APPENDIX

For flowing conditions, a material balance equation can be obtained by considering the fracture system:

\[ n_p = n_2 + n_d - n_2 \]

A-1

Where \( n_p \) is the gas desorption into fracture system. Substituting the real gas law into above equation:

\[
\frac{G_p P_{SC}}{Z_{SC}RT_{SC}} = \frac{V_{b2}\phi_i (1-S_{wi}) P_i}{Z_i RT} - \frac{V_{b2}\phi (1-S_{wavg}) P}{ZRT} + \frac{G_d P_{SC}}{Z_{SC}RT_{SC}}
\]

A-2

Where \( G_d \) is in SCF. Solving for \( G_p \):

\[
G_p = \frac{V_{b2}\phi_i Z_{SC} T_{SC}}{P_{SC} T} \left[ \frac{(1-S_{wi}) P_i}{Z_i} - \frac{\phi (1-S_{wavg}) P}{\phi_i Z} \right] + G_d
\]

A-3

Substituting the definition of compressibility:

\[
G_p = \frac{V_{b2}\phi_i Z_{SC} T_{SC}}{P_{SC} T} \left[ \frac{(1-S_{wi}) P_i}{Z_i} - \frac{1-C\phi (P_i - P) (1-S_{wavg}) P}{Z} \right] + G_d
\]

A-4
The term $G_d$ can be obtained by assuming pseudo-steady state flow. This is accomplished by using a discretized form of Fick’s first law:

$$\frac{dG_1}{dt} = -Da(G_1 - V_E)$$ \tag{A-5}

Where, ‘a’ is a shape factor. Equation (A-6) is subjected to initial condition:

$$G_{1i} = V_E(P_i); t = 0$$ \tag{A-6}

For a time varying function, $V_E$, this initial value problem has the formal solution:

$$G_1 = G_{1i} - Da \int_0^t (G_{1i} - V_E) e^{-Da(t-t_i)} dt$$ \tag{A-7}

The volume of desorbed gas is then:

$$G_d = V_{b2} \left( G_{1i} - G_1 \right)$$ \tag{A-8a}

Or,

$$G_d = V_{b2} Da \int_0^t (G_{1i} - V_E) e^{-Da(t-t_i)} dt$$

It should be noted that in all formulations, $V_E$ and $G_1$ were considered to be based on the bulk-volume of the total fracture/matrix system.