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Supplementary Backward Equations $v(p, T)$ for the Critical and Supercritical Regions (Region 3) of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam[1]

When steam power cycles are modeled, thermodynamic properties as functions of pressure and temperature are required in the critical and supercritical regions (region 3 of IAPWS-IF97). With IAPWS-IF97, such calculations require cumbersome iterative calculations, because temperature and volume are the independent variables in the formulation for this region. In order to reduce the computing time, the International Association for the Properties of Water and Steam (IAPWS) adopted a set of backward equations for volume as a function of pressure and temperature in region 3. The necessary numerical consistency is achieved by dividing the region into 20 subregions, plus auxiliary subregions near the critical point in which the consistency requirements are relaxed due to the singular behavior at the critical point. In this work, we provide complete documentation of these equations, along with a discussion of their numerical consistency and the savings in computer time. The numerical consistency of these equations should be sufficient for most applications in heat-cycle, boiler, and steam-turbine calculations; if even higher consistency is required, the equations may be used to generate guesses for iterative procedures. [DOI: 10.1115/1.3028630]

1 Introduction

The International Association for the Properties of Water and Steam (IAPWS) adopted the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97) [1–3] as the standard for calculation of thermodynamic properties of water and steam in the power industry in 1997 and extended it in 2007. It contains basic equations, saturation equations, and equations for the commonly used "backward" functions $T(p,h)$ and $T(p,s)$ valid in the liquid region 1 and the vapor region 2; see Fig. 1.

In 2001, IAPWS-IF97 was supplemented by "Backward Equations for Pressure as a Function of Enthalpy and Entropy $p(h,s)$ to the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam" [4,5], referred to here as IAPWS-IF97-S01. These equations are valid in regions 1 and 2.

An additional supplementary release "Backward Equations for

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