

determined from the equilibrium  $h'$  and  $h''$  values calculated for the given pressure) at pressures from the triple-point pressure, see Eq. (1.8), up to 10 MPa. The consistency of Eq. (2.9) with the basic equation  $g_2(p, T)$ , Eq. (2.6), along the saturated-vapour line is characterized by the following maximum inconsistencies in the properties  $v$ ,  $h$ ,  $c_p$ ,  $s$ ,  $g$ , and  $w$ :

$$\begin{aligned} |\Delta v|_{\max} &= 0.014\% & |\Delta s|_{\max} &= 0.082 \text{ J kg}^{-1} \text{ K}^{-1} \\ |\Delta h|_{\max} &= 0.043 \text{ kJ kg}^{-1} & |\Delta g|_{\max} &= 0.023 \text{ kJ kg}^{-1} \\ |\Delta c_p|_{\max} &= 0.78\% & |\Delta w|_{\max} &= 0.051\% \end{aligned}$$

These maximum inconsistencies are clearly smaller than the consistency requirements along the region boundaries corresponding to the so-called Prague values [18]. Along the 10 MPa isobar in the metastable-vapour region, the transition between Eq. (2.9) and Eq. (2.6) is not smooth, but for practical calculations the inconsistency is sufficiently small.

*Computer-Program Verification.* To assist the user in computer-program verification of Eq. (2.9), Table 2.14 contains test values of the most relevant properties.

**Table 2.13** The residual part  $\gamma^r$  of the dimensionless Gibbs free energy, Eq. (2.10), and its derivatives

$$\begin{aligned} \gamma^r &= \sum_{i=1}^{13} n_i \pi^{I_i} (\tau - 0.5)^{J_i} & \gamma_{\tau}^r &= \sum_{i=1}^{13} n_i \pi^{I_i} J_i (\tau - 0.5)^{J_i - 1} \\ \gamma_{\pi}^r &= \sum_{i=1}^{13} n_i I_i \pi^{I_i - 1} (\tau - 0.5)^{J_i} & \gamma_{\tau\tau}^r &= \sum_{i=1}^{13} n_i \pi^{I_i} J_i (J_i - 1) (\tau - 0.5)^{J_i - 2} \\ \gamma_{\pi\pi}^r &= \sum_{i=1}^{13} n_i I_i (I_i - 1) \pi^{I_i - 2} (\tau - 0.5)^{J_i} & \gamma_{\pi\tau}^r &= \sum_{i=1}^{13} n_i I_i \pi^{I_i - 1} J_i (\tau - 0.5)^{J_i - 1} \end{aligned}$$


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$$\gamma_{\pi}^r = \left( \frac{\partial \gamma^r}{\partial \pi} \right)_{\tau}, \quad \gamma_{\pi\pi}^r = \left( \frac{\partial^2 \gamma^r}{\partial \pi^2} \right)_{\tau}, \quad \gamma_{\tau}^r = \left( \frac{\partial \gamma^r}{\partial \tau} \right)_{\pi}, \quad \gamma_{\tau\tau}^r = \left( \frac{\partial^2 \gamma^r}{\partial \tau^2} \right)_{\pi}, \quad \gamma_{\pi\tau}^r = \left( \frac{\partial^2 \gamma^r}{\partial \pi \partial \tau} \right)$$

**Table 2.14** Thermodynamic property values calculated from the  $g_{2,\text{meta}}(p, T)$  equation, Eq. (2.9), for selected values of temperature and pressure <sup>a</sup>

Property	$T = 450 \text{ K}$ $p = 1 \text{ MPa}$	$T = 440 \text{ K}$ $p = 1 \text{ MPa}$	$T = 450 \text{ K}$ $p = 1.5 \text{ MPa}$
$v [\text{m}^3 \text{ kg}^{-1}]$	0.192 516 540	0.186 212 297	0.121 685 206
$h [\text{kJ kg}^{-1}]$	$0.276 881 115 \times 10^4$	$0.274 015 123 \times 10^4$	$0.272 134 539 \times 10^4$
$u [\text{kJ kg}^{-1}]$	$0.257 629 461 \times 10^4$	$0.255 393 894 \times 10^4$	$0.253 881 758 \times 10^4$
$s [\text{kJ kg}^{-1} \text{ K}^{-1}]$	$0.656 660 377 \times 10^1$	$0.650 218 759 \times 10^1$	$0.629 170 440 \times 10^1$
$c_p [\text{kJ kg}^{-1} \text{ K}^{-1}]$	$0.276 349 265 \times 10^1$	$0.298 166 443 \times 10^1$	$0.362 795 578 \times 10^1$
$c_v [\text{kJ kg}^{-1} \text{ K}^{-1}]$	$0.195 830 730 \times 10^1$	$0.208 622 142 \times 10^1$	$0.241 213 708 \times 10^1$
$w [\text{m s}^{-1}]$	$0.498 408 101 \times 10^3$	$0.489 363 295 \times 10^3$	$0.481 941 819 \times 10^3$
$\alpha_v [\text{K}^{-1}]$	$0.318 819 824 \times 10^{-2}$	$0.348 506 136 \times 10^{-2}$	$0.418 276 571 \times 10^{-2}$
$\kappa_T [\text{MPa}^{-1}]$	$0.109 364 239 \times 10^1$	$0.111 133 230 \times 10^1$	0.787 967 952

<sup>a</sup> Programmed functions should be verified using 8 byte real values for all variables.