INTRODUCTION

The International Conference on the Properties of Water and Steam held in Orlando, Florida, September 11-16, 1994 was the twelfth in a series dating back to 1929 when the first conference was held in London. This latest conference was attended by 160 scientists and engineers from 17 countries who had a choice of 138 papers covering 11 major topics. As might be expected, many changes have occurred in the conferences since 1929.

A solid understanding of the thermodynamic basis for the operation of steam turbines to produce electricity had been achieved by the first decade of the twentieth century. Manufacturers of steam turbines used this understanding to calculate the capacity and efficiency of their turbines and purchasers of turbines used it to write specifications and to test new equipment to see that the specifications were met. There was one problem. These calculations depended on the thermodynamic properties of water and steam and there were several competing and conflicting sets of tables for these properties. The first conference was called with the objective of preparing an internationally accepted set of tables for these properties which would serve as a world-wide industrial standard and eliminate the problem of multiple competing data sets.

The first six conferences focused on the thermodynamic properties of water and steam exclusively. There were several reasons: agreement was hard to obtain, primarily because the measurements on which the data were based were limited in their coverage and, on occasion, contradictory. New measurements had to be specified and carried out. Advances in the technology of construction materials allowed boiler and turbine manufacturers to produce equipment operating at higher temperatures so as to obtain a higher thermodynamic efficiency until World War II stopped all activities for several years.

The earliest results were skeleton tables, uniform grids of data points over the field defined by the independent variables. The data at the grid points were obtained by interpolation and extrapolation of nearby measured data points, the tolerance at the grid points was estimated from the number, measurement uncertainty and consistency of the measured points used. The skeleton tables increased in the properties covered and range of coverage until 1964 when a definitive set of international skeleton tables was established. In the meantime other developments were occurring. It had been recognized from the start that equations would be more flexible to use for many purposes and it was understood that an equation that fitted all, or part, of a skeleton table within the established tolerances would be recognized as an acceptable international equation over the range of fit.

The computer was also developing rapidly toward the end of the period covered by the first six conferences and this development enhanced the capabilities of scientists and engineers to devise equations to fit data sets many fold. The use of computerized formulations to provide input data for the solution of technical and scientific problems was also developing concurrently. For steam these developments led to the publication of the *IFC 1967 Formulation for Industrial Use* by the International Formulating Committee, a group established by the International Conferences. Here formulation is a generalized term for a mathematical representation of experimental data by one or more equations or other methods. This formulation covered the range of the skeleton tables and fitted them within their tolerances. Software was developed to make it possible to use this formulation for industrial performance calculations in an efficient fashion and it is so used to this day. A year later the *IFC 1968 Formulation for Scientific and General Use* was published. During this period an independent wide-ranging formulation was also published by Keenan, Keyes, Hill and Moore.

In addition, properties other than thermodynamic properties were beginning to appear on the agenda. Early steps were being taken toward the establishment of internationally accepted

skeleton tables and formulations for the viscosity and thermal conductivity of water and steam in the 1960s.

Finally, the organization was developing. It had become evident that the activities were too continuing and complex to be handled on a purely *ad hoc* basis. An organization called the International Association for the Properties of Steam (now the **International Association for the Properties of Water and Steam**) was established at the 7th International Conference in Tokyo. This organization was to be responsible for the development, publication and maintenance of the international formulations and for the planning, organization and administration of the international conferences. Each participating country would be represented and experts from around the world would be invited to participate in the development of new international formulations.

The 1970s saw two major developments. The formulations for the core thermodynamic properties were joined by formulations for other properties, such as the transport properties, the surface tension, the dielectric constant and the dissociation constant.

