

Water and Steam

Thermophysical Properties for MATLAB[®]

KHACE

A suite of MATLAB Toolbox style functions for calculating Thermodynamic Properties according to the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, with Transport Properties calculated using the recent IAPWS equations.ⁱ

This function suite will be invaluable to Mechanical Engineers, Chemical Engineers, Process Control Engineers and others carrying out engineering design calculations in the MATLAB environment for processes and equipment using water or steam, or where water vapour is present, such as wet air compression and HVAC.ⁱⁱ Functions may also be incorporated into Simulink simulations to support dynamic simulation of process plant with rigorous properties for water and steam.

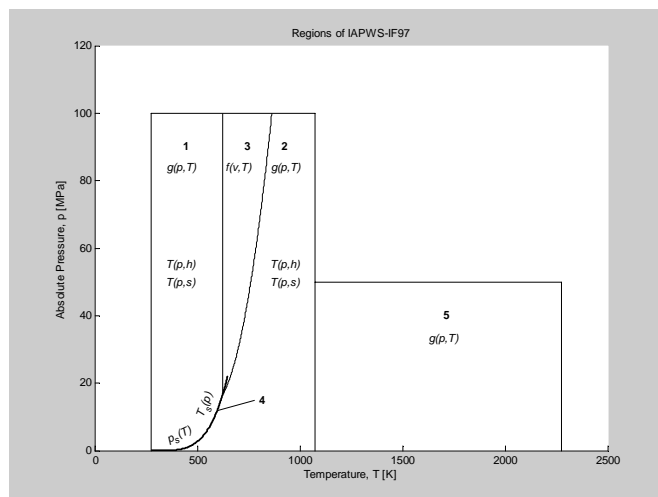
Typical applications would include design calculations, analysis, modelling and dynamic simulation for:

- Steam-generating and power plant
- Steam supply and distribution systems
- Coolers, condensers
- Steam turbines
- Air handling and air compression plant
- Heating, Ventilating and Air Conditioning (HVAC)

OVERVIEW

The IAPWS-IF97 standard is a formulation of the thermodynamic properties of water and steam for industrial use. It replaces the previous formulation, IFC-67, that had formed the basis for power-plant calculations and other industrial applications since the 1960s. The IF97 standard, together with recent IAPWS equations for Transport Properties (viscosity, refractive index, etc.) have been published in book form. (See Documentation, below.)

Water and Steam, Thermophysical properties for MATLAB provides a suite of more than 50 functions that have been programmed for the MATLAB user from the published equations. Additional functions



build on the IAPWS equations to provide extended practical functionality.

SYSTEM REQUIREMENTS

Water and Steam, Thermophysical properties for MATLAB is available as standard for MATLAB under Windows. Single user or network licensing is available.

Please enquire for availability on other platforms.

KEY FEATURES

Water and Steam, Thermophysical properties for MATLAB includes functions that return into the MATLAB environment the many numerical coefficients and parameters that are used in the underlying IAPWS equations; e.g. for the Gibbs and Helmholtz free energy equations. These coefficients and parameters may be used both to verify the numerical basis of the functions and to facilitate the user's own programming or re-programming of functions or extensions. For example:

if97t331 Returns the coefficients and exponents from Table 3.11 of Wagner and Kruse. (See Documentation, below.)

IAPWS-IF97 divides the pressure/temperature map into five regions (see illustration, above). Separate thermodynamic functions are provided

for each of the regions; e.g., Region 1 functions include:

wsr1pt2cp	Specific heat at constant pressure, $c_p = f(p, T)$
wsr1pt2cv	Specific heat at constant volume, $c_v = f(p, T)$
wsr1pt2h	Specific enthalpy, $h = f(p, T)$
wsr1pt2s	Specific entropy, $u = f(p, T)$
wsr1pt2u	Specific internal energy, $u = f(p, T)$
wsr1pt2v	Specific volume, $v = f(p, T)$
wsr1pt2w	Speed of sound, $w = f(p, T)$

Functions for IAPWS-IF97 backwards equations are included, for example for Region 2:

wsr2ph2t	Temperature, $T = f(p, h)$
wsr2ps2t	Temperature, $T = f(p, s)$

Functions for IAPWS-IF97 Supplementary Release September 2001 are also included, for example for Region 2:

wsr2hs2p	Pressure, $p = f(h, s)$
----------	-------------------------

For a reminder of the definitions of the various IAPWS-IF97 regions, and the ranges of validity of the functions, additional functions give command-line and pictorial help, e.g.:

wsr1def	Help text describing Region 1
wsr3tst	Tests for (p, T) within Region 3
wspt2r	Finds the Region, $R = f(p, T)$
wsregions	Plots a figure showing the regions (see figure, above)

DOCUMENTATION

The *Water and Steam, Thermophysical properties for MATLAB User's Guide* includes a tutorial section and a complete reference for all the top-level thermodynamic and transport property functions, with examples of how to use each function.

The essential reference, and companion text for *Water and Steam, Thermophysical properties for MATLAB* is:

Wagner, W., A. Kruse, 'Properties of Water and Steam. The Industrial Standard IAPWS-IF97 for the Thermodynamic Properties and Supplementary Equations for Other Properties,' Springer, Berlin, 1998. ISBN 3-540-64339-7

– which may be ordered on-line at:

<http://www.khace.com/support/books/wagner&kruse.htm>

EXTENSIBILITY AND OPENNESS

Most of the top-level functions in *Water and Steam, Thermophysical properties for MATLAB* are implemented in programmable M-files – routines written in the MATLAB language – that give you access to the source code.

Only low-level functions are implemented in P-files, i.e. pre-compiled M-files. However, the P-files all have on-line help text describing their functionality and function call syntax.

This dual M-file/P-file approach provides a reasonable compromise between traditional MATLAB openness and extensibility, and the need to protect the intellectual property rights of the authors.

UPGRADE OPTIONS

Licensees of *Water and Steam, Thermophysical properties for MATLAB* may upgrade at any time to SimSteam at a discount.ⁱⁱⁱ

ⁱ IAPWS: International Association for the Properties of Water and Steam.

ⁱⁱ HVAC: Heating, Ventilating and Air-conditioning.

ⁱⁱⁱ SimSteam includes a complete version of *Water and Steam, Thermophysical properties for MATLAB*. See <http://www.khace.com/products/simsteam/index.htm>.

