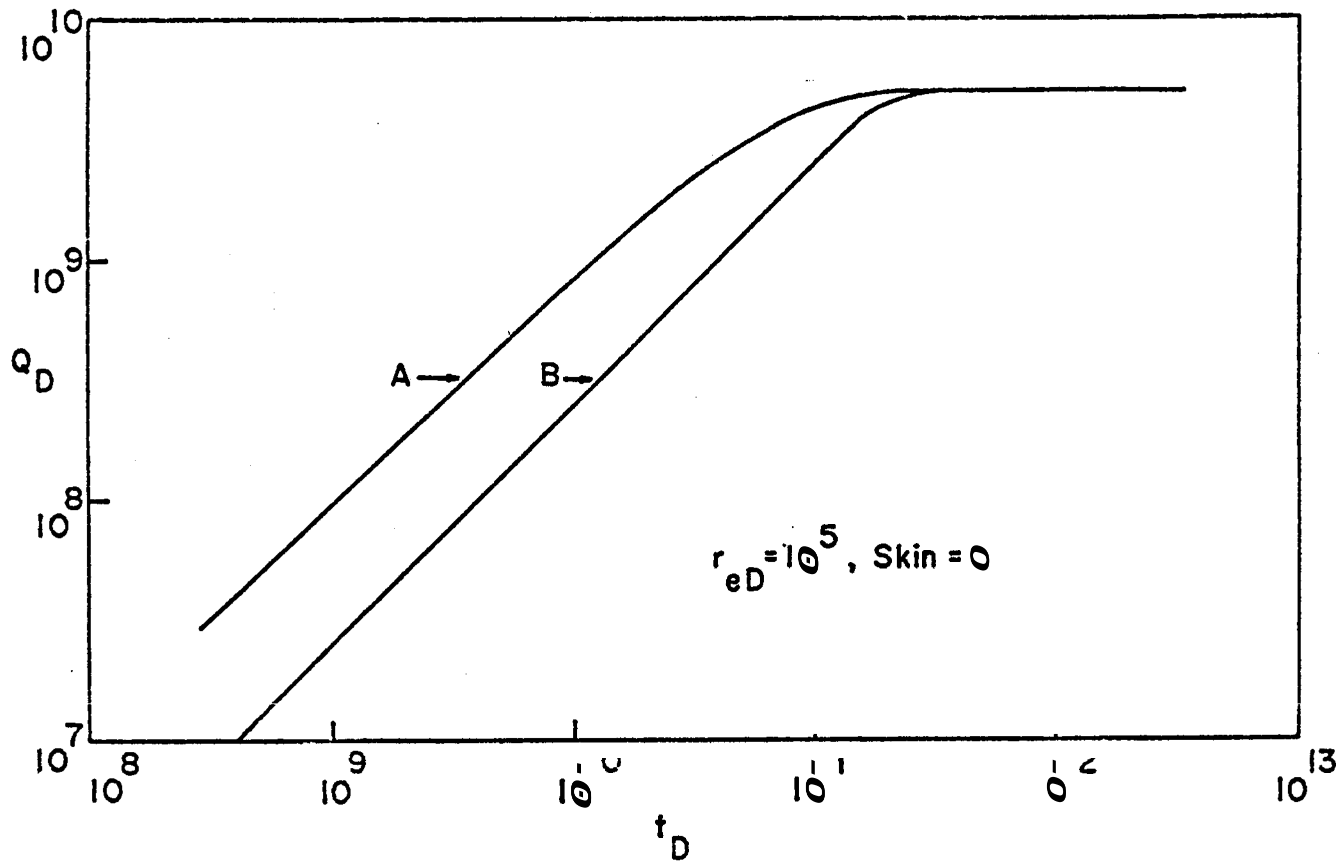

Figure 3.6: Cumulative Recovery for Rate Histories in Fig. 3.5

skin factor. The rate histories are compared in Fig. 3.7, and Fig. 3.8 shows the cumulative production.

3.4.3 Interference among Flowing Wells

The following derivation shows a general method for determining the pressure distribution and transient rate solutions for wells producing at constant pressures in interference with other wells producing at arbitrary constant rates or pressures. The pressure drop at any point (x,y) is given by:

$$p_i - p(x,y,t) = \sum_i \Delta p_i(t) \tag{3.36}$$

where Δp_i is the pressure drop due to the well at the point (x_i, y_i) produced at the rate q_i. If q_i is constant, then:

$$\Delta p_i(t) = p_D([(x_i - x)^2 + (y_i - y)^2]^{\frac{1}{2}}, t) \cdot \frac{q_i \mu}{2\pi kh} \tag{3.37}$$

(In this section, p_D refers to the dimensionless pressure drop for constant rate production. If the well at (x_i, y_i) is produced at a constant pressure:

$$\Delta p_j(t) = \frac{\mu}{2\pi kh} \int_0^t q_j(\tau) \frac{dp_D}{d\tau} ([x_j - x)^2 + (y_j - y)^2]^{\frac{1}{2}}, t - \tau) d\tau \tag{3.38}$$

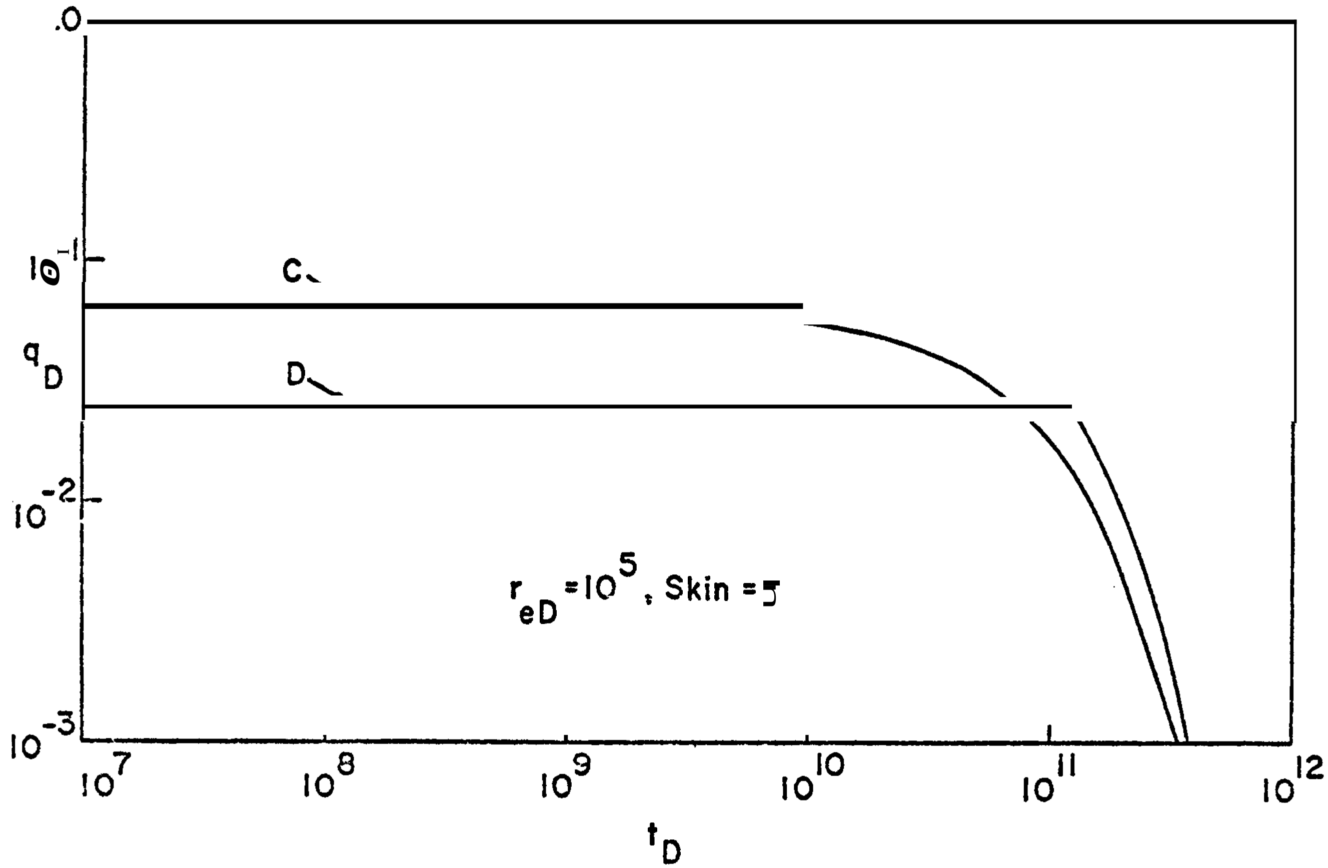

Figure 3.7: Two Rate Histories with Nonzero Skin

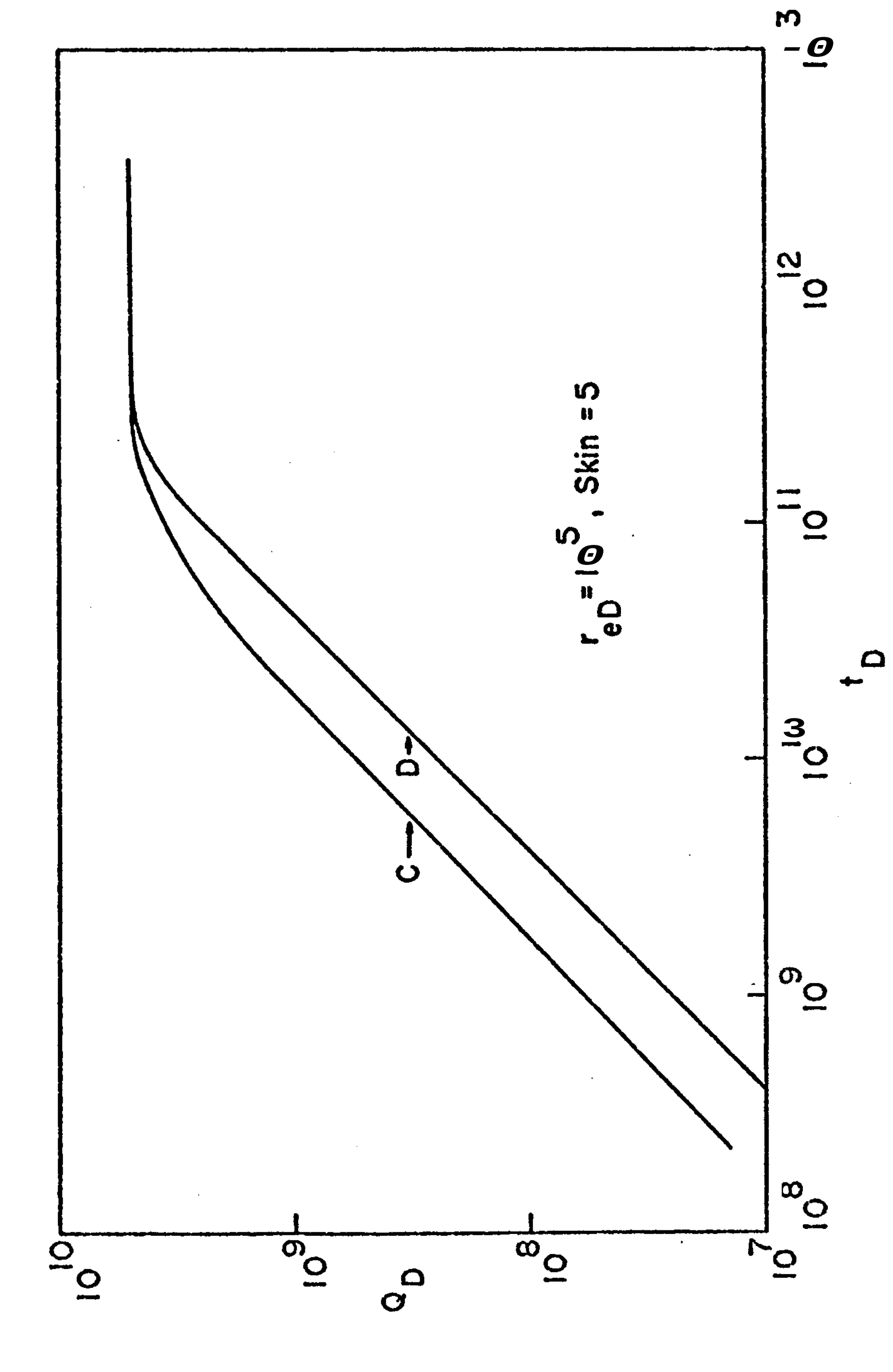

Figure 3.8: Cumulative Recovery for Rate Histories in Fig. 3.7

The rate functions, q_i, must be determined first; then the pressure distribution is computed using Eq. 3.35. To deter- mine the rate functions, apply the Laplace transformation to the equations for the producing pressure at each constant pressure well:

$$\frac{p_i - \bar{p}(x_k,y_k)}{\ell} = \frac{\mu}{2\pi kh}\left\{\sum_{i\neq k} q_j\ \bar{p}_D(r_{ik},\ell)\right.$$

$$\left. + \sum_{j\neq k} \bar{q}_j(\ell)\ell\ \bar{p}_D(r_{jk},\ell) + \bar{q}_k(\ell)\ell\bar{p}_{wD}(\ell)\right. \qquad (3.39)$$

where $r_{ij} = [(x_i-x_j)^2 + (y_i-y_j)^2]^{1/2}$. The system of equations can be written in the form:

$$[\Delta\bar{p}]_N = [b]_{N\times N} \cdot [\bar{q}]_N \qquad (3.40)$$

where:

$$\Delta\bar{p}_k = \frac{p_i - \bar{p}(x_k,y_k)}{\ell} - \frac{\mu}{2\pi kh}\sum_{i\neq k} \bar{p}_D(r_{ik},\ell)q_i \qquad (3.41)$$

and:

$$b_{kj} = \begin{cases} \frac{\mu}{2\pi kh}\ \ \bar{p}_D(r_{jk},\ell) & k \neq j \\ \ell\ p_{wD}\ (\ell) & k = j \end{cases} \qquad (3.42)$$

Once the rate functions are determined, the pressure distribution follows from Eq. 3.35. As an example, consider the case of two wells at a distance r_D, each produced at a constant pressure p_{wf}. Then:

$$p_i - p_{wf} = \frac{\mu}{2\pi kh}\int_0^t q(\tau)p'_{wD}(t-\tau)\,d\tau + \frac{\mu}{2\pi kh}\int_0^t q(\tau)p'_D(r_D,t-\tau)\,d\tau \quad (3.43)$$

or:

$$1 = \int_0^{t_D} q_D(\tau)p'_{wD}(t_D-\tau) + \int_0^{t_D} q_D(\tau)p'_D(r_D,t_D-\tau)\,d\tau \quad (3.44)$$

In Laplace space:

$$\frac{1}{\ell} = \ell\bar{q}_D(\ell)\bar{p}_{wD}(\ell) + \ell q_D(\ell)\bar{p}_D(r_D,\ell) \quad (3.45)$$

Solving for $\bar{q}_D(\ell)$:

$$\bar{q}_D(\ell) = \frac{1}{\ell^2[\bar{p}_{wD}(\ell) + \bar{p}_D(r_D,\ell)]} \quad (3.46)$$

or

$$\bar{q}_D(\ell) = \frac{K_1(\sqrt{\ell})}{\sqrt{\ell}[K_o(\sqrt{\ell}) + s\sqrt{\ell}\,K_1(\sqrt{\ell}) + K_o(r_D\sqrt{\ell})]} \quad (3.47)$$

Using the Stehfest algorithm, a solution for $q_D(t_D)$ can be determined numerically.

The Laplace space solution for $[p_i-p(x,y,t)]/(p_i-p_{wf})$ is given by:

$$\frac{p_i - \bar{p}(x,y,t)}{p_i - p_{wf}} = \bar{q}_D(\ell)[\bar{p}_D(r_1,t) + \bar{p}_D(r_2,t)] \quad (3.48)$$

This concludes the section on the use of superposition in time of continuously varying rates as a method for generating solutions involving wells produced at constant pressure. The method is a powerful tool, and the solutions presented here are meant to suggest important ways in which this tool can be used.

SECTION 4

CONCLUSIONS

The solutions provided in this work show that well test analysis methods for wells produced at constant pressure provide the same information about the reservoir as is determined from the conventional methods derived for constant-rate production. For nearly every constant-rate well test method there is an analogous constant-pressure method. A notable exception is interference analysis. Methods for analyzing interference between producing wells are more complicated, and require additional study.

The transient rate analysis methods may be limited in their effectiveness by practical problems. The technology for measuring production rates is not nearly as advanced as the measurement of transient pressures. However, for the same reason, maintaining a constant wellhead pressure is more reliable than maintaining a constant rate. Pressure buildup following constant-pressure production is not technology bound, and appears to be a viable alternative method which avoids the necessity for establishing a constant rate for some length of time prior to shut-in.

In summary, the methods provided here include the following:

1. Determination of k and ϕe^{-2s} by type curve matching with a graph of log q_D vs log t for the infinite system

2. Determination of k and s from the semilog straight line in a graph of 1/q vs log t

3. Determination of reservoir area and approximate shape from a graph of log q vs t after the onset of exponential decline

4. Analysis of transient rates when the wellhead pressure is constant

5. Determination of k and ϕe^{-2s} from an interference test by type curve matching with a graph of log p vs log t_D/r_D^2 for the infinite system

6. Determination of C_D, s, x_f for fractures penetrated by the wellbore, and other inner boundary effects, by type curve matching of early pressure buildup data with conventional pressure transient solutions

7. Horner buildup analysis for wells produced at constant pressure

8. Analogous methods for Matthews, Brons, Hazebroek determination of the static reservoir pressure

REFERENCES

1. Abramowitz, M., and I.A. Stegun: Handbook of Mathematical Functions, Dover Publications, Inc., 1972.

2. Carslaw, H.S., and Jaeger, J.C.: Conduction of Heat in Solids, Oxford at the Clarendon Press, 1959.

3. Chen, H.K., and Brigham, W.E.: "Pressure Buildup for a Well with Storage and Skin in a Closed Square", Paper SPE 4890, presented at the 44th Annual California Regional Meeting of the SPE of AIME, 1974.

4. Clegg, M.W.: "Some Approximate Solutions of Radial Flow Problems Associated with Production at Constant Well Pressure", J. Pet. Tech., Mar. 1967, 31-42.

5. Craft, B.C., and Hawkins, M.F.: Applied Petroleum Reservoir Engineering, Prentice-Hall, Inc., 1959, 284.

6. Earlougher, R.C., Jr.: Advances in Well Test Analysis, Monograph Series, SPE of AIME, Dallas, 1977, 5.

7. Earlougher, R.C., Jr., and Ramey, H.J., Jr.: "The Use of Interpolation to Obtain Shape Factors for Pressure Buildup Calculations", J. Pet. Tech., May 1968, 449-450.

8. Ferris, J., Knowles, D.B., Brown, R.G., and Stallman, R.W.: "Theory of Aquifer Tests", U.S.G.S. Water Supply Paper 1563E, 1962, 109.

9. Fetkovich, M.J.: "Decline Curve Analysis Using Type Curves", Paper SPE 4629, presented at the 48th Annual Fall Meeting of SPE of AIME, 1973.

10. Horner, D.R.: "Pressure Build-Up in Wells", Proc., Third World Pet. Cong., the Hague, 1951, Sec. II, 503-523.

11. Hurst, W.: "Unsteady Flow of Fluids in Oil Reservoirs", Physics, Jan. 1934, 5, 20.

12. Hurst, W.: "Water Influx into a Reservoir and Its Application to the Equation of Volumetric Balance", Trans., AIME, 1943, 151, 57.

13. Hurst, W., Clark, J.D., and Brauer, E.B.: "The Skin Effect in Producing Wells", J. Pet. Tech., Nov. 1969, 1483-1489.

14. Jacob, C.E., and Lohman, S.W.: "Nonsteady Flow to a Well of Constant Drawdown in an Extensive Aquifer", Trans., AGU, Aug. 1952, 559-569.

15. Juan-Camas, I.: "Determinacion de las Propiedades de un Yacimiento Mediante Pruebas de Gasto en un Pozo a Presion Constante", M.S. Report, University of Mexico, 1977.

16. Kucuk, R., and Brigham, W.E.: "Transient Flow in Elliptical Systems", Paper SPE 7488, presented at the 53rd Annual Fall Technical Conference and Exhibition of the SPE of AIME, Houston, Texas, Oct. 1-3, 1978.

17. Locke, C.D., and Sawyer, W.K.: "Constant Pressure Injection Test in a Fractured Reservoir - History Match Using Numerical Simulation and Type Curve Analysis", Paper SPE 5594, presented at the 50th Annual Fall Meeting of the SPE of AIME, 1975.

18. Matthews, C.S., Brons, F., and Hazebroek, P.: "A Method for Determination of Average Pressures in a Bounded Reservoir", Trans., AIME, 1954, 201, 182-191.

20. Moore, T.V., Schilthuis, R.J., and Hurst, W.: "The Determination of Permeability from Field Data", Proc., API Bull., 1933, 211, 4.

21. Mueller, T.D., and Witherspoon, P.A.: "Pressure Interference Effects within Reservoirs and Aquifers", J. Pet. Tech., April 1965, 471-474.

22. Odeh, A.S., and Jones, L.G.: "Two-Rate Flow Test, Variable-Rate Case--Application to Gas-Lift and Pumping Wells", J. Pet. Tech., March 1974, 93-99; Trans., AIME, 257.

23. Odeh, A.S., and Nabor, G.W.: "The Effect of Production History on Determination of Formation Characteristics from Flow Tests", Paper SPE 1515, presented at the 41st Annual Fall Meeting of SPE of AIME, 1966.

24. Odeh, A.S., and Selig, F.: "Pressure Build-Up Analysis, Variable-Rate Case", J. Pet. Tech., July 1963, 790-794; Trans., AIME, 228.

25. Poettmann, F.H., and Beck, R.L.: "New Charts Developed to Predict Gas-Liquid Flow Through Chokes", World Oil, March 1963, 95-101, 156.

26. Prats, M., Hazebroek, P., and Strickler, W.R.: "Effect of Vertical Fractures on Reservoir Behavior--Compressible-Fluid Case", Soc. Pet. Eng. J., June 1962, 87-94.

27. Ramey, H.J.,Jr., and Cobb, W.M.: "A General Pressure Buildup Theory for a Well in a Closed Drainage Area", J. Pet. Tech., Dec. 1971, 1493-1504.

28. Samaniego, V. and Cinco-L., H.: "Production Rate Decline in Pressure Sensitive Reservoirs", Paper No. 78-29-25, presented at the 29th Annual Technical Meeting of the Petroleum Society of CIM, 1978.

29. Sandrea, R.: "An Evaluation of Horner's Approximation in Pressure Buildup Analysis", unpublished manuscript, 1971.

30. Stehfest, H.: "Numerical Inversion of Laplace Transforms", Communications of the ACM, Jan. 1970, **13**, No. 1, 47-49.

31. Tsarevich, K.A., and Kuranov, I.F.: "Calculation of the Flow Rates for the Center Well in a Circular Reservoir Under Elastic Conditions", Problems of Reservoir Hydrodynamics, Part I, Leningrad, 1956, 9-34.

32. van Everdingen, A.F., and Hurst, W.: "The Application of the Laplace Transformation to Flow Problems in Reservoirs", Trans., AIME, Dec. 1949, 305-324.

