

Extended Equation for Region 5 of the Industrial Formulation IAPWS-IF97

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The IAPWS Industrial Formulation 1997 [1, 2], called IAPWS-IF97 for short, consists of a set of equations for different regions which cover the following range of validity:

$$273.15 \text{ K} \leq T \leq 1073.15 \text{ K} \quad p \leq 100 \text{ MPa}$$

$$1073.15 \text{ K} < T \leq 2273.15 \text{ K} \quad p \leq 50 \text{ MPa}$$

Figure 1 shows the five regions into which the entire range of validity of IAPWS-IF97 is divided. Both regions 1 and 2 are individually covered by a fundamental equation for the specific Gibbs free energy $g(p, T)$, region 3 by a fundamental equation for the specific Helmholtz free energy $f(\rho, T)$, where ρ is the density, and the saturation curve by a saturation-pressure equation $p_s(T)$. The high-temperature region 5 is also covered by a $g(p, T)$ equation. These five equations, shown in rectangular boxes in Fig. 1, form the so-called *basic equations*.

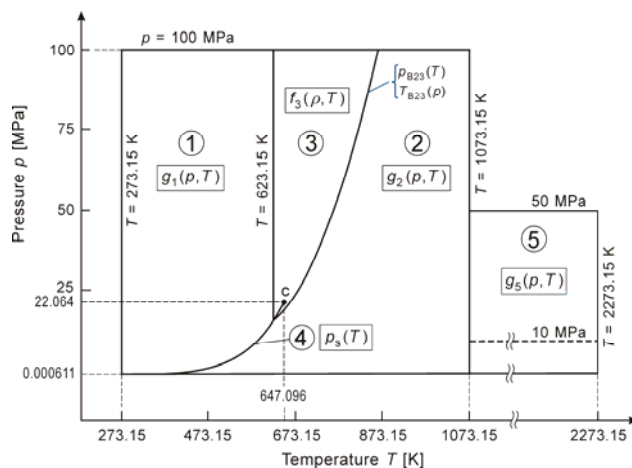


Fig. 1 Regions and equations of IAPWS-IF97. The dashed line in region 5 corresponds to the upper pressure limit of the previous equation $g_5(p, T)$.

The high-temperature region 5 (1073.15 K to 2273.15 K, see Fig. 1) was covered by a basic equation $g_5(p, T)$ that was valid for pressures up to 10 MPa [3] until 2007. However, in order to enable users to calculate values of thermodynamic properties for designing future high-temperature power cycles and other processes for pressures above 10 MPa, a new basic equation $g_5(p, T)$ was developed that covers the high-temperature region 5 for pressures up to 50 MPa. This equation was adopted at the IAPWS Meeting in Lucerne in 2007.

The presentation will give details about the development of the extended high-temperature equation of

IAPWS-IF97. In addition, it shows the accuracy of the equation and its consistency with the basic equation $g_2(p, T)$ of region 2 at the boundary between regions 2 and 5.

Further details about IAPWS-IF97 including the extended high-temperature basic equation of region 5 can be found in [1, 2]. Details about the development of IAPWS-IF97 are given in [3].

- [1] IAPWS (2009), *Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*, available at the IAPWS website <http://www.iapws.org>.
- [2] Wagner, W., Kretzschmar, H.-J. *International Steam Tables – Properties of Water and Steam Based on the Industrial Formulation IAPWS-IF97*. Springer-Verlag, Berlin, 2008.
- [3] Wagner, W., Cooper, J. R., Dittmann, A., Kijima, J., Kretzschmar, H.-J., Kruse, A., Mareš, R., Oguchi, K., Sato, H., Stöcker, I., Šifner, O., Takaishi, Y., Tanishita, I., Trübenbach, J., Willkommen, Th. (2000), The IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, *J. Eng. Gas Turbines Power* **122**, 150182.

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