$$\left(\frac{\partial E}{\partial V}\right)_H = \frac{dE_H}{dV}, \quad \left(\frac{\partial E}{\partial V}\right)_T = \frac{dE_T}{dV} = \beta B_T T - P_T .$$

Substituting the right-hand side of Eq. (38) for the right-hand side of Eq. (46), the differential equation for P_T is expressed as

$$\frac{dP_T}{d\alpha} + k(\beta B_T - P_T) = \frac{C^2}{(V_0 - M\alpha)^3}\left[V_0 + \alpha(M - kV_0)\right] \tag{51}$$

where $\alpha = V_0 - V$. The term $k\beta B_T T$ can be written as

$$k\beta B_T T = k^2 C_V T \tag{52}$$

since

$$k = \Gamma_0 / V_0 = \beta B_T / C_V$$

where C_V is the specific heat at constant volume. This term is constant since k is assumed fixed as defined by Eq. (34), C_V is also taken to be constant, and T is the specified temperature along the isotherm. Eq. (51) can be solved using the integrating factor $\exp(\int k d\alpha)$ to form

$$P_T = A' e^{k\alpha} + kC_V T + e^{k\alpha} \int \frac{C^2\left[V_0 + \alpha(M - kV_0)\right] e^{-k\alpha}}{(V_0 - M\alpha)^3} d\alpha . \tag{53}$$

The term containing the integral is identical with that in the expression for the isentrope, Eq. (39). Aided by this information, the solution becomes

$$P_T = A' e^{k\alpha} + kC_V T + P_H + \frac{C^2}{(V_0 - M\alpha)^2} \sum_{i=3}^{\infty} A_i \alpha^i \tag{54}$$

where A_0, A_1, A_2, and A_i are determined from Eqs. (41) and (42). The constant of integration A' is found from the point at which the isotherm and the Hugoniot curves cross provided T is known. At this point, $P_T = P_H$ and $\alpha = \alpha_H$ so that

$$A' = e^{-k\alpha_H}\left[kC_V T + \frac{C^2}{(V_0 - M\alpha)^2} \sum_{i=3}^{\infty} A_i \alpha_H^i\right] . \tag{55}$$