NOMENCLATURE

A = area, L^2

C_A = shape factor

C_D = dimensionless wellbore storage coefficient, $\frac{V_w c_w}{2\pi\phi c_t h r_w^2}$

c_t = total compressibility, Lt^2/m

c_w = wellbore fluid compressibility, Lt^2/m

D = wellbore diameter, L

f_M = Moody friction factor

g_c = units conversion factor

h = reservoir thickness, L

H = wellbore vertical length, L

I_0, I_1 = Modified Bessel functions

k = reservoir absolute permeability, L^2

K_0, K_1 = Modified Bessel functions

ℓ = Laplace space variable

L = wellbore length, L

m = slope of Horner buildup graph, m/Lt^2

m_q = slope of $\frac{1}{q}$ vs log t graph for a constant-pressure test, t/L^3

m = slope of the log q vs t graph for a constant pressure test

N_{RE} = Reynold's number

p = pressure, m/Lt^2

p_D = dimensionless pressure ratio, $\frac{p_i - p_{r,t}}{p_i - p_{wf}}$

p_{wD} = dimensionless wellbore pressure, $2\pi kh(p_i - p_{wf})/q\mu$

p_i = initial reservoir pressure, m/Lt^2

p_{tf} = flowing wellhead pressure, m/Lt^2

p_{wf} = flowing bottom-hole pressure, m/Lt^2

p_{ws} = bottom-hole pressure after shut-in, m/Lt^2

p = extrapolated pressure on Horner buildup graph, m/Lt^2

$\bar{p}$ = volumetric average reservoir pressure, m/Lt^2

q = production rate, L^3/t

q_D = dimensionless production rate, $\frac{q\mu}{2\pi kh(p_i - p_{wf})}$

q_c = constant initial flow rate, L^3/t

$(q_c)_D$ = dimensionless constant initial flow rate, $\frac{q_c\mu}{2\pi kh(p_i - p_{wf})}$

q_M = flow rate at match point for type curve matching, L^3/t

$(q_D)_M$ = dimensionless flow rate at match point for type curve matching

$(\frac{1}{q})_{1hr}$ = ordinate value at 1 hour on straight-line graph of $(\frac{1}{q})$ vs log t, t/L^3

Q = cumulative production, L^3

Q_D = dimensionless cumulative production, $Q/[2\pi\phi c_t h r_w^2 (p_i - p_{wf})]$

r_D = dimensionless radius, r/r_w

r_e = reservoir radius, L

r_{eD} = dimensionless reservoir radius, r_e/r_w

r_w = wellbore radius, L

r_w' = effective wellbore radius, $r_w e^{-s}$, L

t = time

t_D = dimensionless time, $\frac{kt}{\phi\mu c_t r_w^2}$

t_{DA} = dimensionless time based on drainage area, $\frac{kt}{\phi\mu c_t r_w^2}$

t_M = time at match point for type curve matching, t

$(t_D)_M$ = dimensionless time at match point for type curve matching

t_p = production time, t

t_P = Horner corrected production time, t

t_{pss} = time at the beginning of pseudo-steady state flow, t

$(t_{pss})_D$ = dimensionless time at the beginning of pseudo-steady state flow

At = shut-in time, t

Δt_D = dimensionless shut-in time

s = skin factor

U = wellbore fluid velocity, L/t

v = wellbore fluid specific volume, L^3/m

V_w = wellbore volume, L^3

W_f = wellbore friction energy loss, mL^2/t^2

W_s = shaft work, mL^2/t^2

γ = exponential of Euler's constant, $\gamma \cong 1.781$

ϕ = porosity

μ = fluid viscosity, m/Lt

$\bar{\rho}$ = average wellbore fluid density, m/L^3

τ = variable of integration

APPENDIX A

UNITS CONVERSIONS

Variable	Darcy, SI Metric Units	English Units
t_D	$\frac{kt}{\phi\mu c_t r_w^2}$	$\frac{.000264\ kt}{\phi\mu c_t r_w^2}$
q_D	$\frac{qB\mu}{2\pi kh(p_i - p_{wf})}$	$\frac{141.2\ qB\mu}{2\pi kh(p_i - p_{wf})}$
Q_D	$Q/[2\pi\phi c_t h r_w^2 (p_i - p_{wf})]$	$Q/[2\pi\phi c_t h r_w^2 (p_i - p_{wf})]$
m	$\frac{.1832\ qB\mu}{kh}$	$\frac{162.6\ qB\mu}{kh}$
$\frac{kh(p^* - \bar{p})}{q_{t_P} B\mu} \cdot \alpha$	$a = 2\pi$	$\alpha = \frac{1}{141.2}$
c	atm^{-1}, Pa^{-1}	psi^{-1}
h	cm, m	ft
k	darcy, m^2	md
p	atm, Pa	psi
q	cm^3/sec, m^3/sec	barrels/day
r	cm, m	ft
t	sec, sec	hr
μ	cp, Pa-sec	cp

APPENDIX B

TABULATED SOLUTIONS

CONTENTS

page

Table B.1
INFINITE **OUTER** BOUNDARY
Skin = 0

t_D	QD	q_D	t_D	QD	q_D
1.00D-01	4.0435D-01	2.2489D 00	1.00D 04	2.1986D 03	1.9594D-01
2.00D-01	5.9803D-01	1.7153D 00	2.00D 04	4.0887D 03	1.8371D-01
3.00D-01	7.5642D-01	1.4764D 00	3.00D 04	5.8710D 03	1.7722D-01
4.00D-01	8.9676D-01	1.3326D 00	4.00D 04	7.6405D 03	1.7289D-01
5.00D-01	1.0244D 00	1.2336D 00	5.00D 04	9.3527D 03	1.6966D-01
6.00D-01	1.1439D 00	1.1601D 00	6.00D 04	1.1036D 04	1.6712D-01
7.00D-01	1.2569D 00	1.1025D 00	7.00D 04	1.2697D 04	1.6502D-01
8.00D-01	1.3648D 00	1.0558D 00	8.00D 04	1.4338D 04	1.6325D-01
9.00D-01	1.4684D 00	1.0169D 00	9.00D 04	1.5963D 04	1.6172D-01
1.00D 00	1.5684D 00	9.8393D-01	1.00D 05	1.7573D 04	1.6037D-01
2.00D 00	2.4455D 00	8.0063D-01	2.00D 05	3.3140D 04	1.5203D-01
3.00D 00	3.1299D 00	7.1624D-01	3.00D 05	4.8102D 04	1.4753D-01
4.00D 00	3.6805D 00	6.6443D-01	4.00D 05	6.2697D 04	1.4450D-01
5.00D 00	4.5339D 00	6.2821D-01	5.00D 05	7.7030D 04	1.4223D-01
6.00D 00	5.1480D 00	6.0091D-01	6.00D 05	9.1161D 04	1.4043D-01
7.00D 00	5.7377D 00	5.7930D-01	7.00D 05	1.0513D 05	1.3894D-01
8.00D 00	6.3079D 00	5.6160D-01	8.00D 05	1.1896D 05	1.3767D-01
9.00D 00	6.8619D 00	5.4671D-01	9.00D 05	1.3267D 05	1.3658D-01
1.00D 01	7.4021D 00	5.3394D-01	1.00D 06	1.4628D 05	1.3561D-01
2.00D 01	1.2321D 01	4.6116D-01	2.00D 06	2.7850D 05	1.2957D-01
3.00D 01	1.6742D 01	4.2612D-01	3.00D 06	4.0632D 05	1.2628D-01
4.00D 01	2.0386D 01	4.0399D-01	4.00D 06	5.3144D 05	1.2405D-01
5.00D 01	2.4843D 01	3.8820D-01	5.00D 06	6.5462D 05	1.2237D-01
6.00D 01	2.8662D 01	3.7609D-01	6.00D 06	7.7631D 05	1.2103D-01
7.00D 01	3.2373D 01	3.6638D-01	7.00D 06	8.9678D 05	1.1992D-01
8.00D 01	3.5996D 01	3.5833D-01	8.00D 06	1.0162D 06	1.1897D-01
9.00D 01	3.9544D 01	3.5149D-01	9.00D 06	1.1348D 06	1.1815D-01
1.00D 02	4.3029D 01	3.4557D-01	1.00D 07	1.2526D 06	1.1742D-01
2.00D 02	7.5595D 01	3.1081D-01	2.00D 07	2.4012D 06	1.1286D-01
3.00D 02	1.0573D 02	2.9335D-01	3.00D 07	3.5164D 06	1.1035D-01
4.00D 02	1.3447D 02	2.8204D-01	4.00D 07	4.6110D 06	1.0863D-01
5.00D 02	1.6224D 02	2.7382D-01	5.00D 07	5.6908D 06	1.0734D-01
6.00D 02	1.8930D 02	2.6744D-01	6.00D 07	6.7590D 06	1.0631D-01
7.00D 02	2.1576D 02	2.6226D-01	7.00D 07	7.8178D 06	1.0545D-01
8.00D 02	2.4178D 02	2.5792D-01	8.00D 07	8.8696D 06	1.0471D-01
9.00D 02	2.6739D 02	2.5421D-01	9.00D 07	9.9126D 06	1.0408D-01
1.00D 03	2.9264D 02	2.5097D-01	1.00D 08	1.0951D 07	1.0351D-01
2.00D 03	5.3254D 02	2.3151D-01	2.00D 08	2.1102D 07	9.9943D-02
3.00D 03	7.5862D 02	2.2142D-01	3.00D 08	3.0992D 07	9.7967D-02
4.00D 03	9.7651D 02	2.1477D-01	4.00D 08	4.0718D 07	9.6612D-02
5.00D 03	1.1880D 03	2.0986D-01	5.00D 08	5.0327D 07	9.5586D-02
6.00D 03	1.3967D 03	2.0602D-01	6.00D 08	5.9845D 07	9.4764D-02
7.00D 03	1.6011D 03	2.0287D-01	7.00D 08	6.9287D 07	9.4080D-02
8.00D 03	1.8026D 03	2.0022D-01	8.00D 08	7.8666D 07	9.3495D-02
9.00D 03	2.0012D 03	1.9794D-01	9.00D 08	8.7991D 07	9.2985D-02

INFINITE **OUTER** BOUNDARY
Skin = 5

t_D	Q_D	q_D	t_D	QD	q_D
1.00D-01	1.9171D-02	1.8805D-01	1.00D 04	1.0495D 03	9.9464D-02
2.00D-01	3.7768D-02	1.8415D-01	2.00D 04	2.0258D 03	9.6165D-02
3.00D-01	5.6045D-02	1.8146D-01	3.00D 04	2.9778D 03	9.4334D-02
4.00D-01	7.4086D-02	1.7938D-01	4.00D 04	3.9146D 03	9.3076D-02
5.00D-01	9.1933D-02	1.7767D-01	5.00D 04	4.8405D 03	9.2124D-02
6.00D-01	1.0963D-01	1.7620D-01	6.00D 04	5.7579D 03	9.1359D-02
7.00D-01	1.2719D-01	1.7492D-01	7.00D 04	6.6684D 03	9.0723D-02
8.00D-01	1.4463D-01	1.7378D-01	8.00D 04	7.5727D 03	9.0179D-02
9.00D-01	1.6195D-01	1.7276D-01	9.00D 04	8.4724D 03	8.9704D-02
1.00D 00	1.7919D-01	1.7183D-01	1.00D 05	9.3674D 03	8.9284D-02
2.00D 00	3.4748D-01	1.6537D-01	2.00D 05	1.8147D 04	8.6614D-02
3.00D 00	5.1075D-01	1.6140D-01	3.00D 05	2.6729D 04	8.5124D-02
4.00D 00	6.7068D-01	1.5854D-01	4.00D 05	3.5189D 04	8.4098D-02
5.00D 00	8.2808D-01	1.5631D-01	5.00D 05	4.3539D 04	8.3319D-02
6.00D 00	9.8347D-01	1.5449D-01	6.00D 05	5.1860D 04	8.2693D-02
7.00D 00	1.1372D 00	1.5295D-01	7.00D 05	6.0103D 04	8.2171D-02
8.00D 00	1.2895D 00	1.5162D-01	8.00D 05	6.8299D 04	8.1724D-02
9.00D 00	1.4405D 00	1.5046D-01	9.00D 05	7.6452D 04	8.1333D-02
1.00D 01	1.5905D 00	1.4942D-01	1.00D 06	8.4569D 04	8.0987D-02
2.00D 01	3.0473D 00	1.4273D-01	2.00D 06	1.6433D 05	7.8783D-02
3.00D 01	4.4545D 00	1.3897D-01	3.00D 06	2.4246D 05	7.7548D-02
4.00D 01	5.8308D 00	1.3639D-01	4.00D 06	3.1957D 05	7.6694D-02
5.00D 01	7.1845D 00	1.3442D-01	5.00D 06	3.9593D 05	7.6045D-02
6.00D 01	8.5208D 00	1.3285D-01	6.00D 06	4.7172D 05	7.5523D-02
7.00D 01	9.8428D 00	1.3155D-01	7.00D 06	5.4703D 05	7.5087D-02
8.00D 01	1.1153D 01	1.3044D-01	8.00D 06	6.2194D 05	7.4714D-02
9.00D 01	1.2452D 01	1.2947D-01	9.00D 06	6.9649D 05	7.4387D-02
1.00D 02	1.3743D 01	1.2862D-01	1.00D 07	7.7074D 05	7.4098D-02
2.00D 02	2.6303D 01	1.2324D-01	2.00D 07	1.5014D 06	7.2247D-02
3.00D 02	3.8469D 01	1.2028D-01	3.00D 07	2.2184D 06	7.1206D-02
4.00D 02	5.0392D 01	1.1826D-01	4.00D 07	2.9268D 06	7.0486D-02
5.00D 02	6.2140D 01	1.1674D-01	5.00D 07	3.6289D 06	6.9937D-02
6.00D 02	7.3752D 01	1.1552D-01	6.00D 07	4.3261D 06	6.9495D-02
7.00D 02	8.5254D 01	1.1451D-01	7.00D 07	5.0192D 06	6.9126D-02
8.00D 02	9.6662D 01	1.1365D-01	8.00D 07	5.7089D 06	6.8809D-02
9.00D 02	1.0799D 02	1.1290D-01	9.00D 07	6.3957D 06	6.8532D-02
1.00D 03	1.1925D 02	1.1224D-01	1.00D 08	7.0799D 06	6.8286D-02
2.00D 03	2.2915D 02	1.0806D-01	2.00D 08	1.3821D 07	6.6710D-02
3.00D 03	3.3599D 02	1.0576D-01	3.00D 08	2.0445D 07	6.5822D-02
4.00D 03	4.4093D 02	1.0419D-01	4.00D 08	2.6996D 07	6.5206D-02
5.00D 03	5.4451D 02	1.0300D-01	5.00D 08	3.3493D 07	6.4736D-02
6.00D 03	6.4703D 02	1.0204D-01	6.00D 08	3.9948D 07	6.4357D-02
7.00D 03	7.4868D 02	1.0125D-01	7.00D 08	4.6368D 07	6.4039D-02
8.00D 03	8.4960D 02	1.0057D-01	8.00D 08	5.2759D 07	6.3767D-02
9.00D 03	9.4982D 02	9.9986D-02	9.00D 08	5.9124D 07	6.3529D-02

INFINITE OUTER **BOUNDARY**

Skin = 10

t_D	QD	q_D	t_D	QD	q_D
1.00D-01	9.7696D-03	9.6936D-02	1.00D 04	6.8868D 02	6.4960D-02
2.00D-01	1.9429D-02	9.5901D-02	2.00D 04	1.3453D 03	6.5001D-02
3.00D-01	2.8983D-02	9.5178D-02	3.00D 04	1.9909D 03	6.4157D-02
4.00D-01	3.8472D-02	9.4607D-02	4.00D 04	2.6295D 03	6.3572D-02
5.00D-01	4.7910D-02	9.4137D-02	5.00D 04	3.2630D 03	6.3125D-02
6.00D-01	5.7305D-02	9.3730D-02	6.00D 04	3.8925D 03	6.2764D-02
7.00D-01	6.6661D-02	9.3372D-02	7.00D 04	4.5186D 03	6.2463D-02
8.00D-01	7.5983D-02	9.3052D-02	8.00D 04	5.1420D 03	6.2204D-02
9.00D-01	8.5275D-02	9.2762D-02	9.00D 04	5.7630D 03	6.1977D-02
1.00D 00	9.4539D-02	9.2496D-02	1.00D 05	6.3818D 03	6.1776D-02
2.00D 00	1.8602D-01	9.0619D-02	2.00D 05	1.2498D 04	6.0483D-02
3.00D 00	2.7602D-01	8.9431D-02	3.00D 05	1.8498D 04	5.9752D-02
4.00D 00	3.6501D-01	8.8557D-02	4.00D 05	2.4447D 04	5.9243D-02
5.00D 00	4.5322D-01	8.7864D-02	5.00D 05	3.0352D 04	5.8855D-02
6.00D 00	5.4080D-01	8.7292D-02	6.00D 05	3.6222D 04	5.8541D-02
7.00D 00	6.2785D-01	8.6803D-02	7.00D 05	4.2064D 04	5.8279D-02
8.00D 00	7.1445D-01	8.6378D-02	8.00D 05	4.7881D 04	5.8053D-02
9.00D 00	8.0065D-01	8.6001D-02	9.00D 05	5.3677D 04	5.7856D-02
1.00D 01	8.6649D-01	8.5663D-02	1.00D 06	5.9454D 04	5.7680D-02
2.00D 01	1.7308D 00	8.3434D-02	2.00D 06	1.1651D 05	5.6551D-02
3.00D 01	2.5583D 00	8.2139D-02	3.00D 06	1.7273D 05	5.5911D-02
4.00D 01	3.3750D 00	8.1230D-02	4.00D 06	2.2841D 05	5.5466D-02
5.00D 01	4.1838D 00	8.0532D-02	5.00D 06	2.8371D 05	5.5125D-02
6.00D 01	4.9863D 00	7.9967D-02	6.00D 06	3.3870D 05	5.4850D-02
7.00D 01	5.7837D 00	7.9493D-02	7.00D 06	3.9344D 05	5.4619D-02
8.00D 01	6.5766D 00	7.9095D-02	8.00D 06	4.4796D 05	5.4421D-02
9.00D 01	7.3658D 00	7.8729D-02	9.00D 06	5.0230D 05	5.4247D-02
1.00D 02	8.1515D 00	7.8411D-02	1.00D 07	5.5649D 05	5.4093D-02
2.00D 02	1.5879D 01	7.6375D-02	2.00D 07	1.0719D 06	5.3099D-02
3.00D 02	2.3456D 01	7.5224D-02	3.00D 07	1.6200D 06	5.2534D-02
4.00D 02	3.0938D 01	7.4427D-02	4.00D 07	2.1433D 06	5.2141D-02
5.00D 02	3.8350D 01	7.3819D-02	5.00D 07	2.6632D 06	5.1839D-02
6.00D 02	4.5707D 01	7.3329D-02	6.00D 07	3.1804D 06	5.1596D-02
7.00D 02	5.3020D 01	7.2920D-02	7.00D 07	3.6954D 06	5.1392D-02
8.00D 02	6.0295D 01	7.2568D-02	8.00D 07	4.2085D 06	5.1216D-02
9.00D 02	6.7537D 01	7.2261D-02	9.00D 07	4.7199D 06	5.1062D-02
1.00D 03	7.4750D 01	7.1989D-02	1.00D 08	5.2299D 06	5.0925D-02
2.00D 03	1.4577D 02	7.0244D-02	2.00D 08	1.0274D 07	5.0043D-02
3.00D 03	2.1550D 02	6.9261D-02	3.00D 08	1.5252D 07	4.9541D-02
4.00D 03	2.8441D 02	6.8580D-02	4.00D 08	2.0138D 07	4.9191D-02
5.00D 03	3.5273D 02	6.8060D-02	5.00D 08	2.5094D 07	4.8923D-02
6.00D 03	4.2055D 02	6.7642D-02	6.00D 08	2.9976D 07	4.8706D-02
7.00D 03	4.8805D 02	6.7292D-02	7.00D 08	3.4838D 07	4.8524D-02
8.00D 03	5.5520D 02	6.6992D-02	8.00D 08	3.9693D 07	4.8367D-02
9.00D 03	6.2207D 02	6.6729D-02	9.00D 08	4.4513D 07	4.8230D-02

INFINITE OUTER BOUNDARY
Skin = 20

t_D	Q_D	q_D	t_D	QD	q_D
1.00D-01	4.9473D-03	4.9224D-02	1.00D 04	4.0793D 02	3.9957D-02
2.00D-01	9.8561D-03	4.8959D-02	2.00D 04	8.0450D 02	3.9412D-02
3.00D-01	1.4743D-02	4.8770D-02	3.00D 04	1.1970D 03	3.9100D-02
4.00D-01	1.9613D-02	4.8621D-02	4.00D 04	1.5869D 03	3.8861D-02
5.00D-01	2.4469D-02	4.8497D-02	5.00D 04	1.9749D 03	3.8714D-02
6.00D-01	2.9314D-02	4.8390D-02	6.00D 04	2.3614D 03	3.8577D-02
7.00D-01	3.4147D-02	4.8295D-02	7.00D 04	2.7466D 03	3.8463D-02
8.00D-01	3.8775D-02	4.8210D-02	8.00D 04	3.1308D 03	3.8365D-02
9.00D-01	4.3793D-02	4.8132D-02	9.00D 04	3.5141D 03	3.8278D-02
1.00D 00	4.8603D-02	4.8063D-02	1.00D 05	3.8965D 03	3.8201D-02
2.00D 00	9.6394D-02	4.7554D-02	2.00D 05	7.6893D 03	3.7703D-02
3.00D 00	1.4378D-01	4.7227D-02	3.00D 05	1.1445D 04	3.7417D-02
4.00D 00	1.9089D-01	4.6984D-02	4.00D 05	1.5176D 04	3.7217D-02
5.00D 00	2.3778D-01	4.6790D-02	5.00D 05	1.8891D 04	3.7063D-02
6.00D 00	2.8449D-01	4.6628D-02	6.00D 05	2.2591D 04	3.6938D-02
7.00D 00	3.3106D-01	4.6469D-02	7.00D 05	2.6280D 04	3.6833D-02
8.00D 00	3.7749D-01	4.6368D-02	8.00D 05	2.9959D 04	3.6743D-02
9.00D 00	4.2381D-01	4.6260D-02	9.00D 05	3.3630D 04	3.6664D-02
1.00D 01	4.7003D-01	4.6162D-02	1.00D 06	3.7293D 04	3.6593D-02
2.00D 01	9.2809D-01	4.5510D-02	2.00D 06	7.3635D 04	3.6135D-02
3.00D 01	1.3812D 00	4.5123D-02	3.00D 06	1.0963D 05	3.5972D-02
4.00D 01	1.8310D 00	4.4843D-02	4.00D 06	1.4542D 05	3.5688D-02
5.00D 01	2.2785D 00	4.4635D-02	5.00D 06	1.8104D 05	3.5547D-02
6.00D 01	2.7240D 00	4.4461D-02	6.00D 06	2.1653D 05	3.5432D-02
7.00D 01	3.1679D 00	4.4314D-02	7.00D 06	2.5192D 05	3.5336D-02
8.00D 01	3.6105D 00	4.4189D-02	8.00D 06	2.8721D 05	3.5252D-02
9.00D 01	4.0518D 00	4.4076D-02	9.00D 06	3.2243D 05	3.5179D-02
1.00D 02	4.4922D 00	4.3977D-02	1.00D 07	3.5759D 05	3.5114D-02
2.00D 02	8.8542D 00	4.3228D-02	2.00D 07	7.0642D 05	3.4692D-02
3.00D 02	1.3168D 01	4.2956D-02	3.00D 07	1.0521D 06	3.4450D-02
4.00D 02	1.7450D 01	4.2694D-02	4.00D 07	1.3958D 06	3.4281D-02
5.00D 02	2.1710D 01	4.2493D-02	5.00D 07	1.7379D 06	3.4150D-02
6.00D 02	2.5951D 01	4.2330D-02	6.00D 07	2.0789D 06	3.4044D-02
7.00D 02	3.0178D 01	4.2193D-02	7.00D 07	2.4190D 06	3.3955D-02
8.00D 02	3.4392D 01	4.2076D-02	8.00D 07	2.7582D 06	3.3870D-02
9.00D 02	3.8593D 01	4.1972D-02	9.00D 07	3.0967D 06	3.3811D-02
1.00D 03	4.2788D 01	4.1880D-02	1.00D 08	3.4345D 06	3.3751D-02
2.00D 03	8.4339D 01	4.1282D-02	2.00D 08	6.7883D 06	3.3361D-02
3.00D 03	1.2544D 02	4.0941D-02	3.00D 08	1.0113D 07	3.3137D-02
4.00D 03	1.6627D 02	4.0701D-02	4.00D 08	1.3419D 07	3.2980D-02
5.00D 03	2.0698D 02	4.0518D-02	5.00D 08	1.6711D 07	3.2859D-02
6.00D 03	2.4732D 02	4.0369D-02	6.00D 08	1.9992D 07	3.2761D-02
7.00D 03	2.8763D 02	4.0244D-02	7.00D 08	2.3264D 07	3.2678D-02
8.00D 03	3.2783D 02	4.0136D-02	8.00D 08	2.6529D 07	3.2607D-02
9.00D 03	3.6792D 02	4.0041D-02	9.00D 08	2.9787D 07	3.2545D-02

Table B.2

CLOSED OUTER BOUNDARY

Skin = 0

r_{eD} = 20

t_D	Q_D	q_D	
1.00D 02	4.2904D 01	3.3930D-01	
2.00D 02	7.3403D 01	2.7261D-01	*
3.00D 02	9.7998D 01	2.1951D-01	*
4.00D 02	1.1780D 02	1.7668D-01	*
5.00D 02	1.3374D 02	1.4245D-01	*
6.00D 02	1.4650D 02	1.1472D-01	*
7.00D 02	1.5472D 02	9.2448D-02	*
8.00D 02	1.6494D 02	7.4708D-02	*
9.00D 02	1.7155D 02	6.0391D-02	*
1.00D 03	1.7687D 02	4.8906D-02	*
2.00D 03	1.9671D 02	5.7903D-03	*
3.00D 03	1.9924D 02	3.9577D-05	*

r_{eD} = 50

t_D	QD	q_D	
1.00D 03	2.8977D 02	2.3921D-01	*
2.00D 03	5.0184D 02	1.8640D-01	*
3.00D 03	6.6720D 02	1.4503D-01	*
4.00D 03	7.9614D 02	1.1308D-01	*
5.00D 03	8.9598D 02	8.6067D-02	*
6.00D 03	9.7362D 02	6.8794D-02	*
7.00D 03	1.0337D 03	5.3741D-02	*
8.00D 03	1.0808D 03	4.2227D-02	*
9.00D 03	1.1169D 03	3.3011D-02	*
1.00D 04	1.1451D 03	2.5842D-02	*
2.00D 04	1.2412D 03	2.1489D-03	*

r_{eD} = 100

t_D	Q_D	q_D	
1.00D 02	4.3029D 01	3.4557D-01	
2.00D 02	7.5595D 01	3.1081D-01	
3.00D 02	1.0573D 02	2.9335D-01	
4.00D 02	1.3447D 02	2.8204D-01	
5.00D 02	1.6225D 02	2.7381D-01	
6.00D 02	1.8930D 02	2.6742D-01	
7.00D 02	2.1577D 02	2.6223D-01	
8.00D 02	2.4177D 02	2.5790D-01	
9.00D 02	2.6736D 02	2.5419D-01	
1.00D 03	2.9260D 02	2.5097D-01	
2.00D 03	5.3222D 02	2.3097D-01	
3.00D 03	7.5652D 02	2.1815D-01	
4.00D 03	9.6904D 02	2.0701D-01	*
5.00D 03	1.1709D 03	1.9660D-01	*
6.00D 03	1.3627D 03	1.8677D-01	*
7.00D 03	1.5450D 03	1.7741D-01	*
8.00D 03	1.7183D 03	1.6854D-01	*
9.00D 03	1.8829D 03	1.6008D-01	*
1.00D 04	2.0372D 03	1.5201D-01	*
2.00D 04	3.2311D 03	9.0824D-02	*
3.00D 04	3.9394D 03	5.4407D-02	*
4.00D 04	4.3581D 03	3.2786D-02	*
5.00D 04	4.6110D 03	2.0023D-02	*
6.00D 04	4.7626D 03	1.2181D-02	*
7.00D 04	4.8548D 03	7.3842D-03	*
8.00D 04	4.9127D 03	4.4884D-03	*
9.00D 04	4.9476D 03	2.5927D-03	*
1.00D 05	4.9732D 03	1.5664D-03	*

r_{eD} = 200

t_D	Q_D	q_D	
1.00D 04	2.1962D 03	1.9496D-01	
2.00D 04	4.0379D 03	1.7418D-01	*
3.00D 04	5.6892D 03	1.5617D-01	*
4.00D 04	7.1709D 03	1.3999D-01	*
5.00D 04	8.5022D 03	1.2556D-01	*
6.00D 04	9.6946D 03	1.1250D-01	*
7.00D 04	1.0763D 04	1.0079D-01	*
8.00D 04	1.1721D 04	9.0330D-02	*
9.00D 04	1.2579D 04	8.0974D-02	*
1.00D 05	1.3348D 04	7.2638D-02	*
2.00D 05	1.7732D 04	2.4722D-02	*
3.00D 05	1.9214D 04	8.6759D-03	*
4.00D 05	1.9743D 04	3.0241D-03	*
5.00D 05	1.9911D 04	7.6652D-04	*
6.00D 05	1.9994D 04	1.4622D-04	*

r_{eD} = 500

t_D	QD	q_D	
1.00D 05	1.7485D 04	1.5663D-01	*
2.00D 05	3.2062D 04	1.3539D-01	*
3.00D 05	4.4675D 04	1.1698D-01	*
4.00D 05	5.5599D 04	1.0113D-01	*
5.00D 05	6.5035D 04	8.7331D-02	*
6.00D 05	7.3193D 04	7.5493D-02	*
7.00D 05	8.0222D 04	6.5196D-02	*
8.00D 05	8.6315D 04	5.6464D-02	*
9.00D 05	9.1337D 04	4.8803D-02	*
1.00D 06	9.6024D 04	4.2142D-02	*
2.00D 06	1.1800D 05	1.0222D-02	*
3.00D 06	1.2333D 05	2.4339D-03	*
4.00D 06	1.2470D 05	4.1139D-04	*

r_{eD} = 1000

t_D	QD	q_D	
1.00D 05	1.7572D 04	1.6036D-01	
2.00D 05	3.3128D 04	1.5186D-01	
3.00D 05	4.8027D 04	1.4637D-01	
4.00D 05	6.2420D 04	1.4158D-01	*
5.00D 05	7.6348D 04	1.3704D-01	*
6.00D 05	8.9834D 04	1.3269D-01	*
7.00D 05	1.0289D 05	1.2846D-01	*
8.00D 05	1.1554D 05	1.2439D-01	*
9.00D 05	1.2778D 05	1.2043D-01	*
1.00D 06	1.3964D 05	1.1657D-01	*
2.00D 06	2.3947D 05	8.4286D-02	*
3.00D 06	3.1165D 05	6.0898D-02	*
4.00D 06	3.6367D 05	4.4089D-02	*
5.00D 06	4.0107D 05	3.1989D-02	*
6.00D 06	4.2803D 05	2.3289D-02	*
7.00D 06	4.4751D 05	1.7001D-02	*
8.00D 06	4.6164D 05	1.2435D-02	*
9.00D 06	4.7184D 05	9.0737D-03	*
1.00D 07	4.7946D 05	6.6599D-03	*
2.00D 07	4.9971D 05	9.7431D-05	*

