Package 'IAPWS95'

September 8, 2016

Title Thermophysical Properties of Water and Steam

Version 1.0.0

Description Functions for Water and Steam Properties based on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use and on the releases for viscosity, conductivity, surface tension and melting pressure.

Depends R (>= 3.2.1)

License MIT + file LICENSE

LazyData true

LinkingTo Rcpp

Imports Rcpp, pander, ggplot2

RoxygenNote 5.0.1

Suggests knitr, rmarkdown, testthat

VignetteBuilder knitr

NeedsCompilation yes

Author Benedito Baptista [aut, cre]

Maintainer Benedito Baptista <bene46@msn.com>

Repository CRAN

Date/Publication 2016-09-08 02:13:58

R topics documented:

BT *Second Virial Coefficient (B), Function of Temperature*

Description

The function `BT(T)` returns the second virial coefficient, B [m3 kg-1], for a given T [K]

Usage

```
BT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The second virial coefficient: B [m3 kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
BT(T)
```

CndTD *Thermal Conductivity, Function of Temperature and Density*

Description

The function `CndTD(T,D)` calculates the Thermal Conductivity, k [W m-1 K-1] for given T [K] and D [kg/m3], returning the calculated thermal conductivity and an error message, if an error occur. errorCodes

Usage

```
CndTD(T, D)
```

Arguments

`T`	- Temperature [K]
`D`	- Density [kg m-3]

Details

This function calls a Fortran DLL that solves the equations developed by the International Association for the Properties of Water and Steam, valid from the triple point to the pressure of 1000 MPa and temperature of 1173.15K. http://www.iapws.org/relguide/ThCond.html

Value

The calculated Thermal Conductivity: k [W m-1 K-1] and an Error message (if an error occur)

Examples

```
T <- 500.
D <- 838.025
CndTD(T,D)

T <- 0.
D <- 200.
CndTD(T,D)
```

CpfT *Specific Isobaric Heat Capacity of Fluid Phase, Function of Temperature*

Description

The function `CpfT(T)` returns the Isobaric Heat Capacity of Fluid Phase [kJ kg-1 K-1], Cpf, for given T [K]

Usage

```
CpfT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Isobaric Heat Capacity of Fluid Phase: Cpf [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
CpfT(T)
```

CpgT *Specific Isobaric Heat Capacity of Gas Phase, Function of Temperature*

Description

The function `CpgT(T)` returns the Isobaric Heat Capacity of Gas Phase [kJ kg-1 K-1], Cpg, for given T [K]

Usage

```
CpgT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Isobaric Heat Capacity of Gas Phase: Cpg [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
CpgT(T)
```

CpTD *Specific Isobaric Heat Capacity, Function of Temperature and Density*

Description

The function CpTD(T,D) returns the Specific Isobaric Heat Capacity, Cp [kJ kg-1 K-1], for given T [K] and D [kg/m3].

Usage

```
CpTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Isobaric Heat Capacity: Cp [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
CpTD(T,D)
```

CpTp *Specific Isobaric Heat Capacity, Function of Temperature and Pressure*

Description

The function `CpTp(T,p)` returns the Specific Isobaric Heat Capacity, Cp [kJ kg-1 K-1], for given T [K] and D [kg/m3].

Usage

```
CpTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Isobaric Heat Capacity: Cp [kJ kg-1 K-1] and an (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
CpTp(T,p)
```

CT *Third Virial Coefficient (C), Function of Temperature*

Description

The function `CT(T)` returns the third virial coefficient, C [m3 kg-1]**2, for a given T [K]

Usage

```
CT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The second virial coefficient: C [m3 kg-1]**2 and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
CT(T)
```

CvfT *Specific Isochoric Heat Capacity of Fluid Phase, Function of Temperature*

Description

The function `CvfT(T)` returns the Isochoric Heat Capacity of Fluid Phase [kJ kg-1 K-1], Cvf, for given T [K]

Usage

```
CvfT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Isochoric Heat Capacity of Fluid Phase: Cvf [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
CvfT(T)
```

CvgT *Specific Isochoric Heat Capacity of Gas Phase, Function of Temperature*

Description

The function `CvgT(T)` returns the Isochoric Heat Capacity of Gas Phase [kJ kg-1 K-1], Cvg, for given T [K]

Usage

```
CvgT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Isochoric Heat Capacity of GaS Phase: Cvg [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
CvgT(T)
```

CvTD *Specific Isochoric Heat Capacity, Function of Temperature and Density*

Description

The function CvTD(T,D) returns the Specific Isochoric Heat Capacity, Cv [kJ kg-1 K-1], for given T [K] and D [kg/m3].

Usage

```
CvTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Isochoric Heat Capacity: Cv [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
CvTD(T,D)
```

`CvTp` *Specific Isochoric Heat Capacity, Function of Temperature and Pressure*

Description

The function `CvTp(T,p)` returns the Specific Isochoric Heat Capacity, Cv [kJ kg-1 K-1], for given T [K] and D [kg/m3].

