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R topics documented:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT</td>
<td>4</td>
</tr>
<tr>
<td>CndTD</td>
<td>5</td>
</tr>
<tr>
<td>CpfT</td>
<td>6</td>
</tr>
<tr>
<td>CpgT</td>
<td>7</td>
</tr>
<tr>
<td>CpTD</td>
<td>8</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>CpTp</td>
<td>9</td>
</tr>
<tr>
<td>CT</td>
<td>10</td>
</tr>
<tr>
<td>CvT</td>
<td>10</td>
</tr>
<tr>
<td>CvgT</td>
<td>11</td>
</tr>
<tr>
<td>CvTD</td>
<td>12</td>
</tr>
<tr>
<td>CvTp</td>
<td>13</td>
</tr>
<tr>
<td>DCrit</td>
<td>14</td>
</tr>
<tr>
<td>dDdTTD</td>
<td>14</td>
</tr>
<tr>
<td>dDdTTp</td>
<td>15</td>
</tr>
<tr>
<td>Dfp</td>
<td>16</td>
</tr>
<tr>
<td>Dfs</td>
<td>17</td>
</tr>
<tr>
<td>DrT</td>
<td>17</td>
</tr>
<tr>
<td>DrTr</td>
<td>18</td>
</tr>
<tr>
<td>Dgp</td>
<td>19</td>
</tr>
<tr>
<td>Dgs</td>
<td>19</td>
</tr>
<tr>
<td>DgT</td>
<td>20</td>
</tr>
<tr>
<td>DgTr</td>
<td>21</td>
</tr>
<tr>
<td>Dhs</td>
<td>21</td>
</tr>
<tr>
<td>dpdDTD</td>
<td>22</td>
</tr>
<tr>
<td>dpdDTp</td>
<td>23</td>
</tr>
<tr>
<td>dpdTTD</td>
<td>24</td>
</tr>
<tr>
<td>dpdTTp</td>
<td>25</td>
</tr>
<tr>
<td>Dph</td>
<td>26</td>
</tr>
<tr>
<td>Dps</td>
<td>27</td>
</tr>
<tr>
<td>DpTcteTab</td>
<td>28</td>
</tr>
<tr>
<td>DTh</td>
<td>29</td>
</tr>
<tr>
<td>DTp</td>
<td>30</td>
</tr>
<tr>
<td>DTpcteTab</td>
<td>31</td>
</tr>
<tr>
<td>DTs</td>
<td>32</td>
</tr>
<tr>
<td>errorCodes</td>
<td>33</td>
</tr>
<tr>
<td>fTD</td>
<td>33</td>
</tr>
<tr>
<td>fTp</td>
<td>34</td>
</tr>
<tr>
<td>FugaTp</td>
<td>35</td>
</tr>
<tr>
<td>GibbsTp</td>
<td>36</td>
</tr>
<tr>
<td>hCrit</td>
<td>37</td>
</tr>
<tr>
<td>hT</td>
<td>37</td>
</tr>
<tr>
<td>hgT</td>
<td>38</td>
</tr>
<tr>
<td>hps</td>
<td>39</td>
</tr>
<tr>
<td>hpTcteTab</td>
<td>40</td>
</tr>
<tr>
<td>hTD</td>
<td>41</td>
</tr>
<tr>
<td>hTp</td>
<td>42</td>
</tr>
<tr>
<td>hTpcteTab</td>
<td>43</td>
</tr>
<tr>
<td>JTpCTD</td>
<td>44</td>
</tr>
<tr>
<td>KapaTD</td>
<td>45</td>
</tr>
<tr>
<td>KViscTD</td>
<td>46</td>
</tr>
<tr>
<td>pcrit</td>
<td>46</td>
</tr>
<tr>
<td>phi0</td>
<td>47</td>
</tr>
<tr>
<td>phi0D</td>
<td>48</td>
</tr>
</tbody>
</table>
### Topics Documented:

- phi0DD ........................................... 49
- phi0DT ........................................... 50
- phi0T ........................................... 50
- phi0TT ........................................... 51
- phir .............................................. 52
- phirD ............................................. 53
- phirDD ............................................ 54
- phirDT ............................................ 55
- phirT ............................................. 56
- phirTT ............................................ 57
- pMeltT ........................................... 58
- PrandtTD ....................................... 59
- pSatD ............................................. 60
- pSats ............................................ 61
- pSatT ............................................. 61
- pTD .............................................. 62
- pTr ............................................... 63
- Rwater .......................................... 64
- satTabhT ....................................... 64
- satTabp ......................................... 65
- satTabpT ....................................... 66
- satTabT ......................................... 67
- satTabTp ....................................... 68
- satTabvp ....................................... 69
- satTabvT ....................................... 70
- sCrit ............................................. 71
- sfT ............................................... 71
- sfTr ............................................. 72
- sgT ............................................... 73
- sgTr ............................................. 73
- SigmaT .......................................... 74
- sph .............................................. 75
- spTeteTab ...................................... 76
- sTD ............................................... 77
- sTp ............................................... 78
- sTpcteTab ..................................... 79
- TCrit ............................................ 80
- TDh ............................................... 80
- TDP ............................................... 81
- TDs ............................................... 82
- ThrcTD ......................................... 83
- Ths ............................................... 84
- Tph ............................................... 85
- Tps ............................................... 86
- TSatD ........................................... 87
- TSatp ........................................... 88
- TSats ........................................... 88
- TTr ............................................... 89
Description

The function BT(Temp, digits=9) returns the second virial coefficient, \( B \) [ m\(^3\) kg\(^{-1}\) ], for a given \( T \) [K].

Usage

\[
\text{BT}(\text{Temp}, \text{digits} = 9)
\]

Arguments

- **Temp**: Temperature [K]
- **digits**: Digits of results (optional)

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](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: \( B \) [ m\(^3\) kg\(^{-1}\) ] and an Error Message (if an error occur: errorCodes)

Examples

```
Temp <- 500.
B_T <- BT(Temp)
B_T
```
**CndTD**

Thermal Conductivity, Function of Temperature and Density

---

**Description**

The function `CndTD(Temp, D, digits=9)` calculates the Thermal Conductivity, \( k \ [ \text{W m}^{-1} \text{K}^{-1} ] \) for given \( \text{Temp} \ [\text{K}] \) and \( D \ [\text{kg/m}^3] \), returning the computed thermal conductivity and an error message if an error occur.

**Usage**

`CndTD(Temp, D, digits = 9)`

**Arguments**

- **Temp**
  - Temperature \( [\text{K}] \)

- **D**
  - Density \( [\text{kg/m}^3] \)

- **digits**
  - Digits of results (optional)

**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](http://www.iapws.org/relguide/ThCond.html)

**Value**

The Thermal Conductivity: \( k \ [ \text{W m}^{-1} \text{K}^{-1} ] \) and an Error message if necessary

**Examples**

```r
Temp <- 500.
D <- 838.025
Cond <- CndTD(Temp,D)
Cond
```
Specific Isobaric Heat Capacity of Fluid Phase, Function of Temperature

Description

The function \( \text{CpfT}(\text{Temp}, \text{digits}=9) \) returns the Isobaric Heat Capacity of Fluid Phase \([\text{kJ kg}^{-1} \text{K}^{-1}]\), \(\text{Cpf}\), for given \( T \) [K].

Usage

\( \text{CpfT}(\text{Temp}, \text{digits} = 9) \)

Arguments

- **Temp**: Temperature [K]
- **digits**: Digits of results (optional)

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](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: \(\text{Cpf} [\text{kJ kg}^{-1} \text{K}^{-1}]\) and an Error Message (if an error occur: \text{errorCodes})

Examples

\[
\begin{align*}
\text{Temp} & \leftarrow 450. \\
\text{Cpf} & \leftarrow \text{CpfT}(\text{Temp}) \\
\text{Cpf} &
\end{align*}
\]
**CpgT**

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

**Description**

The function `CpgT(Temp, digits=9)` returns the Isobaric Heat Capacity of Gas Phase [kJ kg\(^{-1}\) K\(^{-1}\)], Cpg, for given Temp [K].

**Usage**

`CpgT(Temp, digits = 9)`

**Arguments**

- **Temp**  
  Temperature [K]
- **digits**  
  Digits of results (optional)

**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](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**

```
Temp <- 450.
Cpg <- CpgT(Temp)
Cpg
```
**Description**

The function \( \text{CpTD}(\text{Temp}, \text{D}, \text{digits}=9) \) returns the Specific Isobaric Heat Capacity, \( \text{Cp} \ [\text{kJ kg}^{-1} \text{K}^{-1}] \), for given \( \text{Temp} \ [\text{K}] \) and \( \text{D} \ [\text{kg/m}^3] \).

**Usage**

\[ \text{CpTD}(\text{Temp}, \text{D}, \text{digits} = 9) \]

**Arguments**

- **Temp**: Temperature [K]
- **D**: Density [kg m\(^{-3}\)]
- **digits**: Digits of results (optional)

**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](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: \( \text{Cp} \ [\text{kJ kg}^{-1} \text{K}^{-1}] \) and an Error Message (if an error occur: \text{errorCodes})

**Examples**

\[
\text{Temp} \gets 500. \\
\text{D} \gets 838.025 \\
\text{Cp} \gets \text{CpTD}(\text{Temp}, \text{D}) \\
\text{Cp}
\]
The function \( CpTp(Temp, p, digits=9) \) returns the Specific Isobaric Heat Capacity, \( Cp \ [\text{kJ kg}^{-1} \text{K}^{-1}] \), for given \( Temp \ [\text{K}] \) and \( D \ [\text{kg/m}^3] \).

