

## **IAPWS Certified Research Need - ICRN**

### **Thermodynamic Properties of Metastable Steam**

The IAPWS Working Groups "Thermophysical Properties of Water and Steam" and "Industrial Requirements and Solutions" have examined the published work and common industrial practice in the area of the thermodynamic properties of supercooled vapor which is of interest to the electric power industry.

IAPWS recognizes that there is a requirement for work to be pursued in this field and has prepared this document to assist potential investigators to obtain sponsorship. The knowledge of the thermophysical properties of metastable steam is necessary for accurate system design of power plants (e.g. low-pressure (LP) steam turbines).

Although encouraging this work, IAPWS is not able under its statutes to provide financial support. The IAPWS contact can provide any further development information and will liaise between research groups.

**Issued by the**

**International Association for the Properties of  
Water and Steam**

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## Background

Calculation of three-dimensional viscous flows in steam turbines is sufficiently time consuming that full treatment of the transition from dry to wet steam poses a formidable challenge. The characteristically homogeneous nucleation process requires a very small step size for adequate step-by-step representation. The transition process cannot be adequately simulated without accounting for the sensible energy and the enthalpy of evaporation of the growing droplets, each of which has its own temperature. The task is difficult enough for assumed one-dimensional condensing flows when the steam vapor is approximated by ideal gas thermodynamics. Allowance for real gas effects and the full details of the nucleation and droplet growth processes in condensing three-dimensional viscous flow calculations is so time consuming that it is not currently a practical part of turbine stage design or analysis.

The availability of property data for super cooled metastable states would advance the design process.

## Previous Work

In the early 90s, the "IAPWS Task Group on Metastable-State Water" (Chairman: H. Sato) performed an extensive investigation on the status and problems in this region /1/.

In contrast to supercooled and superheated water, apparently no experimental data for supercooled steam were recorded.

## The Range of Thermodynamic Properties Required

For this ICRN, the region of practical interest is defined to include the entire range of single-phase states that is required for LP steam turbine design ( 3 kPa to about 500 kPa).

Measurements should be for density and speed of sound or any other thermodynamic property in the stable single-phase region ( for which data already exist ) and **extend into the metastable region.**



**Bibliography**

/ 1 / Sato, H. ; Watanabe, K.; Levelt Sengers J.M.H.; Gallagher J.S.; Hill, P.G.; Straub J.; Wagner W.: *"Sixteen Thousand Evaluated Experimental Thermodynamic Property Data for Water and Steam."* J. Phys. Chem. Ref. Data, Vol. 20, No. 5, 1991, pp. 1023-1044.

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