Usage

```
CvTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Isochoric Heat Capacity: Cv [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
CvTp(T,p)
```

`DCrit` *Water Critical Density*

Description

The function `DCrit()` returns the water density at the critical point [kg m-3]

Usage

```
DCrit()
```

Value

The Water Critical Density: Dc [kg m-3]

Examples

```
DCrit()
```

`dDdTTD` *Density Derivative with respect to Temperature, Function of Temperature and Density*

Description

The function `dDdTTD(T,D)` returns the pressure derivative with respect to Density, dpdD, for given T [K] and D [kg m-3]

Usage

```
dDdTTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density Derivative with respect to T: dD/dT [kg m-3 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
dDdTTD(T,D)
```

---

dDdTTp — *Density Derivative with respect to Temperature, Function of Temperature and Pressure*

Description

The function `dDdTTp(T,p)` returns the Density derivative with respect to Temperature, dDdT, for given T [K] and p [MPa]

Usage

```
dDdTTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density derivative with respect to T: dD/dT [kg m-3 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
dDdTTp(T,p)
```

`Dfp` *Saturated Liquid Density, Funtion of Pressure*

Description

The function `Dfp(p)` returns the saturated liquid density [kg m-3], Df, for given p [MPa]

Usage

```
Dfp(p)
```

Arguments

`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated liquid density: Df [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 0.932203564
Dfp(p)
```

Dfs *Saturated Liquid Density, Function of Entropy*

Description

The function `Dfs(s)` returns the saturated liquid density [kg m-3], Df, for given s [kJ kg-1 K-1]

Usage

```
Dfs(s)
```

Arguments

`s`	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated Liquid density: Df [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
s <- 2.10865845
Dfs(s)
```

DfT *Saturated Liquid Density, Function of Temperature*

Description

The function `DfT(T)` returns the saturated liquid density [kg m-3], Df, for given T [K]

Usage

```
DfT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated liquid density: Df [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
DfT(T)
```

`DfTr` *Liquid Water Density at Triple Point*

Description

The function `DfTr()` returns the Water Liquid Density at Triple Point

Usage

```
DfTr()
```

Value

Triple Point Liquid Density: DfTr [kg m-3]

Examples

```
DfTr()
```

Dgp *Saturated Gas Density, Funtion of Pressure*

Description

The function `Dgp(p)` returns the saturated gas density [kg m-3], Dg, for given p [MPa]

Usage

```
Dgp(p)
```

Arguments

p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated gas density: Dg [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 0.932203564
Dgp(p)
```

Dgs *Saturated Gas Density, Function of Entropy*

Description

The function `Dgs(s)` returns the saturated gas density [kg m-3], Dg, for given s [kJ kg-1 K-1]

Usage

```
Dgs(s)
```

Arguments

s	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated Gas density: Dg [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
s <- 6.60921221
Dgs(s)

s <- 2.10865845
Dgs(s)
```

DgT *Saturated Gas Density, Function of Temperature*

Description

The function `DgT(T)` returns the saturated gas density [kg m-3], Dg, for given T [K]

Usage

```
DgT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated gas density: Dg [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
DgT(T)
```

DgTr *Water Gas Density at Triple Point*

Description

The function `DgTr()` returns the Water Gas Density at Triple Point

Usage

```
DgTr()
```

Value

Triple Gas Density: DgTr [kg m-3]

Examples

```
DgTr()
```

Dhs *Density, Function of Enthalpy and Entropy*

Description

The function `Dhs(h,s)` returns the water density, D [kg m-3], for given h [kJ k-1] and s [kJ k-1 K-1].

Usage

```
Dhs(h, s)
```

Arguments

h	Enthalpy [kJ kg-1]
s	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density: D [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
h <- 977.181624
s <- 2.56690919
Dhs(h,s)
```

---

dpdDTD *Pressure Derivative with respect to Density, Function of Temperature and Density*

Description

The function dpdDTD(T,D) returns the pressure derivative with respect to Density, dpdD, for given T [K] and D [kg m-3]

Usage

```
dpdDTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The pressure derivative with respect to D: dp/dD [MPa kg-1 m3] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
dpdDTD(T,D)
```

---

dpdDTp *Pressure Derivative with respect to Density, Function of Temperature and Pressure*

Description

The function dpdDTp(T,p) returns the pressure derivative with respect to Density, dpdD, for given T [K] and p [MPa]

Usage

```
dpdDTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The pressure derivative with respect to d: dp/dD [MPa kg-1 m3] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
dpdDTp(T,p)
```

dpdTTD *Pressure Derivative with Respect to Temperature, Function of Temperature and Density*

Description

The function dpdTTD(T,D) returns the pressure derivative with respect to Temperature, dpdT, for given T [K] and D [kg/m3]

Usage

```
dpdTTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The pressure derivative with respect to T: dp/dT [MPa K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
dpdTTD(T,D)
```

dpdTTp — *Pressure Derivative with respect to Temperature, Function of Temperature and Pressure*

Description

The function `dpdTTp(T,p)` returns the pressure derivative with respect to Temperature, dpdT, for given T [K] and p [MPa]

Usage

```
dpdTTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The pressure derivative with respect to T: dp/dT [MPa K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
dpdTTp(T,p)
```

Dph — *Density, Function of Pressure and Enthalpy*

Description

The function `Dph(p,h)` returns the water density, D [kg m-3], for given p [MPa] and h [kJ k-1].

Usage

```
Dph(p, h)
```

Arguments

p	Pressure [MPa]
h	Enthalpy [kJ kg-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density: D [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 10.0003858
h <- 977.181624
Dph(p,h)
```

Dps — *Density, Function of Pressure and Entropy*

Description

The function `Dps(p,s)` returns the water density, D [kg m-3], for given p [MPa] and s [kJ k-1 K-1].

Usage

```
Dps(p, s)
```

Arguments

p	Pressure [MPa]
s	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density: D [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 10.0003858
s <- 2.56690919
Dps(p,s)
```

DpTcteTab *Table of Densities, Function of Pressure for a Fixed Temperature*

Description

The function `DpTcteTab(p1, p2, dp, T)` returns a table of Densities [kg m-3] for a fixed T [K] within a range of p [MPa]: p1:p2 [MPa]

Usage

```
DpTcteTab(p1, p2, dp, T)
```

Arguments

p1	initial Pressure [MPa]
p2	final Pressure [MPa]
dp	Pressure increment [MPa]
T	Temperature [K]

Details

This function provides a table of the densities [kg m-3] for a given T [K] within a range of p [MPa]

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of Densities for fixed T and a p Interval: p1:p2.

Examples

```
p1 <- 1.0
p2 <- 10.
dp <- 1.
T <- 500.
DpTcteTab(p1, p2, dp, T)

p1 <- 10.
p2 <- 100.
dp <- 10.
T <- 450.
TabD <- DpTcteTab(p1, p2, dp, T)
```

DTh *Density, Function of Temperature and Enthalpy*

Description

The function `DTh(T,h)` returns the water density, D [kg m-3], for given T [K] and h [kJ kg-1] (it may have two solutions for Density).

Usage

```
DTh(T, h)
```

Arguments

T	Temperature in Kelvin
h	Enthaly in [kJ kg-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density 1: Density_1 [kg m-3]

The Density 2: Density_2 [kg m-3]

Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
h <- 977.181624
DTh(T,h)
```

DTp *Density, Function of Temperature and Pressure*

Description

The function `DTp(T,p)` returns the water density, D [kg m-3], for given T [K] and D [kg/m3].

