

FINAL REPORT

ASHRAE RP-1767

Transport Properties of Real Moist Air, Dry Air, Steam, and Water

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Abstract

This research set up an ASHRAE transport properties model of moist air as a "real-gas mixture" using a modification of the mixing model of Vesovic and Wakeham. It uses the latest research from IAPWS, IUPAC, and NIST. The new model has a broadened range of validity with pressure from 0.01 kPa to 10 MPa, temperature from –70 to 300°C, and humidity ratio from 0 to 10 kg_w/kg_a.

The model will be used to produce transport property tables for moist air and for H₂O at saturation states for the Psychrometrics Chapter in the 2021 ASHRAE Handbook Fundamentals for the first time. The new moist air table and the H₂O saturation table contain values for viscosity, kinematic viscosity, thermal conductivity, and Prandtl number. In addition, the diagrams of the Psychrometrics Chapter which show values for viscosity and thermal conductivity have been revised. Furthermore, tables showing the underlying data for plotting the figures were prepared.

The results of psychrometric research serves (1) ASHRAE and the air-conditioning industry, (2) the World Meteorological Organization and others involved in atmospheric research and meteorology, (3) the Association of Agricultural Engineers who rely on psychrometrics in their modeling and tracking of soil moisture and evaporation and plant transpiration, and (4) the engineering community that deals with (a) air conditioning from deep mines to space capsules, (b) deep vacuum processes, (c) high pressure processes, and (d) the gas and light oil turbine processes that power our airplanes and gas turbine-powered generators.

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Executive Summary

This research establishes an ASHRAE model for transport properties of moist air as a real-gas mixture of dry air and steam using a modification of the mixing model reported by Vesovic and Wakeham. This model described herein uses the latest data from the National Institute of Standards and Technology (NIST) for the evaluation of the properties of the real gas dry air and the latest data of the International Association for the Properties of Water and Steam (IAPWS) for the real gas water vapor. The transport properties of moist air are calculated from the modified Vesovic-Wakeham model which consists in the calculation of the:

- Viscosity and thermal conductivity of dry air from the NIST equations of Lemmon and Jacobsen
- "Release on the IAPWS Formulation 2008 for the Viscosity of Ordinary Water Substance" (IAPWS-2008)
- "Release on the IAPWS Formulation 2011 for the Thermal Conductivity of Ordinary Water Substance" (IAPWS-2011)
- "Revised Release on Surface Tension of Ordinary Water Substance" (IAPWS-2014)

The Thermodynamic properties of dry air, steam, and water, saturation and sublimation pressure of water, and the vapor-pressure enhancement factor are described in the ASHRAE RP-1485 report.