* exponential rate decline

CLOSED OUTER BOUNDARY
Skin = 0

r_{eD} = 2000

t_D	Q_D	q_D	
1.00D 05	1.7574D 04	1.6037D-01	
2.00D 05	3.3141D 04	1.5202D-01	
3.00D 05	4.9102D 04	1.4752D-01	
4.00D 05	6.2693D 04	1.4449D-01	
5.00D 05	7.7020D 04	1.4223D-01	
6.00D 05	9.1145D 04	1.4042D-01	
7.00D 05	1.0510D 05	1.3889D-01	
8.00D 05	1.1892D 05	1.3754D-01	
9.00D 05	1.3261D 05	1.3632D-01	
1.00D 06	1.4618D 05	1.3519D-01	
2.00D 06	2.7631D 05	1.2539D-01	*
3.00D 06	3.9724D 05	1.1660D-01	*
4.00D 06	5.0974D 05	1.0841D-01	*
5.00D 06	6.1447D 05	1.0083D-01	*
6.00D 06	7.1186D 05	9.3730D-02	*
7.00D 06	8.0245D 05	8.7124D-02	*
8.00D 06	8.8674D 05	8.0990D-02	*
9.00D 06	9.6513D 05	7.5283D-02	*
1.00D 07	1.0380D 06	6.9989D-02	*
2.00D 07	1.5349D 06	3.3823D-02	*
3.00D 07	1.7723D 06	1.6553D-02	*
4.00D 07	1.8874D 06	8.2023D-03	*
5.00D 07	1.9442D 06	4.0446D-03	*
6.00D 07	1.9730D 06	1.9604D-03	*
7.00D 07	1.9870D 06	8.4045D-04	*
8.00D 07	1.9953D 06	3.4154D-04	*
9.00D 07	1.9986D 06	3.8975D-05	*

r_{eD} = 5000

t_D	QD	q_D	
1.00D 06	1.4628D 05	1.3561D-01	
2.00D 06	2.7850D 05	1.2957D-01	
3.00D 06	4.0628D 05	1.2628D-01	
4.00D 06	5.3134D 05	1.2403D-01	
5.00D 06	6.5443D 05	1.2227D-01	
6.00D 06	7.7591D 05	1.2076D-01	
7.00D 06	8.9596D 05	1.1938D-01	
8.00D 06	1.0147D 06	1.1808D-01	*
9.00D 06	1.1321D 06	1.1683D-01	*
1.00D 07	1.2483D 06	1.1561D-01	*
2.00D 07	2.3468D 06	1.0432D-01	*
3.00D 07	3.3384D 06	9.4113D-02	*
4.00D 07	4.2344D 06	8.4932D-02	*
5.00D 07	5.0433D 06	7.6611D-02	*
6.00D 07	5.7740D 06	6.9117D-02	*
7.00D 07	6.4328D 06	6.2328D-02	*
8.00D 07	7.0281D 06	5.6264D-02	*
9.00D 07	7.5633D 06	5.0734D-02	*
1.00D 08	8.0152D 06	4.5754D-02	*
2.00D 08	1.0888D 07	1.6579D-02	*
3.00D 08	1.1903D 07	6.1330D-03	*
4.00D 08	1.2281D 07	2.2355D-03	*
5.00D 08	1.2428D 07	7.4516D-04	*
6.00D 08	1.2484D 07	1.6453D-04	*

r_{eD} = 1x10^4

t_D	Q_D	q_D	
1.00D 07	1.2525D 06	1.1742D-01	
2.00D 07	2.4006D 06	1.1278D-01	
3.00D 07	3.5126D 06	1.0976D-01	
4.00D 07	4.5968D 06	1.0712D-01	*
5.00D 07	5.6552D 06	1.0460D-01	*
6.00D 07	6.6888D 06	1.0217D-01	*
7.00D 07	7.6984D 06	9.9786D-02	*
8.00D 07	8.6845D 06	9.7466D-02	*
9.00D 07	9.6478D 06	9.5195D-02	*
1.00D 08	1.0588D 07	9.2969D-02	*
2.00D 08	1.8881D 07	7.3411D-02	*
3.00D 08	2.5439D 07	5.7921D-02	*
4.00D 08	3.0616D 07	4.5721D-02	*
5.00D 08	3.4690D 07	3.6109D-02	*
6.00D 08	3.7895D 07	2.8559D-02	*
7.00D 08	4.0416D 07	2.2621D-02	*
8.00D 08	4.2401D 07	1.7942D-02	*
9.00D 08	4.3959D 07	1.4229D-02	*
1.00D 09	4.5201D 07	1.1330D-02	*
2.00D 09	4.9536D 07	1.0964D-03	*

r_{eD} = 5x10^4

t_D	QD	q_D	
1.00D 08	1.0951D 07	1.0351D-01	
2.00D 08	2.1102D 07	9.9939D-02	
3.00D 08	3.0939D 07	9.7967D-02	
4.00D 08	4.0713D 07	9.6604D-02	
5.00D 08	5.0316D 07	9.5532D-02	
6.00D 08	5.9821D 07	9.4611D-02	
7.00D 08	6.9239D 07	9.3772D-02	
8.00D 08	7.8576D 07	9.2980D-02	*
9.00D 08	8.7835D 07	9.2217D-02	*
1.00D 09	9.7019D 07	9.1474D-02	*
2.00D 09	1.8493D 08	8.4491D-02	*
3.00D 09	2.6615D 08	7.8039D-02	*
4.00D 09	3.4124D 08	7.2094D-02	*
5.00D 09	4.1063D 08	6.6585D-02	*
6.00D 09	4.7480D 08	6.1505D-02	*
7.00D 09	5.3408D 08	5.6788D-02	*
8.00D 09	5.8892D 08	5.2470D-02	*
9.00D 09	6.3948D 08	4.8440D-02	*
1.00D 10	6.8618D 08	4.4718D-02	*
2.00D 10	9.9443D 08	2.0282D-02	*
3.00D 10	1.1323D 09	9.3372D-03	*
4.00D 10	1.1951D 09	4.3295D-03	*
5.00D 10	1.2247D 09	1.9934D-03	*
6.00D 10	1.2389D 09	8.8085D-04	*
7.00D 10	1.2462D 09	3.6523D-04	*
8.00D 10	1.2490D 09	8.5455D-05	*

CLOSED OUTER BOUNDARY
Skin = 0

$r_{eD} = 1x10^5$

t_D	QD	q_D	
1.00D 08	1.0931D 07	1.0351D-01	
2.00D 08	2.1102D 07	9.9943D-02	
3.00D 08	3.0992D 07	9.7767D-02	
4.00D 08	4.0719D 07	9.6612D-02	
5.00D 08	5.0328D 07	9.5595D-02	
6.00D 08	5.9846D 07	9.4762D-02	
7.00D 08	6.9288D 07	9.4077D-02	
8.00D 08	7.8665D 07	9.3491D-02	
9.00D 08	8.7989D 07	9.2982D-02	
1.00D 09	9.7264D 07	9.2531D-02	
2.00D 09	1.8816D 08	8.9623D-02	
3.00D 09	2.7680D 08	8.7722D-02	
4.00D 09	3.6367D 08	8.6052D-02	*
5.00D 09	4.4891D 08	8.4456D-02	*
6.00D 09	5.3257D 08	8.2904D-02	*
7.00D 09	6.1469D 08	8.1380D-02	*
8.00D 09	6.9531D 08	7.9888D-02	*
9.00D 09	7.7445D 08	7.8420D-02	*
1.00D 10	8.5211D 08	7.6975D-02	*
2.00D 10	1.5551D 09	6.3931D-02	*
3.00D 10	2.1399D 09	5.3068D-02	*
4.00D 10	2.6260D 09	4.4050D-02	*
5.00D 10	3.0292D 09	3.6567D-02	*
6.00D 10	3.3634D 09	3.0375D-02	*
7.00D 10	3.6403D 09	2.5256D-02	*
8.00D 10	3.8690D 09	2.0996D-02	*
9.00D 10	4.0583D 09	1.7470D-02	*
1.00D 11	4.2155D 09	1.4560D-02	*
2.00D 11	4.8697D 09	2.3993D-03	*
3.00D 11	4.9822D 09	3.0237D-04	*

$r_{eD} = 1x10^6$

t_D	QD	q_D	
1.00D 10	8.7486D 08	8.3654D-02	
2.00D 10	1.6983D 09	8.1304D-02	
3.00D 10	2.5044D 09	7.9990D-02	
4.00D 10	3.2977D 09	7.9082D-02	
5.00D 10	4.0870D 09	7.8392D-02	
6.00D 10	4.8682D 09	7.7837D-02	
7.00D 10	5.6443D 09	7.7373D-02	
8.00D 10	6.4161D 09	7.6976D-02	
9.00D 10	7.1841D 09	7.6630D-02	
1.00D 11	7.9488D 09	7.6323D-02	
2.00D 11	1.5470D 10	7.4332D-02	
3.00D 11	2.2835D 10	7.3027D-02	
4.00D 11	3.0080D 10	7.1877D-02	*
5.00D 11	3.7211D 10	7.0777D-02	*
6.00D 11	4.4234D 10	6.9702D-02	*
7.00D 11	5.1150D 10	6.8645D-02	*
8.00D 11	5.7961D 10	6.7604D-02	*
9.00D 11	6.4668D 10	6.6581D-02	*
1.00D 12	7.1273D 10	6.5567D-02	*
2.00D 12	1.3209D 11	5.6268D-02	*
3.00D 12	1.8434D 11	4.8268D-02	*
4.00D 12	2.2924D 11	4.1406D-02	*
5.00D 12	2.6777D 11	3.5513D-02	*
6.00D 12	3.0081D 11	3.0466D-02	*
7.00D 12	3.2910D 11	2.6143D-02	*
8.00D 12	3.5332D 11	2.2442D-02	*
9.00D 12	3.7400D 11	1.9260D-02	*
1.00D 13	3.9176D 11	1.6559D-02	*
2.00D 13	4.7554D 11	3.7418D-03	*
3.00D 13	4.9463D 11	8.1472D-04	*
4.00D 13	4.9933D 11	1.0647D-04	*

$r_{eD} = 5x10^5$

t_D	Q_D	q_D	
1.00D 10	8.7487D 08	8.3654D-02	
2.00D 10	1.6983D 09	8.1302D-02	
3.00D 10	2.5043D 09	7.9989D-02	
4.00D 10	3.2993D 09	7.9078D-02	
5.00D 10	4.0863D 09	7.8358D-02	
6.00D 10	4.8666D 09	7.7740D-02	
7.00D 10	5.6412D 09	7.7176D-02	
8.00D 10	6.4102D 09	7.6644D-02	*
9.00D 10	7.1741D 09	7.6130D-02	*
1.00D 11	7.9328D 09	7.5629D-02	*
2.00D 11	1.5254D 10	7.0890D-02	*
3.00D 11	2.2118D 10	6.6454D-02	*
4.00D 11	2.8555D 10	6.2297D-02	*
5.00D 11	3.4594D 10	5.8412D-02	*
6.00D 11	4.0256D 10	5.4743D-02	*
7.00D 11	4.5568D 10	5.1311D-02	*
8.00D 11	5.0550D 10	4.8091D-02	*
9.00D 11	5.5221D 10	4.5071D-02	*
1.00D 12	5.9602D 10	4.2242D-02	*
2.00D 12	9.0750D 10	2.2133D-02	*
3.00D 12	1.0690D 11	1.1695D-02	*
4.00D 12	1.1533D 11	6.2397D-03	*
5.00D 12	1.1982D 11	3.3494D-03	*
6.00D 12	1.2234D 11	1.7832D-03	*
7.00D 12	1.2358D 11	9.2902D-04	*
8.00D 12	1.2432D 11	4.6204D-04	*
9.00D 12	1.2460D 11	1.8229D-04	*
1.00D 13	1.2493D 11	4.8446D-05	*

CLOSED OUTER BOUNDARY
Skin = 5

r_{eD} = 20

t_D	Q_D	q_D
1.00D 02	1.3734D 01	1.2821D-01
2.00D 02	2.6101D 01	1.1942D-01
3.00D 02	3.7641D 01	1.1148D-01
4.00D 02	4.8416D 01	1.0406D-01
5.00D 02	5.8486D 01	9.7156D-02
6.00D 02	6.7886D 01	9.0666D-02
7.00D 02	7.6662D 01	8.4599D-02
8.00D 02	8.4863D 01	7.8956D-02
9.00D 02	9.2519D 01	7.3680D-02
1.00D 03	9.9667D 01	6.8762D-02
2.00D 03	1.4936D 02	3.4503D-02
3.00D 03	1.7400D 02	1.7470D-02
4.00D 03	1.8648D 02	9.0212D-03
5.00D 03	1.9272D 02	4.5726D-03
6.00D 03	1.9606D 02	2.3307D-03
7.00D 03	1.9777D 02	1.0951D-03
8.00D 03	1.9874D 02	4.7251D-04
9.00D 03	1.9911D 02	9.0990D-05

r_{eD} = 50

t_D	QD	q_D	
1.00D 03	1.1886D 02	1.1060D-01	*
2.00D 03	2.2419D 02	1.0028D-01	*
3.00D 03	3.1974D 02	9.0918D-02	*
4.00D 03	4.0650D 02	8.2464D-02	*
5.00D 03	4.8520D 02	7.4745D-02	*
6.00D 03	5.5665D 02	6.7771D-02	*
7.00D 03	6.2142D 02	6.1423D-02	*
8.00D 03	6.8023D 02	5.5715D-02	*
9.00D 03	7.3335D 02	5.0475D-02	*
1.00D 04	7.8151D 02	4.5741D-02	*
2.00D 04	1.0720D 03	1.7377D-02	*
3.00D 04	1.1807D 03	6.7337D-03	*
4.00D 04	1.2222D 03	2.5360D-03	*
5.00D 04	1.2405D 03	9.8331D-04	*
6.00D 04	1.2468D 03	2.6539D-04	*

r_{eD} = 100

t_D	Q_D	q_D	
1.00D 03	1.1924D 02	1.1223D-01	
2.00D 03	2.2909D 02	1.0779D-01	
3.00D 03	3.3564D 02	1.0523D-01	
4.00D 03	4.3964D 02	1.0281D-01	*
5.00D 03	5.4126D 02	1.0050D-01	*
6.00D 03	6.4062D 02	9.8258D-02	*
7.00D 03	7.3776D 02	9.6049D-02	*
8.00D 03	8.3275D 02	9.3933D-02	*
9.00D 03	9.2562D 02	9.1839D-02	*
1.00D 04	1.0164D 03	8.9785D-02	*
2.00D 04	1.8212D 03	7.1649D-02	*
3.00D 04	2.4645D 03	5.7130D-02	*
4.00D 04	2.9775D 03	4.5547D-02	*
5.00D 04	3.3864D 03	3.6383D-02	*
6.00D 04	3.7109D 03	2.9052D-02	*
7.00D 04	3.9697D 03	2.3225D-02	*
8.00D 04	4.1741D 03	1.8605D-02	*
9.00D 04	4.3372D 03	1.4909D-02	*
1.00D 05	4.4671D 03	1.2019D-02	*
2.00D 05	4.9415D 03	1.3092D-03	*

r_{eD} = 200

t_D	QD	q_D	
1.00D 04	1.0491D 03	9.9255D-02	
2.00D 04	2.0147D 03	9.4018D-02	*
3.00D 04	2.9395D 03	8.9232D-02	*
4.00D 04	3.7998D 03	8.4685D-02	*
5.00D 04	4.6255D 03	8.0394D-02	*
6.00D 04	5.4090D 03	7.6287D-02	*
7.00D 04	6.1527D 03	7.2386D-02	*
8.00D 04	6.8594D 03	6.8692D-02	*
9.00D 04	7.5304D 03	6.5186D-02	*
1.00D 05	8.1676D 03	6.1868D-02	*
2.00D 05	1.2975D 04	3.6610D-02	*
3.00D 05	1.5838D 04	2.1788D-02	*
4.00D 05	1.7512D 04	1.3075D-02	*
5.00D 05	1.8493D 04	7.8108D-03	*
6.00D 05	1.9093D 04	4.7606D-03	*
7.00D 05	1.9445D 04	2.8080D-03	*
8.00D 05	1.9581D 04	1.7221D-03	*
9.00D 05	1.9815D 04	9.8830D-04	*
1.00D 06	1.9881D 04	4.9166D-04	*

r_{eD} = 500

t_D	Q_D	q_D	
1.00D 05	9.3445D 03	8.8305D-02	*
2.00D 05	1.7844D 04	8.1807D-02	*
3.00D 05	2.5719D 04	7.5788D-02	*
4.00D 05	3.3021D 04	7.0230D-02	*
5.00D 05	3.9789D 04	6.5048D-02	*
6.00D 05	4.6066D 04	6.0269D-02	*
7.00D 05	5.1882D 04	5.5812D-02	*
8.00D 05	5.7282D 04	5.1733D-02	*
9.00D 05	6.2275D 04	4.7905D-02	*
1.00D 06	6.6894D 04	4.4340D-02	*
2.00D 06	9.7886D 04	2.0711D-02	*
3.00D 06	1.1216D 05	9.8018D-03	*
4.00D 06	1.1895D 05	4.6837D-03	*
5.00D 06	1.2208D 05	2.2330D-03	*
6.00D 06	1.2365D 05	1.0274D-03	*
7.00D 06	1.2445D 05	4.3472D-04	*
8.00D 06	1.2484D 05	1.4856D-04	*

r_{eD} = 1000

t_D	QD	q_D	
1.00D 05	9.3671D 03	8.9282D-02	
2.00D 05	1.8143D 04	8.6571D-02	
3.00D 05	2.6708D 04	8.4793D-02	
4.00D 05	3.5109D 04	8.3239D-02	*
5.00D 05	4.3357D 04	8.1749D-02	*
6.00D 05	5.1458D 04	8.0300D-02	*
7.00D 05	5.9414D 04	7.8975D-02	*
8.00D 05	6.7231D 04	7.7481D-02	*
9.00D 05	7.4908D 04	7.6107D-02	*
1.00D 06	8.2447D 04	7.4751D-02	*
2.00D 06	1.5093D 05	6.2495D-02	*
3.00D 06	2.0327D 05	5.2218D-02	*
4.00D 06	2.5625D 05	4.3634D-02	*
5.00D 06	2.9532D 05	3.6439D-02	*
6.00D 06	3.2977D 05	3.0480D-02	*
7.00D 06	3.5764D 05	2.5495D-02	*
8.00D 06	3.8086D 05	2.1339D-02	*
9.00D 06	4.0017D 05	1.7859D-02	*
1.00D 07	4.1634D 05	1.4934D-02	*
2.00D 07	4.6525D 05	2.6416D-03	*
3.00D 07	4.9778D 05	3.8796D-04	*

CLOSED OUTER BOUNDARY

Skin = *5*

r_{eD} = 2000

t_D	QD	q_D	
1.00D 05	9.3674D 03	8.9234D-02	
2.00D 05	1.8147D 04	8.6613D-02	
3.00D 05	2.6730D 04	8.5122D-02	
4.00D 05	3.5188D 04	8.4096D-02	
5.00D 05	4.3556D 04	8.3318D-02	
6.00D 05	5.1855D 04	8.2690D-02	
7.0QD 05	6.0095D 04	8.2157D-02	
8.00D 05	6.8286D 04	8.1686D-02	
9.00D 05	7.6432D 04	8.1257D-02	
1.00D 06	8.4537D 04	8.0856D-02	
2.00D 06	1.6361D 05	7.7393D-02	*
3.00D 06	2.3938D 05	7.4200D-02	*
4.00D 06	3.1202D 05	7.1139D-02	*
5.00D 06	3.8170D 05	6.8216D-02	*
6.00D 06	4.4849D 05	6.5395D-02	*
7.00D 06	5.1255D 05	6.2690D-02	*
8.00D 06	5.7399D 05	6.0100D-02	*
9.00D 06	6.3293D 05	5.7615D-02	*
1.00D 07	6.8747D 05	5.5235D-02	*
2.00D 07	1.1414D 06	3.6183D-02	*
3.00D 07	1.4367D 06	2.3735D-02	*
4.00D 07	1.6291D 06	1.5638D-02	*
5.00D 07	1.7544D 06	1.0343D-02	*
6.00D 07	1.8368D 06	6.8749D-03	*
7.00D 07	1.8909D 06	4.5517D-03	*
8.00D 07	1.9277D 06	3.0479D-03	*
9.00D 07	1.9518D 06	2.0043D-03	*
1.00D 08	1.9682D 06	1.3138D-03	*

r_{eD} = 5000

t_D	QD	q_D	
1.00D 06	8.4570D 04	8.0987D-02	
2.00D 06	1.6433D 05	7.8780D-02	
3.00D 06	2.4244D 05	7.7547D-02	
4.00D 06	3.1953D 05	7.6690D-02	
5.00D 06	3.9587D 05	7.6014D-02	
6.00D 06	4.7158D 05	7.5431D-02	
7.00D 06	5.4674D 05	7.4901D-02	
8.00D 06	6.2139D 05	7.4400D-02	*
9.00D 06	6.9554D 05	7.3917D-02	*
1.00D 07	7.6922D 05	7.3446D-02	*
2.00D 07	1.4810D 06	6.8983D-02	*
3.00D 07	2.1494D 06	6.4792D-02	*
4.00D 07	2.7777D 06	6.0868D-02	*
5.00D 07	3.3680D 06	5.7169D-02	*
6.00D 07	3.9230D 06	5.3700D-02	*
7.00D 07	4.4443D 06	5.0428D-02	*
8.00D 07	4.9348D 06	4.7378D-02	*
9.00D 07	5.3951D 06	4.4484D-02	*
1.00D 08	5.8276D 06	4.1768D-02	*
2.00D 08	8.9360D 06	2.2320D-02	*
3.00D 08	1.0583D 07	1.2019D-02	*
4.00D 08	1.1455D 07	6.5326D-03	*
5.00D 08	1.1929D 07	3.5742D-03	*
6.00D 08	1.2189D 07	1.9446D-03	*
7.00D 08	1.2335D 07	1.0407D-03	*
8.00D 08	1.2418D 07	5.3721D-04	*
9.00D 08	1.2459D 07	2.3230D-04	*
1.00D 07	1.2488D 07	8.0538D-05	*

r_{eD} = 1x10^4

t_D	QD	q_D	
1.00D 07	7.7072D 05	7.4096D-02	
2.00D 07	1.5012D 06	7.2218D-02	
3.00D 07	2.2170D 06	7.0986D-02	
4.00D 07	2.9213D 06	6.9901D-02	*
5.00D 07	3.6151D 06	6.8861D-02	*
6.00D 07	4.2985D 06	6.7847D-02	*
7.00D 07	4.9718D 06	6.6847D-02	*
8.00D 07	5.6352D 06	6.5865D-02	*
9.00D 07	6.2888D 06	6.4895D-02	*
1.00D 08	6.9327D 06	6.3936D-02	*
2.00D OH	1.2876D 07	5.5115D-02	*
3.0011 08	1.8005D 07	4.7493D-02	*
4.00D 08	2.2432D 07	4.0925D-02	*
5.00D 08	2.6248D 07	3.5259D-02	*
6.00D 08	2.9536D 07	3.0383D-02	*
7.00D 08	3.2365D 07	2.6187D-02	*
8.00D 08	3.4797D 07	2.2578D-02	*
9.00D 08	3.6884D 07	1.9462D-02	*
1.00D 09	3.8684D 07	1.6804D-02	*
2.00D 05'	4.7333D 07	3.9609D-03	*
3.00D 09	4.9382D 07	9.1110D-04	*
4.00D OY	4.9906D 07	1.4290D-04	*

r_{eD} = 5x10^4

t_D	QD	q_D	
1.00D 08	7.0799D 06	6.8286D-02	
2.00D 08	1.3821D 07	6.6709D-02	
3.00D 08	2.0444D 07	6.5821D-02	
4.00D 08	2.6994D 07	6.5202D-02	
5.00D 08	3.3488D 07	6.4713D-02	
6.00D 08	3.9938D 07	6.4292D-02	
7.00D 08	4.6349D 07	6.3908D-02	
8.00D 08	5.2720D 07	6.3545D-02	*
9.00D 08	5.9037D 07	6.3194D-02	*
1.00D 09	6.5359D 07	6.2853D-02	*
2.00D 09	1.2656D 08	5.9600D-02	*
3.00D 09	1.8459D 08	5.6517D-02	*
4.00D 09	2.3964D 08	5.3604D-02	*
5.00D 09	2.9185D 08	5.0831D-02	*
6.00D 09	3.4140D 08	4.8206D-02	*
7.00D 09	3.8840D 08	4.5707D-02	*
8.00D 09	4.3302D 08	4.3355D-02	*
9.00D 09	4.7532D 08	4.1102D-02	*
1.00D 10	5.1545D 08	3.8965D-02	*
2.00D 10	8.1856D 08	2.2893D-02	*
3.00D 10	9.9543D 08	1.3506D-02	*
4.00D 10	1.0986D 09	8.0194D-03	*
5.00D 10	1.1595D 09	4.7966D-03	*
6.00D 10	1.1957D 09	2.8782D-03	*
7.00D 10	1.2179D 09	1.7356D-03	*
8.00D 10	1.2309D 07	1.0139D-03	*
9.00D 10	1.2389D 09	5.7250D-04	*
1.00D 11	1.2448D 09	3.4051D-04	*