Usage

```
DTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density: D [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
DTp(T,p)
```

DTpcteTab *Table of Densities, Function of Temperature for Fixed Pressure*

Description

The function DTpcteTab(T1, T2, dT, p) returns a table of densities [kg m-3] for a fixed p [MPa] within a range of T [K]: T1:T2 [K]

Usage

```
DTpcteTab(T1, T2, dT, p)
```

Arguments

T1	initial Temperature [K]
T2	final Temperature [K]
dT	Temperature increment [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of Densities for fixed p and a T Interval: T1:T2.

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
p <- 5.
DTpcteTab(T1, T2, dT, p)

T1 <- 300.
T2 <- 500.
```

```
dT <- 10.
p <- 10.
TabD <- DTpcteTab(T1, T2, dT, p)
```

DTs *Density, Function of Temperature and Entropy*

Description

The function `DTs(T,s)` returns the water density, D [kg m-3], for given T [K] and s [kJ k-1 K-1].

Usage

```
DTs(T, s)
```

Arguments

`T`	Temperature [K]
`s`	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Density: D [kg m-3] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
s <- 2.56690919
DTs(T,s)
```

errorCodes *Error Codes*

Description

Error codes due values out of validity range, incorrect inputs, and/or convergence issues

Usage

```
errorCodes
```

Format

An object of class `data.frame` with 21 rows and 2 columns.

Source

errorCodes.rda

fTD *Helmholtz Free Energy, Function of Temperature and Density*

Description

The function `fTD(T,D)` returns the Helmholtz Free Energy, f [kJ kg-1], for given T [K] and D [kg/m3].

Usage

```
fTD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Helmholtz Free Energy: f [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
fTD(T,D)
```

`fTp` *Helmholtz Free Energy, Function of Temperature and Pressure*

Description

The function `fTp(T,p)` returns the Helmholtz Free Energy, f [kJ kg-1], for given T [K] and D [kg/m3].

Usage

```
fTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Helmholtz Free Energy: f [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
fTp(T,p)
```

FugaTp *Fugacity, Function of Temperature and Pressure*

Description

The function FugaTp(T,p) returns the Fugacity, [MPa], for given T [K] and D [kg/m3].

Usage

```
FugaTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Fugacityy: Fuga [MPa] and an (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
FugaTp(T,p)
```

GibbsTp *Specific Gibbs Energy, Function of Temperature and Pressure*

Description

The function GibbsTp(T,p) returns the Specific Gibbs Energy, [MPa], for given T [K] and D [kg/m3].

Usage

```
GibbsTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Gibbs Energy: Gibbs [MPa] and an (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
GibbsTp(T,p)
```

---

hCrit *Water Critical Enthalpy*

Description

@description The function `hCrit()` returns the water enthalpy at the critical point [kJ kg-1]

Usage

```
hCrit()
```

Value

The Water Critical Enthalpy: hc [kJ kg-1]

Examples

```
hCrit()
```

hfT *Saturated Liquid Enthalpy, Function of Temperature*

Description

The function `hfT(T)` returns the saturated liquid enthalpy [kJ kg-1], hf, for given T [K]

Usage

```
hfT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated liquid enthalpy: hf [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
hfT(T)
```

hgT *Saturated Gas Enthalpy, Function of Temperature*

Description

The function `hgT(T)` returns the saturated gas enthalpy [kJ kg-1], hg, for given T [K]

Usage

```
hgT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated gas enthalpy: hg [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
hgT(T)
```

`hps` *Enthalpy, Function of Pressure and Entropy*

Description

The function `hps(p,s)` returns the water enthalpy, h [kJ kg-1], for given p [MPa] and s [kJ k-1 K-1].

Usage

```
hps(p, s)
```

Arguments

`p`	Pressure [MPa]
`s`	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Enthalpy: h [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 10.0003858
s <- 2.56690919
hps(p,s)
```

---

hpTcteTab *Table of Enthalpies, Function of Pressure for Fixed Temperature*

Description

The function hpTcteTab(p1, p2, dp, T) returns a table of Enthalpies [kJ kg-1] for a fixed T [K] within a range of p [MPa]: p1:p2 [MPa]

Usage

```
hpTcteTab(p1, p2, dp, T)
```

Arguments

p1	initial Pressure [MPa]
p2	final Pressure [MPa]
dp	Pressure increment [MPa]
T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of Enthalpies for fixed T and a p Interval: p1:p2.

Examples

```
p1 <- 1.0
p2 <- 10.
dp <- 1.
T <- 500.
hpTcteTab(p1, p2, dp, T)

p1 <- 10.
p2 <- 100.
```

```
dp <- 10.
T <- 450.
Tabh <- hpTcteTab(p1, p2, dp, T)
```

---

hTD *Specific Enthalpy, Function of Temperature and Density*

Description

The function `hTD(T,D)` returns the Specific Enthalpy, h [kJ kg-1], for given T [K] and D [kg/m3].

Usage

