W. Wagner[1]

J. R. Cooper[2]

A. Dittmann[3]

J. Kijima[4]

H.-J. Kretzschmar[5]

A. Kruse[6]

R. Mareš[7]

K. Oguchi[4]

H. Sato[8]

I. Stöcker[5]

O. Šifner[9]

Y. Takaishi[4]

I. Tanishita[4]

J. Trübenbach[3]

Th. Willkommen[3]

The IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam

In 1997, the International Association for the Properties of Water and Steam (IAPWS) adopted a new formulation for the thermodynamic properties of water and steam for industrial use. This new formulation, called IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97), replaces the previous industrial formulation, IFC-67, that had formed the basis for power-plant calculations and other applications in energy engineering since the late 1960's. IAPWS-IF97 improves significantly both the accuracy and the speed of the calculation of the thermodynamic properties compared with IFC-67. The differences between IAPWS-IF97 and IFC-67 will require many users, particularly boiler and turbine manufacturers, to modify design and application codes. This paper summarizes the need and the requirements for such a new industrial formulation and gives the entire numerical information about the individual equations of IAPWS-IF97. Moreover, the scientific basis for the development of the equations is summarized and the achieved quality of IAPWS-IF97 is presented regarding the three criterions accuracy, consistency along region boundaries, and computation speed. For comparison, corresponding results for the previous standard IFC-67 are also presented.

1 Introduction

In the 1960s an industrial formulation for the thermodynamic properties of water and steam was developed. This was called "The 1967 IFC Formulation for Industrial Use" (IFC-67) [1]. IFC-67 was formally recognized for the calculation of thermodynamic properties of water and steam for official use such as performance guarantee calculations of power cycles. In addition to this, IFC-67 was used for innumerable other industrial applications. However, compared with today's requirements IFC-67 contains a number of weaknesses. Moreover, because of the progress that has been achieved in mathematical methods to develop accurate equations of state, a number of reasons warranted the development of a new industrial formulation.

This newly developed formulation was adopted by the International Association for the Properties of Water and Steam (IAPWS) at its meeting in Erlangen (Germany), September 1997, under the name "IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam" abbreviated to "IAPWS Industrial Formulation 1997" or even shorter IAPWS-IF97 [2]. Since this date IAPWS-IF97 has been officially valid. However, due to the need to modify design and application codes, IAPWS has recommended an introductory period, lasting until January 1, 1999, during which IAPWS-IF97 should not be used for contractual commitments.

This article contains details relevant to the development of IAPWS-IF97, the full numerical information on the individual equations needed for their use, details of their accuracy, consistency along region boundaries, and results of computing-time investigations in comparison with IFC-67.

[1] Ruhr-Universität Bochum, Lehrstuhl für Thermodynamik, D-44780 Bochum, Germany, corresponding author

[2] Queen Mary and Westfield College, Department of Engineering, London, United Kingdom

[3] Technische Universität Dresden, Institut für Thermodynamik und Technische Gebäudeausrüstung, Dresden, Germany

[4] Kanagawa Institute of Technology, Faculty of Engineering, Atsugi, Japan

[5] Hochschule Zittau/Görlitz (FH), Fachgebiet Technische Thermodynamik, Zittau, Germany

[6] Ruhr-Universität Bochum, Lehrstuhl für Thermodynamik, Bochum, Germany
Current address: Bayern Innovativ GmbH, Nürnberg, Germany

[7] University of West Bohemia, Department of Thermodynamics, Plzen, Czech Republic

[8] Keio University, Faculty of Science & Technology, Yokohama, Japan

[9] Academy of Sciences of Czech Republic, Institute of Thermomechanics, Prague, Czech Republic