**Usage**

\[ CpTp(Temp, p, digits = 9) \]

**Arguments**

- **Temp**: Temperature \([\text{K}]\)
- **p**: Pressure \([\text{MPa}]\)
- **digits**: Digits of results (optional)

**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](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: \( Cp \ [\text{kJ kg}^{-1} \text{K}^{-1}] \) and an (if an error occur: errorCodes)

**Examples**

\[
\begin{align*}
\text{Temp} & \leftarrow 500. \\
p & \leftarrow 10.0003858 \\
Cp & \leftarrow \text{CpTp(Temp,p)} \\
\text{Cp}
\end{align*}
\]
CT

Third Virial Coefficient (C), Function of Temperature

Description

The function CT(Temp, digits=9) returns the third virial coefficient, C \[ m^3 \text{kg}^{-2} \], for a given Temp [K].

Usage

CT(Temp, digits = 9)

Arguments

Temp                Temperature [K]
digits              Digits of results (optional)

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 \[ m^3 \text{kg}^{-2} \] and an Error Message (if an error occurs: errorCodes)

Examples

Temp <- 500.
C_T <- CT(Temp)
C_T

CvfT

Specific Isochoric Heat Capacity of Fluid Phase, Function of Temperature

Description

The function CvfT(Temp, digits=9) returns the Isochoric Heat Capacity of Fluid Phase \[ \text{kJ kg}^{-1} \text{K}^{-1} \], Cvf, for given Temp [K].
**CvgT**

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

**Usage**

```
CvgT(Temp, digits = 9)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [K]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

**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](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: \( C_vf \) [kJ kg\(^{-1}\) K\(^{-1}\)] and an Error Message (if an error occur: `errorCodes`)

**Examples**

```
Temp <- 450.
Cvf <- CvfT(Temp)
Cvf
```

---

The function `CvgT(Temp,digits=9)` returns the Isochoric Heat Capacity of Gas Phase [kJ kg\(^{-1}\) K\(^{-1}\)], `Cvg`, for given `Temp` [K].

**Usage**

```
CvgT(Temp, digits = 9)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [K]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>
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: \( C_{\text{vg}} \) [kJ kg\(^{-1}\) K\(^{-1}\)] and an Error Message (if an error occur: errorCodes)

Examples

```r
Temp <- 450.
Cvg <- CvgT(Temp)
Cvg
```

Description

The function \( \text{CvTD}(\text{Temp}, D, \text{digits}=9) \) returns the Specific Isochoric Heat Capacity, \( C_v \) [kJ kg\(^{-1}\) K\(^{-1}\)], for given \( \text{Temp} \) [K] and \( D \) [kg/m\(^3\)].

Usage

\( \text{CvTD}(\text{Temp}, \text{D}, \text{digits} = 9) \)

Arguments

- **Temp**: Temperature [K]
- **D**: Density [kg m\(^{-3}\)]
- **digits**: Digits of results (optional)

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.
CvTp

**Value**

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

**Examples**

```
Temp <- 500.
D <- 838.025
Cv <- CvTD(Temp, D)
Cv
```

| CvTp | Specific Isochoric Heat Capacity, Function of Temperature and Pressure |

**Description**

The function \( CvTp(Temp, p, digits=9) \) returns the Specific Isochoric Heat Capacity, \( Cv \) [ kJ kg\(^{-1}\) K\(^{-1}\) ], for given Temp [K] and D [kg/m\(^3\)].

**Usage**

\( CvTp(Temp, p, digits = 9) \)

**Arguments**

- **Temp** Temperature [ K ]
- **p** Pressure [ MPa ]
- **digits** Digits of results (optional)

**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**

```r
Temp <- 500.
p <- 10.0003858
Cv <- CvTp(Temp, p)
Cv
```

---

**DCrit**

*Water Critical Density*

---

**Description**

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

**Usage**

```r
DCrit()
```

**Value**

The Water Critical Density: $D_c$ [kg m⁻³]

**Examples**

```r
DC <- DCrit()
DC
```

---

**dDdTTD**

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

---

**Description**

The function `dDdTTD(Temp, D, digits=9)` returns the pressure derivative with respect to Density, $dp_dD$, for given Temp [K] and D [kg m⁻³].

**Usage**

```r
dDdTTD(Temp, D, digits = 9)
```

**Arguments**

- **Temp**: Temperature [K]
- **D**: Density [kg m⁻³]
- **digits**: Digits of results (optional)
**dDdTTP**

**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/dTemp [ kg m⁻³ K⁻¹ ] and an Error Message (if an error occur: errorCodes)

**Examples**

```r
Temp <- 500.
D <- 838.025
dDdTp <- dDdTDP(Temp,D)
dDdTp
```

**Description**

The function `dDdTTP(Temp, p, digits=9)` returns the Density derivative with respect to Temperature, dDdTp, for given Temp [K] and p [MPa].

**Usage**

`dDdTTP(Temp, p, digits = 9)`

**Arguments**

- `Temp` Temperature [ K ]
- `p` Pressure [ MPa ]
- `digits` Digits of results (optional)

**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 Temp: \( \frac{dD}{dT} \) [ kg m\(^{-3}\) K\(^{-1}\) ] and an Error Message (if an error occur: `errorCodes`)

**Examples**

```r
Temp <- 500. 
p <- 10.0003858
dDdTTemp <- dDdTTemp(Temp,p)
dDdTTemp
```

---

**Dfp**

*Saturated Liquid Density, Function of Pressure*

**Description**

The function `Dfp(p, digits=9)` returns the saturated liquid density [kg m\(^{-3}\)], \( D_f \), for given \( p \) [ MPa ].

**Usage**

`Dfp(p, digits = 9)`

**Arguments**

- `p`: Pressure [ MPa ]
- `digits`: Digits of results (optional)

**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](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: \( D_f \) [kg m\(^{-3}\)] and an Error Message (if an error occur: `errorCodes`)

**Examples**

```r
p <- 0.932203564
Df <- Dfp(p)
Df
```
**Dfs**

*Saturated Liquid Density, Function of Entropy*

**Description**

The function \( \text{Dfs}(s, \text{digits}=9) \) returns the saturated liquid density \([\text{kg m}^{-3}]\), \(D_f\), for given \(s\) [kJ kg\(^{-1}\) K\(^{-1}\)].

**Usage**

\[
\text{Dfs}(s, \text{digits} = 9)
\]

**Arguments**

- **s**
  - Entropy [kJ kg\(^{-1}\) K\(^{-1}\)]
- **digits**
  - Digits of results (optional)

**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](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: \(D_f\) [kg m\(^{-3}\)] and an Error Message (if an error occur: errorCodes)

**Examples**

\[
s <- 2.10865845
Df <- \text{Dfs}(s)
Df
\]

---

**DfT**

*Saturated Liquid Density, Function of Temperature*

**Description**

The function \( \text{DfT}(\text{Temp}, \text{digits}=9) \) returns the saturated liquid density \([\text{kg m}^{-3}]\), \(D_f\), for given \(\text{Temp}\) [K].

**Usage**

\[
\text{DfT}(\text{Temp}, \text{digits} = 9)
\]

**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](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: \(D_f\) [kg m\(^{-3}\)] and an Error Message (if an error occur: errorCodes)

**Examples**

\[
s <- 2.10865845
Df <- \text{DfT}(s)
Df
\]
Arguments

Temp Temperature [ K ]
digits Digits of results (optional)

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

```r
Temp <- 450.
Df <- DfT(Temp)
Df
```

Description

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

Usage

DfTr()

Value

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

Examples

```r
DfTrip <- DfTr()
DfTrip
```
**Dgp**

*Saturated Gas Density, Function of Pressure*

**Description**

The function `Dgp(p, digits=9)` returns the saturated gas density [kg m⁻³], Dg, for given p [MPa].

**Usage**

```r
Dgp(p, digits = 9)
```

**Arguments**

- `p` Pressure [MPa]
- `digits` Digits of results (optional)

**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](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**

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

---

**Dgs**

*Saturated Gas Density, Function of Entropy*

**Description**

The function `Dgs(s, digits=9)` returns the saturated gas density [kg m⁻³], Dg, for given s [kJ kg⁻¹ K⁻¹].

**Usage**

```r
Dgs(s, digits = 9)
```
Arguments

s Entropy [kJ kg⁻¹ K⁻¹]
digits Digits of results (optional)

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 <- 5.4731
Dg <- Dgs(s)
Dg

---

DgT Saturated Gas Density, Function of Temperature

Description

The function DgT(Temp, digits=9) returns the saturated gas density [kg m⁻³], Dg, for given Temp [K].

Usage

DgT(Temp, digits = 9)

Arguments

Temp Temperature [ K ]
digits Digits of results (optional)

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.
**DgTr**

**Value**

The saturated gas density: \( Dg \ [ \text{kg m}^{-3} ] \) and an Error Message (if an error occur: `errorCodes`)

**Examples**

```r
Temp <- 450.
Dg <- DgT(Temp)
Dg
```

---

**Dhs**

**Density, Function of Enthalpy and Entropy**

**Description**

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

**Usage**

`Dhs(h, s, digits = 9)`
Arguments

- \( h \) : Enthalpy [ kJ kg\(^{-1}\) ]
- \( s \) : Entropy [ kJ kg\(^{-1}\) K\(^{-1}\) ]
- digits : Digits of results (optional)

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](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

\[
\begin{align*}
  h & \leftarrow 977.181624 \\
  s & \leftarrow 2.56690919 \\
  D_{hs} & \leftarrow Dhs(h, s) \\
  D_{hs}
\end{align*}
\]

Description

The function \( dpdDTD(\text{Temp}, D, \text{digits}=9) \) returns the pressure derivative with respect to Density, \( dpdD \), for given \( T \) [K] and \( D \) [kg m\(^{-3}\)].

