PURPOSE
The program computes a set of values for initial oil in place for a partial water drive reservoir with no gas cap. One calculation is performed for each time step and corresponding reservoir pressure and for cumulative production during the available performance history. Water influx computations are performed utilizing the Van Everdingen-Hurst unsteady-state equation. A set of response functions \( \{Q_T\} \) and corresponding dimensionless time \( \{T_D\} \) values are provided by the user. The selection of the \( Q_T \) function set is based on the assumed size of the aquifer compared to the size of the reservoir.

Although the material balance calculations can be performed above the bubble point pressure, this program is designed to perform all computations below the bubble point pressure. At pressures above the bubble point and slightly below, the material balance calculations are highly sensitive to slight errors in pressures and fluid property data. High sensitivity to such errors makes it very difficult to obtain a reliable estimate above the bubble point pressure.

Computational results are also quite sensitive to the values of formation volume factors. Therefore, a very high degree of accuracy (6 or 7 decimal places) is suggested for these parameters. It is realized that such accuracy is not obtainable from the laboratory measurement. However, this can be achieved by expressing the formation volume factor and pressure relationship with an equation, which may then be solved to obtain the desired accuracy.

METHOD

\[
N = \frac{N_p[B_T + B_p(R_p - R_u)] + W_p - W_e}{B_T - B_u}.
\]  

(7.1)
Rearranging equation (7.1), we may write
\[
N_p[B_t + B_s(R_p - R_o)] + W_p \frac{W_e}{B_t - B_{oi}} = \frac{W_e}{B_t - B_{oi}} + N. \tag{7.2}
\]

\[W_e = B \sum_{i=1}^{n} \Delta P_i Q_T(n + 1 - i). \tag{7.3}\]

Substitution of equation (7.3) in (7.2) yields
\[
N_p[B_t + B_s(R_p - R_o)] + W_p \frac{B \sum_{i=1}^{n} \Delta P_i Q_T(n + 1 - i)}{B_t - B_{oi}} = \frac{B \sum_{i=1}^{n} \Delta P_i Q_T(n + 1 - i)}{B_t - B_{oi}} + N. \tag{7.4}
\]

Let
\[
N_p[B_t + B_s(R_p - R_o)] + W_p \frac{B \sum_{i=1}^{n} \Delta P_i Q_T(n + 1 - i)}{B_t - B_{oi}} = Y \tag{7.5}
\]

and
\[
\sum_{i=1}^{n} \frac{\Delta P_i Q_T(n + 1 - i)}{B_t - B_{oi}} = X. \tag{7.6}
\]

Then substitution of equations (7.5) and (7.6) in (7.4) yields
\[
Y = BX + N, \tag{7.7}
\]

\[N = \Sigma x^2 \Sigma y - \Sigma \times \Sigma \times y /[n(\Sigma x^2 - (\Sigma x)^2)], \tag{7.8}\]

and
\[
B = \frac{\Sigma y - nN}{\Sigma x}. \tag{7.9}
\]

Equation (7.7) defines a straight line with a slope $B$ and intercept value $N$. $N$ is the original oil in place, and $B$ is the proportionality factor of the Van Everdingen-Hurst equation. The reduction of the material balance equation (7.1) to the form of equation (7.7) is important. This reduction allows one to verify the input data and, specifically, the assumption regarding the aquifer size and selection of the corresponding $Q_T$ function value set.

A reasonably constant computed value of $B$, particularly during the later stages, will indicate that reliable estimates and assumptions have been made. Otherwise, the assumptions should be changed and the computation repeated.

For equation (7.1) to (7.9),