```
hTD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Enthalpy: h [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
hTD(T,D)
```

hTp *Specific Enthalpy, Function of Temperature and Pressure*

Description

The function `hTp(T,p)` returns the Specific Enthalpy, h [kJ kg-1], for given T [K] and D [kg/m3].

Usage

```
hTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Enthalpy: h [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
hTp(T,p)
```

hTpcteTab *Table of Enthalpies, Function of Temperature and Fixed Pressure*

Description

The function `hTpcteTab(T1, T2, dT, p)` returns a table of enthalpies [kJ kg-1] for a fixed p [MPa] within a range of T [K]: T1:T2 [K]

Usage

```
hTpcteTab(T1, T2, dT, p)
```

Arguments

T1	initial Temperature [K]
T2	final Temperature [K]
dT	Temperature increment [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of Enthalpies for fixed p and a T Interval: T1:T2.

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
p <- 5.
hTpcteTab(T1, T2, dT, p)

T1 <- 300.
T2 <- 500.
dT <- 10.
p <- 10.
Tabh <- hTpcteTab(T1, T2, dT, p)
```

JTcTD *Joule-Thomson Coefficient, Function of Temperature and Density*

Description

The function JTcTD(T,D) returns the Joule-Thomson coefficient for given T [K] and D [kg/m3].

Usage

```
JTcTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273. The temperature change produced during a Joule-Thomson expansion is quantified by the Joule-Thomson coefficient, which may be positive (cooling) or negative (heating).

Value

The Joule-Thomson coefficient and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
JTcTD(T,D)
```

KapaTD *Isothermal Compressibility, Function of Temperature and Density*

Description

The function `KapaTD(T,D)` returns the Isothermal Compressibility, Kapa, for given T [K] and D [kg m-3]

Usage

```
KapaTD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Isothermal Compressibility: Kapa [MPa-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
KapaTD(T,D)
```

`KViscTD` *Kinematic Viscosity, Function of Temperature and Density*

Description

The function `KViscTD(T,D)` calculates the Kinematic Viscosity [m2 s-1] for given T [K] and D [kg/m3], returning the calculated viscosity and an error message, if an error occur. errorCodes

Usage

```
KViscTD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calculates the Kinematic Viscosity that is the relation `ViscTD(D,T)/D`, valid from the triple point to the pressure of 1000 MPa and temperature of 1173.15K.

Value

The Kinematic viscosity: [m2 s-1] and an Error Message (if an error occur)

Examples

```
T <- 500.
D <- 838.025
KViscTD(T,D)

T <- 500.
D <- 0.
KViscTD(T,D)
```

pCrit *Water Critical Pressure*

Description

This function `pCrit()` returns the water critical pressure [MPa]

Usage

```
pCrit()
```

Value

The Water Critical Pressure: pc [MPa]

Examples

```
pCrit()
```

phi0 *Ideal-Gas part of the Dimensionless Helmholtz Energy Equation, Function of Temperature and Density*

Description

The function `phi0(T,D)` returns the Ideal-gas part of the dimensionless Helmholtz Energy Equation, phi0, for given T [K] and D [kg/m3]

Usage

```
phi0(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Ideal-gas part of the Helmholtz Energy Equation: phi0 and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phi0(T,D)
```

`phi0D` *First Derivative of the Ideal-Gas part of the Dimensionless Helmholtz Energy Equation with respect to Density, Function of Density*

Description

The function `phi0D(D)` returns the First Derivative of the Ideal-gas part of the dimensionless Helmholtz Energy Equation for a given D [kg/m3]

Usage

```
phi0D(D)
```

Arguments

`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The First D Derivative of Ideal-gas part of the Helmholtz Energy: phi0D and an Error Message (if an error occur: errorCodes)

Examples

```
D <- 838.025
phi0D(D)
```

phi0DD — *Second Derivative of the Ideal-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density, Function of Density*

Description

The function `phi0DD(D)` returns the Second Derivative of the Ideal-gas part of the dimensionless Helmholtz Energy Equation for a given D [kg/m3]

Usage

```
phi0DD(D)
```

Arguments

`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Second D Derivative of Ideal-gas part of the Helmholtz Energy: phi0DD and an Error Message (if an error occur: errorCodes)

Examples

```
D <- 838.025
phi0DD(D)
```

phi0DT — *Second Derivative of the Ideal-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density and Temperature*

Description

The function `phi0DT()` returns the Second Derivative of the Ideal-gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density and Temperature

Usage

```
phi0DT()
```

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Second DT Derivative of Ideal-gas Part of the Helmholtz Energy: phi0DT and an Error Message (if an error occur: errorCodes)

Examples

```
phi0DT()
```

---

phi0T — *First Derivative of the Ideal-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, Function of Temperature and Density*

Description

The function `phi0T(T,D)` returns the First Derivative of the Ideal-gas Part of the dimensionless Helmholtz Energy Equation with respect to Temperature, for given T [K] and D [kg/m3]

Usage

```
phi0T(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The First T Derivative of Ideal-gas part of the Helmholtz Energy: phi0T and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phi0T(T,D)
```

`phi0TT` *Second Derivative of the Ideal-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, Function of Temperature and Density*

Description

The function `phi0TT(T,D)` returns the Second Derivative of the Ideal-gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, for given T [K] and D [kg/m3]

Usage

```
phi0TT(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Second T Derivative of Ideal-gas part of the Helmholtz Energy: phi0TT and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phi0TT(T,D)
```

phir *Residual-Gas Part of the Dimensionless Helmholtz Energy Equation, Function of Temperature and Density*

Description

The function `phir(T,D)` returns the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation for given T [K] and D [kg/m3]

Usage

```
phir(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Residual-Gas Part of the Dimensionless Helmholtz Energy Equation: phir and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phir(T,D)
```

phirD — *First Derivative of the Residual-Gas part of the Dimensionless Helmholtz Energy Equation with respect to Density, Function of Temperature and Density*

Description

The function `phirD(T,D)` returns the First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation for given T [K] and D [kg/m3]

Usage

