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Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice (RP-1485)

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This paper is based on findings resulting from ASHRAE Research Project RP-1485.

This research updates the modeling of moist air as a real gas mixture using the virial equation of state. It includes the Hyland and Wexler model (1983a, 1983b) and considers the Nelson-Sauer model (2002). All new National Institute of Standards and Technology reference equations and the latest International Association for the Properties of Water and Steam (IAPWS) standards, as well as the current values for the molar masses and gas constants, have been incorporated. The deviations of the proposed model to the Hyland-Wexler and Nelson-Sauer models are very low at ambient pressures but increase with increasing pressures and temperatures. The range of validity of the new model is in pressure from 0.01 kPa up to 10 MPa, in temperature from –143.15°C up to 350°C, and in humidity ratio from 0 kg_w/kg_a up to 10 kg_w/kg_a. This model was used to produce moist air and H_2O saturation property tables for the psychrometric chapter in the 2009 ASHRAE Handbook—Fundamentals *(ASHRAE 2009). The paper summarizes ASHRAE Research Project 1485 (RP-1485).*

INTRODUCTION

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) has long been a leader in the field of psychrometric research, publications, and data. The current psychrometric tables in the *2005 ASHRAE Handbook—Fundamentals* (ASHRAE 2005) are now 25 years old and are based on the Hyland-Wexler RP-216 (1983a, 1983b) and the Stewart et al. RP-257 (1983) research projects.

Research completed in recent years has resulted in new data and the new formulations listed below. The net effect is changes in the properties of moist air and in the saturation properties of H_2O. These changes are small for air-conditioning system psychrometrics, but they are more significant at higher pressures and temperatures (e.g., the pressures and temperatures encountered in the compression stage of gas turbines and in compressed-air energy storage applications). New developments include:

- the fundamental equation of Lemmon et al. (2000) for the calculation of the dry air properties,

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