Substances other than pure water and steam made their first appearance when a session on aqueous solutions was held at the 8th International Conference at Giens. Both scientific and practical interest in aqueous solutions developed rapidly and will expand in the foreseeable future. The behavior of aqueous solutions is complex, particularly for electrolyte solutions and for all solutions in the region of the critical points of water and of the solution. Dissolved substances play an important role in the rates of corrosion and erosion of materials of construction. The rates of dissolution, transport and deposition of dissolved and suspended affect turbine and steam generator efficiency and reliability. Understanding the distribution and ultimate fates of water chemistry control additives and of impurities is critical to reliable operation of power plants and other industrial facilities. It is perhaps unexpected that, although the input water is highly purified, the dynamic nature of the power cycle permits the build up of appreciable local concentrations with resulting chemical changes. The chemistry of the power cycle is surprisingly complex.

The data needs and the data base available for aqueous solutions are markedly different from those for water and steam. Much of the following activities was devoted to determining the most effective and efficient way to approach the subject of aqueous solutions.

The *IAPS Formulation 1984 for Scientific and General Use* was published to replace the formulation published 1968. This formulation was developed without recourse to skeleton tables. Computer capabilities had developed to the point that formulations could be developed from and compared directly to individual sets of experimental data. Nevertheless the *IAPS Skeleton Tables 1986 for the Thermodynamic Properties of Ordinary Water Substance* were also published to replace the 1964 tables.

A major project in the current decade will lead to the replacement of both formulations of thermodynamic properties, the *1967 Formulation for Industrial Use* and the *1984 Formulation for Scientific and General Use*. It is noteworthy that the major improvement sought in the industrial formulation is a substantial (3-fold) increase in the speed with which values for data points can be obtained. This may seem paradoxical since the speed of computers has increased enormously over the last thirty years and the 1967 formulation is unchanged. However, the engineering calculations have become much more detailed and accurate and, as a result, much more demanding in their needs for data values. The result is that data point lookup is still the pacing activity in industrial calculations. The need to replace the 1984 Formulation for Scientific and General Use arises partly from the need for a formulation in such areas of current interest as metastable supercooled water, supercritical steam and high-pressure water, regions for which the 1984 formulation was not designed and in which it shows

deficiencies, and also from the need for better values of properties, such as the dielectric constant of water, especially at high and low temperatures. These properties may depend on the first or second derivative of the Helmholtz energy which is the fundamental property of the formulation. Again the current formulation may show deficiencies as it approaches its limits of designed applicability. These collateral properties will play a central role in the development of high-quality formulations for aqueous solutions, particularly for solutions containing electrolytes.

The 12th Conference continued a trend of covering an increasingly wide range of topics associated with water, steam and high-temperature aqueous systems. In addition to the traditional subjects such as the thermophysical properties of water and steam for scientific and for scientific and for industrial use, the Proceedings include papers on such topics as metastable states and nucleation, supercooled, superheated and stretched water, molecular modeling of aqueous systems, frontiers of physical chemistry of aqueous solutions and a large number of papers on high-temperatures aqueous systems including measurement techniques, hydrothermal oxidation, chemical processes in steam cycles and plant cycle chemistry.

A list of the conferences, their locations and dates is given on the following page.

The work of the International Association for the Properties of Water and Steam is disseminated in a number of ways. One line of products obviously consists of the Proceedings of the International Conferences of which the present volume is an example. There are three other series, namely Releases, Guidelines and IAPWS Certified Research Needs. The first two are well established, the third is just getting started. The Releases are the longest-standing series. They present critically evaluated internationally accepted formulations for properties in the form of equations with accompanying tables for casual use and to enable a user to verify a program for reproducing the data electronically. The measurements underlying the formulation in a release are of such quantity and quality that the values presented by the formulation are expected to be reliable for some time. The Guidelines are the same type of product, however, the nature of the underlying data base is such that the formulation may be subject to substantial revision as additional measurements are published. A complete collection of the current Releases and Guidelines is given in an appendix in this volume. The IAPWS Certified Research Needs are ephemeral short-term documents designed to draw attention to important gaps in the existing data base. Copies of the latest versions of all IAPWS documents can be obtained from the Executive Secretary of IAPWS whose address is also given in the appendix.

The Editors