```
phirD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation: phirD, and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phirD(T,D)
```

phirDD — *Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density, Function of Temperature and Density*

Description

The function `phirDD(T,D)` returns the Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation for given T [K] and D [kg/m3]

Usage

```
phirDD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation: phirDD, and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phirDD(T,D)
```

phirDT — *Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density and Temperature, Function of Temperature and Density*

Description

The function `phirDT(T,D)` returns the Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to D and T, for given T [K] and D [kg/m3]

Usage

```
phirDT(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to D and T: phirTT, and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phirDT(T,D)
```

phirT — *First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, Function of Temperature and Density*

Description

The function `phirT(T,D)` returns the First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to T, for given T [K] and D [kg/m3]

Usage

```
phirT(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to T: phirT, and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phirT(T,D)
```

phirTT — *Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, Function of Temperature and Density*

Description

The function `phirTT(T,D)` returns the Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to T, for given T [K] and D [kg/m3]

Usage

```
phirTT(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to T: phirTT, and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
phirTT(T,D)
```

pMeltT *Melting Pressure, Function of Temperature*

Description

The function pMeltT(T) returns the water melting pressur, pMelt [MPa], for a given T [K]

Usage

```
pMeltT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the equations given at the Revised Release on the Pressure along the Melting and Sublimation Curves of Ordinary Water Substance (September 2011), developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/MeltSub.html. It is valid from the Temperature of 256.164 [K] to the Temperature of 715 [K].

Value

The melting pressure: pMelt [MPa] for regions III, V , VI and VII

The melting pressure: pMeltIh [MPa] for region Ih

The sublimation pressure: pSubl [MPa], below triple point Temperature

Error message (if an error occur)

Examples

```
T <- 275.
pMeltT(T)
```

PrandtTD — *Prandt Number, Function of Temperature and Density*

Description

The function `PrandtTD(T,D)` computes the Prandt Number, i.e., the product of the dynamic viscosity by the specific isobaric heat capacity, divided by the thermal conductivity of water for given T [K] and D [kg/m3].

Usage

```
PrandtTD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that computes the Prandt Number, valid from the triple point to the pressure of 1000 MPa and temperature of 1173.15K.

Value

The Prandt Number: Pr [-]

Error message (if an error occur)

Examples

```
T <- 500.
D <- 838.025
PrandtTD(T,D)
```

pSatD — *Saturation Pressure, Function of Density*

Description

The function `pSatD(D)` returns the saturation pressure [MPa], pSat, for given D [kg m-3]: it may have two different values!

Usage

```
pSatD(D)
```

Arguments

D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The first saturation pressure: pSat_1 [MPa]

The second saturation pressure: pSat_2 [MPa]

An Error Message (if an error occur: errorCodes)

Examples

```
D <- 890.341250
pSatD(D)

D <- 999.887406
pSatD(D)
```

---

pSats *Saturation Pressure, Function of Entropy*

Description

The function pSats(s) returns the saturation pressure [MPa], pSat, for given s [kJ kg-1 K-1]

Usage

```
pSats(s)
```

Arguments

s	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturation pressure: pSat [MPa] and an Error Message (if an error occur: errorCodes)

Examples

```
s <- 2.10865845
pSats(s)
```

`pSatT` *Saturation Pressure, Function of Temperature*

Description

The function `pSatT(T)` returns the saturation pressure [MPa], pSat, for given T [K]

Usage

```
pSatT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturation pressure: pSat [MPa] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
pSatT(T)
```

pTD *Pressure, Function of Temperature and Density*

Description

The function pTD(T,D) returns the water pressure, p [MPa], for given T [K] and D [kg/m3], returning also an error message, if any error occur. errorCodes

Usage

```
pTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Pressure: p [MPa] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
pTD(T,D)

T <- 647.096
D <- 322.
pTD(T,D)
```

pTr *Water Pressure at Triple Point*

Description

The function `pTr()` returns the Water Pressure at Triple Point [MPa]

Usage

```
pTr()
```

Value

The Triple Point Pressure: pTr [MPa]

Examples

```
pTr()
```

Rwater *Water Specific Gas Constant*

Description

The function `Rwater()` returns the Water Specific Gas Constant

Usage

```
Rwater()
```

Value

Water Specific Gas Constant: R [K-1]

Examples

```
Rwater()
```

satTabhT *Table of Saturation Liquid Phase Enthalpies, Function of Temperature*

Description

The function satTabhT(T1, T2, dT) returns a table of saturation liquid enthalpies [kJ kg-1 K-1] for a Temperature interval, T1:T2 [K]

Usage

```
satTabhT(T1, T2, dT)
```

Arguments

T1	Initial Temperature [K]
T2	Final Temperature [K]
dT	Temperature increment [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of saturation fluid enthalpies, function of T

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
satTabhT(T1, T2, dT)

T1 <- 300.
T2 <- 500.
dT <- 10.
TabT <- satTabhT(T1, T2, dT)
```

satTabp *Table of Saturation Densities, Enthalpies and Entropies, Function of Pressure*

Description

The function satTabp(p1, p2, dp) returns a table of threee saturation properties for two phases: Density [kg/m3], Enthalpy [kJ kg-1] and Entropy [kJ kg K-1] for a Pressure interval, p1:p2 [MPa]

Usage

```
satTabp(p1, p2, dp)
```

Arguments

p1	Initial Pressure [MPa]
p2	Final Pressure [MPa]
dp	Pressure increment [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of saturation D, h and s, function of p

Examples

```
p1 <- 1.0
p2 <- 10.
dp <- 0.5
satTabp(p1, p2, dp)

p1 <- 0.1
p2 <- 10.
dp <- 0.5
Tabp <- satTabp(p1, p2, dp)
```

satTabpT *Table of Saturation Pressures, Function of Temperature*

Description

The function satTabpT(T1, T2, dT) returns a table of saturation pressures [MPa] for a Temperature interval, T1:T2 [K]