CLOSED OUTER BOUNDARY
Skin = 5

$r_{eD} = 1x10^5$

t_D	QD	q_D	
1.00D 09	6.5466D 07	6.3316D-02	
2.00D 09	1.2802D 08	6.1940D-02	
3.00D 09	1.8949D 08	6.1034D-02	
4.00D 09	2.5012D 08	6.0236D-02	*
5.00D 09	3.0996D 08	5.9469D-02	*
6.00D 09	3.6905D 08	5.8720D-02	*
7.00D 09	4.2739D 08	5.7980D-02	*
8.00D 09	4.8500D 08	5.7252D-02	*
9.00D 09	5.4187D 08	5.6531D-02	*
1.00D 10	5.9802D 08	5.5817D-02	*
2.00D 10	1.1222D 09	4.9171D-02	*
3.00D 10	1.5845D 09	4.3305D-02	*
4.00D 10	1.9921D 09	3.8137D-02	*
5.00D 10	2.3515D 09	3.3581D-02	*
6.00D 10	2.6681D 09	2.9571D-02	*
7.00D 10	2.9468D 09	2.6046D-02	*
8.00D 10	3.1917D 09	2.2934D-02	*
9.00D 10	3.4069D 09	2.0197D-02	*
1.00D 11	3.5963D 09	1.7800D-02	*
2.00D 11	4.5945D 09	5.1313D-03	*
3.00D 11	4.8808D 09	1.4960D-03	*
4.00D 11	4.9715D 09	4.2229D-04	*
5.00D 11	4.9959D 09	5.8351D-05	*

$r_{eD} = 5x10^5$

t_D	QD	q_D	
1.00D 10	6.0383D 08	5.9022D-02	
2.00D 10	1.1925D 09	5.7840D-02	
3.00D 10	1.7673D 09	5.7171D-02	
4.00D 10	2.3366D 09	5.6704D-02	
5.00D 10	2.9017D 09	5.6333D-02	
6.00D 10	3.4634D 09	5.6014D-02	
7.00D 10	4.0221D 09	5.5723D-02	
8.00D 10	4.5779D 09	5.5448D-02	*
9.00D 10	5.1311D 09	5.5183D-02	*
1.00D 11	5.6816D 09	5.4923D-02	*
2.00D 11	1.1048D 10	5.2448D-02	*
3.00D 11	1.6173D 10	5.0087D-02	*
4.00D 11	2.1067D 10	4.7835D-02	*
5.00D 11	2.5744D 10	4.5691D-02	*
6.00D 11	3.0210D 10	4.3630D-02	*
7.00D 11	3.4477D 10	4.1655D-02	*
8.00D 11	3.8554D 10	3.9788D-02	*
9.00D 11	4.2450D 10	3.7994D-02	*
1.00D 12	4.6171D 10	3.6281D-02	*
2.00D 12	7.5329D 10	2.2867D-02	*
3.00D 12	9.3629D 10	1.4440D-02	*
4.00D 12	1.0508D 11	9.1634D-03	*
5.00D 12	1.1229D 11	5.8518D-03	*
6.00D 12	1.1685D 11	3.7499D-03	*
7.00D 12	1.1978D 11	2.4087D-03	*
8.00D 12	1.2167D 11	1.5454D-03	*
9.00D 12	1.2287D 11	9.6747D-04	*
1.00D 13	1.2369D 11	6.0515D-04	*

$r_{eD} = 1x10^6$

t_D	QD	q_D	
1.00D 10	6.0882D 08	5.9022D-02	
2.00D 10	1.1925D 09	5.7841D-02	
3.00D 10	1.7674D 09	5.7172D-02	
4.00D 10	2.3368D 09	5.6706D-02	
5.00D 10	2.9021D 09	5.6350D-02	
6.00D 10	3.4642D 09	5.6062D-02	
7.00D 10	4.0236D 09	5.5820D-02	
8.00D 10	4.5808D 09	5.5613D-02	
9.00D 10	5.1361D 09	5.5432D-02	
1.00D 11	5.6596D 09	5.5271D-02	
2.00D 11	1.1158D 10	5.4219D-02	
3.00D 11	1.6544D 10	5.3526D-02	
4.00D 11	2.1866D 10	5.2913D-02	*
5.00D 11	2.7128D 10	5.2326D-02	*
6.00D 11	3.2331D 10	5.1749D-02	*
7.00D 11	3.7477D 10	5.1180D-02	*
8.00D 11	4.2566D 10	5.0617D-02	*
9.00D 11	4.7599D 10	5.0062D-02	*
1.00D 12	5.2575D 10	4.9510D-02	*
2.00D 12	9.9438D 10	4.4325D-02	*
3.00D 12	1.4142D 11	3.9675D-02	*
4.00D 12	1.7905D 11	3.5514D-02	*
5.00D 12	2.1276D 11	3.1783D-02	*
6.00D 12	2.4295D 11	2.8445D-02	*
7.00D 12	2.6998D 11	2.5457D-02	*
8.00D 12	2.9415D 11	2.2783D-02	*
9.00D 12	3.1574D 11	2.0394D-02	*
1.00D 13	3.3507D 11	1.8253D-02	*
2.00D 13	4.4460D 11	6.1309D-03	*
3.00D 13	4.8095D 11	2.1029D-03	*
4.00D 13	4.9359D 11	7.0050D-04	*
5.00D 13	4.9834D 11	2.0504D-04	*
6.00D 13	4.9985D 11	1.5131D-05	*

CLOSED OUTER BOUNDARY
Skin = 10

r_{eD} = 20

t_D	Q_D	q_D
1.00D 02	8.1484D 00	7.8277D-02
2.00D 02	1.5810D 01	7.5036D-02
3.00D 02	2.3161D 01	7.2031D-02
4.00D 02	3.0217D 01	6.9152D-02
5.00D 02	3.6994D 01	6.6395D-02
6.00D 02	4.3500D 01	6.3753D-02
7.00D 02	4.9745D 01	6.1174D-02
8.00D 02	5.5745D 01	5.8725D-02
9.00D 02	6.1507D 01	5.6370D-02
1.00D 03	6.7041D 01	5.4111D-02
2.00D 03	1.1158D 02	3.5905D-02
3.00D 03	1.4106D 02	2.3835D-02
4.00D 03	1.6057D 02	1.5927D-02
5.00D 03	1.7337D 02	1.0630D-02
6.00D 03	1.8193D 02	7.1576D-03
7.00D 03	1.8763D 02	4.8060D-03
8.00D 03	1.9151D 02	3.2425D-03
9.00D 03	1.9404D 02	2.1452D-03
1.00D 04	1.9581D 02	1.4194D-03

r_{eD} = 50

t_D	QD	q_D	
1.00D 03	7.4606D 01	7.1371D-02	*
2.00D 03	1.4383D 02	6.7159D-02	*
3.00D 03	2.0897D 02	6.3195D-02	*
4.00D 03	2.7031D 02	5.9482D-02	*
5.00D 03	3.2804D 02	5.5967D-02	*
6.00D 03	3.8241D 02	5.2670D-02	*
7.00D 03	4.3360D 02	4.9556D-02	*
8.00D 03	4.8184D 02	4.6664D-02	*
9.00D 03	5.2717D 02	4.3372D-02	*
1.00D 04	5.6986D 02	4.1269D-02	*
2.00D 04	8.7973D 02	2.2468D-02	*
3.00D 04	1.0468D 03	1.2314D-02	*
4.00D 04	1.1369D 03	6.7761D-03	*
5.00D 04	1.1874D 03	3.8191D-03	*
6.00D 04	1.2148D 03	2.1045D-03	*
7.00D 04	1.2303D 03	1.1414D-03	*
8.00D 04	1.2395D 03	6.0470D-04	*
9.00D 04	1.2444D 03	2.8460D-04	*
1.00D 05	1.2484D 03	1.4265D-04	*

r_{eD} = 100

t_D	Q_D	q_D	
1.00D 03	7.4749D 01	7.1987D-02	
2.00D 03	1.4575D 02	7.0217D-02	
3.00D 03	2.1536D 02	6.9052D-02	
4.00D 03	2.8389D 02	6.8027D-02	*
5.00D 03	3.5142D 02	6.7043D-02	*
6.00D 03	4.1797D 02	6.6084D-02	*
7.00D 03	4.8357D 02	6.5138D-02	*
8.00D 03	5.4823D 02	6.4207D-02	*
9.00D 03	6.1196D 02	6.3288D-02	*
1.00D 04	6.7476D 02	6.2379D-02	*
2.00D 04	1.2557D 03	5.4001D-02	*
3.00D 04	1.7573D 03	4.6731D-02	*
4.00D 04	2.1956D 03	4.0429D-02	*
5.00D 04	2.5737D 03	3.4998D-02	*
6.00D 04	2.9006D 03	3.0278D-02	*
7.00D 04	3.1829D 03	2.6197D-02	*
8.00D 04	3.4270D 03	2.2681D-02	*
9.00D 04	3.6375D 03	1.9637D-02	*
1.00D 05	3.8201D 03	1.7041D-02	*
2.00D 05	4.7102D 03	4.1732D-03	*
3.00D 05	4.9314D 03	1.0413D-03	*
4.00D 05	4.9710D 03	2.1742D-04	*

r_{eD} = 200

t_D	Q_D	q_D	
1.00D 04	6.8848D 02	6.6411D-02	
2.00D 04	1.3406D 03	6.4080D-02	*
3.00D 04	1.9704D 03	6.1917D-02	*
4.00D 04	2.5787D 03	5.9827D-02	*
5.00D 04	3.1671D 03	5.7818D-02	*
6.00D 04	3.7353D 03	5.5862D-02	*
7.00D 04	4.2843D 03	5.3971D-02	*
8.00D 04	4.8131D 03	5.2148D-02	*
9.00D 04	5.3281D 03	5.0386D-02	
1.00D 05	5.8242D 03	4.8689D-02	*
2.00D 05	9.9543D 03	3.4496D-02	
3.00D 05	1.2882D 04	2.4459D-02	*
4.00D 05	1.4949D 04	1.7382D-02	*
5.00D 05	1.6399D 04	1.2335D-02	
6.00D 05	1.7429D 04	8.8367D-03	*
7.00D 05	1.8153D 04	6.2937D-03	*
8.00D 05	1.8683D 04	4.5532D-03	*
9.00D 05	1.9053D 04	3.2620D-03	*
1.00D 06	1.9309D 04	2.3021D-03	*
2.00D 06	2.0006D 04	8.6366D-06	*

r_{eD} = 500

t_D	Q_D	q_D	
1.00D 05	6.3716D 03	6.1335D-02	*
2.00D 05	1.2348D 04	5.8240D-02	*
3.00D 05	1.8022D 04	5.5303D-02	*
4.00D 05	2.3412D 04	5.2524D-02	*
5.00D 05	2.8531D 04	4.9870D-02	*
6.00D 05	3.3395D 04	4.7362D-02	*
7.00D 05	3.8015D 04	4.4966D-02	*
8.00D 05	4.2410D 04	4.2715D-02	*
9.00D 05	4.6579D 04	4.0551D-02	*
1.00D 06	5.0537D 04	3.8486D-02	*
2.00D 06	8.0370D 04	2.2924D-02	*
3.00D 06	9.8500D 04	1.3700D-02	*
4.00D 06	1.0904D 05	8.2425D-03	
5.00D 06	1.1534D 05	4.9949D-03	*
6.00D 06	1.1913D 05	3.0335D-03	
7.00D 06	1.2145D 05	1.8409D-03	*
8.00D 06	1.2288D 05	1.1095D-03	*
9.00D 06	1.2373D 05	6.3734D-04	*
1.00D 07	1.2431D 05	3.6016D-04	*

r_{eD} = 1000

t_D	QD	q_D	
1.00D 05	6.3817D 03	6.1775D-02	
2.00D 05	1.2486D 04	6.0464D-02	
3.00D 05	1.8488D 04	5.9601D-02	
4.00D 05	2.4410D 04	5.8840D-02	*
5.00D 05	3.0257D 04	5.8109D-02	*
6.00D 05	3.6031D 04	5.7395D-02	*
7.00D 05	4.1734D 04	5.6697D-02	*
8.00D 05	4.7367D 04	5.5995D-02	*
9.00D 05	5.2931D 04	5.5307D-02	*
1.00D 06	5.8425D 04	5.4624D-02	*
2.00D 06	1.0980D 05	4.8270D-02	*
3.00D 06	1.5525D 05	4.2643D-02	*
4.00D 06	1.9545D 05	3.7673D-02	*
5.00D 06	2.3100D 05	3.3275D-02	*
6.00D 06	2.6241D 05	2.9393D-02	*
7.00D 06	2.9013D 05	2.5964D-02	*
8.00D 06	3.1463D 05	2.2937D-02	*
9.00D 06	3.3618D 05	2.0258D-02	*
1.00D 07	3.5524D 05	1.7912D-02	*
2.00D 07	4.5699D 05	5.3213D-03	*
3.00D 07	4.8698D 05	1.6050D-03	*
4.00D 07	4.9642D 05	4.4569D-04	*
5.00D 07	4.9951D 05	8.6115D-05	*

CLOSED OUTER BOUNDARY
Skin = 10

$r_{eD} = 2000$

t_D	Q_D	q_D	
1.00D 05	6.3819D 03	6.1776D-02	
2.00D 05	1.2488D 04	6.0483D-02	
3.00D 05	1.8498D 04	5.9750D-02	
4.00D 05	2.4447D 04	5.9242D-02	
5.00D 05	3.0351D 04	5.8855D-02	
6.00D 05	3.6220D 04	5.8540D-02	
7.00D 05	4.2060D 04	5.8273D-02	
8.00D 05	4.7875D 04	5.8036D-02	
9.00D 05	5.3667D 04	5.7820D-02	
1.00D 06	5.9439D 04	5.7618D-02	
2.00D 06	1.1616D 05	5.5866D-02	*
3.00D 06	1.7120D 05	5.4234D-02	*
4.00D 06	2.2462D 05	5.2650D-02	*
5.00D 06	2.7650D 05	5.1118D-02	*
6.00D 06	3.2685D 05	4.9622D-02	*
7.00D 06	3.7573D 05	4.8170D-02	*
8.00D 06	4.2319D 05	4.6762D-02	*
9.00D 06	4.6929D 05	4.5394D-02	*
1.00D 07	5.1405D 05	4.4069D-02	*
2.00D 07	8.9614D 05	3.2734D-02	*
3.00D 07	1.1803D 06	2.4307D-02	*
4.00D 07	1.3908D 06	1.8070D-02	*
5.00D 07	1.5463D 06	1.3450D-02	*
6.00D 07	1.6614D 06	1.0039D-02	*
7.00D 07	1.7465D 06	7.4936D-03	*
8.00D 07	1.8102D 06	5.6305D-03	*
9.00D 07	1.8573D 06	4.2169D-03	*
1.00D 08	1.8927D 06	3.1671D-03	*
2.00D 08	1.9766D 06	1.2622D-04	*

$r_{eD} = 5000$

t_D	QD	q_D	
1.00D 06	5.9455D 04	5.7680D-02	
2.00D 06	1.1651D 05	5.6550D-02	
3.00D 06	1.7272D 05	5.5911D-02	
4.00D 06	2.2839D 05	5.5464D-02	
5.00D 06	2.8367D 05	5.5109D-02	
6.00D 06	3.3863D 05	5.4804D-02	
7.00D 06	3.9329D 05	5.4526D-02	
8.00D 06	4.4769D 05	5.4262D-02	*
9.00D 06	5.0182D 05	5.4008D-02	*
1.00D 07	5.5571D 05	5.3760D-02	*
2.00D 07	1.0813D 06	5.1390D-02	*
3.00D 07	1.5836D 06	4.9126D-02	*
4.00D 07	2.0640D 06	4.6969D-02	*
5.00D 07	2.5232D 06	4.4901D-02	*
6.00D 07	2.9625D 06	4.2927D-02	*
7.00D 07	3.3824D 06	4.1032D-02	*
8.00D 07	3.7844D 06	3.9235D-02	*
9.00D 07	4.1684D 06	3.7499D-02	*
1.00D 08	4.5358D 06	3.5841D-02	*
2.00D 08	7.4360D 06	2.2822D-02	*
3.00D 08	9.2657D 06	1.4552D-02	*
4.00D 08	1.0426D 07	9.3271D-03	*
5.00D 08	1.1164D 07	6.0129D-03	*
6.00D 08	1.1635D 07	3.8901D-03	*
7.00D 08	1.1941D 07	2.5235D-03	*
8.00D 08	1.2139D 07	1.6363D-03	*
9.00D 08	1.2266D 07	1.0582D-03	*
1.00D 09	1.2354D 07	6.5914D-04	*

$r_{eD} = 1x10^4$

t_D	Q_D	q_D	
1.00D 07	5.5647D 05	5.4092D-02	
2.00D 07	1.0918D 06	5.3084D-02	
3.00D 07	1.6192D 06	5.2419D-02	
4.00D 07	2.1404D 06	5.1833D-02	*
5.00D 07	2.6559D 06	5.1269D-02	*
6.00D 07	3.1658D 06	5.0717D-02	*
7.0011 07	3.6702D 06	5.0170D-02	*
8.00D 07	4.1691D 06	4.9631D-02	*
9.0011 07	4.6626D 06	4.9097D-02	*
1.00D 08	5.1508D 06	4.8567D-02	*
2.00D 08	9.7531D 06	4.3584D-02	*
3.00D 08	1.3886D 07	3.9105D-02	*
4.00D OD	1.7598D 07	3.5087D-02	*
5.00D 0a	2.0933D 07	3.1476D-02	*
I.00D 08	2.3926D 07	2.8237D-02	*
7.00D 0a	2.6612D 07	2.5330D-02	*
8.00D 08	2.9021D 07	2.2723D-02	*
9.00D 08	3.1177D 07	2.0378D-02	*
1.00D 09	3.3112D 07	1.8291D-02	*
2.00D 09	4.4199D 07	6.2824D-03	*
3.00D 09	4.7960D 07	2.2043D-03	*
4.0011 09	4.9304D 07	7.5592D-04	*
5.00D 07	4.9805D 07	2.3277D-04	*
6.00D 09	4.9973D 07	2.8205D-05	*

$r_{eD} = 5x10^4$

t_D	Q_D	q_D	
1.00D 08	5.2300D 06	5.0925D-02	
2.00D 08	1.0274D 07	5.0042D-02	
3.00D 08	1.5251D 07	4.9541D-02	
4.00D OH	2.0187D 07	4.9189D-02	
5.00D 08	2.5092D 07	4.8911D-02	
6.00D 08	2.9970D 07	4.8670D-02	
7.00D 08	3.4827D 07	4.8451D-02	
8.00D 08	3.9661D 07	4.8244D-02	*
9.00D 08	4.4476D 07	4.8044D-02	*
1.0011 c9	4.9271D 07	4.7848D-02	*
2.00D 09	9.6170D 07	4.5976D-02	*
3.001: 09	1.4123D 08	4.4178D-02	*
4.00D 09	1.8453D OB	4.2456D-02	*
5.0011 09	2.261411 08	4.0796D-02	*
6.00D 09	2.6615D 08	3.9205D-02	*
7.00D 09	3.0459D 08	3.7670D-02	*
8.00D 09	3.4157D OD	3.6205D-02	*
9.00D 09	3.7709D 08	3.4784D-02	*
1.00D 10	4.1123D OB	3.3419D-02	*
2.00D 10	6.8764D 08	2.2410D-02	*
3.00D 10	8.7262D OH	1.5037D-02	*
4.00D 10	9.9587D 08	1.0118D-02	*
5.00D 10	1.0782D 09	6.8415D-03	*
6.0011 10	1.1334D 09	4.6456D-03	*
7.0011 10	1.1709D 09	3.1741D-03	*
8.00D 10	1.1960D 09	2.1539D-03	*
9.00D 10	1.2131D 09	1.4570D-03	*
1.0311 11	1.2258D 09	1.0083D-03	*

CLOSED OUTER BOUNDARY
Skin = 10

$r_{eD} = 1x10^5$

t_D	Q_D	q_D	
1.00D 09	4.9330D 07	4.6107D-02	
2.00D 09	9.6994D 07	4.7309D-02	
3.00D 09	1.4403D 08	4.6781D-02	
4.00D 09	1.9058D 08	4.6314D-02	*
5.00D 09	2.3667D 08	4.5866D-02	*
6.00D 09	2.8231D 08	4.5426D-02	*
7.00D 09	3.2751D 08	4.4991D-02	*
8.00D 09	3.7228D 08	4.4561D-02	*
9.00D 09	4.1662D 08	4.4134D-02	*
1.00D 10	4.6053D 08	4.3710D-02	*
2.00D 10	8.7717D 08	3.9699D-02	*
3.00D 10	1.2557D 09	3.6051D-02	*
4.00D 10	1.5999D 09	3.2738D-02	*
5.00D 10	1.9127D 09	2.9726D-02	*
6.00D 10	2.1970D 09	2.6992D-02	*
7.00D 10	2.4553D 09	2.4510D-02	*
8.00D 10	2.6897D 09	2.2249D-02	*
9.00D 10	2.9023D 09	2.0197D-02	*
1.00D 11	3.0934D 09	1.8340D-02	*
2.00D 11	4.2665D 09	7.0566D-03	*
3.00D 11	4.7111D 09	2.7710D-03	*
4.00D 11	4.8891D 09	1.1093D-03	*
5.00D 11	4.9582D 09	4.0593D-04	*
6.00D 11	4.9863D 09	1.1353D-04	*

$r_{eD} = 5x10^5$

t_D	Q_D	q_D	
1.00D 10	4.6681D 08	4.5586D-02	
2.00D 10	9.1877D 08	4.4876D-02	
3.00D 10	1.3654D 09	4.4473D-02	
4.00D 10	1.8086D 09	4.4189D-02	
5.00D 10	2 2494D 09	4.3964D-02	
6.00D 10	2.6880D 09	4.3770D-02	
7.00D 10	3.1249D 09	4.3593D-02	
8.00D 10	3.5600D 09	4.3426D-02	*
9.00D 10	3.9934D 09	4.3264D-02	*
1.00D 11	4.4253D 09	4.3106D-02	*
2.00D 11	8.6591D 09	4.1588D-02	*
3.00D 11	1.2743D 10	4.0127D-02	*
4.00D 11	1.6685D 10	3.8719D-02	*
5.00D 11	2.0488D 10	3.7364D-02	*
6.00D 11	2.4159D 10	3.6049D-02	*
7.00D 11	2.7699D 10	3.4783D-02	*
8.00D 11	3.1118D 10	3.3560D-02	*
9.00D 11	3.4417D 10	3.2380D-02	*
1.00D 12	3.7602D 10	3.1241D-02	*
2.00D 12	6.3938D 10	2.1831D-02	*
3.00D 12	8.2327D 10	1.5255D-02	*
4.00D 12	9.5111D 10	1.0681D-02	*
5.00D 12	1.0400D 11	7.5065D-03	*
6.00D 12	1.1019D 11	5.2920D-03	*
7.00D 12	1.1454D 11	3.7440D-03	*
8.00D 12	1.1760D 11	2.6555D-03	*
9.00D 12	1.1973D 11	1.8719D-03	*
1.00D 13	1.2129D 11	1.3270D-03	*

$r_{eD} = 1x10^6$

t_D	Q_D	q_D	
1.00D 10	4.6691D 08	4.5586D-02	
2.00D 10	9.1876D 08	4.4877D-02	
3.00D 10	1.3654D 09	4.4473D-02	
4.00D 10	1.8088D 09	4.4191D-02	
5.00D 10	2.2496D 09	4.3974D-02	
6.00D 10	2.6885D 09	4.3798D-02	
7.00D 10	3.1258D 09	4.3651D-02	
8.00D 10	3.5617D 09	4.3524D-02	
9.00D 10	3.9964D 09	4.3413D-02	
1.00D 11	4.4301D 09	4.3314D-02	
2.00D 11	8.7255D 09	4.2665D-02	
3.00D 11	1.2970D 10	4.2236D-02	
4.00D 11	1.7175D 10	4.1856D-02	*
5.00D 11	2.1342D 10	4.1492D-02	*
6.00D 11	2.5473D 10	4.1133D-02	*
7.00D 11	2.9568D 10	4.0779D-02	*
8.00D 11	3.3628D 10	4.0427D-02	*
9.00D 11	3.7653D 10	4.0079D-02	*
1.00D 12	4.1642D 10	3.9732D-02	*
2.00D 12	7.9693D 10	3.6434D-02	*
3.00D 12	1.1459D 11	3.3406D-02	*
4.00D 12	1.4662D 11	3.0631D-02	*
5.00D 12	1.7602D 11	2.8083D-02	*
6.00D 12	2.0299D 11	2.5747D-02	*
7.00D 12	2.2773D 11	2.3604D-02	*
8.00D 12	2.5042D 11	2.1637D-02	*
9.00D 12	2.7121D 11	1.9829D-02	*
1.00D 13	2.9028D 11	1.9182D-02	*
2.00D 13	4.1145D 11	7.6758D-03	*
3.00D 13	4.6190D 11	3.2793D-03	*
4.00D 13	4.8354D 11	1.4290D-03	*
5.00D 13	4.9312D 11	6.1130D-04	*
6.00D 13	4.9731D 11	2.3236D-04	*
7.00D 13	4.9952D 11	8.1987D-05	*

