Package: wsif97 (via r-universe)

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Type Package

Title Industrial Formulation for Properties of Ordinary Water and Steam

Version 0.0.1

Description Implementation of some methods for fast calculation of thermophysical properties of ordinary water and steam as they formulated by International Association for the Properties of Water and Steam (IAPWS).

URL https://omega1x.github.io/wsif97/

BugReports https://github.com/omega1x/wsif97/issues

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Depends R (>= 3.5.0)

Imports Rcpp (>= 1.0.5)

LinkingTo Rcpp, testthat

RoxygenNote 7.1.1

Suggests testthat (>= 3.0.0), xml2, covr

Config/testthat/edition 3

Repository https://omega1x.r-universe.dev

RemoteUrl https://github.com/omega1x/wsif97

RemoteRef HEAD

RemoteSha adedbaca05eebc630e1a4ea3a005a18658c6f1ee

Contents

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wsif97-package   *Industrial Formulation for Properties of Ordinary Water and Steam*

Description

Implementation of some methods for fast calculation of thermophysical properties of water and steam as they formulated by *International Association for the Properties of Water and Steam* (IAPWS).

Details

The package is inspired by Java IF97 library and iapws *python*-module and tries to bring similar functionality to **R-community** without unwanted external dependencies. The package grows in functionality smoothly as needed in conjunction with analytic requirements of the author's company.

Unlike most others the package contains vectorized functions aimed for speed by using Rcpp-package and by avoiding double cycling. For actual information about the package see package README.md.

Author(s)

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References

IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. August 2007.

IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. June 2014.

IAPWS AN5-13(2016), Advisory Note No. 5: *Industrial Calculation of the Thermodynamic Properties of Seawater*. September 2013.

Examples

```
## Calculate density of ordinary water at different temperatures
## and pressures:
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
density <- tpr(t, p)  # [kg/m^3]
print(density)
```

---

tpcp   *Isobaric heat capacity vs temperature and pressure*

Description

Calculate specific *isobaric heat capacity* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpcp(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, [*K*]. Type: `NumericVector`
p	absolute pressure in validity range $0 - 100$ *MPa*, [*MPa*]. Type: `NumericVector`

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

specific isobaric heat capacity, $[kJ/kg/K]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: `NumericVector`

References

- *IAPWS R7-97 (2012)*, *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* August 2007.
- *IAPWS SR5-05 (2016)*, *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* June 2014.

See Also

Other properties in temperature-pressure space: `tpcv()`, `tpe()`, `tph()`, `tpi()`, `tpr()`, `tps()`, `tpu()`, `tpv()`, `tpw()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpcp(t, p)
```

---

tpcv   *Isochoric heat capacity vs temperature and pressure*

Description

Calculate specific *isochoric heat capacity* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpcv(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, [*K*]. Type: `NumericVector`
p	absolute pressure in validity range $0 - 100$ *MPa*, [*MPa*]. Type: `NumericVector`

Details

Vectors `T` and `p` both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

specific isochoric heat capacity, $[kJ/kg/K]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: `NumericVector`

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* August 2007.
- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* June 2014.

See Also

Other properties in temperature-pressure space: `tpcp()`, `tpe()`, `tph()`, `tpi()`, `tpr()`, `tps()`, `tpu()`, `tpv()`, `tpw()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpcv(t, p)
```

---

tpe   *Expansion coefficient vs temperature and pressure*

Description

Calculate *cubic expansion coefficient* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpe(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: `NumericVector`
p	absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: `NumericVector`

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

cubic expansion coefficient, $[1/K]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: `NumericVector`

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. August 2007.

- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. June 2014.

- IAPWS AN5-13(2016), Advisory Note No. 5: *Industrial Calculation of the Thermodynamic Properties of Seawater*. September 2013.//'

See Also

Other properties in temperature-pressure space: `tpcp()`, `tpcv()`, `tph()`, `tpi()`, `tpr()`, `tps()`, `tpu()`, `tpv()`, `tpw()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpe(t, p)
```

| tph | *Enthalpy vs temperature and pressure* |

Description

Calculate specific *enthalpy* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tph(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: NumericVector
p	absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: NumericVector

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

specific enthalpy, $[kJ/kg]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: NumericVector

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. August 2007.
- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. June 2014.

See Also

Other properties in temperature-pressure space: `tpcp()`, `tpcv()`, `tpe()`, `tpi()`, `tpr()`, `tps()`, `tpu()`, `tpv()`, `tpw()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tph(t, p)
```

---

tpi   *Compressibility vs temperature and pressure*

Description

Calculate *isothermal compressibility* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpi(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, [*K*]. Type: NumericVector
p	absolute pressure in validity range $0 - 100$ *MPa*, [*MPa*]. Type: NumericVector

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

isothermal compressibility, $[1/MPa]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: NumericVector

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* August 2007.
- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* June 2014.
- IAPWS AN5-13(2016), Advisory Note No. 5: *Industrial Calculation of the Thermodynamic Properties of Seawater.* September 2013.