Usage

\( dpdDTD(\text{Temp}, D, \text{digits} = 9) \)

Arguments

- \( \text{Temp} \) : Temperature [ K ]
- \( D \) : Density [ kg m\(^{-3}\) ]
- digits : Digits of results (optional)
**dpdDTp**

**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](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 occurs: errorCodes)

**Examples**
```r
Temp <- 500.
D <- 838.025
dpdD <- dpdDTD(Temp,D)
dpdD
```

---

**Description**
The function `dpdDTp(Temp, p)` returns the pressure derivative with respect to Density, dpdD, for given Temp [K] and p [MPa].

**Usage**
```r
dpdDTp(Temp, p, digits = 9)
```

**Arguments**
- `Temp` Temperature [ K ]
- `p` Pressure [ MPa ]
- `digits` Digits of results (optional)

**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](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 pressure derivative with respect to \( d \): \( \frac{dp}{dD} \) [MPa kg\(^{-1}\) m\(^3\)] and an Error Message (if an error occur: errorCodes)

**Examples**

```r
Temp <- 500.
p <- 10.0003858
dpdD <- dpdTP(Temp,p)
dpdD
```

---

**dpdT**

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

**Description**

The function `dpdT(Temp, D, digits=9)` returns the pressure derivative with respect to Temperature, \( dp/dT \), for given Temp [K] and D [kg/m\(^3\)].

**Usage**

`dpdT(Temp, D, digits = 9)`

**Arguments**

- **Temp**
  - Temperature [K]
- **D**
  - Density [kg m\(^{-3}\)]
- **digits**
  - Digits of results (optional)

**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](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 Temp: \( dp/dTemp \) [MPa K\(^{-1}\)] and an Error Message (if an error occur: errorCodes)
**dpdTTP**

**Examples**

```r
Temp <- 500.
D <- 838.025
dpdTemp <- dpdTTP(Temp,D)
dpdTemp
```

---

**dpdTTP**  
*Pressure Derivative with respect to Temperature, Function of Temperature and Pressure*

**Description**

The function `dpdTTP(Temp, p, digits=9)` returns the pressure derivative with respect to Temperature, `dpdTTemp`, for given `Temp [K]` and `p [MPa]`.

**Usage**

`dpdTTP(Temp, p, digits = 9)`

**Arguments**

- `Temp`  
  Temperature [K]
- `p`  
  Pressure [MPa]
- `digits`  
  Digits of results (optional)

**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](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 Temp: dp/dTemp [MPa K⁻¹] and an Error Message (if an error occur: errorCodes)

**Examples**

```r
Temp <- 500.
p <- 10.0003858
dpdTemp <- dpdTTP(Temp,p)
dpdTemp
```
Density, Function of Pressure and Enthalpy

Description

The function \( D_{ph}(p, h, \text{digits}=9) \) returns the water density, \( D \text{ [ kg m}^{-3} \text{ ]}, \) for given \( p \text{ [MPa]} \) and \( h \text{ [kJ kg}^{-1} \text{ ]} \).

Usage

\[ D_{ph}(p, h, \text{digits} = 9) \]

Arguments

- \( p \): Pressure [ MPa ]
- \( h \): Enthalpy [ kJ kg\(^{-1}\) ]
- \( \text{digits} \): Digits of results (optional)

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, \url{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: \( D \text{ [ kg m}^{-3} \text{ ]} \) and an Error Message (if an error occur: \text{errorCodes})

Examples

\begin{verbatim}
p <- 10.0003858
h <- 977.181624
D_ph <- Dph(p, h)
D_ph
\end{verbatim}
The function \texttt{Dps(p, s, digits=9)} returns the water density, $D$ [ kg m$^{-3}$], for given $p$ [MPa] and $s$ [ kJ kg$^{-1}$ K$^{-1}$].

**Usage**

\texttt{Dps(p, s, digits = 9)}

**Arguments**

- \texttt{p} Pressure [ MPa ]
- \texttt{s} Entropy [ kJ kg$^{-1}$ K$^{-1}$ ]
- \texttt{digits} Digits of results (optional)

**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, \url{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**

\begin{verbatim}
p <- 10.0003858
s <- 2.56690919
D_ps <- Dps(p, s)
D_ps
\end{verbatim}
Table of Densities, Function of Pressure for a Fixed Temperature

Description

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

Usage

$DpTcteTab(p1, p2, dp, Temp)$

Arguments

- $p1$: first pressure value [ MPa ]
- $p2$: final pressure [ MPa ]
- $dp$: Pressure increment [ MPa ]
- $Temp$: Temperature [ K ]

Details

This function provides a table of the densities [kg m$^{-3}$] for a given Temp [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

```r
p1 <- 1.0
p2 <- 10.
dp <- 1.
Temp <- 500.
TabD <- DpTcteTab(p1, p2, dp, Temp)
TabD
```

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

The function \( D\text{Th}(\text{Temp}, h, \text{digits}=9) \) returns the water density, \( D \ [\text{kg m}^{-3}] \), for given \( \text{Temp} \ [\text{K}] \) and \( h \ [\text{kJ kg}^{-1}] \) (it may have two solutions for Density).

**Usage**

\( D\text{Th}(\text{Temp}, h, \text{digits} = 9) \)

**Arguments**

- **Temp**: Temperature in Kelvin
- **h**: Enthalpy in [kJ kg\(^{-1}\)]
- **digits**: Digits of results (optional)

**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](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: \( \text{Density}_1 \ [\text{kg m}^{-3}] \)

The Density 2: \( \text{Density}_2 \ [\text{kg m}^{-3}] \)

**Error Message** (if an error occurs: errorCodes)

**Examples**

\begin{verbatim}
Temp <- 500.
h <- 977.181624
D_Th <- DTh(Temp, h)
D_Th
\end{verbatim}
**Description**

The function \( \text{DTp}(\text{Temp}, p, \text{digits}=9) \) returns the water density, \( D \) [ kg m\(^{-3}\) ], for given Temp [K] and \( D \) [kg/m\(^3\)].

**Usage**

\[ \text{DTp}(\text{Temp}, p, \text{digits} = 9) \]

**Arguments**

- **Temp**: Temperature [ K ]
- **p**: Pressure [ MPa ]
- **digits**: Digits of results (optional)

**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](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: \text{errorCodes})

**Examples**

\[
\begin{align*}
\text{Temp} & \leftarrow 500. \\
p & \leftarrow 10.0003858 \\
D & \leftarrow \text{DTp}(\text{Temp}, p) \\
D &
\end{align*}
\]
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 Temp [K]: T1:T2 [K].

Usage

DTpcteTab(T1, T2, dT, p)

Arguments

- T1: first Temperature value [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](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

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

T1 <- 300.
T2 <- 500.
dT <- 10.
p <- 10.
TabD <- DTpcteTab(T1, T2, dT, p)
TabD
```
**DTs**  

*Density, Function of Temperature and Entropy*

**Description**

The function `DTs(Temp, s, digits=9)` returns the water density, \( D \ [ \text{kg m}^{-3} ] \), for given \( \text{Temp} \ [\text{K}] \) and \( s \ [\text{kJ kg}^{-1} \text{K}^{-1}] \).

**Usage**

`DTs(Temp, s, digits = 9)`

**Arguments**

- **Temp**  
  Temperature [K]
- **s**  
  Entropy [kJ kg\(^{-1}\) K\(^{-1}\)]
- **digits**  
  Digits of results (optional)

**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: \( D \ [ \text{kg m}^{-3} ] \) and an Error Message (if an error occur: `errorCodes`)

**Examples**

```r
Temp <- 500.
s <- 2.56690919
D_Ts <- DTs(Temp, s)
D_Ts
```
**Description**

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

**Usage**

```r
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, digits=9)` returns the Helmholtz Free Energy, \( f \ [\text{kJ kg}^{-1}] \), for given Temp \([\text{K}]\) and \( D \ [\text{kg m}^{-3}] \).

**Usage**

```r
fTD(Temp, D, digits = 9)
```

**Arguments**

- **Temp**  
  Temperature \([\text{K}]\)
- **D**  
  Density \([\text{kg m}^{-3}]\)
- **digits**  
  Digits of results (optional)

**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

```
Temp <- 500.
D <- 838.025
f <- fTD(Temp,D)
f
```

---

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

Description

The function \( \text{fTp}(\text{Temp}, p, \text{digits}=9) \) returns the Helmholtz Free Energy, \( f \) [ kJ kg\(^{-1}\) ], for given Temp [K] and D [kg/m\(^3\)].

Usage

```
fTp(Temp, p, digits = 9)
```

Arguments

- **Temp**: Temperature [K]
- **p**: Pressure [MPa]
- **digits**: Digits of results (optional)

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](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

```
Temp <- 500.
p <- 10.0003858
f <- fTp(Temp,p)
f
```
**FugaTp**

**Fugacity, Function of Temperature and Pressure**

---

**Description**

The function `FugaTp(Temp, p, digits=9)` returns the Fugacity, [ MPa ], for given Temp [K] and D [kg/m3].