Usage

```
satTabpT(T1, T2, dT)
```

Arguments

T1	Initial Temperature [K]
T2	Final Temperature [K]
dT	Temperature increment [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of saturation pressures, function of T

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
satTabpT(T1, T2, dT)

T1 <- 300.
T2 <- 500.
dT <- 10.
TabT <- satTabpT(T1, T2, dT)
```

satTabT *Table of Saturation Densities, Enthalpies and Entropies, Function of Temperature*

Description

The function satTabT(T1, T2, dT) returns a table of threee saturation properties for two phases: Density [kg/m3], Enthalpy [kJ kg-1] and Entropy [kJ kg K-1] for a Temperature interval, T1:T2 [K]

Usage

```
satTabT(T1, T2, dT)
```

Arguments

T1	Initial Temperature [K]
T2	Final Temperature [K]
dT	Temperature increment [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of saturation D, h and s, function of T

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
satTabT(T1, T2, dT)

T1 <- 300.
T2 <- 500.
dT <- 10.
TabT <- satTabT(T1, T2, dT)
```

satTabTp *Table of Saturation Temperatures, Function of Pressure*

Description

The function satTabTp(p1, p2, dp) returns a table of Saturation Temperatures [K] for a Pressure interval, p1:p2 [MPa]

Usage

```
satTabTp(p1, p2, dp)
```

Arguments

p1	Initial Pressure [MPa]
p2	Final Pressure [MPa]
dp	Pressure increment [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A Table of Saturation Temperatures, function of p

Examples

```
p1 <- 1.0
p2 <- 10.
dp <- 0.5
satTabTp(p1, p2, dp)

p1 <- 0.1
p2 <- 10.
dp <- 0.5
Tabp <- satTabTp(p1, p2, dp)
```

satTabvp *Table of Saturation Volumes, Enthalpies and Entropies, Function of Pressure*

Description

The function satTabvp(p1, p2, dp) returns a table of threee saturation properties for two phases: Specific Volume [m3 kg-1], Enthalpy [kJ kg-1] and Entropy [kJ kg K-1] for a Pressure interval, p1:p2 [MPa]

Usage

```
satTabvp(p1, p2, dp)
```

Arguments

p1	Initial Pressure [MPa]
p2	Final Pressure [MPa]
dp	Pressure increment [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of saturation v, h and s, function of p

Examples

```
p1 <- 1.0
p2 <- 10.
dp <- 0.5
satTabvp(p1, p2, dp)

p1 <- 0.1
p2 <- 10.
dp <- 0.5
Tabp <- satTabvp(p1, p2, dp)
```

satTabvT *Table of Saturation Volumes, Enthalpies and Entropies, Function of of Temperature*

Description

The function satTabvT(T1, T2, dT) returns a table of threee saturation properties for two phases: Specific Volume [m3 kg-1], Enthalpy [kJ kg-1] and Entropy [kJ kg K-1] for a Temperature interval, T1:T2 [K]

Usage

```
satTabvT(T1, T2, dT)
```

Arguments

T1	Initial Temperature [K]
T2	Final Temperature [K]
dT	Temperature increment [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of saturation v, h and s, function of T

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
satTabvT(T1, T2, dT)

T1 <- 300.
T2 <- 500.
dT <- 10.
TabT <- satTabvT(T1, T2, dT)
```

sCrit *Water Critical Entropy*

Description

The function `sCrit()` returns the entropy at the critical point [kJ k-1 K-1]

Usage

```
sCrit()
```

Value

The Water Critical Entropy: sc [kJ kg-1 K-1]

Examples

```
sCrit()
```

sfT *Saturated Liquid Entropy, Function of Temperature*

Description

The function `sfT(T)` returns the saturated liquid entropy [kJ kg-1 K-1], sf, for given T [K]

Usage

```
sfT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated liquid entropy: sf [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
sfT(T)
```

---

sfTr *Liquid Water Entropy at Triple Point*

Description

The function `sfTr()` returns the Water Liquid Entropy at Triple Point

Usage

```
sfTr()
```

Value

Triple Point Liquid Entropy: sfTr [kJ kg-1 K-1]

Examples

```
sfTr()
```

---

sgT *Saturated Gas Entropy, Function of Temperature*

Description

The function `sgT(T)` returns the saturated gas entropy [kJ kg-1 K-1], sg, for given T [K]

Usage

```
sgT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated gas entropy: sg [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
sgT(T)
```

---

sgTr *Water Gas Entropy at Triple Point*

Description

The function `sgTr()` returns the Water Gas Entropy at Triple Point

Usage

```
sgTr()
```

Value

Triple Point Gas Entropy: sgTr [kJ kg-1 K-1]

Examples

```
sgTr()
```

SigmaT *Surface Tension, Function of Temperature*

Description

The function `SigmaT(T)` calculates the Surface Tension [mN m-1] for a given T [K], returning the calculated Surface Tension and an error message, if an error occur. errorCodes

Usage

```
SigmaT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the equations developed by the International Association for the Properties of Water and Steam, valid from the triple point to the critical temperature [273.13K to 647.096K]. http://www.iapws.org/relguide/Surf-H2O.html

Value

The Surface Tension: Sigma [mN m-1] and an Error Message (if an error occur)

Examples

```
T <- 500.
SigmaT(T)

T <- 700.
SigmaT(T)
```

---

sph *Entropy, Function of Pressure and Enthalpy*

Description

The function `sph(p,h)` returns the water entropy, s [kJ kg-1 K-1], for given p [MPa] and h [kJ k-1].

