

Appendix

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1. compressible BNL equation

$$\frac{v^2}{2} + gz + \int \frac{dp}{\rho(p)} = c$$

$$p_1 v_1^\gamma = p_2 v_2^\gamma$$

$$\frac{p_1}{\rho_1^\gamma} = \frac{p_2}{\rho_2^\gamma} = c_1$$

$$p = c_1 \rho^\gamma$$

$$\begin{aligned} \int \frac{d(c_1 \rho^\gamma)}{\rho} &= c_1 \int \frac{\gamma \rho^{\gamma-1} d\rho}{\rho} \\ &= c_1 \gamma \int \rho^{\gamma-2} d\rho \\ &= c_1 \frac{\gamma}{\gamma-1} \rho^{\gamma-1} \\ &= \frac{\gamma}{\gamma-1} \frac{c_1 \rho^\gamma}{\rho} \\ &= \frac{\gamma}{\gamma-1} \frac{p}{\rho} \end{aligned}$$

\Rightarrow

$$\frac{v^2}{2} + gz + \frac{\gamma}{\gamma-1} \frac{p}{\rho} = \text{constant} \quad (1)$$