CLOSED OUTER BOUNDARY
Skin = 20

r_{eD} = 20

t_D	QD	q_D
1.00D 02	4.4912D 00	4.3938D-02
2.00D 02	8.8333D 00	4.2923D-02
3.00D 02	1.3077D 01	4.1968D-02
4.00D 02	1.7226D 01	4.1034D-02
5.00D 02	2.1284D 01	4.0124D-02
6.00D 02	2.5250D 01	3.9230D-02
7.00D 02	2.9127D 01	3.8354D-02
8.00D 02	3.2919D 01	3.7501D-02
9.00D 02	3.6627D 01	3.6666D-02
1.00D 03	4.0254D 01	3.5851D-02
2.00D 03	7.2389D 01	2.8612D-02
3.00D 03	9.8080D 01	2.2819D-02
4.00D 03	1.1860D 02	1.8221D-02
5.00D 03	1.3490D 02	1.4527D-02
6.00D 03	1.4789D 02	1.1611D-02
7.00D 03	1.5820D 02	9.2815D-03
8.00D 03	1.6643D 02	7.4381D-03
9.00D 03	1.7293D 02	5.9503D-03
1.00D 04	1.7813D 02	4.7748D-03
2.00D 04	1.9720D 02	5.3330D-04
3.00D 04	1.9953D 02	9.9822D-06

r_{eD} = 50

t_D	Q_D	q_D	
1.00D 03	4.2742D 01	4.1683D-02	*
2.00D 03	8.3709D 01	4.0266D-02	*
3.00D 03	1.2328D 02	3.8896D-02	*
4.00D 03	1.6151D 02	3.7580D-02	*
5.00D 03	1.9843D 02	3.6302D-02	*
6.00D 03	2.3411D 02	3.5072D-02	*
7.00D 03	2.6859D 02	3.3879D-02	*
8.00D 03	3.0192D 02	3.2734D-02	*
9.00D 03	3.3410D 02	3.1616D-02	*
1.00D 04	3.6520D 02	3.0539D-02	*
2.00D 04	6.2411D 02	2.1603D-02	*
3.00D 04	8.0718D 02	1.5278D-02	*
4.00D 04	9.3586D 02	1.0807D-02	*
5.00D 04	1.0269D 03	7.7069D-03	*
6.00D 04	1.0907D 03	5.4852D-03	*
7.00D 04	1.1358D 03	3.9168D-03	*
8.00D 04	1.1681D 03	2.8092D-03	*
9.00D 04	1.1911D 03	2.0087D-03	*

r_{eD} = 100

t_D	Q_D	q_D	
1.00D 03	4.2787D 01	4.1879D-02	
2.00D 03	8.4332D 01	4.1274D-02	
3.00D 03	1.2540D 02	4.0873D-02	
4.00D 03	1.6610D 02	4.0518D-02	*
5.00D 03	2.0644D 02	4.0176D-02	*
6.00D 03	2.4645D 02	3.9840D-02	*
7.00D 03	2.8612D 02	3.9509D-02	*
8.00D 03	3.2546D 02	3.9179D-02	*
9.00D 03	3.6447D 02	3.8852D-02	*
1.00D 04	4.0315D 02	3.8527D-02	*
2.00D 04	7.7263D 02	3.5431D-02	*
3.00D 04	1.1125D 03	3.2579D-02	*
4.00D 04	1.4252D 03	2.9955D-02	*
5.00D 04	1.7132D 03	2.7550D-02	*
6.00D 04	1.9780D 03	2.5328D-02	*
7.00D 04	2.2217D 03	2.3282D-02	*
8.00D 04	2.4458D 03	2.1405D-02	*
9.00D 04	2.6518D 03	1.9675D-02	*
1.00D 05	2.8415D 03	1.8100D-02	*
2.00D 05	4.0628D 03	7.8521D-03	*
3.00D 05	4.5869D 03	3.4835D-03	*
4.00D 05	4.8179D 03	1.5658D-03	*
5.00D 05	4.9177D 03	6.6656D-04	*
6.00D 05	4.9675D 03	2.8497D-04	*
7.00D 05	4.9903D 03	1.0033D-04	*

r_{eD} = 200

t_D	Q_D	q_D	
1.00D 04	4.0786D 02	3.9929D-02	
2.00D 04	8.0287D 02	3.9090D-02	*
3.00D 04	1.1898D 03	3.8302D-02	*
4.00D 04	1.5689D 03	3.7530D-02	*
5.00D 04	1.9403D 03	3.6777D-02	*
6.00D 04	2.3043D 03	3.6035D-02	*
7.00D 04	2.6608D 03	3.5307D-02	*
8.00D 04	3.0102D 03	3.4595D-02	*
9.00D 04	3.3526D 03	3.3898D-02	*
1.00D 05	3.6882D 03	3.3217D-02	*
2.00D 05	6.6958D 03	2.7089D-02	*
3.00D 05	9.1537D 03	2.2091D-02	*
4.00D 05	1.1160D 04	1.8015D-02	*
5.00D 05	1.2789D 04	1.4669D-02	*
6.00D 05	1.4118D 04	1.1981D-02	*
7.00D 05	1.5194D 04	9.7665D-03	*
8.00D 05	1.6075D 04	8.0043D-03	*
9.00D 05	1.6788D 04	6.5468D-03	*
1.00D 06	1.7361D 04	5.3425D-03	*
2.00D 06	1.9640D 04	7.4685D-04	*
3.00D 06	1.9976D 04	6.2562D-05	*

r_{eD} = 500

t_D	QD	q_D	
1.00D 05	3.8928D 03	3.8041D-02	*
2.00D 05	7.6374D 03	3.6862D-02	*
3.00D 05	1.1265D 04	3.5721D-02	*
4.00D 05	1.4782D 04	3.4620D-02	*
5.00D 05	1.8188D 04	3.3547D-02	*
6.00D 05	2.1491D 04	3.2512D-02	*
7.00D 05	2.4691D 04	3.1504D-02	*
8.00D 05	2.7795D 04	3.0537D-02	*
9.00D 05	3.0802D 04	2.9590D-02	*
1.00D 06	3.3715D 04	2.8668D-02	*
2.00D 06	5.8375D 04	2.0928D-02	*
3.00D 06	7.6384D 04	1.5270D-02	*
4.00D 06	8.9480D 04	1.1153D-02	*
5.00D 06	9.8995D 04	8.1678D-03	*
6.00D 06	1.0591D 05	5.9959D-03	*
7.00D 06	1.1095D 05	4.4152D-03	*
8.00D 06	1.1464D 05	3.2596D-03	*
9.00D 06	1.1733D 05	2.3993D-03	*
1.00D 07	1.1935D 05	1.7758D-03	*
2.00D 07	1.2486D 05	3.3983D-05	*

r_{eD} = 1000

t_D	Q_D	q_D	
1.00D 05	3.8965D 03	3.8201D-02	
2.00D 05	7.6887D 03	3.7696D-02	
3.00D 05	1.1441D 04	3.7361D-02	
4.00D 05	1.5162D 04	3.7064D-02	*
5.00D 05	1.8855D 04	3.6779D-02	*
6.00D 05	2.2519D 04	3.6499D-02	*
7.00D 05	2.6154D 04	3.6221D-02	*
8.00D 05	2.9762D 04	3.5946D-02	*
9.00D 05	3.3343D 04	3.5673D-02	*
1.00D 06	3.6895D 04	3.5400D-02	*
2.00D 06	7.0969D 04	3.2796D-02	*
3.00D 06	1.0254D 05	3.0381D-02	*
4.00D 06	1.3181D 05	2.8145D-02	*
5.00D 06	1.5894D 05	2.6071D-02	*
6.00D 06	1.8409D 05	2.4150D-02	*
7.00D 06	2.0740D 05	2.2368D-02	*
8.00D 06	2.2901D 05	2.0717D-02	*
9.00D 06	2.4901D 05	1.9183D-02	*
1.00D 07	2.6756D 05	1.7770D-02	*
2.00D 07	3.9161D 05	8.28[illegible]D-03	*
3.00D 07	4.4871D 05	3.9177D-03	*
4.00D 07	4.7552D 05	1.8734D-03	*
5.00D 07	4.8843D 05	8.9731D-04	*
6.00D 07	4.9465D 05	4.0867D-04	*
7.00D 07	4.9802D 05	1.8479D-04	*
9.00D 07	4.9923D 05	4.9103D-05	*

CLOSED OUTER BOUNDARY
Skin = 20

r_{eD} = 2000

t_D	Q_D	q_D	
1.00D 06	3.7287D 04	3.6569D-02	
2.00D 06	7.3499D 04	3.5866D-02	*
3.00D 06	1.0703D 05	3.5204D-02	*
4.00D 06	1.4390D 05	3.4555D-02	*
5.00D 06	1.7814D 05	3.3920D-02	*
6.00D 06	2.1173D 05	3.3294D-02	*
7.00D 06	2.4471D 05	3.2679D-02	*
8.00D 06	2.7707D 05	3.2076D-02	*
9.00D 06	3.0885D 05	3.1485D-02	*
1.00D 07	3.4004D 05	3.0905D-02	*
2.00D 07	6.2218D 05	2.5650D-02	*
3.00D 07	8.5677D 05	2.1283D-02	*
4.00D 07	1.0516D 06	1.7657D-02	*
5.00D 07	1.2132D 06	1.4647D-02	*
6.00D 07	1.3469D 06	1.2157D-02	*
7.00D 07	1.4575D 06	1.0089D-02	*
8.00D 07	1.5492D 06	8.3933D-03	*
9.00D 07	1.6248D 06	6.9778D-03	*
1.00D 08	1.6875D 06	5.8102D-03	*
2.00D 08	1.9487D 06	9.6258D-04	*
3.00D 08	1.9939D 06	1.2684D-04	*

r_{eD} = 5000

t_D	QD	q_D	
1.00D 06	3.7294D 04	3.6593D-02	
2.00D 06	7.3635D 04	3.6134D-02	
3.00D 06	1.0963D 05	3.5872D-02	
4.00D 06	1.4541D 05	3.5687D-02	
5.00D 06	1.8102D 05	3.5541D-02	
6.00D 06	2.1650D 05	3.5414D-02	
7.00D 06	2.5186D 05	3.5298D-02	
8.00D 06	2.8710D 05	3.5189D-02	*
9.00D 06	3.2224D 05	3.5083D-02	*
1.00D 07	3.5728D 05	3.4980D-02	*
2.00D 07	7.0205D 05	3.3984D-02	*
3.00D 07	1.0370D 06	3.3018D-02	*
4.00D 07	1.3624D 06	3.2083D-02	*
5.00D 07	1.6786D 06	3.1171D-02	*
6.00D 07	1.9858D 06	3.0288D-02	*
7.00D 07	2.2843D 06	2.9426D-02	*
8.00D 07	2.5745D 06	2.8595D-02	*
9.00D 07	2.8563D 06	2.7780D-02	*
1.00D 08	3.1302D 06	2.6989D-02	*
2.00D 08	5.4799D 06	2.0224D-02	*
3.00D 08	7.2422D 06	1.5145D-02	*
4.00D 08	8.5591D 06	1.1349D-02	*
5.00D 08	9.5417D 06	8.5216D-03	*
6.00D 08	1.0274D 07	6.4107D-03	*
7.00D 08	1.0822D 07	4.8358D-03	*
8.00D 08	1.1233D 07	3.6565D-03	*
9.00D 08	1.1539D 07	2.7597D-03	*
1.00D 09	1.1774D 07	2.0936D-03	*
2.00D 09	1.2467D 07	8.7718D-05	*

$r_{eD} = 1x10^4$

t_D	Q_D	q_D	
1.00D 07	3.5758D 05	3.5114D-02	
2.00D 07	7.0637D 05	3.4687D-02	
3.00D 07	1.0518D 06	3.4403D-02	
4.00D 07	1.3946D 06	3.4152D-02	*
5.00D 07	1.7349D 06	3.3911D-02	*
6.00D 07	2.0728D 06	3.3673D-02	*
7.00D 07	2.4084D 06	3.3437D-02	*
8.00D 07	2.7415D 06	3.3204D-02	*
9.00D 07	3.0724D 06	3.2971D-02	*
1.00D 08	3.4009D 06	3.2740D-02	*
2.00D 08	6.5618D 06	3.0520D-02	*
3.00D 08	9.5085D 06	2.8447D-02	*
4.00D 08	1.2257D 07	2.6518D-02	*
5.00D 08	1.4820D 07	2.4717D-02	*
6.00D 08	1.7211D 07	2.3039D-02	*
7.00D 08	1.9441D 07	2.1472D-02	*
8.00D 08	2.1521D 07	2.0011D-02	*
9.00D 08	2.3459D 07	1.8645D-02	*
1.00D 09	2.5267D 07	1.7378D-02	*
2.00D 09	3.7748D 07	8.6086D-03	*
3.00D 09	4.3858D 07	4.3127D-03	*
4.00D 09	4.6892D 07	2.1855D-03	*
5.00D 09	4.8430D 07	1.1141D-03	*
6.00D 09	4.9214D 07	5.5192D-04	*
7.00D 09	4.9651D 07	2.7498D-04	*
8.00D 09	4.9838D 07	1.0575D-04	*
9.00D 09	4.9982D 07	4.1144D-05	*

$r_{eD} = 5x10^4$

t_D	Q_D	q_D	
1.00D 08	3.4345D 06	3.3751D-02	
2.00D 08	6.7883D 06	3.3360D-02	
3.00D 08	1.0113D 07	3.3137D-02	
4.00D 08	1.3418D 07	3.2979D-02	
5.00D 08	1.6710D 07	3.2853D-02	
6.00D 08	1.9990D 07	3.2745D-02	
7.00D 08	2.3260D 07	3.2646D-02	
8.00D 08	2.6520D 07	3.2553D-02	*
9.00D 08	2.9771D 07	3.2462D-02	*
1.00D 09	3.3013D 07	3.2371D-02	*
2.00D 09	6.4958D 07	3.1529D-02	*
3.00D 09	9.6059D 07	3.0694D-02	*
4.00D 09	1.2634D 08	2.9890D-02	*
5.00D 09	1.5583D 08	2.9105D-02	*
6.00D 09	1.8455D 08	2.8342D-02	*
7.00D 09	2.1251D 08	2.7597D-02	*
8.00D 09	2.3975D 08	2.6876D-02	*
9.00D 09	2.6627D 08	2.6169D-02	*
1.00D 10	2.9209D 08	2.5479D-02	*
2.00D 10	5.1620D 08	1.9521D-02	*
3.00D 10	6.8812D 08	1.4946D-02	*
4.00D 10	8.1957D 08	1.1446D-02	*
5.00D 10	9.1991D 08	8.7784D-03	*
6.00D 10	9.7562D 08	6.7450D-03	*
7.00D 10	1.0550D 09	5.1993D-03	*
8.00D 10	1.0995D 09	4.0042D-03	*
9.00D 10	1.1336D 09	3.0885D-03	*
1.00D 11	1.1605D 09	2.4045D-03	*
2.00D 11	1.2430D 09	1.3170D-04	*

CLOSED OUTER BOUNDARY
Skin = 20

$r_{eD} = 1x10^5$

t_D	Q_D	q_D	
1.00D 09	3.3039D 07	3.2489D-02	
2.00D 09	6.5326D 07	3.2122D-02	
3.00D 09	9.7325D 07	3.1879D-02	
4.00D 09	1.2910D 08	3.1664D-02	*
5.00D 09	1.6066D 08	3.1457D-02	*
6.00D 09	1.9202D 08	3.1253D-02	*
7.00D 09	2.2317D 08	3.1050D-02	*
8.00D 09	2.5411D 08	3.0850D-02	*
9.00D 09	2.8486D 08	3.0650D-02	*
1.00D 10	3.1540D 08	3.0451D-02	*
2.00D 10	6.1016D 08	2.8535D-02	*
3.00D 10	8.8638D 08	2.6738D-02	*
4.00D 10	1.1453D 09	2.5055D-02	*
5.00D 10	1.3881D 09	2.3478D-02	*
6.00D 10	1.6157D 09	2.1999D-02	*
7.00D 10	1.8292D 09	2.0614D-02	*
8.00D 10	2.0273D 09	1.9312D-02	*
9.00D 10	2.2168D 09	1.8091D-02	*
1.00D 11	2.3926D 09	1.6949D-02	*
2.00D 11	3.6396D 09	8.8397D-03	*
3.00D 11	4.2835D 09	4.6520D-03	*
4.00D 11	4.6205D 09	2.4895D-03	*
5.00D 11	4.7965D 09	1.3245D-03	*
6.00D 11	4.8913D 09	6.9635D-04	*
7.00D 11	4.9435D 09	3.5640D-04	*
8.00D 11	4.9684D 09	1.5246D-04	*
9.00D 11	4.9884D 09	7.0612D-05	*
1.00D 12	4.9976D 09	2.2351D-05	*

$r_{eD} = 5x10^5$

t_D	QD	q_D	
1.00D 10	3.1829D 08	3.1318D-02	
2.00D 10	6.2964D 08	3.0981D-02	
3.00D 10	9.3845D 08	3.0789D-02	
4.00D 10	1.2456D 09	3.0652D-02	
5.00D 10	1.5516D 09	3.0544D-02	
6.00D 10	1.8566D 09	3.0450D-02	
7.00D 10	2.1607D 09	3.0365D-02	
8.00D 10	2.4640D 09	3.0284D-02	*
9.00D 10	2.7664D 09	3.0206D-02	*
1.00D 11	3.0681D 09	3.0130D-02	*
2.00D 11	6.0440D 09	2.9392D-02	*
3.00D 11	8.9468D 09	2.8675D-02	*
4.00D 11	1.1779D 10	2.7975D-02	*
5.00D 11	1.4541D 10	2.7295D-02	*
6.00D 11	1.7236D 10	2.6627D-02	*
7.00D 11	1.9866D 10	2.5977D-02	*
8.00D 11	2.2432D 10	2.5343D-02	*
9.00D 11	2.4935D 10	2.4724D-02	*
1.00D 12	2.7376D 10	2.4121D-02	*
2.00D 12	4.8781D 10	1.8834D-02	*
3.00D 12	6.5518D 10	1.4697D-02	*
4.00D 12	7.8371D 10	1.1470D-02	*
5.00D 12	8.8732D 10	8.9615D-03	*
6.00D 12	9.6629D 10	7.0099D-03	*
7.00D 12	1.0278D 11	5.4940D-03	*
8.00D 12	1.0754D 11	4.3139D-03	*
9.00D 12	1.1128D 11	3.3947D-03	*
1.00D 13	1.1421D 11	2.6668D-03	*
2.00D 13	1.2408D 11	2.2064D-04	*

$r_{eD} = 1x10^6$

t_D	Q_D	q_D	
1.00D 10	3.1829D 08	3.1318D-02	
2.00D 10	6.2963D 08	3.0982D-02	
3.00D 10	9.3847D 08	3.0789D-02	
4.00D 10	1.2457D 09	3.0653D-02	
5.00D 10	1.5517D 09	3.0548D-02	
6.00D 10	1.8568D 09	3.0463D-02	
7.00D 10	2.1611D 09	3.0392D-02	
8.00D 10	2.4648D 09	3.0330D-02	
9.00D 10	2.7678D 09	3.0276D-02	
1.00D 11	3.0704D 09	3.0228D-02	
2.00D 11	6.0758D 09	2.9911D-02	
3.00D 11	9.0562D 09	2.9700D-02	
4.00D 11	1.2017D 10	2.9514D-02	*
5.00D 11	1.4960D 10	2.9334D-02	*
6.00D 11	1.7884D 10	2.9157D-02	*
7.00D 11	2.0791D 10	2.8981D-02	*
8.00D 11	2.3680D 10	2.8806D-02	*
9.00D 11	2.6552D 10	2.8633D-02	*
1.00D 12	2.9406D 10	2.8460D-02	*
2.00D 12	5.7017D 10	2.6790D-02	*
3.00D 12	8.3007D 10	2.5217D-02	*
4.00D 12	1.0748D 11	2.3738D-02	*
5.00D 12	1.3053D 11	2.2344D-02	*
6.00D 12	1.5224D 11	2.1032D-02	*
7.00D 12	1.7268D 11	1.9797D-02	*
8.00D 12	1.9194D 11	1.8632D-02	*
9.00D 12	2.1006D 11	1.7533D-02	*
1.00D 13	2.2714D 11	1.6503D-02	*
2.00D 13	3.5113D 11	9.0032D-03	*
3.00D 13	4.1817D 11	4.9468D-03	*
4.00D 13	4.5463D 11	2.7451D-03	*
5.00D 13	4.7474D 11	1.5363D-03	*
6.0011 13	4.8591D 11	8.5170D-04	*
7.00D 13	4.9249D 11	4.7821D-04	*
8.00D 13	4.9587D 11	2.4293D-04	*
9.00D 13	4.9825D 11	1.2907D-04	*
1.00D 14	4.9923D 11	5.2991D-05	*

CONSTANT PRESSURE OUTER BCUNDARY

r_{eD} = 20

Skin = 0

t_D	Q_D	q_D
1.00D 01	7.4020D 00	5.3394D-01
2.00D 01	1.2321D 01	4.6119D-01
3.00D 01	1.6744D 01	4.2613D-01
4.00D 01	2.0870D 01	4.0393D-01
5.00D 01	2.4849D 01	3.8819D-01
6.00D 01	2.8670D 01	3.7643D-01
7.00D 01	3.2395D 01	3.6742D-01
8.00D 01	3.6020D 01	3.6043D-01
9.00D 01	3.9592D 01	3.5495D-01
1.00D 02	4.3115D 01	3.5063D-01
2.00D 02	7.7151D 01	3.3551D-01
3.00D 02	1.1061D 02	3.3380D-01
4.00D 02	1.4400D 02	3.3363D-01
5.00D 02	1.7739D 02	3.3376D-01
6.00D 02	2.1076D 02	3.3371D-01
7.00D 02	2.4415D 02	3.3386D-01
8.00D 02	2.7756D 02	3.3390D-01
9.00D 02	3.1093D 02	3.3385D-01

Skin = 10

t_d	Q_D	q_D
1.00D 01	8.8649D-01	8.5663D-02
2.00D 01	1.7309D 00	8.3434D-02
3.00D 01	2.5584D 00	8.2141D-02
4.00D 01	3.3752D 00	8.1230D-02
5.00D 01	4.1841D 00	8.0530D-02
6.00D 01	4.9868D 00	7.9968D-02
7.00D 01	5.7842D 00	7.9504D-02
8.00D 01	6.5774D 00	7.9118D-02
9.00D 01	7.3669D 00	7.8794D-02
1.00D 02	8.1535D 00	7.8521D-02
2.00D 02	1.5927D 01	7.7279D-02
3.00D 02	2.3639D 01	7.7014D-02
4.00D 02	3.1339D 01	7.6953D-02
5.00D 02	3.9036D 01	7.6944D-02
6.00D 02	4.6731D 01	7.6939D-02
7.00D 02	5.4428D 01	7.6946D-02
8.00D 02	6.2124D 01	7.6949D-02
9.00D 02	6.9820D 01	7.6948D-02

Skin = 5

t_D	Q_D	q_D
1.00D 01	1.5905D 00	1.4942D-01
2.00D 01	3.0472D 00	1.4273D-01
3.00D 01	4.4544D 00	1.3897D-01
4.00D 01	5.8312D 00	1.3638D-01
5.00D 01	7.1854D 00	1.3442D-01
6.00D 01	8.5219D 00	1.3286D-01
7.00D 01	9.8443D 00	1.3159D-01
8.00D 01	1.1155D 01	1.3055D-01
9.00D 01	1.2456D 01	1.2968D-01
1.00D 02	1.3749D 01	1.2896D-01
2.00D 02	2.6441D 01	1.2581D-01
3.00D 02	3.8985D 01	1.2519D-01
4.00D 02	5.1501D 01	1.2506D-01
5.00D 02	6.4011D 01	1.2505D-01
6.00D 02	7.6518D 01	1.2504D-01
7.00D 02	8.9029D 01	1.2506D-01
8.00D 02	1.0154D 02	1.2507D-01
9.00D 02	1.1405D 02	1.2507D-01

Skin = 20

t_D	Q_D	q_D
1.00D 01	4.7003D-01	4.6162D-02
2.00D 01	9.2807D-01	4.5510D-02
3.00D 01	1.3812D 00	4.5124D-02
4.00D 01	1.8311D 00	4.4848D-02
5.00D 01	2.2786D 00	4.4635D-02
6.00D 01	2.7241D 00	4.4461D-02
7.00D 01	3.1681D 00	4.4317D-02
8.00D 01	3.6107D 00	4.4197D-02
9.00D 01	4.0522D 00	4.4095D-02
1.00D 02	4.4927D 00	4.4008D-02
2.00D 02	8.8684D 00	4.3603D-02
3.00D 02	1.3224D 01	4.3512D-02
4.00D 02	1.7574D 01	4.3489D-02
5.00D 02	2.1924D 01	4.3485D-02
6.00D 02	2.6273D 01	4.3483D-02
7.00D 02	3.0623D 01	4.3485D-02
8.00D 02	3.4972D 01	4.3486D-02
9.00D 02	3.9321D 01	4.3486D-02

r_{eD} = 50

Skin = 0

t_D	QD	q_D
1.00D 02	4.3028D 01	3.4558D-01
2.00D 02	7.5603D 01	3.1082D-01
3.00D 02	1.0575D 02	2.9331D-01
4.00D 02	1.3450D 02	2.8220D-01
5.00D 02	1.6231D 02	2.7462D-01
6.00D 02	1.8947D 02	2.6930D-01
7.00D 02	2.1619D 02	2.6551D-01
8.00D 02	2.4256D 02	2.6280D-01
9.00D 02	2.6872D 02	2.6083D-01
1.00D 03	2.9472D 02	2.5940D-01
2.00D 03	5.5151D 02	2.5565D-01
3.00D 03	8.0724D 02	2.5557D-01
4.00D 03	1.0628D 03	2.5555D-01
5.00D 03	1.3186D 03	2.5568D-01
6.00D 03	1.5742D 03	2.5561D-01
7.00D 03	1.8300D 03	2.5574D-01
8.00D 03	2.0858D 03	2.5555D-01
9.00D 03	2.3415D 03	2.5576D-01

Skin = 5

t_D	Q_D	q_D
1.00D 02	1.3743D 01	1.2862D-01
2.00D 02	2.6304D 01	1.2324D-01
3.00D 02	3.8473D 01	1.2028D-01
4.00D 02	5.0399D 01	1.1827D-01
5.00D 02	6.2150D 01	1.1681D-01
6.00D 02	7.3773D 01	1.1572D-01
7.00D 02	8.5300D 01	1.1490D-01
8.00D 02	9.6754D 01	1.1428D-01
9.00D 02	1.0815D 02	1.1380D-01
1.00D 03	1.1951D 02	1.1344D-01
2.00D 03	2.3217D 02	1.1228D-01
3.00D 03	3.4443D 02	1.1220D-01
4.00D 03	4.5664D 02	1.1219D-01
5.00D 03	5.6889D 02	1.1221D-01
6.00D 03	6.8110D 02	1.1220D-01
7.00D 03	7.9336D 02	1.1223D-01
8.00D 03	9.0551D 02	1.1219D-01
9.00D 03	1.0178D 03	1.1223D-01

CONSTANT PRESSURE OUTER BOUNDARY

$r_{eD} = 50$

Skin = 10

t_D	Q_D	q_D
1.00D 02	8.1515D 00	7.8412D-02
2.00D 02	1.5880D 01	7.6376D-02
3.00D 02	2.3458D 01	7.5223D-02
4.00D 02	3.0940D 01	7.4429D-02
5.00D 02	3.8354D 01	7.3844D-02
6.00D 02	4.5715D 01	7.3401D-02
7.00D 02	5.3037D 01	7.3062D-02
8.00D 02	6.0329D 01	7.2801D-02
9.00D 02	6.7598D 01	7.2599D-02
1.00D 03	7.4849D 01	7.2442D-02
2.00D 03	1.4694D 02	7.1923D-02
3.00D 03	2.1886D 02	7.1878D-02
4.00D 03	2.9074D 02	7.1872D-02
5.00D 03	3.6264D 02	7.1882D-02
6.00D 03	4.3453D 02	7.1878D-02
7.00D 03	5.0643D 02	7.1888D-02
8.00D 03	5.7829D 02	7.1875D-02
9.00D 03	6.5022D 02	7.1890D-02

Skin = 20

t_D	Q_D	q_D
1.00D 02	4.4921D 00	4.3977D-02
2.00D 02	8.8543D 00	4.3329D-02
3.00D 02	1.3168D 01	4.2955D-02
4.00D 02	1.7451D 01	4.2695D-02
5.00D 02	2.1711D 01	4.2501D-02
6.00D 02	2.5954D 01	4.2352D-02
7.00D 02	3.0183D 01	4.2238D-02
8.00D 02	3.4402D 01	4.2148D-02
9.00D 02	3.8614D 01	4.2079D-02
1.00D 03	4.2819D 01	4.2024D-02
2.00D 03	8.4721D 01	4.1938D-02
3.00D 03	1.2656D 02	4.1820D-02
4.00D 03	1.6838D 02	4.1817D-02
5.00D 03	2.1021D 02	4.1820D-02
6.00D 03	2.5203D 02	4.1819D-02
7.00D 03	2.9387D 02	4.1822D-02
8.00D 03	3.3568D 02	4.1818D-02
9.00D 03	3.7752D 02	4.1823D-02