Usage

```
sph(p, h)
```

Arguments

p	Pressure [MPa]
h	Enthalpy [kJ kg-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Entropy: s [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 10.0003858
h <- 977.181624
sph(p,h)
```

---

spTcteTab *Table of Entropies, Function of Pressure for Fixed Temperature*

Description

The function spTcteTab(p1, p2, dp, T) returns a table of Entropies [kJ kg-1 K-1] for a fixed T [K] within a range of p [MPa]: p1:p2 [MPa]

Usage

```
spTcteTab(p1, p2, dp, T)
```

Arguments

p1	initial Pressure [MPa]
p2	final Pressure [MPa]
dp	Pressure increment [MPa]
T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of Entropies for fixed T and a p Interval: p1:p2.

Examples

```
p1 <- 1.0
p2 <- 10.
dp <- 1.
T <- 500.
spTcteTab(p1, p2, dp, T)

p1 <- 10.
p2 <- 100.
```

```
dp <- 10.
T <- 450.
Tabs <- spTcteTab(p1, p2, dp, T)
```

---

sTD *Specific Entropy, Function of Temperature and Density*

Description

The function sTD(T,D) returns the Specific Entropy, h [kJ kg-1 k-1], for given T [K] and D [kg/m3].

Usage

```
sTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Entropy: s [kJ kg-1 K-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
sTD(T,D)
```

sTp — *Specific Entropy, Function of Temperature and Pressure*

Description

The function `sTp(T,p)` returns the Specific Entropy, h [kJ kg-1 K-1], for given T [K] and D [kg/m3].

Usage

```
sTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Entropy: s [kJ kg-1 K-1] and an Error message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
sTp(T,p)
```

sTpcteTab — *Table of Entropies, Function of Temperature for a Fixed Pressure*

Description

The function `sTpcteTab(T1, T2, dT, p)` returns a table of entropies [kJ kg-1 K-1] for a fixed p [MPa] within a range of T [K]: T1:T2 [K]

Usage

```
sTpcteTab(T1, T2, dT, p)
```

Arguments

T1	initial Temperature [K]
T2	final Temperature [K]
dT	Temperature increment [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

A table of Entropies for fixed p and a T Interval: T1:T2.

Examples

```
T1 <- 275.
T2 <- 450.
dT <- 5.
p <- 5.
sTpcteTab(T1, T2, dT, p)

T1 <- 300.
T2 <- 500.
dT <- 10.
p <- 10.
Tabs <- sTpcteTab(T1, T2, dT, p)
```

TCrit *Water Critical Temperature*

Description

@description The function TCrit() returns the water critical temperature [K]

Usage

```
TCrit()
```

Value

The Water Critical Temperature: Tc [K]

Examples

```
TCrit()
```

TDh *Temperature, Function of Density and Enthalpy*

Description

The function `TDh(D,h)` returns the water temperature, T [K], for given D [kg/m3] and h [kJ kg-1].

Usage

```
TDh(D, h)
```

Arguments

`D`	Density [kg m3]
`h`	Enthaly in [kJ kg-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Temperature: T [K] and an Error Message (if an error occur: errorCodes)

Examples

```
D <- 838.025
h <- 977.181624
TDh(D,h)
```

TDp *Temperature, Function of Density and Pressure*

Description

The function `TDp(D,p)` returns the water temperature, T [K], for given D [kg/m3] and p [MPa].

Usage

```
TDp(D, p)
```

Arguments

`D`	Density [kg m3]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Temperature: T [K] and an Error Message (if an error occur: errorCodes)

Examples

```
D <- 838.025
p <- 10.0003858
TDp(D,p)
```

TDs *Temperature, Function of Density and Entropy*

Description

The function `TDs(D,s)` returns the water temperature, T [K], for given D [kg/m3] and s [kJ kg-1 K-1].

Usage

```
TDs(D, s)
```

Arguments

D	Density [kg m3]
s	Entropy in [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Temperature: T [K] and an Error Message (if an error occur: errorCodes)

Examples

```
D <- 838.025
s <- 2.56690919
TDs(D,s)
```

ThrcTD — *Isothermal Throttling Coefficient, Function of Tenoerature and Density*

Description

The function ThrcTD(T,D) returns the Isothermal Throttling Coefficient, Thrc, for given T [K] and D [kg m-3]

Usage

```
ThrcTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Isothermal Throttling Coefficient: Thrc [kJ kg-1 MPa-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
ThrcTD(T,D)
```

Ths *Temperature, Function of Enthalpy and Entropy*

Description

The function `Ths(h,s)` returns the water Temperature, T [K], for given h [kJ k-1] and s [kJ k-1 K-1].

Usage

```
Ths(h, s)
```

Arguments

h	Enthalpy [kJ kg-1]
s	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Temperature: T [K] and an Error Message (if an error occur: errorCodes)

Examples

```
h <- 977.181624
s <- 2.56690919
Ths(h,s)
```

Tph — *Temperature, Function of Pressure and Enthalpy*

Description

The function `Tph(p,h)` returns the water temperature, T [K], for given p [MPa] and h [kJ k-1].

Usage

```
Tph(p, h)
```

Arguments

p	Pressure [MPa]
h	Enthalpy [kJ kg-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Temperature: T [K] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 10.0003858
h <- 977.181624
Tph(p,h)
```

Tps — *Temperature, Function of Pressure and Entropy*

Description

The function `Tps(p,s)` returns the water temperature, T [K], for given p [MPa] and s [kJ k-1 K-1].

