

Brief History of the ASME Properties of Steam Subcommittee

In the early 1900s, the steam power industry was experiencing rapid growth, and was extending its range of operation to higher pressures and temperatures. A significant obstacle to progress was the lack of accurate and standardized values for the thermodynamic properties of water and steam. Different sets of “steam tables” varied in their properties, particularly at higher pressures, making it difficult for different parties in the industry to compare bids and equipment performance.

The first step toward resolving this problem was taken in 1921, when the ASME brought together a group of scientists and engineers to address the problem at a meeting in Cambridge, Massachusetts. The key organizers of this first meeting were Prof. Harvey Davis of Harvard University (who later served as President of the Stevens Institute of Technology and also served a term as President of ASME) and Mr. George Orrok, an engineer with New York Edison who was very active in ASME.

This first meeting resulted in an official ASME research project, with experimental work carried out at Harvard (led by Prof. Davis), MIT (led by Prof. Frederick Keyes), and the National Bureau of Standards (led by Nathan S. Osborne). A Committee was formed (chaired first by Orrok and later by Dr. Alex Dow of Detroit Edison), to raise money from industrial and utility concerns to pay for the research and to oversee the projects. The total amount raised was around \$100,000, and the research institutions all contributed significant amounts of their own funding to the work, which continued through the mid-1930s.

Because of the increasingly international nature of the electric power industry, parallel efforts were undertaken in other countries (notably England, Germany, and Czechoslovakia). International cooperation was solidified in a series of international “steam-table” conferences. The first conference was held in London in 1929, the second in Berlin in 1930, and the third in the U.S. (Washington, Cambridge, and New York) in 1934. These conferences resulted in the adoption of a standard set of “skeleton tables” giving thermodynamic properties on a grid of temperatures and pressures. The data on which these tables were based also became the basis for a 1936 “Steam Tables” book by J.H. Keenan (of MIT, previously at General Electric and then the Stevens Institute) and F.G. Keyes; their tables were the *de facto* standard for water and steam properties in the power industry for the next 30 years. There was also an “ASME” steam tables book produced by Keenan in 1930, but almost everybody used Keenan and Keyes instead. The ASME Steam Properties Committee became dormant in the mid or late 1930s, as the existing tables were seen as sufficient to meet the needs of industry at the time.

In the early 1950s, it became clear that the steam tables needed to be extended to higher pressures and temperatures in order to serve the new power plants being designed. In addition, new data had become available that offered the opportunity to improve the accuracy of the tables. In 1953, the ASME reconstituted the Research Committee on Properties of Steam, with the mandate to help fill in gaps in the needed data and to work toward a new set of steam tables. This effort again involved international collaboration, and international steam-table conferences were held in Philadelphia in 1954, London in 1956, and New York in 1963. These meetings were supplemented by working meetings devoted to the development of new standards for water and steam properties.

In 1967, a new formulation (commonly known as IFC-67) was adopted as an international standard for power-industry calculations; the international effort in this regard was officially organized in 1968 and for many years was called the International Association for the Properties of Steam (in 1989 it became the International Association for the Properties of Water and Steam, IAPWS, see www.iapws.org). As the IFC-67 formulation was being finalized, the ASME Committee worked in parallel to produce a new set of steam tables; for the first time this involved using computers to generate the printed tables. The first edition of the *ASME Steam Tables* was published in 1967, prepared by Charles Meyer (Westinghouse),

Ralph McClintock (General Electric), George Silvestri (Westinghouse), and Robert Spencer (GE). This book (which went through six printings) included tables and charts of both thermodynamic and transport properties, and was widely used throughout the world for over 30 years.

The ASME Committee continued to work on improved property representations, and also represented the United States in IAPWS. Committee members Lester Haar and John Gallagher (both of the National Bureau of Standards, which became the National Institute of Standards and Technology [NIST] in 1988) played a key role in developing a new thermodynamic standard for general and scientific use that was officially adopted in 1984. As IAPWS expanded its scope to include high-temperature aqueous physical chemistry (including power-cycle chemistry), the Committee grew to include members with those interests.

In the early 1990s, IAPWS began to develop new standards, taking advantage of new data and of advances in the technology for developing thermodynamic property formulations. A new formulation for general and scientific use (commonly known as IAPWS-95) was adopted in 1995 to replace the previous formulation from 1984. In 1997, a new standard for industrial use (known as IAPWS-IF97) was adopted to replace the IFC-67 formulation in the steam power industry. While a German group led the development of these formulations, the ASME Committee made many contributions in the process, particularly in the area of specifications and testing.

Software for general and scientific use, implementing IAPWS-95, was developed as a NIST Standard Reference Database in an effort led by Allan Harvey (NIST). Software for industrial use implementing IAPWS-IF97 was developed in an effort led by William Parry (General Electric); this software was published in 1998 (and updated in 2003) and is distributed by the ASME. Finally, a new steam-tables book, based on IAPWS-IF97, was produced to replace the venerable *ASME Steam Tables* that dated back to 1967. *ASME International Steam Tables for Industrial Use*, produced by William Parry (GE), James Bellows (Siemens Westinghouse, now Siemens Energy), John Gallagher (NIST, retired) and Allan Harvey (NIST), was published in 2000. A second edition of the book came out in 2009, reflecting new IAPWS standards for the viscosity of water and steam and for high-temperature properties. A new *Compact Steam Tables* booklet, intended for quick lookup of properties by students and engineers, was issued in 2006.

In 1989, as a result of a reorganization of ASME's Research committees, the Committee on Properties of Steam became the Properties of Steam Subcommittee of the ASME Research and Technology Committee on Water and Steam in Thermal Systems. This has enabled closer collaboration with water-treatment chemists working in steam generation systems in both industrial and utility settings.

Since it was reconstituted in the 1950s, Chairs of the Committee (and later the Subcommittee) have included J.W. Parker (Detroit Edison), D.W.G. Morgan (Drexel Institute), Walker Cisler (Detroit Edison), John Tillinghast (American Electric Power), Charles Meyer (Westinghouse), Robert Spencer (General Electric), Fred Pocock (Babcock and Wilcox), James Bellows (Siemens Westinghouse), William Parry (GE), Allan Harvey (NIST), and Richard Harwood (Siemens Energy). Secretaries have included John Tillinghast (American Electric Power), Joseph Keenan (MIT), Ernest Garbinski (Detroit Edison), Howard White (NBS), John Gallagher (NIST), Allan Harvey (NIST), Carolyn Davis (ASME), and James Bellows (Siemens Westinghouse). There was also an associated "Technical Committee" from the mid-50s through mid-60s; this was chaired by P.H. Knowlton (GE). Another key position is that of U.S. National Delegate to IAPWS; this has been filled by Joseph Kestin (Brown University), Anneke Levelt Sengers (NBS/NIST), Dan Friend (NIST), and Allan Harvey (NIST).

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