Thermal Expansivity

A. Underpinning Purposes

1. Experience in using a *known* substance to calibrate a device, for subsequent application to an *unknown* substance.

2. Acquaintance with two simple devices — the *pycnometer* and the *dilatometer* — capable of giving very precise results for a fundamental physical property of liquid substances.

B. Theory

1. \[ \alpha \equiv \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_P = \left( \frac{\partial \ln V}{\partial T} \right)_P \] and, since \( \rho = m/V \), \[ \alpha = - \left( \frac{\partial \ln \rho}{\partial T} \right)_P \]

2. Integration \( \Rightarrow \) \[ V = V_r \exp[\alpha(T-T_r)] \] where \( \alpha \) is assumed to be independent of \( T \) near some reference \( T = T_r \).

3. More general: If \( f(T,T_r) \) is a function that \( = 0 \) when \( T = T_r \), \( \alpha \) is expressed \( \Rightarrow \) \[ V = V_r \exp[f(T,T_r)] \]
\[ \alpha = df/dT \]
C. Experiment

1. Known is “standard mean ocean water.” Its density is a function of $T$, so calibration requires measuring $m$ and $T$.

2. Both this and the unknown (an alcohol) must be degassed beforehand to prevent air bubble formation.

3. Thermal equilibrium is *not* achieved instantly!

4. Data obtained in range 10-40°C; suffices to determine whether $\alpha$ is $T$-dependent over this range.

5. Etched scales on both devices are in cm and mm.

6. Minor complications:
   Buoyancy correction in pycnometry masses.
   Thermal expansivity of Pyrex not negligible.

7. Modified instructions:
   (1) Do dilatometry for just three $T$ ranges: $\sim 15, 25, 35^\circ\text{C}$
   (2) Get density (pycnometry) for at least 4 $T$s in this range.