**Usage**

`FugaTp(Temp, p, digits = 9)`

**Arguments**

- **Temp**  
  Temperature [ K ]
- **p**  
  Pressure [ MPa ]
- **digits**  
  Digits of results (optional)

**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](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 Fugacity: Fuga [ MPa ] and an (if an error occur: errorCodes)

**Examples**

```r
Temp <- 500.
p <- 10.0003858
Fuga <- FugaTp(Temp,p)
Fuga
```
**GibbsTp**

*Specific Gibbs Energy, Function of Temperature and Pressure*

**Description**

The function `GibbsTp(Temp, p, digits=9)` returns the Specific Gibbs Energy, [ MPa ], for given Temp [K] and D [kg/m³].

**Usage**

`GibbsTp(Temp, p, digits = 9)`

**Arguments**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [ K ]</td>
</tr>
<tr>
<td>p</td>
<td>Pressure [ MPa ]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

**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](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**

```r
Temp <- 500.
p <- 10.0003858
Gibbs <- GibbsTp(Temp, p)
Gibbs
```
**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: \( h_c \) [kJ kg⁻¹]

**Examples**

```r
hC <- hCrit()
hC
```

---

**hfT**  

*Saturated Liquid Enthalpy, Function of Temperature*

**Description**

The function hfT(Temp, digits=9) returns the saturated liquid enthalpy [kJ kg⁻¹], \( h_f \), for given Temp [K].

**Usage**

hfT(Temp, digits = 9)

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [K]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

**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](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: \( \text{hf} \) [kJ kg\(^{-1}\)] and an Error Message (if an error occur: \text{errorCodes})

Examples
\[
\text{Temp} \leftarrow 450. \\
\text{hf} \leftarrow \text{hfT} (\text{Temp}) \\
\text{hf}
\]

---

\text{hgT} \text{  
Saturated Gas Enthalpy, Function of Temperature  
}

Description
The function \text{hgT}(\text{Temp}, \text{digits}=9) returns the saturated gas enthalpy [kJ kg\(^{-1}\)], \( \text{hg} \), for given \text{Temp} [K].

Usage
\text{hgT}(\text{Temp, digits = 9})

Arguments
\begin{align*}
\text{Temp} & \quad \text{Temperature [ K ]} \\
\text{digits} & \quad \text{Digits of results (optional)}
\end{align*}

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, \text{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: \( \text{hg} \) [kJ kg\(^{-1}\)] and an Error Message (if an error occur: \text{errorCodes})

Examples
\[
\text{Temp} \leftarrow 450. \\
\text{hg} \leftarrow \text{hgT} (\text{Temp}) \\
\text{hg}
\]
The function \( hps(p, s, \text{digits}=9) \) returns the water enthalpy, \( h \ [ \text{kJ kg}^{-1} \] \), for given \( p \ [\text{MPa}] \) and \( s \ [\text{kJ kg}^{-1} \text{K}^{-1}] \).

### Usage

\[
\text{hps}(p, s, \text{digits} = 9)
\]

### Arguments

- **\( p \)**: Pressure [MPa]
- **\( s \)**: Entropy [kJ kg\(^{-1}\) K\(^{-1}\)]
- **\( \text{digits} \)**: Digits of results (optional)

### 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](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: \( h \ [\text{kJ kg}^{-1}] \) and an Error Message (if an error occur: \text{errorCodes})

### Examples

```r
p <- 10.0003858
s <- 2.56690919
h_ps <- hps(p, s)
h_ps
```
Description

The function \( \text{hpTcteTab}(p1, p2, dp, \text{Temp}) \) returns a table of Enthalpies [kJ kg\(^{-1}\)] for a fixed \( \text{Temp} \) [K] within a range of \( p \) [MPa]: \( p1:p2 \) [MPa].

Usage

\( \text{hpTcteTab}(p1, p2, dp, \text{Temp}) \)

Arguments

- \( p1 \)  
  
  first pressure value [MPa]

- \( p2 \)  
  
  final pressure [MPa]

- \( dp \)  
  
  Pressure increment [MPa]

- \( \text{Temp} \)  
  
  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](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

```r
p1 <- 1.0
p2 <- 10.
dp <- 1.
Temp <- 500.
Tabh <- hpTcteTab(p1, p2, dp, Temp)
Tabh

p1 <- 10.
p2 <- 100.
dp <- 10.
Temp <- 450.
Tabh <- hpTcteTab(p1, p2, dp, Temp)
Tabh
```
**Description**

The function `hTD(Temp, D, digits=9)` returns the Specific Enthalpy, \( h \) [kJ kg\(^{-1}\)], for given Temp [K] and D [kg/m\(^3\)].

**Usage**

`hTD(Temp, D, digits = 9)`

**Arguments**

- **Temp** Temperature [K]
- **D** Density [kg m\(^{-3}\)]
- **digits** Digits of results (optional)

**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](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**

```r
Temp <- 500.
D <- 838.025
h <- hTD(Temp, D)
h
```
**hTp**

*Specific Enthalpy, Function of Temperature and Pressure*

**Description**

The function `hTp(Temp, p, digits=9)` returns the Specific Enthalpy, \( h \) [kJ kg\(^{-1}\)], for given Temp [K] and D [kg/m\(^3\)].

**Usage**

\[ hTp(Temp, p, digits = 9) \]

**Arguments**

- **Temp**: Temperature [K]
- **p**: Pressure [MPa]
- **digits**: Digits of results (optional)

**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](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**

```r
Temp <- 500
p <- 10.0003858
h <- hTp(Temp, p)
h
```
The function \( hTpcteTab(T_1, T_2, dT, p) \) returns a table of enthalpies [kJ kg\(^{-1}\)] for a fixed \( p \) [MPa] within a range of Temp [K]: \( T_1:T_2 \) [K].

### Usage

\[
\text{hTpcteTab}(T_1, T_2, dT, p)
\]

### Arguments

- \( T_1 \)  
  first Temperature value [K]
- \( T_2 \)  
  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](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: \( T_1:T_2 \).

### Examples

\[
\begin{align*}
T_1 & \leftarrow 275. \\
T_2 & \leftarrow 450. \\
dT & \leftarrow 5. \\
p & \leftarrow 5. \\
\text{Tabh} & \leftarrow hTpcteTab(T_1, T_2, dT, p) \\
\text{Tabh}
\end{align*}
\]

\[
\begin{align*}
T_1 & \leftarrow 300. \\
T_2 & \leftarrow 500. \\
dT & \leftarrow 10. \\
p & \leftarrow 10. \\
\text{Tabh} & \leftarrow hTpcteTab(T_1, T_2, dT, p) \\
\text{Tabh}
\end{align*}
\]
Description

The function \( \text{JTcTD}(\text{Temp}, \text{D}, \text{digits}=9) \) returns the Joule-Thomson coefficient for given \( \text{Temp} \) [K] and \( \text{D} \) [kg/m^3].

Usage

\( \text{JTcTD}(\text{Temp}, \text{D}, \text{digits} = 9) \)

Arguments

- \( \text{Temp} \) Temperature [ K ]
- \( \text{D} \) Density [ kg m^{-3} ]
- \( \text{digits} \) Digits of results (optional)

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, \( \text{http://www.iapws.org/relguide/IAPWS-95.html} \). 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

\[
\begin{align*}
\text{Temp} & \leftarrow 500. \\
\text{D} & \leftarrow 838.025 \\
\text{JT} & \leftarrow \text{JTcTD}(\text{Temp}, \text{D}) \\
\text{JT} &
\end{align*}
\]
KapaTD

Isothermal Compressibility, Function of Temperature and Density

Description

The function KapaTD(Temp, D, digits=9) returns the Isothermal Compressibility, Kapa, for given Temp [K] and D [kg m^{-3}].

Usage

KapaTD(Temp, D, digits = 9)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [ K ]</td>
</tr>
<tr>
<td>D</td>
<td>Density [ kg m^{-3} ]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

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](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: error-Codes)

Examples

```r
Temp <- 500.
D <- 838.025
Kapa <- KapaTD(Temp,D)
Kapa
```
### KViscTD

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

**Description**

The function `KViscTD(Temp, D, digits=9)` computes 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 occurs.

**Usage**

```r
KViscTD(Temp, D, digits = 9)
```

**Arguments**

- **Temp** Temperature [ K ]
- **D** Density [ kg m⁻³ ]
- **digits** Digits of results (optional)

**Details**

This function calculates the Kinematic Viscosity that is the relation \( \frac{\text{ViscTD}(D, \text{Temp})}{D} \), 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**

```r
Temp <- 500.
D <- 838.025
KVis <- KViscTD(Temp, D)
KVis
```

---

### pCrit

**Water Critical Pressure**

**Description**

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

**Usage**

```r
pCrit()
```
phi0

Value
The Water Critical Pressure: pc [MPa]

Examples
```
pc <- pCrit()
p
c
```

---

phi0

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

Description
The function phi0(Temp,D,digits=9) returns the Ideal-gas part of the dimensionless Helmholtz Energy Equation, phi0, for given Temp [K] and D [kg/m3].

Usage
```
phi0(Temp, D, digits = 9)
```

Arguments
```
Temp         Temperature [ K ]
D            Density [ kg m-3 ]
digits       Digits of results (optional)
```

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
```
Temp <- 500.
D <- 838.025
phi_0 <- phi0(Temp,D)
phi_0
```
phi0D

**Description**

The function `phi0D(D, digits=9)` returns the First Derivative of the Ideal-gas part of the dimensionless Helmholtz Energy Equation for a given D [kg/m³].