See Also

Other properties in temperature-pressure space: tpcp(), tpcv(), tpe(), tph(), tpr(), tps(), tpu(), tpv(), tpw()

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpi(t, p)
```

---

tpr   *Mass density vs temperature and pressure*

Description

Calculate *mass density* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpr(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: NumericVector
p	absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: NumericVector

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for tpv.

Value

mass density, $[kg/m^3]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity
    of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in
    undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly
    values of one or both arguments are in undeterminable subspace or near singularity.

Type: `NumericVector`

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the
  Thermodynamic Properties of Water and Steam.* August 2007.

- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific
  Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial
  Formulation 1997 for the Thermodynamic Properties of Water and Steam.* June 2014.

See Also

Other properties in temperature-pressure space: `tpcp()`, `tpcv()`, `tpe()`, `tph()`, `tpi()`, `tps()`,
`tpu()`, `tpv()`, `tpw()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpr(t, p)
```

---

tps   *Entropy vs temperature and pressure*

Description

Calculate specific *entropy* as a function of *temperature* and *pressure* in accordance with *IAPWS
R7-97* formulation.

Usage

```
tps(T, p)
```

Arguments

T   absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: `NumericVector`

p   absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: `NumericVector`

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

specific entropy, $[kJ/kg/K]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: NumericVector

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* August 2007.
- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.* June 2014.

See Also

Other properties in temperature-pressure space: `tpcp()`, `tpcv()`, `tpe()`, `tph()`, `tpi()`, `tpr()`, `tpu()`, `tpv()`, `tpw()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tps(t, p)
```

---

tpu *Internal energy vs temperature and pressure*

Description

Calculate specific *internal energy* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpu(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: `NumericVector`
p	absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: `NumericVector`

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for `tpv`.

Value

specific internal energy, $[kg/m^3]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: `NumericVector`

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. August 2007.

- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. June 2014.

See Also

Other properties in temperature-pressure space: tpcp(), tpcv(), tpe(), tph(), tpi(), tpr(), tps(), tpv(), tpw()

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpu(t, p)
```

---

tpv *Specific volume vs temperature and pressure*

Description

Calculate *specific volume* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpv(T, p)
```

Arguments

T absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: `NumericVector`

p absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: `NumericVector`

Details

Vectors `T` and `p` both must have the same length. Default recycling rules are not applicable in this context.

In current version numerical consistency of the specific volume in *Region 3* of *IAPWS R7-97* is considered sufficient enough for most applications. That is why no additional iteration procedures are used for reaching higher accuracy in this region.

Value

specific volume, $[m^3/kg]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: `NumericVector`

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. August 2007.

- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. June 2014.

See Also

Other properties in temperature-pressure space: tpcp(), tpcv(), tpe(), tph(), tpi(), tpr(), tps(), tpu(), tpw()

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpv(t, p)
```

---

tpw   *Speed of sound vs temperature and pressure*

Description

Calculate *speed of sound* as a function of *temperature* and *pressure* in accordance with *IAPWS R7-97* formulation.

Usage

```
tpw(T, p)
```

Arguments

T	absolute temperature in validity range $273.15 - 2273.15$, $[K]$. Type: NumericVector
p	absolute pressure in validity range $0 - 100$ *MPa*, $[MPa]$. Type: NumericVector

Details

Vectors T and p both must have the same length. Default recycling rules are not applicable in this context.

The accuracy of calculation for this property in *Region 3* depends on accuracy of *specific volume* in this region. See details for tpv.

Value

speed of sound, $[m/s]$, or the next error code:

-10 Fail to determine region in temperature-pressure space into which the entire range of validity of *IAPWS R7-97* is divided. Possibly values of one or both arguments are out of bounds or in undeterminable subspace.

-20 Fail to determine subregion inside *Region 3* in accordance with *IAPWS SR5-05*. Possibly values of one or both arguments are in undeterminable subspace or near singularity.

Type: NumericVector

References

- IAPWS R7-97 (2012), *Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. August 2007.
- IAPWS SR5-05 (2016), *Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*. June 2014.

See Also

Other properties in temperature-pressure space: `tpcp()`, `tpcv()`, `tpe()`, `tph()`, `tpi()`, `tpr()`, `tps()`, `tpu()`, `tpv()`

Examples

```
t <- c(300,300,500,300,700,700,1500,1500,2000,0)  # [K]
p <- c(3,80,3,.35e-2,.35e-2,30,.5,30,30,0)  # [MPa]
tpw(t, p)
```

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