Usage

```
Tps(p, s)
```

Arguments

p	Pressure [MPa]
s	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Temperature: T [K] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 10.0003858
s <- 2.56690919
Tps(p,s)
```

TSatD *Saturation Temperature, Function of Density*

Description

The function TsatD(D) returns the temperature [K], TSat, for given D [kg m-3]: it may have two different values!

Usage

```
TSatD(D)
```

Arguments

D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The first saturation Temperature: TSat_1 [K]

The second saturation pressure: TSat_2 [K]

An Error Message (if an error occur: errorCodes)

Examples

```
D <- 890.341250
TSatD(D)

D <- 999.887406
TSatD(D)
```

TSatp *Saturation Temperature, Function of pressure*

Description

The function `TSatp(p)` returns the temperature [K], TSat, for given p [MPa]

Usage

```
TSatp(p)
```

Arguments

p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Saturation Temperature: Tsat [K] and an Error Message (if an error occur: errorCodes)

Examples

```
p <- 0.932203564
TSatp(p)
```

TSats *Saturation Temperature, Function of Entropy*

Description

The function `TSats(s)` returns the temperature [K], TSat, for given s [kJ kg-1 K-1]

Usage

```
TSats(s)
```

Arguments

`s`	Entropy [kJ kg-1 K-1]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Saturation Temperature: Tsat [K] and an Error Message (if an error occur: errorCodes)

Examples

```
s <- 2.10865845
TSats(s)
```

TTr *Water Temperature at Triple Point*

Description

The function `TTr()` returns the Water Temperature at Triple Point [K]

Usage

```
TTr()
```

Value

The Triple Point Temperature: TTr [K]

Examples

```
TTr()
```

`ufT` *Saturated Liquid Specific Internal Energy, Function of Temperature*

Description

The function `ufT(T)` returns the saturated liquid internal energy [kJ kg-1], uf, for given T [K]

Usage

```
ufT(T)
```

Arguments

`T`	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated liquid internal energy: uf [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
ufT(T)
```

ugT *Saturated Gas Specific Internal Energy, Function of Temperature*

Description

The function ugT(T) returns the saturated gas internal energy [kJ kg-1], ug, for given T [K]

Usage

```
ugT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The saturated gas internal energy: ug [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
ugT(T)
```

uTD *Specific Internal Energy, Function of Temperature and Density*

Description

The function uTD(T,D) returns the Specific Internal Energy, h [kJ kg-1], for given T [K] and D [kg/m3].

Usage

```
uTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Internal Energy: u [kJ kg-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
uTD(T,D)
```

---

uTp *Specific Internal Energy, Function of Temperature and Pressure*

Description

The function uTp(T,p) returns the Specific Internal Energy, h [kJ kg-1], for given T [K] and D [kg/m3].

Usage

```
uTp(T, p)
```

Arguments

T	Temperature [K]
p	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specific Internal Energy: u [kJ kg-1] and an Error message (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
uTp(T,p)
```

`ViscTD` *Dynamic Viscosity, Function of Temperature and Density*

Description

The function `ViscTD(T,D)` calculates the Dynamic Viscosity [Pa s] for given T [K] and D [kg/m3], returning the calculated viscosity and an error message, if an error occur. errorCodes

Usage

```
ViscTD(T, D)
```

Arguments

`T`	Temperature [K]
`D`	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the equations developed by the International Association for the Properties of Water and Steam, valid from the triple point to the pressure of 1000 MPa and temperature of 1173.15K. http://www.iapws.org/relguide/viscosity.html

Value

The Dynamic viscosity: [Pa s] and an Error Message (if an error occur)

Examples

```
T <- 500.
D <- 838.025
ViscTD(T,D)

T <- 500.
D <- 0.
ViscTD(T,D)
```

vTp *Specific Volume, Function of Temperature and Pressure*

Description

The function `vTp(T,p)` returns the Specific Volume, [m3 kg-1], for given T [K] and D [kg/m3].

Usage

```
vTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Specifiv Volume: v [m3 kg-1] and an (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
vTp(T,p)
```

wfT *Speed of Sound of Fluid Phase, Function of Temperature*

Description

The function `wfT(T)` returns the Speed of Sound of Fluid Phase [m s-1], wf, for given T [K]

Usage

```
wfT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Speed of Sound of Fluid Phase: wf [m s-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
wfT(T)
```

---

wgT *Speed of Sound of Gas Phase, Function of Temperature*

Description

The function `wgT(T)` returns the Speed of Sound of Gas Phase [m s-1], wg, for given T [K]

Usage

```
wgT(T)
```

Arguments

T	Temperature [K]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Speed of Sound of Gas Phase: wg [m s-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 450.
wgT(T)
```

---

wTD *Speed of Sound, Function of Temperature and Density*

Description

The function wTD(T,D) returns the Speed of Sound in water, w [m s-1], for given T [K] and D [kg/m3].

Usage

```
wTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Speed of Sound: w [m s-1]

Error message (if an error occur)

The Speed of Sound: w [m s-1] and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
wTD(T,D)

T <- 500.
D <- 0.435
wTD(T,D)
```

wTp *Speed of Sound, Function of Temperature and Pressure*

Description

The function `wTp(T,p)` returns the Speed of Sound, [m s-1], for given T [K] and D [kg/m3].

Usage

```
wTp(T, p)
```

Arguments

`T`	Temperature [K]
`p`	Pressure [MPa]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Speed of Sound: w [m s-1] and an (if an error occur: errorCodes)

Examples

```
T <- 500.
p <- 10.0003858
wTp(T,p)
```

ZTD *Compressibility Factor, Function of Temperature and Density*

Description

The function `ZTD(T,D)` returns the Compressibility Factor, Z [-], for given T [K] and D [kg/m3].

Usage

```
ZTD(T, D)
```

Arguments

T	Temperature [K]
D	Density [kg m-3]

Details

This function calls a Fortran DLL that solves the Helmholtz Energy Equation. in accordance with the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (June 2014) developed by the International Association for the Properties of Water and Steam, http://www.iapws.org/relguide/IAPWS-95.html. It is valid from the triple point to the pressure of 1000 MPa and temperature of 1273.

Value

The Compressibility Factor and an Error Message (if an error occur: errorCodes)

Examples

```
T <- 500.
D <- 838.025
ZTD(T,D)
```

Index