Direct Application of Volume Shift to Z-Factor

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Given the following:

$$v = v_{EOS} - c\,, \quad s = \frac{c}{b}\,, \quad b = \Omega_B \frac{RT_c}{P_c}\,, \quad \text{and } B = \frac{bP}{RT} = \Omega_B \frac{P_r}{T_r}$$

So:

$$c = s \cdot b = s\,\Omega_B \frac{RT_c}{P_c} \qquad \text{and} \qquad v = v_{EOS} - s\,\Omega_B \frac{RT_c}{P_c}$$

Knowing that:

$$v = \frac{ZRT}{P}$$

$$\frac{ZRT}{P} = \frac{Z_{EOS}RT}{P} - s\,\Omega_B \frac{RT_c}{P_c}$$

Dividing through by $\frac{RT}{P}$ yields:

$$Z = Z_{EOS} - s\,\Omega_B \frac{P}{T} \cdot \frac{T_c}{P_c} = Z_{EOS} - s\,\Omega_B \frac{P_r}{T_r} = Z_{EOS} - sB$$

When applying to a multi-component system this becomes:

$$Z = Z_{EOS} - \sum_{i=1}^{N} x_i s_i B_i$$