**Usage**

`phi0D(D, digits = 9)`

**Arguments**

- **D**  
  Density [kg m⁻³]

- **digits**  
  Digits of results (optional)

**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](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**

```r
D <- 838.025
phi_0 <- phi0D(D)
phi_0
```
\texttt{phi\textbar DD} \hspace{1cm} \textit{Second Derivative of the Ideal-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density, Function of Density}

**Description**

The function \texttt{phi\textbar DD(D,digits=9)} returns the Second Derivative of the Ideal-gas part of the dimensionless Helmholtz Energy Equation for a given \( D \) [kg/m\(^3\)].

**Usage**

\texttt{phi\textbar DD(D, digits = 9)}

**Arguments**

\begin{itemize}
\item \texttt{D} \hspace{0.5cm} \text{Density [ kg m\(^{-3}\) ]}
\item \texttt{digits} \hspace{0.5cm} \text{Digits of results (optional)}
\end{itemize}

**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, \url{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: \texttt{phi\textbar DD} and an Error Message (if an error occur: \texttt{errorCodes})

**Examples**

\begin{verbatim}
D <- 838.025
phi_0 <- phi\textbar DD(D)
phi_0
\end{verbatim}
phi0DT

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

Description

The function phi0DT(digits=9) returns the Second Derivative of the Ideal-gas Part of the Dimensionless Helmholtz Energy Equation with respect to Density and Temperature.

Usage

phi0DT(digits = 9)

Arguments

digits                  Digits of results (optional)

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

phi0_DT <- phi0DT()
phi0_DT

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(Temp,D,digits=9) returns the First Derivative of the Ideal-gas Part of the dimensionless Helmholtz Energy Equation with respect to Temperature, for given Temp [K] and D [kg/m3].
Usage

\[ \text{phi0T}(\text{Temp}, \ D, \ \text{digits} = 9) \]

Arguments

- **Temp**: Temperature [K]
- **D**: Density [kg m\(^{-3}\)]
- **digits**: Digits of results (optional)

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](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 Temp Derivative of Ideal-gas part of the Helmholtz Energy: \text{phi0T} and an Error Message (if an error occur: \text{errorCodes})

Examples

```r
Temp <- 500.
D <- 838.025
phi0_T <- phi0T(Temp,D)
phi0_T
```

\[ \text{phi0TT} \]

*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 \text{phi0TT}(\text{Temp}, \ D, \text{digits} = 9) returns the Second Derivative of the Ideal-gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, for given Temp [K] and D [kg/m3].

Usage

\[ \text{phi0TT}(\text{Temp}, \ D, \ \text{digits} = 9) \]
phir

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [ K ]</td>
</tr>
<tr>
<td>D</td>
<td>Density [ kg m^{-3} ]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

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](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 Temp Derivative of Ideal-gas part of the Helmholtz Energy: \( \phi_0TT \) and an Error Message (if an error occur: errorCodes)

Examples

```r
Temp <- 500.
D <- 838.025
phi0_TT <- phi0TT(Temp,D)
phi0_TT
```

---

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

Description

The function \( \text{phir}(\text{Temp}, \text{D}, \text{digits}=9) \) returns the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation for given Temp [K] and D [kg/m3].

Usage

\( \text{phir}(\text{Temp}, \text{D}, \text{digits} = 9) \)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [ K ]</td>
</tr>
<tr>
<td>D</td>
<td>Density [ kg m^{-3} ]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>
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

Temp <- 500.
D <- 838.025
phir_TD <- phir(Temp,D)
phir_TD

\[
\text{phirD}
\]

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 \text{phirD}(\text{Temp}, \text{D}, \text{digits}=9) returns the First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation for given Temp [K] and D [kg/m3].

Usage

\text{phirD}(\text{Temp}, \text{D}, \text{digits = 9})

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [ K ]</td>
</tr>
<tr>
<td>D</td>
<td>Density [ kg m-3 ]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

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

**Examples**

```r
Temp <- 500.
D <- 838.025
phir_D <- phirD(T,D)
phir_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 \( \text{phirDD}(\text{Temp}, \text{D}, \text{digits}=9) \) returns the Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation for given Temp [K] and D [kg/m\(^3\)].

**Usage**

\( \text{phirDD}(\text{Temp}, \text{D}, \text{digits} = 9) \)

**Arguments**

- **Temp**  
  Temperature [K]
- **D**  
  Density [kg m\(^{-3}\)]
- **digits**  
  Digits of results (optional)

**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, \[\text{http://www.iapws.org/relguide/IAPWS-95.html}\]. 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: \( \text{phirDD} \), and an Error Message (if an error occur: \( \text{errorCodes} \) )
**Examples**

```r
Temp <- 500.
D <- 838.025
phir_DD <- phirDD(Temp,D)
phir_DD
```

**Description**

The function `phirDT(Temp, D, digits=9)` returns the Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to D and Temp, for given Temp [K] and D [kg/m³].

**Usage**

```r
phirDT(Temp, D, digits)
```

**Arguments**

- `Temp`: Temperature [K]
- `D`: Density [kg m⁻³]
- `digits`: Digits of results (optional)

**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](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 Temp: `phirTT`, and an Error Message (if an error occur: `errorCodes`)

**Examples**

```r
Temp <- 500.
D <- 838.025
phir_DT <- phirDT(Temp,D)
phir_DT
```
\textit{phirT} \hspace{2cm} \textit{First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temperature, Function of Temperature and Density}

\textbf{Description}

The function \texttt{phirT(Temp,D,digits=9)} returns the First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temp, for given Temp \([K]\) and \(D \text{ [kg/m}^3\text{]}\).

\textbf{Usage}

\texttt{phirT(Temp, D, digits = 9)}

\textbf{Arguments}

- \texttt{Temp} \hspace{1cm} Temperature \([K]\)
- \texttt{D} \hspace{1cm} Density \([\text{kg m}^{-3}]\)
- \texttt{digits} \hspace{1cm} Digits of results (optional)

\textbf{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, \url{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.

\textbf{Value}

The First Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temp: \texttt{phirT}, and an Error Message (if an error occurs: \texttt{errorCodes})

\textbf{Examples}

\begin{verbatim}
Temp <- 500.
D <- 838.025
phir_T <- phirT(Temp,D)
phir_T
\end{verbatim}
Description

The function `phirTT(Temp, D, digits=9)` returns the Second Derivative of the Residual-Gas Part of the Dimensionless Helmholtz Energy Equation with respect to Temp, for given Temp [K] and D [kg/m³].

Usage

`phirTT(Temp, D, digits = 9)`

Arguments

- `Temp`: Temperature [K]
- `D`: Density [kg m⁻³]
- `digits`: Digits of results (optional)

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](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

```r
Temp <- 500.
D <- 838.025
phir_TT <- phirTT(Temp, D)
phir_TT
```
Description

The function `pMeltT(Temp, digits=9)` returns the water melting pressure, pMelt [MPa], for a given Temp [K].

Usage

```r
pMeltT(Temp, digits = 9)
```

Arguments

- **Temp**: Temperature [K]
- **digits**: Digits of results (optional)

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](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

```r
Temp <- 275.
p_Melt <- pMeltT(Temp)
p_Melt
```
PrandtTD

Prandt Number, Function of Temperature and Density

Description

The function PrandtTD(Temp, D, digits=9) 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(Temp, D, digits = 9)

Arguments

<table>
<thead>
<tr>
<th>Temp</th>
<th>Temperature [ K ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Density [ kg m⁻³ ]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

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

Temp <- 500.
D <- 838.025
Pran <- PrandtTD(Temp, D)
Pran
**Saturation Pressure, Function of Density**

**Description**

The function `pSatD(D, digits=9)` returns the saturation pressure [MPa], `pSat`, for given `D [ kg m^{-3}]`: it may have two different values!

**Usage**

`pSatD(D, digits = 9)`

**Arguments**

- `D` Density [ kg m^{-3}]
- `digits` Digits of results (optional)

**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](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**

```r
D <- 890.341250
p_Sat <- pSatD(D)
p_Sat

D <- 999.887406
p_Sat <- pSatD(D)
p_Sat
```
**pSats**

*Saturation Pressure, Function of Entropy*

**Description**

The function `pSats(s, digits=9)` returns the saturation pressure [MPa], `pSat`, for given `s [kJ kg⁻¹ K⁻¹]`.

**Usage**

```r
pSats(s, digits = 9)
```

**Arguments**

- `s` Entropy [kJ kg⁻¹ K⁻¹]
- `digits` Digits of results (optional)

**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](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**

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

---

**pSatT**

*Saturation Pressure, Function of Temperature*

**Description**

The function `pSatT(T, digits=9)` returns the saturation pressure [MPa], `pSat`, for given `Temp [K]`.

**Usage**

```r
pSatT(Temp, digits = 9)
```
**Arguments**

- **Temp**: Temperature [K]
- **digits**: Digits of results (optional)

**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](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: \( p_{Sat} \) [MPa] and an Error Message (if an error occur: errorCodes)

**Examples**

