Notes on the function gsw_specvol_anom_standard_t_exact(SA,t,p)

This function, **gsw_specvol_anom_standard_t_exact**(SA,t,p), evaluates the specific volume anomaly, $\hat{\delta} = \hat{v}(S_A,\Theta,p) - \hat{v}(S_{SO},\Theta = 0\,°C,p)$, for given input values of Absolute Salinity S_A, *in situ* temperature t, and pressure p. The Standard Ocean Reference Salinity, S_{SO}, is $35.165\,04\ \mathrm{g\ kg^{-1}}$. This function uses the full TEOS-10 Gibbs function $g(S_A,t,p)$ of IOC *et al*. (2010), being the sum of the IAPWS-09 and IAPWS-08 Gibbs functions.

References

IAPWS, 2008: Release on the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater. The International Association for the Properties of Water and Steam. Berlin, Germany, September 2008, available from www.iapws.org. This Release is referred to in the text as **IAPWS-08**.

IAPWS, 2009: Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use. The International Association for the Properties of Water and Steam. Doorwerth, The Netherlands, September 2009, available from http://www.iapws.org. This Release is referred to in the text as **IAPWS-09**.

IOC, SCOR and IAPSO, 2010: *The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties*. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 196 pp. Available from http://www.TEOS-10.org

Here follows section 3.7 of the TEOS-10 Manual (IOC *et al*., 2010).

3.7 Specific volume anomaly

The specific volume anomaly δ is defined as the difference between the specific volume and a given function of pressure. Traditionally δ has been defined as

$$\delta(S_A,t,p) = v(S_A,t,p) - v(S_{SO},0°C,p) \qquad (3.7.1)$$

(where the traditional value of Practical Salinity of 35 has been updated to an Absolute Salinity of $S_{SO} = 35u_{PS} = 35.16504\ \mathrm{g\,kg^{-1}}$ in the present formulation). Note that the second term, $v(S_{SO},0°C,p)$, is a function only of pressure. In order to have a surface of constant specific volume anomaly more accurately approximate neutral tangent planes (see section 3.11), it is advisable to replace the arguments S_{SO} and $0°C$ with more general values $\hat{\hat{S}}_A$ and $\hat{\hat{t}}$ that are carefully chosen (as say the median values of Absolute Salinity and temperature along the surface) so that the more general definition of specific volume anomaly is

$$\hat{\hat{\delta}}(S_A,t,p) = v(S_A,t,p) - v\left(\hat{\hat{S}}_A,\hat{\hat{t}},p\right) = g_P(S_A,t,p) - g_P\left(\hat{\hat{S}}_A,\hat{\hat{t}},p\right). \qquad (3.7.2)$$

The last terms in Eqns. (3.7.1) and (3.7.2) are simply functions of pressure and one has the freedom to choose any other function of pressure in its place and still retain the dynamical properties of specific volume anomaly. In particular, one can construct specific volume and enthalpy to be functions of Conservative Temperature (rather than *in situ* temperature) as $\hat{v}(S_A, \Theta, p)$ and $\hat{h}(S_A, \Theta, p)$ and write a slightly different definition of specific volume anomaly as

$$\tilde{\tilde{\delta}}(S_A, \Theta, p) = \hat{v}(S_A, \Theta, p) - \hat{v}\left(\tilde{\tilde{S}}_A, \tilde{\tilde{\Theta}}, p\right) = \hat{h}_P(S_A, \Theta, p) - \hat{h}_P\left(\tilde{\tilde{S}}_A, \tilde{\tilde{\Theta}}, p\right). \tag{3.7.3}$$

This is the form of specific volume anomaly adopted in the GSW Oceanographic Toolbox where the default values of the reference values $\tilde{\tilde{S}}_A$ and $\tilde{\tilde{\Theta}}$ are $S_{SO} = 35.165\,04 \text{ g kg}^{-1}$ and $0°\text{C}$ respectively. The same can also be done with potential temperature so that in terms of the specific volume $\tilde{v}(S_A, \theta, p)$ and enthalpy $\tilde{h}(S_A, \theta, p)$ we can write another form of the specific volume anomaly as

$$\tilde{v}(S_A, \theta, p) - \tilde{v}\left(\tilde{\tilde{S}}_A, \tilde{\tilde{\theta}}, p\right) = \tilde{h}_P(S_A, \theta, p) - \tilde{h}_P\left(\tilde{\tilde{S}}_A, \tilde{\tilde{\theta}}, p\right). \tag{3.7.4}$$

These expressions exploit the fact that (see appendix A.11)

$$\partial h/\partial P\big|_{S_A,\eta} = \partial h/\partial P\big|_{S_A,\Theta} = \partial h/\partial P\big|_{S_A,\theta} = v\,. \tag{3.7.5}$$