$r_{eD} = 100$

Skin = 0

t_D	Q_D	q_D
1.00D 02	4.3029D 01	3.4557D-01
2.00D 02	7.5595D 01	3.1081D-01
3.00D 02	1.0573D 02	2.9335D-01
4.00D 02	1.3447D 02	2.8204D-01
5.00D 02	1.6224D 02	2.7383D-01
6.00D 02	1.8930D 02	2.6745D-01
7.00D 02	2.1578D 02	2.6227D-01
8.00D 02	2.4180D 02	2.5793D-01
9.00D 02	2.6742D 02	2.5421D-01
1.00D 03	2.9269D 02	2.5096D-01
2.00D 03	5.3271D 02	2.3198D-01
3.00D 03	7.6003D 02	2.2401D-01
4.00D 03	9.8187D 02	2.2037D-01
5.00D 03	1.2013D 03	2.1866D-01
6.00D 03	1.4195D 03	2.1783D-01
7.00D 03	1.6372D 03	2.1742D-01
8.00D 03	1.8546D 03	2.1722D-01
9.00D 03	2.0719D 03	2.1714D-01

Skin = 10

t_D	Q_D	q_D
1.00D 02	8.1515D 00	7.8411D-02
2.00D 02	1.5879D 01	7.6375D-02
3.00D 02	2.3456D 01	7.5224D-02
4.00D 02	3.0938D 01	7.4427D-02
5.00D 02	3.8349D 01	7.3819D-02
6.00D 02	4.5707D 01	7.3330D-02
7.00D 02	5.3020D 01	7.2921D-02
8.00D 02	6.0296D 01	7.2570D-02
9.00D 02	6.7539D 01	7.2262D-02
1.00D 03	7.4753D 01	7.1989D-02
2.00D 03	1.4578D 02	7.0265D-02
3.00D 03	2.1558D 02	6.9426D-02
4.00D 03	2.8476D 02	6.8986D-02
5.00D 03	3.5361D 02	6.8751D-02
6.00D 03	4.2230D 02	6.8621D-02
7.00D 03	4.9089D 02	6.8550D-02
8.00D 03	5.5943D 02	6.8509D-02
9.00D 03	6.2795D 02	6.8458D-02

Skin = 5

t_D	QD	q_D
1.00D 02	1.3743D 01	1.2862D-01
2.00D 02	2.6303D 01	1.2324D-01
3.00D 02	3.8569D 01	1.2028D-01
4.00D 02	5.0392D 01	1.1826D-01
5.00D 02	6.2140D 01	1.1674D-01
6.00D 02	7.3752D 01	1.1552D-01
7.00D 02	8.5254D 01	1.1451D-01
8.00D 02	9.6664D 01	1.1365D-01
9.00D 02	1.0799D 02	1.1290D-01
1.00D 03	1.1925D 02	1.1224D-01
2.00D 03	2.2918D 02	1.0812D-01
3.00D 03	3.3623D 02	1.0619D-01
4.00D 03	4.4182D 02	1.0520D-01
5.00D 03	5.4673D 02	1.0469D-01
6.00D 03	6.5127D 02	1.0441D-01
7.00D 03	7.5561D 02	1.0426D-01
8.00D 03	8.5976D 02	1.0418D-01
9.00D 03	9.6403D 02	1.0414D-01

Skin = 20

t_D	QD	q_D
1.00D 02	4.4922D 00	4.3977D-02
2.00D 02	8.8542D 00	4.3328D-02
3.00D 02	1.3168D 01	4.2956D-02
4.00D 02	1.7450D 01	4.2694D-02
5.00D 02	2.1710D 01	4.2493D-02
6.00D 02	2.5951D 01	4.2331D-02
7.00D 02	3.0178D 01	4.2194D-02
8.00D 02	3.4392D 01	4.2076D-02
9.00D 02	3.8595D 01	4.1972D-02
1.00D 03	4.2789D 01	4.1880D-02
2.00D 03	8.4344D 01	4.1289D-02
3.00D 03	1.2547D 02	4.0794D-02
4.00D 03	1.6630D 02	4.0836D-02
5.00D 03	2.0717D 02	4.0750D-02
6.00D 03	2.4790D 02	4.0702D-02
7.00D 03	2.8859D 02	4.0675D-02
8.00D 03	3.2924D 02	4.0659D-02
9.00D 03	3.6993D 02	4.0650D-02

CONSTANT PRESSURE OUTER BOUNDARY

r_{eD} = 200

Skin = 0

t_D	Q_D	q_D
1.00D 03	2.9264D 02	2.5097D-01
2.00D 03	5.3253D 02	2.3152D-01
3.00D 03	7.5665D 02	2.2143D-01
4.00D 03	9.7666D 02	2.1476D-01
5.00D 03	1.1890D 03	2.0985D-01
6.00D 03	1.3769D 03	2.0603D-01
7.00D 03	1.6914D 03	2.0298D-01
8.00D 03	1.8031D 03	2.0052D-01
9.00D 03	2.0025D 03	1.9850D-01
1.00D 04	2.2000D 03	1.9685D-01
2.00D 04	4.1240D 03	1.9006D-01
3.00D 04	6.0178D 03	1.8891D-01
4.00D 04	7.9065D 03	1.8871D-01
5.00D 04	9.7943D 03	1.8870D-01
6.00D 04	1.1682D 04	1.8869D-01
7.00D 04	1.3570D 04	1.8874D-01
8.00D 04	1.5458D 04	1.8876D-01
9.00D 04	1.7345D 04	1.8875D-01

Skin = 10

t_D	Q_D	q_D
1.00D 03	7.4750D 01	7.1989D-02
2.00D 03	1.4577D 02	7.0244D-02
3.00D 03	2.1550D 02	6.9262D-02
4.00D 03	2.8442D 02	6.8580D-02
5.00D 03	3.5275D 02	6.8059D-02
6.00D 03	4.2061D 02	6.7642D-02
7.00D 03	4.8809D 02	6.7298D-02
8.00D 03	5.5525D 02	6.7011D-02
9.00D 03	6.2214D 02	6.6769D-02
1.00D 04	6.8891D 02	6.6565D-02
2.00D 04	1.3485D 03	6.5626D-02
3.00D 04	2.0036D 03	6.5421D-02
4.00D 04	2.6577D 03	6.5373D-02
5.00D 04	3.3115D 03	6.5363D-02
6.00D 04	3.9653D 03	6.5360D-02
7.00D 04	4.6191D 03	6.5365D-02
8.00D 04	5.2729D 03	6.5367D-02
9.00D 04	5.9266D 03	6.5366D-02

Skin = 5

t_D	Q_D	q_D
1.00D 03	1.1925D 02	1.1224D-01
2.00D 03	2.2914D 02	1.0807D-01
3.00D 03	3.3599D 02	1.0577D-01
4.00D 03	4.4096D 02	1.0419D-01
5.00D 03	5.4456D 02	1.0299D-01
6.00D 03	6.4710D 02	1.0204D-01
7.00D 03	7.4877D 02	1.0127D-01
8.00D 03	8.4971D 02	1.0062D-01
9.00D 03	9.5006D 02	1.0009D-01
1.00D 04	1.0499D 03	9.9636D-02
2.00D 04	2.0334D 03	9.7617D-02
3.00D 04	3.0071D 03	9.7201D-02
4.00D 04	3.9788D 03	9.7110D-02
5.00D 04	4.9501D 03	9.7093D-02
6.00D 04	5.9212D 03	9.7088D-02
7.00D 04	6.8926D 03	9.7100D-02
8.00D 04	7.8638D 03	9.7106D-02
9.00D 04	8.8349D 03	9.7103D-02

Skin = 20

t_D	Q_D	q_D
1.00D 03	4.2788D 01	4.1880D-02
2.00D 03	8.4339D 01	4.1283D-02
3.00D 03	1.2545D 02	4.0941D-02
4.00D 03	1.6627D 02	4.0702D-02
5.00D 03	2.0688D 02	4.0517D-02
6.00D 03	2.4733D 02	4.0369D-02
7.00D 03	2.8765D 02	4.0246D-02
8.00D 03	3.2785D 02	4.0142D-02
9.00D 03	3.6795D 02	4.0055D-02
1.00D 04	4.0797D 02	3.9981D-02
2.00D 04	8.0561D 02	3.9631D-02
3.00D 04	1.2015D 03	3.9551D-02
4.00D 04	1.5970D 03	3.9532D-02
5.00D 04	1.9923D 03	3.9527D-02
6.00D 04	2.3877D 03	3.9526D-02
7.00D 04	2.7830D 03	3.9527D-02
8.00D 04	3.1784D 03	3.9528D-02
9.00D 04	3.5737D 03	3.9528D-02

CONSTANT PRESSURE OUTER BOUNDARY

r_{eD} = 500

Skin = 0

t_D	Q_D	q_D
1.00D 04	2.1986D 03	1.9594D-01
2.00D 04	4.0889D 03	1.8371D-01
3.00D 04	5.8918D 03	1.7721D-01
4.00D 04	7.6417D 03	1.7291D-01
5.00D 04	9.3548D 03	1.6985D-01
6.00D 04	1.1041D 04	1.6761D-01
7.00D 04	1.2708D 04	1.6596D-01
8.00D 04	1.4360D 04	1.6472D-01
9.00D 04	1.6002D 04	1.6380D-01
1.00D 05	1.7635D 04	1.6310D-01
2.00D 05	3.3801D 04	1.6101D-01
3.00D 05	4.9900D 04	1.6093D-01
4.00D 05	6.5971D 04	1.6087D-01

Skin = 10

t_D	Q_D	q_D
1.00D 04	6.8868D 02	6.6476D-02
2.00D 04	1.3454D 03	6.5002D-02
3.00D 04	1.9910D 03	6.4157D-02
4.00D 04	2.6297D 03	6.3573D-02
5.00D 04	3.2633D 03	6.3142D-02
6.00D 04	3.8930D 03	6.2814D-02
7.00D 04	4.5199D 03	6.2563D-02
8.00D 04	5.1444D 03	6.2369D-02
9.00D 04	5.7673D 03	6.2218D-02
1.00D 05	6.3888D 03	6.2100D-02
2.00D 05	1.2573D 04	6.1707D-02
3.00D 05	1.8742D 04	6.1670D-02
4.00D 05	2.4910D 04	6.1666D-02

Skin = 5

t_D	Q_D	q_D
1.00D 04	1.0494D 03	9.9464D-02
2.00D 04	2.0259D 03	9.6160D-02
3.00D 04	2.9780D 03	9.4332D-02
4.00D 04	3.9150D 03	9.3080D-02
5.00D 04	4.8411D 03	9.2164D-02
6.00D 04	5.7592D 03	9.1475D-02
7.00D 04	6.6711D 03	9.0951D-02
8.00D 04	7.5783D 03	9.0550D-02
9.00D 04	8.4820D 03	9.0241D-02
1.00D 05	9.3830D 03	9.0003D-02
2.00D 05	1.8331D 04	8.9228D-02
3.00D 05	2.7252D 04	8.9162D-02
4.00D 05	3.6170D 04	8.9156D-02

Skin = 20

t_D	Q_D	q_D
1.00D 04	4.0792D 02	3.9957D-02
2.00D 04	8.0451D 02	3.9412D-02
3.00D 04	1.1970D 03	3.9100D-02
4.00D 04	1.5870D 03	3.8862D-02
5.00D 04	1.9750D 03	3.8719D-02
6.00D 04	2.3616D 03	3.8595D-02
7.00D 04	2.7471D 03	3.8479D-02
8.00D 04	3.1317D 03	3.8424D-02
9.00D 04	3.5156D 03	3.8366D-02
1.00D 05	3.8990D 03	3.8320D-02
2.00D 05	7.7208D 03	3.8162D-02
3.00D 05	1.1537D 04	3.8146D-02
4.00D 05	1.5352D 04	3.8144D-02

r_{eD} = 1000

Skin = 0

t_D	Q_D	q_D
1.00D 04	2.1986D 03	1.9594D-01
2.00D 04	4.0887D 03	1.8371D-01
3.00D 04	5.8909D 03	1.7722D-01
4.00D 04	7.6404D 03	1.7289D-01
5.00D 04	9.3526D 03	1.6967D-01
6.00D 04	1.1036D 04	1.6712D-01
7.00D 04	1.2697D 04	1.6503D-01
8.00D 04	1.4339D 04	1.6326D-01
9.00D 04	1.5964D 04	1.6172D-01
1.00D 05	1.7575D 04	1.6037D-01
2.00D 05	3.3147D 04	1.5216D-01
3.00D 05	4.8150D 04	1.4845D-01
4.00D 05	6.2888D 04	1.4663D-01
5.00D 05	7.7498D 04	1.4571D-01
6.00D 05	9.2044D 04	1.4524D-01
7.00D 05	1.0656D 05	1.4499D-01
8.00D 05	1.2105D 05	1.4486D-01
9.00D 05	1.3554D 05	1.4479D-01

Skin = 10

t_D	Q_D	q_D
1.00D 04	6.8568D 02	6.6496D-02
2.00D 04	1.3453D 03	6.5001D-02
3.00D 04	1.9909D 03	6.4157D-02
4.00D 04	2.6295D 03	6.3572D-02
5.00D 04	3.2630D 03	6.3125D-02
6.00D 04	3.8924D 03	6.2765D-02
7.00D 04	4.5187D 03	6.2464D-02
8.00D 04	5.1421D 03	6.2205D-02
9.00D 04	5.7631D 03	6.1978D-02
1.00D 05	6.3820D 03	6.1776D-02
2.00D 05	1.2489D 04	6.0498D-02
3.00D 05	1.8504D 04	5.9871D-02
4.00D 05	2.4472D 04	5.9540D-02
5.00D 05	3.0417D 04	5.9352D-02
6.00D 05	3.6348D 04	5.9263D-02
7.00D 05	4.2272D 04	5.9209D-02
8.00D 05	4.8192D 04	5.9176D-02
9.00D 05	5.4110D 04	5.9159D-02

Skin = 5

t_D	Q_D	q_D
1.00D 04	1.0496D 03	9.9464D-02
2.00D 04	2.0253D 03	9.6165D-02
3.00D 04	2.9777D 03	9.4334D-02
4.00D 04	3.9146D 03	9.3076D-02
5.00D 04	4.8405D 03	9.2124D-02
6.00D 04	5.7579D 03	9.1361D-02
7.00D 04	6.6694D 03	9.0725D-02
8.00D 04	7.5731D 03	9.0181D-02
9.00D 04	8.4722D 03	8.9706D-02
1.00D 05	9.3679D 03	8.9285D-02
2.00D 05	1.8145D 04	8.6648D-02
3.00D 05	2.6743D 04	8.5583D-02
4.00D 05	3.5244D 04	8.4728D-02
5.00D 05	4.3697D 04	8.4382D-02
6.00D 05	5.2125D 04	8.4194D-02
7.00D 05	6.0546D 04	8.4091D-02
8.00D 05	6.8948D 04	8.4032D-02
9.00D 05	7.7332D 04	8.4002D-02

Skin = 20

t_D	Q_D	q_D
1.00D 04	4.0793D 02	3.9957D-02
2.00D 04	8.0450D 02	3.9412D-02
3.00D 04	1.1970D 03	3.9100D-02
4.00D 04	1.5869D 03	3.8881D-02
5.00D 04	1.9749D 03	3.8714D-02
6.00D 04	2.3614D 03	3.8578D-02
7.00D 04	2.7466D 03	3.8464D-02
8.00D 04	3.1308D 03	3.8365D-02
9.00D 04	3.5141D 03	3.8279D-02
1.00D 05	3.8964D 03	3.8202D-02
2.00D 05	7.6897D 03	3.7708D-02
3.00D 05	1.1447D 04	3.7461D-02
4.00D 05	1.5186D 04	3.7336D-02
5.00D 05	1.8915D 04	3.7256D-02
6.00D 05	2.2639D 04	3.7215D-02
7.00D 05	2.6359D 04	3.7192D-02
8.00D 05	3.0079D 04	3.7179D-02
9.00D 05	3.3797D 04	3.7171D-02

CONSTANT PRESSURE OUTER BOUNDARY

r_{eD} = 2000

Skin = 0

t_D	QD	q_D
1.00D 04	2.1986D 03	1.9394D-01
2.00D 04	4.0687D 03	1.8371D-01
3.00D 04	5.8910D 03	1.7722D-01
4.00D 04	7.6405D 03	1.7289D-01
5.00D 04	9.3527D 03	1.6966D-01
6.00D 04	1.1036D 04	1.6712D-01
7.00D 04	1.2697D 04	1.6502D-01
8.00D 04	1.4338D 04	1.6325D-01
9.00D 04	1.5963D 04	1.6172D-01
1.00D 05	1.7573D 04	1.6037D-01
2.00D 05	3.3139D 04	1.5203D-01
3.00D 05	4.8103D 04	1.4754D-01
4.00D 05	6.2702D 04	1.4450D-01
5.00D 05	7.7039D 04	1.4222D-01
6.00D 05	9.1174D 04	1.4043D-01
7.00D 05	1.0514D 05	1.3897D-01
8.00D 05	1.1898D 05	1.3778D-01
9.00D 05	1.3271D 05	1.3679D-01
1.00D 06	1.4634D 05	1.3597D-01
2.00D 06	2.8000D 05	1.3239D-01
3.00D 06	4.1198D 05	1.3170D-01
4.00D 06	5.4364D 05	1.3156D-01
5.00D 06	6.7524D 05	1.3155D-01
6.00D 06	8.0681D 05	1.3154D-01
7.00D 06	9.3841D 05	1.3156D-01
8.00D 06	1.0700D 06	1.3157D-01
9.00D 06	1.2016D 06	1.3156D-01

Skin = 10

t_D	QD	q_D
1.00D 04	6.6868D 02	6.6496D-02
2.00D 04	1.3453D 03	6.5001D-02
3.00D 04	1.9907D 03	6.4157D-02
4.00D 04	2.6295D 03	6.3572D-02
5.00D 04	3.2630D 03	6.3125D-02
6.00D 04	3.8925D 03	6.2764D-02
7.00D 04	4.5186D 03	6.2463D-02
8.00D 04	5.1420D 03	6.2204D-02
9.00D 04	5.7630D 03	6.1977D-02
1.00D 05	6.3818D 03	6.1776D-02
2.00D 05	1.2488D 04	6.0484D-02
3.00D 05	1.8498D 04	5.9753D-02
4.00D 05	2.4448D 04	5.9244D-02
5.00D 05	3.0354D 04	5.8854D-02
6.00D 05	3.6224D 04	5.8541D-02
7.00D 05	4.2066D 04	5.8283D-02
8.00D 05	4.7885D 04	5.8067D-02
9.00D 05	5.3683D 04	5.7885D-02
1.00D 06	5.9463D 04	5.7731D-02
2.00D 06	1.1675D 05	5.7017D-02
3.00D 06	1.7367D 05	5.6858D-02
4.00D 06	2.3052D 05	5.6820D-02
5.00D 06	2.8735D 05	5.6813D-02
6.00D 06	3.4417D 05	5.6810D-02
7.00D 06	4.0100D 05	5.6813D-02
8.00D 06	4.5783D 05	5.6815D-02
9.00D 06	5.1465D 05	5.6815D-02

Skin = 5

t_D	QD	q_D
1.00D 04	1.0496D 03	9.9464D-02
2.00D 04	2.0258D 03	9.6165D-02
3.00D 04	2.9778D 03	9.4334D-02
4.00D 04	3.9146D 03	9.3076D-02
5.00D 04	4.8405D 03	9.2124D-02
6.00D 04	5.7579D 03	9.1359D-02
7.00D 04	6.6684D 03	9.0723D-02
8.00D 04	7.5729D 03	9.0179D-02
9.00D 04	8.4724D 03	8.9704D-02
1.00D 05	9.3674D 03	8.9284D-02
2.00D 05	1.8147D 04	8.6614D-02
3.00D 05	2.6730D 04	8.5126D-02
4.00D 05	3.5191D 04	8.4099D-02
5.00D 05	4.3562D 04	8.3317D-02
6.00D 05	5.1864D 04	8.2692D-02
7.00D 05	6.0109D 04	8.2180D-02
8.00D 05	6.8306D 04	8.1754D-02
9.00D 05	7.6464D 04	8.1396D-02
1.00D 06	8.4588D 04	8.1095D-02
2.00D 06	1.6481D 05	7.9725D-02
3.00D 06	2.4437D 05	7.9433D-02
4.00D 06	3.2378D 05	7.9365D-02
5.00D 06	4.0316D 05	7.9354D-02
6.00D 06	4.8253D 05	7.9349D-02
7.00D 06	5.6191D 05	7.9355D-02
8.00D 06	6.4128D 05	7.9360D-02
9.00D 06	7.2065D 05	7.9359D-02

Skin = 20

t_D	Q_D	q_D
1.00D 04	4.0793D 02	3.9957D-02
2.00D 04	8.0450D 02	3.9412D-02
3.00D 04	1.1970D 03	3.9100D-02
4.00D 04	1.5869D 03	3.8881D-02
5.00D 04	1.9749D 03	3.8714D-02
6.00D 04	2.3614D 03	3.8577D-02
7.00D 04	2.7466D 03	3.8463D-02
8.00D 04	3.1308D 03	3.8365D-02
9.00D 04	3.5141D 03	3.8278D-02
1.00D 05	3.8965D 03	3.8201D-02
2.00D 05	7.6893D 03	3.7703D-02
3.00D 05	1.1445D 04	3.7417D-02
4.00D 05	1.5177D 04	3.7217D-02
5.00D 05	1.8891D 04	3.7062D-02
6.00D 05	2.2592D 04	3.6938D-02
7.00D 05	2.6281D 04	3.6835D-02
8.00D 05	2.9961D 04	3.6748D-02
9.00D 05	3.3632D 04	3.6675D-02
1.00D 06	3.7297D 04	3.6612D-02
2.00D 06	7.3728D 04	3.6318D-02
3.00D 06	1.1001D 05	3.6250D-02
4.00D 06	1.4626D 05	3.6233D-02
5.00D 06	1.8250D 05	3.6230D-02
6.00D 06	2.1873D 05	3.6229D-02
7.00D 06	2.5497D 05	3.6230D-02
8.00D 06	2.9121D 05	3.6231D-02
9.00D 06	3.2744D 05	3.6230D-02

CONSTANT PRESSURE OUTER BOUNDARY

r_{eD} = 5000

Skin = 0

t_D	Q_D	q_D
1.00D 05	1.2573D 04	1.6037D-01
2.00D 05	3.3140D 04	1.5203D-01
3.00D 05	4.6102D 04	1.4753D-01
4.00D 05	6.2697D 04	1.4450D-01
5.00D 05	7.7030D 04	1.4223D-01
6.00D 05	9.1161D 04	1.4043D-01
7.00D 05	1.0513D 05	1.3894D-01
8.00D 05	1.1896D 05	1.3767D-01
9.00D 05	1.3267D 05	1.3658D-01
1.00D 06	1.4628D 05	1.3561D-01
2.00D 06	2.7851D 05	1.2958D-01
3.00D 06	4.0636D 05	1.2628D-01
4.00D 06	5.3150D 05	1.2406D-01
5.00D 06	6.5473D 05	1.2245D-01
6.00D 06	7.7654D 05	1.2125D-01
7.00D 06	8.9729D 05	1.2035D-01
8.00D 06	1.0172D 06	1.1966D-01
9.00D 06	1.1366D 06	1.1914D-01
1.00D 07	1.2555D 06	1.1874D-01
2.00D 07	2.4344D 06	1.1749D-01
3.00D 07	3.6091D 06	1.1740D-01
4.00D 07	4.7833D 06	1.1739D-01
5.00D 07	5.9577D 06	1.1741D-01
6.00D 07	7.1318D 06	1.1740D-01
7.00D 07	8.3065D 06	1.1743D-01
8.00D 07	9.4799D 06	1.1739D-01
9.00D 07	1.0655D 07	1.1743D-01

Skin = 10

t_D	QD	q_D
1.00D 05	6.3818D 03	6.1776D-02
2.00D 05	1.2498D 04	6.0483D-02
3.00D 05	1.8498D 04	5.9752D-02
4.00D 05	2.4447D 04	5.9243D-02
5.00D 05	3.0352D 04	5.8855D-02
6.00D 05	3.6222D 04	5.8541D-02
7.00D 05	4.2063D 04	5.8279D-02
8.00D 05	4.7881D 04	5.8053D-02
9.00D 05	5.3676D 04	5.7856D-02
1.00D 06	5.9454D 04	5.7680D-02
2.00D 06	1.1651D 05	5.6552D-02
3.00D 06	1.7273D 05	5.5911D-02
4.00D 06	2.2842D 05	5.5457D-02
5.00D 06	2.8373D 05	5.5152D-02
6.00D 06	3.3874D 05	5.4897D-02
7.00D 06	3.9353D 05	5.4694D-02
8.00D 06	4.4814D 05	5.4545D-02
9.00D 06	5.0262D 05	5.4429D-02
1.00D 07	5.5700D 05	5.4338D-02
2.00D 07	1.0984D 06	5.4032D-02
3.00D 07	1.6386D 06	5.4002D-02
4.00D 07	2.1787D 06	5.4000D-02
5.00D 07	2.7189D 06	5.4004D-02
6.00D 07	3.2590D 06	5.4002D-02
7.00D 07	3.7992D 06	5.4009D-02
8.00D 07	4.3391D 06	5.4000D-02
9.00D 07	4.8794D 06	5.4009D-02

Skin = 5

t_D	QD	q_D
1.00D 05	9.3674D 03	8.9284D-02
2.00D 05	1.8147D 04	8.6614D-02
3.00D 05	2.6729D 04	8.5124D-02
4.00D 05	3.5189D 04	8.4098D-02
5.00D 05	4.3559D 04	8.3319D-02
6.00D 05	5.1860D 04	8.2693D-02
7.00D 05	6.0103D 04	8.2170D-02
8.00D 05	6.8298D 04	8.1723D-02
9.00D 05	7.6452D 04	8.1333D-02
1.00D 06	8.4368D 04	8.0987D-02
2.00D 06	1.6433D 05	7.8784D-02
3.00D 06	2.4247D 05	7.7546D-02
4.00D 06	3.1959D 05	7.6696D-02
5.00D 06	3.9598D 05	7.6071D-02
6.00D 06	4.7180D 05	7.5598D-02
7.00D 06	5.4721D 05	7.5237D-02
8.00D 06	6.2229D 05	7.4959D-02
9.00D 06	6.9713D 05	7.4744D-02
1.00D 07	7.7177D 05	7.4577D-02
2.00D 07	1.5139D 06	7.4025D-02
3.00D 07	2.2540D 06	7.3976D-02
4.00D 07	2.9939D 06	7.3972D-02
5.00D 07	3.7339D 06	7.3980D-02
6.00D 07	4.4737D 06	7.3977D-02
7.00D 07	5.2138D 06	7.3968D-02
8.00D 07	5.9533D 06	7.3973D-02
9.00D 07	6.6936D 06	7.3988D-02