```r
Temp <- 450.
p_Sat <- pSatT(Temp)
p_Sat
```

---

**pTD**

*Pressure, Function of Temperature and Density*

**Description**

The function \( pTD(T,D,digits=9) \) returns the water pressure, \( p \) [MPa], for given Temp [K] and \( D \) [kg/m\(^3\)], returning also an error message, if any error occur.

**Usage**

\[ pTD(Temp, D, digits = 9) \]

**Arguments**

- **Temp**: Temperature [K]
- **D**: Density [kg m\(^{-3}\)]
- **digits**: Digits of results (optional)

**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](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

Temp <- 500.
D <- 838.025
p <- pTD(Temp,D)
p

Temp <- 647.096
D <- 322.
p <- pTD(Temp,D)
p

Description

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

Usage

`pTr()`

Value

The Triple Point Pressure: pTr [ MPa ]

Examples

pTrip <- pTr()
pTrip
**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**

Rw <- Rwater()
Rw

---

**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**  
  First Temperature value [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](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.
A table of saturation fluid enthalpies, function of T

Examples

\[
T1 \leftarrow 275. \\
T2 \leftarrow 450. \\
dT \leftarrow 5. \\
TabT \leftarrow \text{satTabhT}(T1, T2, dT) \\
TabT
\]

\[
T1 \leftarrow 300. \\
T2 \leftarrow 500. \\
dT \leftarrow 10. \\
TabT \leftarrow \text{satTabhT}(T1, T2, dT) \\
TabT
\]

---

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

**Description**

The function `satTabp(p1, p2, dp)` returns a table of three 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**: First Pressure value [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](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

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

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

---

**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**

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

**Arguments**

- `T1`  
  First Temperature value [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](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

\begin{verbatim}
T1 <- 275.
T2 <- 450.
dT <- 5.
TabT <- satTabpT(T1, T2, dT)
TabT

T1 <- 300.
T2 <- 500.
dT <- 10.
TabT <- satTabpT(T1, T2, dT)
TabT
\end{verbatim}

Description

The function `satTabT(T1, T2, dT)` returns a table of three 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

- \( T1 \): First Temperature value [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, \texttt{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
satTabTp

**Examples**

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

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

---

**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`  
  First Pressure value [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](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

\begin{verbatim}
  p1 <- 1.0
  p2 <- 10.
  dp <- 0.5
  Tabp <- satTabTp(p1, p2, dp)
  Tabp

  p1 <- 0.1
  p2 <- 10.
  dp <- 0.5
  Tabp <- satTabTp(p1, p2, dp)
  Tabp
\end{verbatim}

---

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

**Description**

The function `satTabvp(p1, p2, dp)` returns a table of three 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**: First Pressure value [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](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

\[
p1 \leftarrow 1.0 \\
p2 \leftarrow 10. \\
dp \leftarrow 0.5 \\
Tabp \leftarrow \text{satTabvp}(p1, p2, dp) \\
Tabp
\]

\[
p1 \leftarrow 0.1 \\
p2 \leftarrow 10. \\
dp \leftarrow 0.5 \\
Tabp \leftarrow \text{satTabvp}(p1, p2, dp) \\
Tabp
\]

\[
\text{satTabvT} \quad Table \ of \ Saturation \ Volumes, \ Enthalpies \ and \ Entropies, \ Function \ of \ Temperature
\]

Description

The function \text{satTabvT}(T1, T2, dT) returns a table of three saturation properties for two phases: Specific Volume [m^3 kg^{-1}], Enthalpy [kJ kg^{-1}] and Entropy [kJ kg K^{-1}] for a Temperature interval, \(T1:T2\) [K].

Usage

\text{satTabvT}(T1, T2, dT)

Arguments

- \(T1\) First Temperature value [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, \url{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
### sCrit

**Water Critical Entropy**

**Description**

The function `sCrit()` returns the entropy at the critical point [kJ kg\(^{-1}\) K\(^{-1}\)].

**Usage**

`sCrit()`

**Value**

The Water Critical Entropy: `sc` [kJ kg\(^{-1}\) K\(^{-1}\)]

**Examples**

```r
sC <- sCrit()
sC
```

### sfT

**Saturated Liquid Entropy, Function of Temperature**

**Description**

The function `sfT(Temp, digits=9)` returns the saturated liquid entropy [kJ kg\(^{-1}\) K\(^{-1}\)], `sf`, for given `Temp` [K].

**Usage**

`sfT(Temp, digits = 9)`
Arguments

Temp  Temperature [ K ]
digits  Digits of results (optional)

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](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 occurs: errorCodes)

Examples

```r
Temp <- 450.
sf <- sfT(Temp)
sf
```

---

**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

```r
sfTrip <- sfTr()
sfTrip
```
sgT

*Saturated Gas Entropy, Function of Temperature*

**Description**

The function `sgT(Temp, digits=9)` returns the saturated gas entropy [kJ kg\(^{-1}\) K\(^{-1}\)], `sg`, for given `Temp [K]`.

**Usage**

`sgT(Temp, digits = 9)`

**Arguments**

- **Temp**  
  Temperature [ K ]
- **digits**  
  Digits of results (optional)

**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](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**

```r
Temp <- 450.
sg <- sgT(Temp)
sg
```

---

sgTr

*Water Gas Entropy at Triple Point*

**Description**

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

**Usage**

`sgTr()`
**SigmaT**

Surface Tension, Function of Temperature

**Description**

The function `SigmaT(Temp, digits=9)` computes the Surface Tension [ mN m⁻¹ ] for a given Temp [K], returning the calculated Surface Tension and an error message, if an error occur. **errorCodes**

**Usage**

`SigmaT(Temp, digits = 9)`

**Arguments**

- `Temp` Temperature [ K ]
- `digits` Digits of results (optional)

**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](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**

```r
temp <- 500.
sigma <- SigmaT(temp)
sigma
```
**sph**  

**Entropy, Function of Pressure and Enthalpy**

**Description**

The function `sph(p, h, digits=9)` returns the water entropy, $s$ [kJ kg$^{-1}$ K$^{-1}$], for given $p$ [MPa] and $h$ [kJ kg$^{-1}$].

**Usage**

`sph(p, h, digits = 9)`

**Arguments**

- **p**  
  Pressure [MPa]

- **h**  
  Enthalpy [kJ kg$^{-1}$]

- **digits**  
  Digits of results (optional)

**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](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**

```r
p <- 10.0003858
h <- 977.181624
s_ph <- sph(p, h)
s_ph
```
spTcteTab  Table of Entropies, Function of Pressure for Fixed Temperature

Description

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

Usage

\texttt{spTcteTab}(p1, p2, dp, Temp)

Arguments

\begin{itemize}
  \item \texttt{p1}  \text{"initial"} first pressure value [ MPa ]
  \item \texttt{p2}  final pressure [ MPa ]
  \item \texttt{dp}  Pressure increment [ MPa ]
  \item \texttt{Temp} Temperature [ K ]
\end{itemize}

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, \url{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 Temp and a p Interval: p1:p2.

Examples

\begin{verbatim}
p1 <- 1.0
p2 <- 10.
dp <- 1.
Temp <- 500.
Tabs <- spTcteTab(p1, p2, dp, Temp)
Tabs

p1 <- 10.
p2 <- 100.
dp <- 10.
Temp <- 450.
Tabs <- spTcteTab(p1, p2, dp, Temp)
Tabs
\end{verbatim}
**sTD**

*Specific Entropy, Function of Temperature and Density*

**Description**

The function `sTD(Temp, D, digits=9)` returns the Specific Entropy, \( h \) [kJ kg\(^{-1}\) K\(^{-1}\)], for given Temp [K] and D [kg/m\(^3\)].

**Usage**

`sTD(Temp, D, digits = 9)`

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature [K]</td>
</tr>
<tr>
<td>D</td>
<td>Density [kg m(^{-3})]</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

**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](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 occurs: `errorCodes`)

**Examples**

```r
Temp <- 500.
D <- 838.025
s <- sTD(Temp, D)
s
```
Specific Entropy, Function of Temperature and Pressure

Description

The function `sTp(Temp, p, digits=9)` returns the Specific Entropy, \( h \) \( [\text{kJ kg}^{-1} \text{K}^{-1}] \), for given \( \text{Temp} \) [K] and \( D \) [kg/m\(^3\)].

Usage

`sTp(Temp, p, digits = 9)`

Arguments

- **Temp**  \( \text{Temperature [ K ]} \)
- **p**  \( \text{Pressure [ MPa ]} \)
- **digits**  \( \text{Digits of results (optional)} \)

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](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: \( s \) \( [\text{kJ kg}^{-1} \text{K}^{-1}] \) and an Error message (if an error occur: `errorCodes`)

Examples

```r
Temp <- 500
p <- 10.0003858
s <- sTp(Temp, p)
s
```
The function \texttt{sTpcteTab(T1, T2, dT, p)} returns a table of entropies [kJ kg$^{-1}$ K$^{-1}$] for a fixed \textit{p} [MPa] within a range of \textit{T} [K]: \textit{T1}:\textit{T2} [K]

\textbf{Usage}

\texttt{sTpcteTab(T1, T2, dT, p)}

\textbf{Arguments}

- \textit{T1} first Temperature value [ K ]
- \textit{T2} final Temperature [ K ]
- \textit{dT} Temperature increment [ K ]
- \textit{p} Pressure [ MPa ]

\textbf{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, \url{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.

\textbf{Value}

A table of Entropies for fixed \textit{p} and a \textit{T} Interval: \textit{T1}:\textit{T2}.

\textbf{Examples}

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

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

*Water Critical Temperature*

**Description**

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

**Usage**

`TCrit()`

**Value**

The Water Critical Temperature: \( T_c \) [K]

**Examples**

