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 α 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 $T = T_r$, where $V = V_r$, then if V is expressed $V = V_r \exp[f(T,T_r)]$

$$\alpha = \mathrm{d}f/\mathrm{d}T$$

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 α 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: ~15, 25, 35°C
   (2) Get density (pycnometry) for at least 4 *T*s in this range.