Skin = 20

t_D	QD	q_D
1.00D 05	3.8965D 03	3.8201D-02
2.00D 05	7.6893D 03	3.7703D-02
3.00D 05	1.1445D 04	3.7417D-02
4.00D 05	1.5176D 04	3.7217D-02
5.00D 05	1.8891D 04	3.7063D-02
6.00D 05	2.2591D 04	3.6938D-02
7.00D 05	2.6280D 04	3.6833D-02
8.00D 05	2.9959D 04	3.6743D-02
9.00D 05	3.3630D 04	3.6664D-02
1.00D 06	3.7293D 04	3.6592D-02
2.00D 06	7.3633D 04	3.6130D-02
3.00D 06	1.0964D 05	3.5872D-02
4.00D 06	1.4542D 05	3.5689D-02
5.00D 06	1.8104D 05	3.5552D-02
6.00D 06	2.1655D 05	3.5447D-02
7.00D 06	2.5195D 05	3.5365D-02
8.00D 06	2.8729D 05	3.5302D-02
9.00D 06	3.2256D 05	3.5253D-02
1.00D 07	3.5780D 05	3.5214D-02
2.00D 07	7.0907D 05	3.5080D-02
3.00D 07	1.0598D 06	3.5066D-02
4.00D 07	1.4106D 06	3.5065D-02
5.00D 07	1.7613D 06	3.5066D-02
6.00D 07	2.1120D 06	3.5066D-02
7.00D 07	2.4628D 06	3.5068D-02
8.00D 07	2.8134D 06	3.5065D-02
9.00D 07	3.1642D 06	3.5068D-02

$r_{eD} = 1x10^4$

Skin = 0

t_D	Q_D	q_D
1.00D 05	1.7575D 04	1.6037D-01
2.00D 05	3.3140D 04	1.5203D-01
3.00D 05	4.8102D 04	1.4753D-01
4.00D 05	6.2597D 04	1.4450D-01
5.00D 05	7.7030D 04	1.4223D-01
6.00D 05	9.1161D 04	1.4043D-01
7.00D 05	1.0513D 05	1.3894D-01
8.00D 05	1.1896D 05	1.3767D-01
9.00D 05	1.3267D 05	1.3658D-01
1.00D 06	1.4628D 05	1.3561D-01
2.00D 06	2.7850D 05	1.2957D-01
3.00D 06	4.0631D 05	1.2628D-01
4.00D 06	5.3143D 05	1.2405D-01
5.00D 06	6.5461D 05	1.2237D-01
6.00D 06	7.7630D 05	1.2103D-01
7.00D 06	8.9679D 05	1.1992D-01
8.00D 06	1.0163D 06	1.1897D-01
9.00D 06	1.1348D 06	1.1815D-01
1.00D 07	1.2527D 06	1.1742D-01
2.00D 07	2.4016D 06	1.1292D-01
3.00D 07	3.5189D 06	1.1081D-01
4.00D 07	4.6208D 06	1.0974D-01
5.00D 07	5.7150D 06	1.0919D-01
6.00D 07	6.8054D 06	1.0889D-01
7.00D 07	7.8936D 06	1.0874D-01
8.00D 07	8.9808D 06	1.0865D-01
9.00D 07	1.0067D 07	1.0860D-01

Skin = 10

t_D	Q_D	q_D
1.00D 05	6.3818D 03	6.1776D-02
2.00D 05	1.2488D 04	6.0493D-02
3.00D 05	1.8498D 04	5.9752D-02
4.00D 05	2.4447D 04	5.9243D-02
5.00D 05	3.0352D 04	5.8855D-02
6.00D 05	3.6222D 04	5.8541D-02
7.00D 05	4.2064D 04	5.8279D-02
8.00D 05	4.7881D 04	5.8053D-02
9.00D 05	5.3677D 04	5.7856D-02
1.00D 06	5.9454D 04	5.7680D-02
2.00D 06	1.1651D 05	5.6551D-02
3.00D 06	1.7273D 05	5.5911D-02
4.00D 06	2.2841D 05	5.5466D-02
5.00D 06	2.9371D 05	5.5125D-02
6.00D 06	3.3870D 05	5.4850D-02
7.00D 06	3.9344D 05	5.4620D-02
8.00D 06	4.4797D 05	5.4422D-02
9.00D 06	5.0231D 05	5.4248D-02
1.00D 07	5.5649D 05	5.4093D-02
2.00D 07	1.0920D 06	5.3110D-02
3.00D 07	1.6204D 06	5.2625D-02
4.00D 07	2.1452D 06	5.2367D-02
5.00D 07	2.6681D 06	5.2227D-02
6.00D 07	3.1900D 06	5.2150D-02
7.00D 07	3.7114D 06	5.2106D-02
8.00D 07	4.2324D 06	5.2081D-02
9.00D 07	4.7533D 06	5.2068D-02

Skin = 5

t_D	QD	q_D
1.00D 05	9.3674D 03	8.9204D-02
2.00D 05	1.8147D 04	8.6614D-02
3.00D 05	2.6729D 04	8.5124D-02
4.00D 05	3.5189D 04	8.4098D-02
5.00D 05	4.3559D 04	8.3319D-02
6.00D 05	5.1860D 04	8.2693D-02
7.00D 05	6.0103D 04	8.2171D-02
8.00D 05	6.8299D 04	8.1724D-02
9.00D 05	7.6452D 04	8.1333D-02
1.00D 06	8.4569D 04	8.0987D-02
2.00D 06	1.6433D 05	7.8783D-02
3.00D 06	2.4246D 05	7.7547D-02
4.00D 06	3.1957D 05	7.6694D-02
5.00D 06	3.9573D 05	7.6046D-02
6.00D 06	4.7172D 05	7.5524D-02
7.00D 06	5.4703D 05	7.5089D-02
8.00D 06	6.2194D 05	7.4715D-02
9.00D 06	6.9651D 05	7.4389D-02
1.00D 07	7.7077D 05	7.4098D-02
2.00D 07	1.5016D 06	7.2270D-02
3.00D 07	2.2193D 06	7.1381D-02
4.00D 07	2.9305D 06	7.0916D-02
5.00D 07	3.6382D 06	7.0668D-02
6.00D 07	4.3442D 06	7.0531D-02
7.00D 07	5.0492D 06	7.0456D-02
8.00D 07	5.7537D 06	7.0413D-02
9.00D 07	6.4579D 06	7.0391D-02

Skin = 20

t_D	Q_D	q_D
1.00D 05	3.8965D 03	3.8201D-02
2.00D 05	7.6893D 03	3.7703D-02
3.00D 05	1.1445D 04	3.7417D-02
4.00D 05	1.5176D 04	3.7217D-02
5.00D 05	1.8891D 04	3.7063D-02
6.00D 05	2.2591D 04	3.6938D-02
7.00D 05	2.6280D 04	3.6833D-02
8.00D 05	2.9959D 04	3.6743D-02
9.00D 05	3.3630D 04	3.6664D-02
1.00D 06	3.7293D 04	3.6593D-02
2.00D 06	7.3635D 04	3.6135D-02
3.00D 06	1.0963D 05	3.5872D-02
4.00D 06	1.4542D 05	3.5688D-02
5.00D 06	1.8103D 05	3.5547D-02
6.00D 06	2.1653D 05	3.5432D-02
7.00D 06	2.5192D 05	3.5336D-02
8.00D 06	2.8722D 05	3.5253D-02
9.00D 06	3.2244D 05	3.5180D-02
1.00D 07	3.5759D 05	3.5115D-02
2.00D 07	7.0646D 05	3.4697D-02
3.00D 07	1.0523D 06	3.4488D-02
4.00D 07	1.3966D 06	3.4375D-02
5.00D 07	1.7400D 06	3.4313D-02
6.00D 07	2.0830D 06	3.4278D-02
7.00D 07	2.4257D 06	3.4259D-02
8.00D 07	2.7683D 06	3.4247D-02
9.00D 07	3.1108D 06	3.4241D-02

CONSTANT PRESSURE OUTER BOUNDARY

$r_{eD} = 5x10^4$

Skin = 0			Skin = 10		
t_D	Q_D	q_D	t_D	QD	q_D
1.00D 07	1.2526D 06	1.1742D-01	1.00D 07	5.5648D 05	5.4093D-02
2.00D 07	2.4012D 06	1.1206D-01	2.00D 07	1.0919D 06	5.3099D-02
3.00D 07	3.5164D 06	1.1035D-01	3.00D 07	1.6200D 06	5.2531D-02
4.00D 07	4.6110D 06	1.0863D-01	4.00D 07	2.1433D 06	5.2141D-02
5.00D 07	5.6908D 06	1.0734D-01	5.00D 07	2.6632D 06	5.1839D-02
6.00D 07	6.7590D 06	1.0631D-01	6.00D 07	3.1804D 06	5.1596D-02
7.00D 07	7.8177D 06	1.0545D-01	7.00D 07	3.6954D 06	5.1392D-02
8.00D 07	8.8685D 06	1.0471D-01	8.00D 07	4.2085D 06	5.1216D-02
9.00D 07	9.9125D 06	1.0408D-01	9.00D 07	4.7199D 06	5.1062D-02
1.00D 08	1.0950D 07	1.0351D-01	1.00D 08	5.2299D 06	5.0926D-02
2.00D 08	2.1102D 07	9.9946D-02	2.00D 08	1.0274D 07	5.0044D-02
3.00D 08	3.0994D 07	9.7965D-02	3.00D 08	1.5253D 07	4.9541D-02
4.00D 08	4.0722D 07	9.6616D-02	4.00D 08	2.0189D 07	4.9192D-02
5.00D 08	5.0334D 07	9.5630D-02	5.00D 08	2.5096D 07	4.8932D-02
6.00D 08	5.9858D 07	9.4890D-02	6.00D 08	2.9979D 07	4.8733D-02
7.00D 08	6.9316D 07	9.4327D-02	7.00D 08	3.4845D 07	4.8582D-02
8.00D 08	7.8725D 07	9.3897D-02	8.00D 08	3.9697D 07	4.8464D-02
9.00D 08	8.8095D 07	9.3566D-02	9.00D 08	4.4536D 07	4.8371D-02
1.00D 09	9.7437D 07	9.3311D-02	1.00D 09	4.9372D 07	4.8299D-02
2.00D 09	1.9017D 08	9.2485D-02	2.00D 09	9.7510D 07	4.8054D-02
3.00D 09	2.8266D 08	9.2416D-02	3.00D 09	1.4556D 08	4.8030D-02
4.00D 09	3.7509D 08	9.2412D-02	4.00D 09	1.9360D 08	4.8028D-02
5.00D 09	4.6754D 08	9.2424D-02	5.00D 09	2.4164D 08	4.8031D-02
6.00D 09	5.5996D 08	9.2418D-02	6.00D 09	2.8967D 08	4.8030D-02
7.00D 09	6.5243D 08	9.2436D-02	7.00D 09	3.3772D 08	4.8034D-02
8.00D 09	7.4481D 08	9.2413D-02	8.00D 09	3.8574D 08	4.8028D-02
9.00D 07	8.3730D 08	9.2435D-02	9.00D 09	4.3380D 08	4.8034D-02

Skin = 0			Skin = 20		
t_D	QD	q_D	t_D	Q_D	q_D
1.00D 07	7.7074D 05	7.4098D-02	1.00D 07	3.5759D 05	3.5114D-02
2.00D 07	1.5014D 06	7.2247D-02	2.00D 07	7.0642D 05	3.4692D-02
3.00D 07	2.2184D 06	7.1206D-02	3.00D 07	1.0521D 06	3.4450D-02
4.00D 07	2.9268D 06	7.0486D-02	4.00D 07	1.3958D 06	3.4281D-02
5.00D 07	3.6289D 06	6.9937D-02	5.00D 07	1.7379D 06	3.4150D-02
6.00D 07	4.3261D 06	6.9495D-02	6.00D 07	2.0789D 06	3.4044D-02
7.00D 07	5.0192D 06	6.9126D-02	7.00D 07	2.4190D 06	3.3955D-02
8.00D 07	5.7089D 06	6.8809D-02	8.00D 07	2.7582D 06	3.3878D-02
9.00D 07	6.3957D 06	6.8532D-02	9.00D 07	3.0967D 06	3.3811D-02
1.00D 08	7.0798D 06	6.8286D-02	1.00D 08	3.4345D 06	3.3751D-02
2.00D 08	1.3821D 07	6.6712D-02	2.00D 08	6.7883D 06	3.3361D-02
3.00D 08	2.0446D 07	6.5821D-02	3.00D 08	1.0113D 07	3.3137D-02
4.00D 08	2.6998D 07	6.5207D-02	4.00D 08	1.3419D 07	3.2980D-02
5.00D 08	3.3496D 07	6.4733D-02	5.00D 08	1.6712D 07	3.2863D-02
6.00D 08	3.9954D 07	6.4409D-02	6.00D 08	1.9994D 07	3.2773D-02
7.00D 08	4.6381D 07	6.4145D-02	7.00D 08	2.3268D 07	3.2704D-02
8.00D 08	5.2784D 07	6.3941D-02	8.00D 08	2.6535D 07	3.2649D-02
9.00D 08	5.9169D 07	6.3783D-02	9.00D 08	2.9798D 07	3.2607D-02
1.00D 09	6.5541D 07	6.3660D-02	1.00D 09	3.3057D 07	3.2573D-02
2.00D 09	1.2893D 08	6.3248D-02	2.00D 07	6.5557D 07	3.2458D-02
3.00D 07	1.9216D 08	6.3209D-02	3.00D 09	9.8014D 07	3.2446D-02
4.00D 09	2.5538D 08	6.3206D-02	4.00D 09	1.3046D 08	3.2445D-02
5.00D 09	3.1861D 08	6.3212D-02	5.00D 09	1.6292D 08	3.2447D-02
6.00D 09	3.8183D 08	6.3210D-02	6.00D 09	1.9537D 08	3.2446D-02
7.00D 09	4.4506D 08	6.3218D-02	7.00D 09	2.2732D 08	3.2448D-02
8.00D 09	5.0826D 08	6.3207D-02	8.00D 09	2.6027D 08	3.2445D-02
9.00D 07	5.7151D 08	6.3218D-02	9.00D 09	2.9273D 08	3.2448D-02

CONSTANT PRESSURE OUTER BOUNDARY

$r_{eD} = 1x10^5$

Skin = 0

t_D	QD	q_D
1.00D 07	1.2526D 06	1.1742D-01
2.00D 07	2.4012D 06	1.1266D-01
3.00D 07	3.5164D 06	1.1035D-01
4.00D 07	4.6110D 06	1.0863D-01
5.00D 07	5.6908D 06	1.0734D-01
6.00D 07	6.7590D 06	1.0631D-01
7.00D 07	7.8175D 06	1.0545D-01
8.00D 07	8.8686D 06	1.0471D-01
9.00D 07	9.9126D 06	1.0408D-01
1.00D 08	1.0951D 07	1.0351D-01
2.00D 08	2.1102D 07	9.9943D-02
3.00D 08	3.0991D 07	9.7967D-02
4.00D 08	4.0718D 07	9.6612D-02
5.00D 08	5.0327D 07	9.5587D-02
6.00D 08	5.9844D 07	9.4766D-02
7.00D 08	6.9287D 07	9.4082D-02
8.00D 08	7.8668D 07	9.3497D-02
9.00D 08	8.7994D 07	9.2987D-02
1.00D 09	9.7272D 07	9.2534D-02
2.00D 09	1.8822D 08	8.9707D-02
3.00D 09	2.7717D 08	8.8353D-02
4.00D 09	3.6512D 08	8.7655D-02
5.00D 09	4.5257D 08	8.7286D-02
6.00D 09	5.3975D 08	8.7086D-02
7.00D 09	6.2679D 08	8.6977D-02
8.00D 09	7.1375D 08	8.6915D-02
9.00D 09	8.0068D 08	8.6884D-02

Skin = 10

t_D	Q_D	q_D
1.00D 07	5.5640D 05	5.4093D-02
2.00D 07	1.0919D 06	5.3099D-02
3.00D 07	1.6200D 06	5.2534D-02
4.00D 07	2.1433D 06	5.2141D-02
5.00D 07	2.6632D 06	5.1839D-02
6.00D 07	3.1804D 06	5.1596D-02
7.00D 07	3.6954D 06	5.1392D-02
8.00D 07	4.2085D 06	5.1216D-02
9.00D 07	4.7199D 06	5.1062D-02
1.00D 08	5.2299D 06	5.0925D-02
2.00D 08	1.0274D 07	5.0043D-02
3.00D 08	1.5252D 07	4.9541D-02
4.00D 08	2.0188D 07	4.9191D-02
5.00D 08	2.5094D 07	4.8923D-02
6.00D 08	2.9976D 07	4.8706D-02
7.00D 08	3.4839D 07	4.8524D-02
8.00D 08	3.9683D 07	4.8368D-02
9.00D 08	4.4514D 07	4.8231D-02
1.00D 09	4.9332D 07	4.8108D-02
2.00D 09	9.7011D 07	4.7329D-02
3.00D 09	1.4413D 08	4.6942D-02
4.00D 09	1.9075D 08	4.6736D-02
5.00D 09	2.3763D 08	4.6623D-02
6.00D 09	2.8422D 08	4.6561D-02
7.00D 09	3.3077D 08	4.6526D-02
8.00D 09	3.7729D 08	4.6505D-02
9.00D 09	4.2380D 08	4.6494D-02

Skin = 5

t_D	QD	q_D
1.00D 07	7.7074D 05	7.4098D-02
2.00D 07	1.5014D 06	7.2247D-02
3.00D 07	2.2184D 06	7.1206D-02
4.00D 07	2.9268D 06	7.0486D-02
5.00D 07	3.6289D 06	6.9937D-02
6.00D 07	4.3261D 06	6.9495D-02
7.00D 07	5.0192D 06	6.9126D-02
8.00D 07	5.7089D 06	6.8809D-02
9.00D 07	6.3957D 06	6.8532D-02
1.00D 08	7.0799D 06	6.8286D-02
2.00D 08	1.3821D 07	6.6710D-02
3.00D 08	2.0445D 07	6.5822D-02
4.00D 08	2.6996D 07	6.5206D-02
5.00D 08	3.3493D 07	6.4736D-02
6.00D 08	3.9949D 07	6.4357D-02
7.00D 08	4.6368D 07	6.4041D-02
8.00D 08	5.2760D 07	6.3769D-02
9.00D 08	5.9126D 07	6.3530D-02
1.00D 09	6.5470D 07	6.3318D-02
2.00D 09	1.2804D 08	6.1977D-02
3.00D 09	1.8966D 08	6.1319D-02
4.00D 09	2.5078D 08	6.0972D-02
5.00D 09	3.1165D 08	6.0795D-02
6.00D 09	3.7238D 08	6.0682D-02
7.00D 09	4.3304D 08	6.0625D-02
8.00D 09	4.7266D 08	6.0593D-02
9.00D 09	5.5426D 08	6.0570D-02

Skin = 20

t_D	Q_D	q_D
1.00D 07	3.5759D 05	3.5114D-02
2.00D 07	7.0642D 05	3.4692D-02
3.00D 07	1.0521D 06	3.4450D-02
4.00D 07	1.3958D 06	3.4281D-02
5.00D 07	1.7379D 06	3.4150D-02
6.00D 07	2.0787D 06	3.4044D-02
7.00D 07	2.4190D 06	3.3955D-02
8.00D 07	2.7582D 06	3.3878D-02
9.00D 07	3.0967D 06	3.3811D-02
1.00D 08	3.4345D 06	3.3751D-02
2.00D 08	6.7853D 06	3.3361D-02
3.00D 08	1.0113D 07	3.3137D-02
4.00D 08	1.3419D 07	3.2980D-02
5.00D 08	1.6711D 07	3.2859D-02
6.00D 08	1.9992D 07	3.2761D-02
7.00D 08	2.3264D 07	3.2678D-02
8.00D 08	2.6529D 07	3.2607D-02
9.00D 08	2.9787D 07	3.2545D-02
1.00D 09	3.3040D 07	3.2489D-02
2.00D 09	6.5334D 07	3.2131D-02
3.00D 09	9.7368D 07	3.1951D-02
4.00D 09	1.2927D 08	3.1854D-02
5.00D 09	1.6109D 08	3.1801D-02
6.00D 09	1.9288D 08	3.1771D-02
7.00D 09	2.2465D 08	3.1754D-02
8.00D 09	2.5640D 08	3.1744D-02
9.00D 09	2.8815D 08	3.1739D-02

CONSTANT PRESSURE OUTER BOUNDARY

$r_{eD} = 5 \times 10^5$

Skin = 0			Skin = 10		
t_D	Q_D	q_D	t_D	QD	q_D
1.00D 09	9.7267D 07	9.2534D-02	1.00D 09	4.9331D 07	4.8108D-02
2.00D 09	1.8820D 08	8.9659D-02	2.00D 09	9.7004D 07	4.7320D-02
3.00D 09	2.7703D 08	8.8074D-02	3.00D 09	1.4409D 08	4.6871D-02
4.00D 09	3.6453D 08	8.6976D-02	4.00D 09	1.9080D 08	4.6557D-02
5.00D 09	4.5109D 08	8.6143D-02	5.00D 09	2.3724D 08	4.6317D-02
6.00D 09	5.3690D 08	8.5474D-02	6.00D 09	2.8346D 08	4.6122D-02
7.00D 09	6.2209D 08	8.4916D-02	7.00D 09	3.2951D 08	4.5959D-02
8.00D 09	7.0677D 08	8.4439D-02	8.00D 09	3.7540D 08	4.5818D-02
9.00D 09	7.9101D 08	8.4023D-02	9.00D 09	4.2116D 08	4.5695D-02
1.00D 10	8.7485D 08	8.3654D-02	1.00D 10	4.6681D 08	4.5586D-02
2.00D 10	1.6983D 09	8.1306D-02	2.00D 10	9.1877D 08	4.4878D-02
3.00D 10	2.5046D 09	7.9988D-02	3.00D 10	1.3655D 09	4.4473D-02
4.00D 10	3.2999D 09	7.9055D-02	4.00D 10	1.8088D 09	4.4191D-02
5.00D 10	4.0874D 09	7.8420D-02	5.00D 10	2.2497D 09	4.3981D-02
6.00D 10	4.8690D 09	7.7918D-02	6.00D 10	2.6888D 09	4.3821D-02
7.00D 10	5.6461D 09	7.7535D-02	7.00D 10	3.1263D 09	4.3698D-02
8.00D 10	6.4199D 09	7.7240D-02	8.00D 10	3.5628D 09	4.3602D-02
9.00D 10	7.1910D 09	7.7012D-02	9.00D 10	3.9984D 09	4.3527D-02
1.00D 11	7.9601D 09	7.6836D-02	1.00D 11	4.4334D 09	4.3468D-02
2.00D 11	1.5605D 10	7.6254D-02	2.00D 11	8.7671D 09	4.3268D-02
3.00D 11	2.3229D 10	7.6201D-02	3.00D 11	1.3093D 10	4.3247D-02
4.00D 11	3.0850D 10	7.6200D-02	4.00D 11	1.7419D 10	4.3246D-02
5.00D 11	3.8472D 10	7.6204D-02	5.00D 11	2.1744D 10	4.3248D-02
6.00D 11	4.6093D 10	7.6203D-02	6.00D 11	2.6070D 10	4.3247D-02
7.00D 11	5.3717D 10	7.6214D-02	7.00D 11	3.0396D 10	4.3251D-02
8.00D 11	6.1336D 10	7.6204D-02	8.00D 11	3.4721D 10	4.3248D-02
9.00D 11	6.8961D 10	7.6216D-02	9.00D 11	3.9047D 10	4.3251D-02
Skin = 5			**Skin = 10**		
t_D	Q_D	q_D	t_D	QD	q_D
1.00D 09	6.5467D 07	6.3318D-02	1.00D 09	3.3039D 07	3.2489D-02
2.00D 09	1.2303D 08	6.1960D-02	2.00D 09	6.5331D 07	3.2127D-02
3.00D 09	1.8959D 08	6.1193D-02	3.00D 09	9.7351D 07	3.1919D-02
4.00D 09	2.5051D 08	6.0660D-02	4.00D 09	1.2920D 08	3.1774D-02
5.00D 09	3.1097D 08	6.0253D-02	5.00D 09	1.6092D 08	3.1661D-02
6.00D 09	3.7106D 08	5.9924D-02	6.00D 09	1.9254D 08	3.1570D-02
7.00D 09	4.3085D 08	5.9649D-02	7.00D 09	2.2407D 08	3.1494D-02
8.00D 09	4.9039D 08	5.9413D-02	8.00D 09	2.5554D 08	3.1428D-02
9.00D 09	5.4970D 08	5.9206D-02	9.00D 09	2.8694D 08	3.1370D-02
1.00D 10	6.0882D 08	5.9022D-02	1.00D 10	3.1829D 08	3.1318D-02
2.00D 10	1.1925D 09	5.7842D-02	2.00D 10	6.2964D 08	3.0982D-02
3.00D 10	1.7675D 09	5.7171D-02	3.00D 10	9.3849D 08	3.0783D-02
4.00D 10	2.3369D 09	5.6707D-02	4.00D 10	1.2457D 09	3.0653D-02
5.00D 10	2.9023D 09	5.6363D-02	5.00D 10	1.5518D 09	3.0552D-02
6.00D 10	3.4646D 09	5.6101D-02	6.00D 10	1.8569D 09	3.0474D-02
7.00D 10	4.0245D 09	5.5900D-02	7.00D 10	2.1614D 09	3.0414D-02
8.00D 10	4.5827D 09	5.5744D-02	8.00D 10	2.4653D 09	3.0367D-02
9.00D 10	5.1395D 09	5.5623D-02	9.00D 10	2.7688D 09	3.0330D-02
1.00D 11	5.6952D 09	5.5528D-02	1.00D 11	3.0720D 09	3.0301D-02
2.00D 11	1.1227D 10	5.5210D-02	2.00D 11	6.0957D 09	3.0201D-02
3.00D 11	1.6747D 10	5.5179D-02	3.00D 11	9.1157D 09	3.0191D-02
4.00D 11	2.2266D 10	5.5177D-02	4.00D 11	1.2135D 10	3.0190D-02
5.00D 11	2.7785D 10	5.5180D-02	5.00D 11	1.5155D 10	3.0191D-02
6.00D 11	3.3304D 10	5.5179D-02	6.00D 11	1.8174D 10	3.0191D-02
7.00D 11	3.8823D 10	5.5184D-02	7.00D 11	2.1194D 10	3.0192D-02
8.00D 11	4.4341D 10	5.5180D-02	8.00D 11	2.4213D 10	3.0191D-02
9.00D 11	4.9861D 10	5.5186D-02	9.00D 11	2.7233D 10	3.0193D-02