```r
Tc <- TCrit()
Tc
```

---

**TDh**

*Temperature, Function of Density and Enthalpy*

**Description**

The function `TDh(D, h, digits=9)` returns the water temperature, \( \text{Temp} \) [K], for given \( D \) [kg/m^3] and \( h \) [kJ kg^{-1}].

**Usage**

`TDh(D, h, digits = 9)`

**Arguments**

- `D`: Density [kg m^3]
- `h`: Enthalpy in [kJ kg^{-1}]
- `digits`: Digits of results (optional)

**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 function \( TDp(D, p, \text{digits}=9) \) returns the water temperature, Temp [ K ], for given \( D \) [kg/m\(^3\)] and \( p \) [MPa].

### Usage

\[ TDp(D, p, \text{digits} = 9) \]

### Arguments

- \( D \): Density [kg m\(^3\)]
- \( p \): Pressure [MPa]
- \( \text{digits} \): Digits of results (optional)

### 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](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: Temp [ K ] and an Error Message (if an error occur: errorCodes)

### Examples

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

```r
TDp
Temperature, Function of Density and Pressure
```

```r
T_Dp <- TDp(D, p)
T_Dp
```
Description

The function TDs(D, s, digits=9) returns the water temperature, Temp [ K ], for given D [kg/m3] and s [kJ kg⁻¹ K⁻¹].

Usage

TDs(D, s, digits = 9)

Arguments

D Density [kg m⁻³]

s Entropy in [kJ kg⁻¹ K⁻¹]

digits Digits of results (optional)

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: Temp [K] and an Error Message (if an error occurs: errorCodes)

Examples

D <- 838.025
s <- 2.56690919
T_Ds <- TDs(D, s)
T_Ds
ThrcTD

| ThrcTD | Isothermal Throttling Coefficient, Function of Temperature and Density |

**Description**

The function \( \text{ThrcTD}(\text{Temp}, D, \text{digits}=9) \) returns the Isothermal Throttling Coefficient, \( \text{Thrc} \), for given \( \text{Temp} \) [K] and \( D \) [kg m\(^{-3}\)].

**Usage**

\( \text{ThrcTD}(\text{Temp}, D, \text{digits} = 9) \)

**Arguments**

- **Temp**  
  Temperature [K]
- **D**  
  Density [kg m\(^{-3}\)]
- **digits**  
  Digits of results (optional)

**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](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: \( \text{Thrc} \) [kJ kg\(^{-1}\) MPa\(^{-1}\)] and an Error Message (if an error occur: errorCodes)

**Examples**

```r
Temp <- 500.
D <- 838.025
\text{Thrc} <- \text{ThrcTD}(\text{Temp},D)
\text{Thrc}
```
Ths(h, s, digits=9) returns the water Temperature, Temp [ K ], for given h [kJ k^{-1}] and s [kJ kg^{-1} K^{-1}].

**Usage**

\[ \text{Ths}(h, s, \text{digits} = 9) \]

**Arguments**

- **h**: Enthalpy [kJ kg^{-1}]
- **s**: Entropy [kJ kg^{-1} K^{-1}]
- **digits**: Digits of results (optional)

**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](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: Temp [ K ] and an Error Message (if an error occur: errorCodes)

**Examples**

```r
h <- 977.181624
s <- 2.56690919
T_hs <- Ths(h, s)
T_hs
```
Description

The function `Tph(p, h, digits = 9)` returns the water temperature, Temp [ K ], for given p [MPa] and h [ kJ kg^{-1} ].

Usage

```r
Tph(p, h, digits = 9)
```

Arguments

- `p` Pressure [ MPa ]
- `h` Enthalpy [ kJ kg^{-1} ]
- `digits` Digits of results (optional)

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](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: Temp [ K ] and an Error Message (if an error occur: `errorCodes`)

Examples

```r
p <- 10.0003858
h <- 977.181624
T_ph <- Tph(p, h)
T_ph
```
Tps

Temperature, Function of Pressure and Entropy

Description

The function Tps(p, s, digits=9) returns the water temperature, Temp [ K ], for given p [MPa] and s [ kJ k-1 K-1 ].

Usage

Tps(p, s, digits = 9)

Arguments

p
Pressure [ MPa ]
s
Entropy [ kJ kg-1 K-1 ]
digits
Digits of results (optional)

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: Temp [ K ] and an Error Message (if an error occur: errorCodes)

Examples

p <- 10.0003858
s <- 2.56690919
T_ps <- Tps(p, s)
T_ps
**TSatD**

**Saturation Temperature, Function of Density**

**Description**

The function `TsatD(D, digits=9)` returns the temperature [K], TSat, for given `D [kg m^-3]`: it may have two different values!

**Usage**

`TSatD(D, digits = 9)`

**Arguments**

- **D**: Density [kg m^-3]
- **digits**: Digits of results (optional)

**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](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 occurs: `errorCodes`)

**Examples**

```r
D <- 890.341250
T_Sat <- TSatD(D)
T_Sat

D <- 999.887406
T_Sat <- TSatD(D)
T_Sat
```
### TSatp

*Saturation Temperature, Function of pressure*

**Description**

The function `TSatp(p, digits=9)` returns the temperature [K], `TSat`, for given `p [ MPa ]`.

**Usage**

`TSatp(p, digits = 9)`

**Arguments**

- `p`  
  Pressure [ MPa ]
- `digits`  
  Digits of results (optional)

**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](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**

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

---

### TSats

*Saturation Temperature, Function of Entropy*

**Description**

The function `TSats(s, digits=9)` returns the temperature [K], `TSat`, for given `s [kJ kg⁻¹ K⁻¹]`.

**Usage**

`TSats(s, digits = 9)`

**Examples**

```r
s <- 1.04  # Example entropy value
T_Sats <- TSats(s)
T_Sats
```
**Arguments**

- `s` : Entropy [kJ kg\(^{-1}\) K\(^{-1}\)]
- `digits` : Digits of results (optional)

**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](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: `Ts` [K] and an Error Message (if an error occur: `errorCodes`)

**Examples**

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

**Description**

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

**Usage**

`TTr()`

**Value**

The Triple Point Temperature: `TTr` [K]

**Examples**

```r
Ttrip <- TTr()
Ttrip
```
ufT | *Saturated Liquid Specific Internal Energy, Function of Temperature*

**Description**

The function `ufT(Temp, digits=0)` returns the saturated liquid internal energy [kJ kg⁻¹], uf, for given Temp [K].

**Usage**

`ufT(Temp, digits = 9)`

**Arguments**

- **Temp** | Temperature [K]
- **digits** | Digits of results (optional)

**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](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: error-Codes)

**Examples**

```r
Temp <- 450.
uf <- ufT(Temp)
uf
```

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

**Description**

The function `ugT(Temp, digits=9)` returns the saturated gas internal energy [kJ kg⁻¹], ug, for given Temp [K].
Usage

\( \text{uTD}(\text{Temp}, \text{digits} = 9) \)

Arguments

\( \text{Temp} \)  
Temperature [ K ]

\( \text{digits} \)  
Digits of results (optional)

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](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: \( \text{ug} \) [kJ kg\(^{-1}\)] and an Error Message (if an error occur: errorCodes)

Examples

\begin{verbatim}
Temp <- 450.
ug <- \text{uTD}(\text{Temp})
ug
\end{verbatim}

---

\( \text{uTD} \quad \text{Specific Internal Energy, Function of Temperature and Density} \)

Description

The function \( \text{uTD}(\text{Temp, D, digits=9}) \) returns the Specific Internal Energy, \( h \) [ kJ kg\(^{-1}\)], for given Temp [K] and D [kg/m\(^3\)].

Usage

\( \text{uTD}(\text{Temp, D, digits = 9}) \)

Arguments

\( \text{Temp} \)  
Temperature [ K ]

\( \text{D} \)  
Density [ kg m\(^{-3}\) ]

\( \text{digits} \)  
Digits of results (optional)
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 \ [ \text{kJ kg}^{-1} \] \text{ and an Error Message (if an error occur: errorCodes)}$

Examples

```r
Temp <- 500.
D <- 838.025
u <- uTD(Temp,D)
```

Description

The function $u\text{Tp}(\text{Temp}, p, \text{digits}=9)$ returns the Specific Internal Energy, $h \ [ \text{kJ kg}^{-1} \]$, for given $\text{Temp} \ [\text{K}]$ and $D \ [\text{kg/m}^3]$.

Usage

$u\text{Tp}(\text{Temp}, p, \text{digits} = 9)$

Arguments

- **Temp**  \ Temperature  \ [K]
- **p**  \ Pressure \ [MPa]
- **digits**  \ Digits of results (optional)

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 \ [ \text{kJ kg}^{-1} \] \text{ and an Error message (if an error occur: errorCodes)}$
**Examples**

```r
Temp <- 500.
p <- 10.0003858
u <- uTp(Temp,p)
u
```

---

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

**Description**

The function `ViscTD(Temp, D, digits=9)` computes the Dynamic Viscosity [ Pa s ] for given Temp [K] and D [kg/m3], returning the computed viscosity and an error message, if an error occur. **error-Codes**

**Usage**

`ViscTD(Temp, D, digits = 9)`

**Arguments**

- **Temp**  
  Temperature [ K ]
- **D**  
  Density [ kg m\(^{-3}\) ]
- **digits**  
  Digits of results (optional)

**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](http://www.iapws.org/relguide/viscosity.html)

**Value**

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

**Examples**

```r
Temp <- 500.
D <- 838.025
Vis <- ViscTD(Temp,D)
Vis
```
Vp  

**Vapor pressure, Function of Temperature**

**Description**

The function \( Vp(Temp, digits=9) \) returns the vapor pressure, \( Vp \ [ kPa ] \), for a given Temp \([K]\).

**Usage**

\[ Vp(Temp, digits = 9) \]

**Arguments**

<table>
<thead>
<tr>
<th>Arguments</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature ([K])</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>

**Details**

This function solves the Wagner Equation (Wagner and Pruss (1993)) which gives one of the best fits to experimental data. It expresses reduced vapor pressure as a function of reduced temperature. This equation, for water, is valid from the temperature of 273.16 K to the critical temperature (624.096 K).

vTp  

**Specific Volume, Function of Temperature and Pressure**

**Description**

The function \( vTp(Temp, p, digits=9) \) returns the Specific Volume, \( [ m^3 kg^{-1} ] \), for given Temp \([K]\) and \( p \ [ kg/m^3] \).

**Usage**

\[ vTp(Temp, p, digits = 9) \]

**Arguments**

<table>
<thead>
<tr>
<th>Arguments</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Temperature ([K])</td>
</tr>
<tr>
<td>p</td>
<td>Pressure ([MPa])</td>
</tr>
<tr>
<td>digits</td>
<td>Digits of results (optional)</td>
</tr>
</tbody>
</table>
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](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 Volume: \( v \) [m\(^3\) kg\(^{-1}\)] and an (if an error occurs: errorCodes)

Examples

\[
\begin{align*}
\text{Temp} & \leftarrow 500. \\
p & \leftarrow 10.0003858 \\
v & \leftarrow vTp(\text{Temp}, p) \\
v
\end{align*}
\]

\[wfT \quad \text{Speed of Sound of Fluid Phase, Function of Temperature}\]

Description

The function \(wfT(\text{Temp}, \text{digits}=9)\) returns the Speed of Sound of Fluid Phase [m s\(^{-1}\)], \(w_f\), for given Temp [K].

Usage

\(wfT(\text{Temp, digits = 9})\)

Arguments

\[
\begin{array}{ll}
\text{Temp} & \text{Temperature [K]} \\
\text{digits} & \text{Digits of results (optional)}
\end{array}
\]

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](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: \(w_f\) [m s\(^{-1}\)] and an Error Message (if an error occurs: errorCodes)
**Examples**

Temp <- 450.
wf <- wfT(Temp)
wf

---

**wgT**

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

**Description**

The function `wgT(Temp, digits=9)` returns the Speed of Sound of Gas Phase \([\text{m s}^{-1}]\), \(wg\), for given \(\text{Temp [K]}\).

**Usage**

`wgT(Temp, digits = 9)`

**Arguments**

- **Temp**
  - Temperature \([\text{K}]\)
- **digits**
  - Digits of results (optional)

**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](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: \(wg \ [\text{m s}^{-1}]\) and an Error Message (if an error occur: `errorCodes`)

**Examples**

Temp <- 450.
wg <- wgT(Temp)
wg
The function `wTD(Temp,D,digits=9)` returns the Speed of Sound in water, \( w \ [ \text{m s}^{-1} ] \), for given Temp \([\text{K}]\) and D \([\text{kg/m}^3]\).

**Usage**

\[ \text{wTD}(\text{Temp}, D, \text{digits} = 9) \]

**Arguments**

- **Temp**: Temperature \([\text{K}]\)
- **D**: Density \([\text{kg m}^{-3}]\)
- **digits**: Digits of results (optional)

**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](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: \( w \ [ \text{m s}^{-1} ] \)

**Error message (if an error occur)**

The Speed of Sound: \( w \ [ \text{m s}^{-1} ] \) and an Error Message (if an error occur: `errorCodes`)

**Examples**

```r
Temp <- 500.
D <- 0.435
w <- wTD(Temp,D)
w
```
Description

The function \( \text{wTp}(\text{Temp}, \text{p}, \text{digits}=9) \) returns the Speed of Sound, \( \text{m s}^{-1} \), for given \( \text{Temp} \) [K] and \( \text{D} \) [kg/m³].

Usage

\[ \text{wTp}(\text{Temp}, \text{p}, \text{digits} = 9) \]

Arguments

- \( \text{Temp} \): Temperature [K]
- \( \text{p} \): Pressure [MPa]
- \( \text{digits} \): Digits of results (optional)

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, \texttt{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: \texttt{errorCodes})

Examples

```
\text{Temp} <- 500.
\text{p} <- 10.0003858
\text{w} <- \text{wTp}(\text{Temp}, \text{p})
\text{w}
```
Description

The function ZTD(Temp, D, digits=9) returns the Compressibility Factor, Z [-], for given Temp [K] and D [kg/m3].

Usage

ZTD(Temp, D, digits = 9)

Arguments

- **Temp**: Temperature [ K ]
- **D**: Density [ kg m-3 ]
- **digits**: Digits of results (optional)

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](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

```r
Temp <- 500.
D <- 838.025
z <- ZTD(Temp, D)
z
```
# Index

* **datasets**
  
<table>
<thead>
<tr>
<th>errorCodes, 33</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT, 4</td>
</tr>
<tr>
<td>CndTD, 5</td>
</tr>
<tr>
<td>CpfT, 6</td>
</tr>
<tr>
<td>CpgT, 7</td>
</tr>
<tr>
<td>CpgD, 8</td>
</tr>
<tr>
<td>CtpT, 9</td>
</tr>
<tr>
<td>CT, 10</td>
</tr>
<tr>
<td>Cvft, 10</td>
</tr>
<tr>
<td>Cvgt, 11</td>
</tr>
<tr>
<td>CvTD, 12</td>
</tr>
<tr>
<td>CvTp, 13</td>
</tr>
<tr>
<td>Dcrit, 14</td>
</tr>
<tr>
<td>dDdTTD, 14</td>
</tr>
<tr>
<td>dDdDTp, 15</td>
</tr>
<tr>
<td>Dfp, 16</td>
</tr>
<tr>
<td>Dfs, 17</td>
</tr>
<tr>
<td>Dft, 17</td>
</tr>
<tr>
<td>DfTr, 18</td>
</tr>
<tr>
<td>Dgp, 19</td>
</tr>
<tr>
<td>Dgs, 19</td>
</tr>
<tr>
<td>Dgt, 20</td>
</tr>
<tr>
<td>DgTr, 21</td>
</tr>
<tr>
<td>Dhs, 21</td>
</tr>
<tr>
<td>dpdDTD, 22</td>
</tr>
<tr>
<td>dpdDTp, 23</td>
</tr>
<tr>
<td>dpdTTD, 24</td>
</tr>
<tr>
<td>dpdTTp, 25</td>
</tr>
<tr>
<td>Dph, 26</td>
</tr>
<tr>
<td>Dps, 27</td>
</tr>
<tr>
<td>DpTcTeTab, 28</td>
</tr>
<tr>
<td>DTh, 29</td>
</tr>
<tr>
<td>Dtp, 30</td>
</tr>
<tr>
<td>DTpcteTab, 31</td>
</tr>
<tr>
<td>DTs, 32</td>
</tr>
</tbody>
</table>

* **errorCodes**
  
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>fTD, 33</td>
</tr>
<tr>
<td>fTp, 34</td>
</tr>
<tr>
<td>FugaTp, 35</td>
</tr>
<tr>
<td>GibbsTp, 36</td>
</tr>
<tr>
<td>hCrit, 37</td>
</tr>
<tr>
<td>hft, 37</td>
</tr>
<tr>
<td>hgT, 38</td>
</tr>
<tr>
<td>hpTcTeTab, 40</td>
</tr>
<tr>
<td>hTD, 41</td>
</tr>
<tr>
<td>hTp, 42</td>
</tr>
<tr>
<td>hTpcteTab, 43</td>
</tr>
<tr>
<td>JtcTD, 44</td>
</tr>
<tr>
<td>KapaTD, 45</td>
</tr>
<tr>
<td>KViscTD, 46</td>
</tr>
<tr>
<td>pCrit, 46</td>
</tr>
<tr>
<td>phi0, 47</td>
</tr>
<tr>
<td>phi0D, 48</td>
</tr>
<tr>
<td>phi0DD, 49</td>
</tr>
<tr>
<td>phi0DT, 50</td>
</tr>
<tr>
<td>phi0T, 50</td>
</tr>
<tr>
<td>phi0TT, 51</td>
</tr>
<tr>
<td>phir, 52</td>
</tr>
<tr>
<td>phirD, 53</td>
</tr>
<tr>
<td>phirDD, 54</td>
</tr>
<tr>
<td>phirDT, 55</td>
</tr>
<tr>
<td>phirT, 56</td>
</tr>
<tr>
<td>phirTT, 57</td>
</tr>
<tr>
<td>pMeltT, 58</td>
</tr>
<tr>
<td>PrandtTD, 59</td>
</tr>
<tr>
<td>pSatD, 60</td>
</tr>
<tr>
<td>pSats, 61</td>
</tr>
</tbody>
</table>
INDEX

pSatT, 61
pTD, 62
pTr, 63

Rwater, 64

satTabhT, 64
satTabp, 65
satTabpT, 66
satTabT, 67
satTabTp, 68
satTabvp, 69
satTabvT, 70
sCrit, 71
sfT, 71
sfTr, 72
sgT, 73
sgTr, 73
SigmaT, 74
sph, 75
spTcteTab, 76
sTD, 77
sTp, 78
sTpcteTab, 79

TCrit, 80
TDh, 80
TDp, 81
TDs, 82
ThrcTD, 83
Ths, 84
Tph, 85
Tps, 86
TSatD, 87
TSatp, 88
TSats, 88
TTr, 89

ufT, 90
ugT, 90
uTD, 91
uTp, 92

ViscTD, 93
Vp, 94
vTp, 94

wfT, 95
wgT, 96
wTD, 97

wTp, 98
ZTD, 99