CONSTANT PRESSURE OUTER BOUNDARY

$r_{eD} = 1x10^6$

Skin = 0			Skin = 10		
t_D	Q_D	q_D	t_D	Q_D	q_D
1.00D 09	9.7267D 07	9.2534D-02	1.00D 09	4.9331D 07	4.8108D-02
2.00D 09	1.8820D 08	8.9669D-02	2.00D 09	9.7004D 07	4.7320D-02
3.00D 09	2.7703D 08	8.8074D-02	3.00D 09	1.4407D 08	4.6871D-02
4.00D 09	3.6453D 08	8.6976D-02	4.00D 09	1.9080D 08	4.6557D-02
5.00D 09	4.5109D 08	8.6143D-02	5.00D 09	2.3724D 08	4.6317D-02
6.00D 09	5.3690D 08	8.5474D-02	6.00D 09	2.8346D 08	4.6122D-02
7.00D 09	6.2209D 08	8.4917D-02	7.00D 09	3.2951D 08	4.5959D-02
8.00D 09	7.0678D 08	8.4439D-02	8.00D 09	3.7540D 08	4.5818D-02
9.00D 09	7.9102D 08	8.4023D-02	9.00D 09	4.2116D 08	4.5693D-02
1.00D 10	8.7486D 08	8.3654D-02	1.00D 10	4.6681D 08	4.5586D-02
2.00D 10	1.6983D 09	8.1304D-02	2.00D 10	9.1876D 08	4.4877D-02
3.00D 10	2.5044D 09	7.9990D-02	3.00D 10	1.3654D 09	4.4473D-02
4.00D 10	3.2996D 09	7.9083D-02	4.00D 10	1.8087D 09	4.4191D-02
5.00D 10	4.0869D 09	7.8393D-02	5.00D 10	2.2496D 09	4.3974D-02
6.00D 10	4.8681D 09	7.7839D-02	6.00D 10	2.6885D 09	4.3799D-02
7.00D 10	5.6443D 09	7.7377D-02	7.00D 10	3.1258D 09	4.3652D-02
8.00D 10	6.4162D 09	7.6980D-02	8.00D 10	3.5617D 09	4.3525D-02
9.00D 10	7.1844D 09	7.6633D-02	9.00D 10	3.9965D 09	4.3414D-02
1.00D 11	7.9494D 09	7.6325D-02	1.00D 11	4.4302D 09	4.3315D-02
2.00D 11	1.5474D 10	7.4387D-02	2.00D 11	8.7269D 09	4.2681D-02
3.00D 11	2.2860D 10	7.3447D-02	3.00D 11	1.2978D 10	4.2366D-02
4.00D 11	3.0177D 10	7.2956D-02	4.00D 11	1.7205D 10	4.2197D-02
5.00D 11	3.7458D 10	7.2693D-02	5.00D 11	2.1420D 10	4.2105D-02
6.00D 11	4.4720D 10	7.2550D-02	6.00D 11	2.5628D 10	4.2053D-02
7.00D 11	5.1971D 10	7.2471D-02	7.00D 11	2.9832D 10	4.2024D-02
8.00D 11	5.9218D 10	7.2427D-02	8.00D 11	3.4035D 10	4.2008D-02
9.00D 11	6.6461D 10	7.2402D-02	9.00D 11	3.8236D 10	4.1998D-02

Skin = 5			Skin = 20		
t_D	QD	q_D	t_D	QD	q_D
1.00D 09	6.5467D 07	6.3318D-02	1.00D 09	3.3039D 07	3.2489D-02
2.00D 09	1.2803D 08	6.1960D-02	2.00D 09	6.5331D 07	3.2127D-02
3.00D 09	1.8959D 08	6.1193D-02	3.00D 09	9.7351D 07	3.1919D-02
4.00D 09	2.5051D 08	6.0660D-02	4.00D 09	1.2920D 08	3.1774D-02
5.00D 09	3.1097D 08	6.0253D-02	5.00D 09	1.6092D 08	3.1661D-02
6.00D 09	3.7106D 08	5.9924D-02	6.00D 09	1.9254D 08	3.1570D-02
7.00D 09	4.3085D 08	5.9649D-02	7.00D 09	2.2407D 08	3.1494D-02
8.00D 09	4.9039D 08	5.9413D-02	8.00D 09	2.5554D 08	3.1428D-02
9.00D 09	5.4970D 08	5.9206D-02	9.00D 09	2.8694D 08	3.1370D-02
1.00D 10	6.0882D 08	5.9022D-02	1.00D 10	3.1829D 08	3.1318D-02
2.00D 10	1.1925D 09	5.7841D-02	2.00D 10	6.2963D 08	3.0982D-02
3.00D 10	1.7674D 09	5.7172D-02	3.00D 10	9.3846D 08	3.0789D-02
4.00D 10	2.3367D 09	5.6706D-02	4.00D 10	1.2457D 09	3.0653D-02
5.00D 10	2.9020D 09	5.6350D-02	5.00D 10	1.5517D 09	3.0548D-02
6.00D 10	3.4641D 09	5.6063D-02	6.00D 10	1.8569D 09	3.0464D-02
7.00D 10	4.0236D 09	5.5822D-02	7.00D 10	2.1611D 09	3.0393D-02
8.00D 10	4.5809D 09	5.5615D-02	8.00D 10	2.4648D 09	3.0331D-02
9.00D 10	5.1362D 09	5.5434D-02	9.00D 10	2.7679D 09	3.0277D-02
1.00D 11	5.6899D 09	5.5272D-02	1.00D 11	3.0705D 09	3.0229D-02
2.00D 11	1.1160D 10	5.4246D-02	2.00D 11	6.0764D 09	2.9919D-02
3.00D 11	1.6557D 10	5.3740D-02	3.00D 11	9.0599D 09	2.9762D-02
4.00D 11	2.1916D 10	5.3472D-02	4.00D 11	1.2032D 10	2.9678D-02
5.00D 11	2.7255D 10	5.3326D-02	5.00D 11	1.4997D 10	2.9632D-02
6.00D 11	3.2584D 10	5.3246D-02	6.00D 11	1.7959D 10	2.9605D-02
7.00D 11	3.7907D 10	5.3200D-02	7.00D 11	2.0919D 10	2.9591D-02
8.00D 11	4.3227D 10	5.3175D-02	8.00D 11	2.3878D 10	2.9582D-02
9.00D 11	4.8544D 10	5.3161D-02	9.00D 11	2.6837D 10	2.9577D-02

APPENDIX C

COMPUTER PROGRAMS

```
C       ANALYTICAL SOLUTIONS FOR CONSTANT WELLBORE PRESSURE
C
        IMF'LICIT REAL18 (A-H,O-Z)
        COMMON/PARA/SKIN,RDIM,REFF,TFLOW
        COMMON/TSOLN/ICHART,NSOLN,ITYPE,IXA,IXR
        COMMON/HB/G1,G2,G3,G4,G5
        COMMON/VAR/QD(1000),TD(1000),TDX(100),AMODES(100)
        CHARACTER*4 SIGN
        DOUBLE PRECISION TFORM,TFORMA,TFORMB,BESKO,BESK1
        EXTERNAL TFORM,TFORMA,TFORMB
        CALL TRAPS (S0,10,100,10,10)
C       N = NUMBER OF TERMS ■ LAPLACE INVERTER
        N=8
        M=0
        SIGN=' '
C
C       SOLUTION DESCR ■T ■N:
C       ICHART = 1 FOR QD US TIS
C                2 FOR QD VS TUA
C                3 FOR INITIALLY CONSTANT RATE
C                4 FOR PD VS RD
C                6 FOR BUILDUP FROM SUPERPOSITION
        ICHART=1
C       LIMITS FOR TD ARE 10**IXA TO 10**IXB
        IXA=-1
        IXB=9
C       NSOLN =  1 FOR INFINITE OUTER BOIJNDRRY
C                2 FOR NO-FLOW OUTER BOUNDARY
C                3 FOR CONSTANT PRESSURE OUTER BOUNDARY
        NSOLN=1
C       NTIMES = NUMEER OF LOG CYCLE5 TO EVALUATE
        NTIMES=(IXB-IXA)
C
C       PARAMETER VALUES:
C       SKIN = WELLBORE SKIN FACTOR
        SKIN=0.
C       RDIM = UIMENSIONLESS RADIUS (1 .LE. RDIM .LE. REFF)
        RDIM=1.0
C       REFF = DIMENSIONLESS RESERVOIR RADIUS (FOR FINITE RESERVOIR)
        REFF=50.
C       TFLOW = FLOW TIME (FOR PRESSURE BUILDUP OR PD VS RD)
        TFLOW=10.
C       NRD = NUMBER OF RADIAL LOG CYCLES
        NRD=5
        IF (ICHART .EQ. 6) GO TO 70
        IF (ICHART .LT. 3) GO TO 5
        IF (ICHART .EQ. 4) GO TO 30
C
```

```
C       CALCULATE TIMES FOR EVALUATION.
C
      5 TO=3.14159 *REFF*REFF*O.1
        TMULT=1.
        DLOGT=1./DFLOAT(NTIMES)
        IF ( ICHART .EQ. 2) TMULT=REFF*REFF
        DO 10 J=1,NTIMES
        DO 10 I=1,9
        K=I+(J-1)*9
        TD(K)=DFLOAT( I)*10.**(IXA+J-1)
     10 TDX(K)=TD(K)*TMULT
     11 CALL OUTFORM
C
C       CALCULATE QD.
C
        NT=9*NTIMES
        DO 20 I=1,NT
        TDI=TD(I)
C       * INDICATES EXPONENTIAL RATE DECLINE
        IF ((TDI .GT. TO) .AND. (NSOLN .EQ. 2)) SIGN='*'
        CALL LINU(TFORM,TDI,QDI,N,M)
        CALL LINU (TFORMA,TDI,QDJ,N,M)
        WRITE (6,300)TDX(I),QDJ,QDI,SIGN
     20 QD(I)=QDI
        IF (SKIN .EQ. 0.) GO TO 21
        IF (SKIN .EQ. 5.) GO TO 22
        IF ( SKIN .EQ. 10.) GO TO 23
        IF (SKIN .EQ. 20. ) GO TO 50
     21 SKIN=5.
        GO TO 11
     22 SKIN=10.
        GO TO 11
     23 SKIN=20.
        GO TO 11
     30 CALL OUTFORM
C
C       CALCULATE PD US RD FOR TU = TFLOW
C
        DO 40 J=1,NRD
        DO 40 I=1,9
        K=I+(J-1)*9
        RDIM=DFLOAT( I)*10.**(J-1)
        CALL LINV(TFORM,TFLOW,PD,N,M)
     40 WRITE (6,300) RDIM,PD
    300 FORMAT (' ',1PE10.2,2X,2(1PE12.4,2X),A1)
     SO STOP
     70 CALL OUTFORM
        CALL SPBU(N,M)
        STOP
        ENU
C
C
C
        SUBROUTINE LINU(P,T,FA,N,M
        IMPLICIT REAL*8 (A-H,O-Z)
        COMMON/LPL/G(50),V(50),H(25),GZ(1)
        DOUBLE PRECISION P
C
C       LINU (LAPLACE INVERTER) IS A FORTRAN TRANSLATION OF THE
C       ALGOL PROCEDURE GIVEN BY STEHFEST (1970). P IS THE LAPLACE
C       SPACE EXPRESSION TO HE NUMERICALLY INVERTED. T IS THE TIME
C       AT WHICH THE SOLUTION IS TO BE EVALUATED. FA IS THE VALUE
C       OF THE SOLUTION AT TIME T DETERMINED BY THE NUMERICAL INVER-
C       SION OF THE LAPLACE SPACE SOLUTION. N IS THE NUMBER OF TERMS
C       IN THE SUMMATION. [SEE STEHFEST (1970)]
C
```

```
      DLOGTW=.6931471805599453
      IF (M .EQ. N) GO TO 100
C     CALCULATE V ARRAY.
      M=N
      G(1)=1.
      NH=N/2
      DO 5 I=2,N
    5 G(I)=G(I-1)*I
      H(1)=2./G(NH-1)
      DO 10 I=2,NH
      FI=I
      IF (I .EQ. NH) GO TO 8
      H(I)=FI**NH*G(2*I)/(G(NH-I)*G(I)*G(I-1))
      GO TO 10
    8 H(I)=FI**NH*G(2*I)/(G(I)*G(I-1))
   10 CONTINUE
      SN=2*(NH-NH/2*2)-1
      DO 50 I=1,N
      V(I)=0.
      K1=(I+1)/2
      K2=I
      IF (K2 .GT. NH) K2=NH
      DO 40 K=K1,K2
      IF (2*K-I .EQ. 0) GO TO 37
      IF (I .EQ. K) GO TO 38
      V(I)=V(I)+H(K)/(G(I-K)*G(2*K-I))
      GO TO 40
   37 V(I)=V(I)+H(K)/G(I-K)
      GO TO 40
   38 V(I)=V(I)+H(K)/G(2*K-I)
   40 CONTINUE
      V(I)=SN*V(I)
      SN=-SN
   50 CONTINUE
  100 FA=0.
      A=DLOGTW/T
      DO 110 I=1,N
      ARG=DFLOAT(I)*A
  110 FA=FA+V(I)*F(ARG)
      FA=A*FA
      RETURN
      END
      DOUBLE PRECISION FUNCTION TFORM(S)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/PARA/SKIN,RDIM,REFF,TFLOW
      COMMON/TSOLN/ICHART,NSOLN,ITYPE,IXA,IXD
      COMMON/HB/G1,G2,G3,G4,G5
      DIMENSION ARG(3),XK(2,3),XI(2,3)
      REAL A,X
      DOUBLE PRECISION BESK0,BESK1
C
C     TFORM CONTAINS THE LAPLACE TRANSFORMED SOLUTIONS FOR THE
C     TRANSIENT RATE DECLINE FOR A WELL PRODUCED AT A CONSTANT
C     PRESSURE FROM A CIRCULAR RESERVOIR. ALSO INCLUDED ARE THE
C     SOLUTIONS FOR THE PRESSURE DISTRIBUTIONS.
C
      S1=DSQRT(S)
      ARG(1)=S1
      ARG(2)=RDIM*S1
      ARG(3)=REFF*S1
      DO 10 J=1,3
      XK(1,J)=BESK0(ARG(J))
      XK(2,J)=BESK1(ARG(J))
      A=ARG(J)
      CALL BESI(A,0,X,IER)
      XI(1,J)=X
```

```
      CALL BESI(A,1,X,IER)
   10 XI(2,J)=X
      IF (ICHART .EQ. 3) GO TO 60
      GO TO (20,30,40),NSOLN
C
C     SOLUTION FOR INFINITE OUTER BOUNDARY
C
   20 DENOM=S*(XK(1,1)+SKIN*S1*XK(2,1))
      ■ (DENOM .EQ. 0.) GO TO 70
      PD=XK(1,2)/DENOM
      QD=S1*XK(2,1)/DENOM
      GO TO 50
C
C     SOLUTION FOR NO-FLOW OUTER BOUNDARY
C
   30 DENOM=S*((XK(2,3)*XI(1,1)+XK(1,1)*XI(2,3))
     1-SKIN*S1*(XK(2,3)*XI(2,1)-XK(2,1)*XI(2,3)))
      IF (DENOM .EQ. 0.) GO TO 70
      PD=(XK(2,3)*XI(1,2)+XK(1,2)*XI(2,3))/DENOM
      QD=S1*(XK(2,1)*XI(2,3)-XK(2,3)*XI(2,1))/DENOM
      GO TO 50
C
C     SOLUTION FOR CONSTANT PRESSURE OUTER BOUNDARY
C
   40 DENOM=S*((-XK(1,3)*XI(1,1)+XK(1,1)*XI(1,3))
     1+SKIN*S1*(XK(1,3)*XI(2,1)+XK(2,1)*XI(1,3)))
      IF (DENOM .EQ. 0.) GO TO 70
      PD=(-XK(1,3)*XI(1,2)+XK(1,2)*XI(1,3))/DENOM
      QD=S1*(XK(2,1)*XI(1,3)+XK(1,3)*XI(2,1))/DENOM
   50 TFORM=PD
      IF (RDIM .EQ. 1) TFORM=QD
      RETURN
   60 TFORM=(-S1*XK(2,1)*G4/XK(1,1)+G2)/(S-G1)
      RETURN
   70 TFORM=-1.
      RETURN
      END
```

Values for the required Bessel functions were obtained through use of BESKO and BESK1 from the FUNPACK PACKET and the internal routine, BESI, available on the IBM 360 168 at the Stanford Computer Facility, Stanford University.

```
      SUBROUTINE SPBU(N,M)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/PARA/SKIN,RDIM,REFF,TFLOW
      COMMON/TSOLN/ICHART,NSOLN,ITYPE,IXA,IXH
      COMMON/VAR/QD(1000),TD(1000),DTD(100),AMODES(100)
      DOUBLE PRECISION TFORM,TFORMA,TFORMB,BESKO,BESK1
      EXTERNAL TFORM,TFORMA,TFORMB
C
C     SPBU COMPUTES PRESSURE BUILDUP SOLUTIONS FOR A WELL PRODUCED
C     AT A CONSTANT PRESSURE PRIOR TO SHUT-IN USING SUPERPOSITION
C     OF CONTINUOUSLY VARYING CONSTANT RATE SOLUTIONS.  THE TECHNIQUE
C     FOR APPROXIMATING THE RESULTING INTEGRAL IS TO DETERMINE TIME
```

```
C     INTERVALS DURING WHICH THE RATE ONLY CHANGES BY A SET AMOUNT,
C     AND THEN APPROXIMATE THE RATE IN EACH SUCH INTERVAL BY A
C     CONSTANT KATE OVER THE INTERVAL. THIS RESULTS IN A SUM OF TERMS
C     CONSISTING OF A RATE TIMES A PRESSURE DIFFERENCE.  THE SUM IS
C     THEN COMPUTED AS THE APPROXIMATION OF THE PRESSURE BUILDUP.
C
      TO=.1*3.1416*REFF*REFF
      T1=.05*REFF*REFF*(DLOG(REFF)-.75+SKIN)
C     KK1 AND K1 SPECIFY WHAT SHUT-IN TIMES ARE TO BE EVALUATED.
      KK1=4
      KK=3
      IF (NSOLN .EQ. 1) GO TO 2
      IF (TFLOW .GT. T1) GO TO 60
    2 DO 1 K1=1,KK1
      DO 1 K=1,KK
      J=K+(K1-1)*KK
    1 DTD(J)=TFLOW*10.**(K1-KK1)*2.**(K-1)
      NDT=KK1*KK
      DTF=DTD(NDT)+TFLOW
C     DELQ IS THE MAXIMUM VARIATION IN THE RATE FOR EACH SUB-INTERVAL
C     IN TIME REPRESENTED BY A TERM IN THE SUMMATION,
C     AN ARRAY OF TD AND QD VALUES ARE CREATED WITH THE SFECIFIED
C     DELQ VALUE.
      DELQ=.005
      DELQX=1000.*DELQ
      CALL QFORM(TFLOW,QD(1),N,M,T1)
      CALL LINV (TFORMA,TFLOW,CUM,N,M)
      TD(1)=TFLOW
      CALL QFORM(DTF,QD(2),N,M,T1)
      IF ((QD(1)-QD(2)) .GT. DELQX) GO TO 25
      TD(2)=DTF
      JK-1
      DO 20 J=2,1000
      DO 10 I=1,8
      IF (J .GT. (JK+1)) GO TO 30
      IF((QD(J-1)-QD(J)) .LT. DELQ) GO TO 20
      JK=JK+1
      DO 5 K=J,JK
      L=JK-K+J+1
      TD(L)=TD(L-1)
    5 QD(L)=QD(L-1)
      TD(J)=(TD(J-1)+TD(J))*.5
   10 CALL QFORM(TD(J),QD(J),N,M,T1)
   20 CONTINUE
   25 WRITE(6,103)
      RETURN
   30 JK=JK+1
      DO 50 I=1,NDT
      TT=DTD(I)+TFLOW
      T=TT-100.
      IF (T .LT. 1.D5) T=TT
      SUM=1.
      CALL PFORM(DTD(I),PDM,N,M,TO)
      DO 40 J=1,JK
      IF (T .LT. TD(J)) GO TO 43
      TP=TT-TD(J)
      CALL PFORM(TP,PDP,N,M,TO)
      IF((PDM-PDP) .GT. 0.) SUM=SUM-QD(J)*(PDM-PDP)
   40 PDM=PDP
   43 IF (TT .GE. 1.D5) GO TO 42
      SUM=(SUM-PDP*QD(J-1))/QD(1)
      GO TO 44
   42 CALL QFORM(T,QDF,N,M,T1)
      JM=J
      IF (J .NE. 1) JM=J-1
      IF ((PDM-2.71) .GT. 0.) SUM=SUM-QD(JM)*(PDM-2.71)
```

```
      SUM=(SUM-2.71*QDF)/QD(1)
   44 DTH=(CUM/QD(1)+DTD(I))/DTD(I)
   50 WRITE(6,100)SUM,DTD(I),DTH
      WRITE (6,101) TFLOW,REFF,NSOLN
      WRITE (6,104) (TD(I),QD(I),I=1,JK)
      RETURN
   60 WRITE (6,102)
      RETURN
  100 FORMAT(' ',3(E12.4,2X))
  102 FORMAT('  EXPONENTIAL DECLINE IN PROGRESS')
  103 FORMAT(' TOO MANY Q EVALUATIONS REQUIRED')
  101 FORMAT (' TFLOW = ',E12.4,2X,'REFF = ',E12.4,2X,'NSOLN = ',I1)
  104 FORMAT (' ',2(E12.4,2X))
      END
      DOUBLE PRECISION FUNCTION TFORMA(S)
      IMPLICIT REAL*8 (A-H,O-Z)
      DOUBLE PRECISION TFORM
      EXTERNAL TFORM
C
C     TFORMA IS THE LAPLACE SPACE SOLUTIONS FOR CUMULATIVE PRODUCTION
C
      TFORMA=TFORM(S)/S
      RETURN
      END
      DOUBLE PRECISION FUNCTION TFORMB(S)
      IMPLICIT REAL*8 (A-H,O-Z)
      DOUBLE PRECISION TFORM
      EXTERNAL TFORM
C
C     TFORMB IS THE LAPLACE SPACE SOLUTIONS FOR TRANSIENT WELLBORE
C     PRESSURE WITH CONSTANT KATE PRODUCTION.
C
      TFORMB=1./(S*S*TFORM(S))
      RETURN
      'END
      SUBROUTINE PFORM(T,P,N,M,TO)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/PARA/SKIN,RDIM,REFF,TFLOW
      COMMON/TSOLN/ICHART,NSOLN,ITYPE,IXA,IXB
      DOUBLE PRECISION TFORM,TFORMA,TFORMB,BESK0,BESK1
      EXTERNAL TFORM,TFORMA,TFORMB
C
C     PFORM USES LIMITING FORMS OF THE WELLBORE PRESSURE SOLUTION
C     FOR CONSTANT RATE PRODUCTION WHENEVER POSSIBLE.
C
    . NCASE=3
      IF (T .LT. 0.01) GO TO 30
    . IF (T .LT. 100.) NCASE=1
      IF (T .GT. TO) NCASE=2
      GO TO (10,20,22),NCASE
   20 GO TO (22,24,26),NSOLN
  27, P=.5*(DLOG(T)+.80907)+SKIN
      RETURN
   24 P=DLOG(REFF)-.75+2.*T/(REFF*REFF)+SKIN
      RETURN
   26 P=DLOG(REFF)+SKIN
      RETURN
   10 CALL LINV(TFORMB,T,P,N,M)
      RETURN
   30 P=DSQRT(4.*T/3.1416)
      RETURN
      END
      SUBROUTINE RFORM (T,Q,N,M,T1)
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/PARA/SKIN,RDIM,REFF,TFLOW
      COMMON/TSOLN/ICHART,NSOLN,ITYPE,IXA,IXB
```

```
      DOUBLE PRECISION TFORM,TFORMA,TFORMB,BESKO,BESK1
      EXTERNAL TFORM,TFORMA,TFORMB
C
C     QFORM USES LIMITING FORMS FOR THE RATE DECLINE FOR CONSTANT
C     PRESSURE F'ROOUCTION WHENEVER POSSIBLE.
C
      NCASE=1
      IF(T .LT. 5.D04) NCASE=1
      IF (T .GT. T1) NCASE=2
   20 GO TO (20,20,28),NCASE
   22 Q=2./((DLOG(T)t.80907)+SKIN)
      RETURN
   24 Q=DEXP(-.1*T/T1)/(DLOG(REFF)-.75+SKIN)
      RETURN
   26 T2=2.*T1
      IF (T .LT. T2) GO TO 10
      Q=1./(DLOG(REFF)+SKIN)
      RETURN
   10 CALL LINV(TFORM,T,Q,N,M)
      RETURN
      END
      SUBROUTINE OUTFORM
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON/PARA/SKIN,RDIM,REFF,TFLOW
      COMMON/TSOLN/ICHART,NSOLN,ITYPE,IXA,IXB
      COMMON/HB/G1,G2,G3,G4,G5
      COMMON/VAR/QD(1000),TD(1000),TDX(100),AMODES(100)
      IF (NSOLN .EQ. 1) WHITE (6,100)
      IF (NSOLN .EQ. 2) WRITE (6,101)
      IF (NSOLN .EQ. 3) WRITE (6,102)
      GO TO (10,20,10,30,40),ICHART
   10 WRITE (6,103) SKIN,RDIM
      IF' (NSOLN .NE. 1) WRITE (6,110) REFF
      IF (RDIM .EQ. 1) WRITE (6,104)
      IF (RDIM .NE. 1) WRITE (6,105)
      RETURN
   20 WRITE (6,103) SKIN,RDIM
      IF (NSOLN .NE. 1) WRITE (61110) REFF
      IF (RDIM .EQ. 1) WRITE (6,106)
      IF (RDIM .NE. 1) WRITE (6,107)
      RETURN
   30 WRITE (6,108) SKIN,TFLOW
      RETURN
   40 WRITE (6,103) SKIN,RDIM
      RETURN
  100 FORMAT ('1UNBOUNDED RESERVOIR' )
  101 FORMAT ('1CLOSED BOUNDED RESERVOIR' )
  102 FORMAT ('1CONSTANT PRESSURE BOUNDED RESERVOIR' )
  103 FORMAT (' SKIN = ',F6.3,3X,'RD = ',E12.4)
  104 FORMAT (/,6X,'TD',11X,'QD')
  105 FORMAT (/,6X,'TD',11X,'PD')
  106 FORMAT (/,5X,'TDA',11X,'QD')
  107 FORMAT (/,5X,'TDA',11X,'PD')
  108 FORMAT (' SKIN = ',F6.3,3X,'TD = ',E12.4,/,6X,'RD',11X,'PD')
  110 FORMA1 (' OUTER RADIUS, RD = ',E12.4)
      END
```