

Introduction

This program is designed for the calculation of the thermodynamic properties of the water and steam, based on “IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam”. VaporHp is compiled as a library and is designed to work in the Hp49G/G+ calculators, was programmed in a 40% in Machine language and a 60% in SystemRpl. Unfortunately this version only works correctly installing it in “port 0”, in the case of installing it in another port, the program will not allow that it is executed.

Allowable Ranges

The allowed ranges are those that are in Figure 1. As it is possible to be observed is divided in five different ranges.

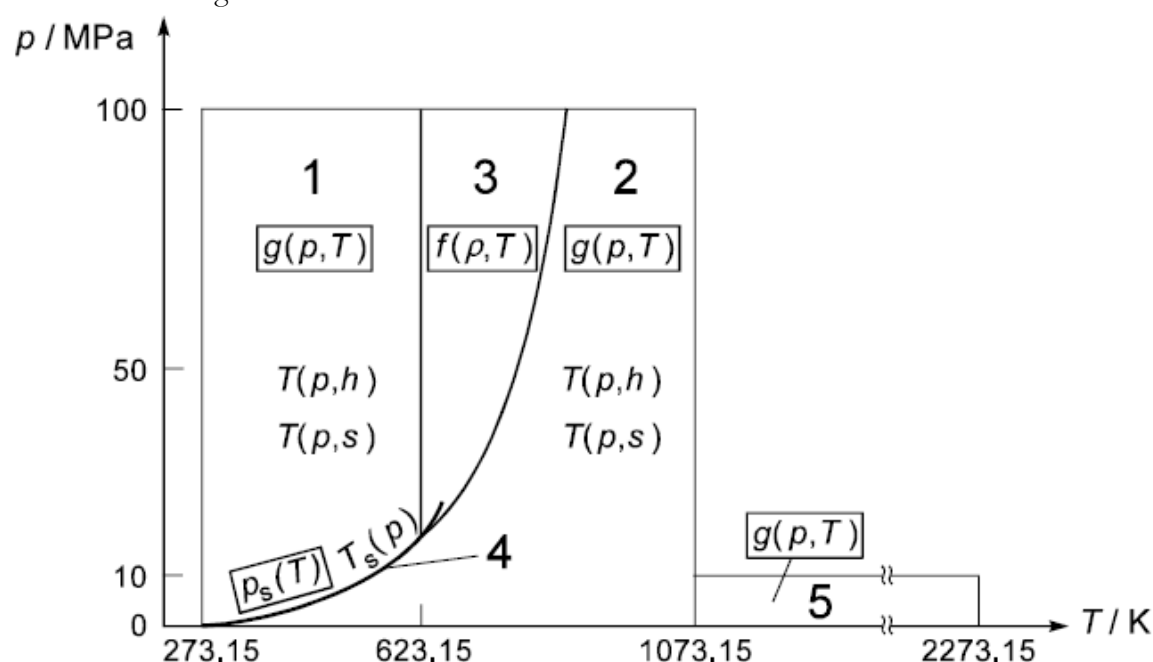


Figure 1 Regions and equations of IAPWS-IF97-Source “Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam”

Combination of allowable property

The calculation of the thermodynamic properties of the water and steam is made from two known conditions, one of which always it must be or the Pressure or the Temperature, in the case that omits one of these it will show an error message. Each region has an equation for the direct calculation based on two properties of the following form:

- Region 1 based on the Pressure and Temperature.
- Region 2 based on the Pressure and Temperature.
- Region 3 based on the Density and Temperature.
- Region 4 based on the Pressure or Temperature and the Quality.
- Region 5 based on the Pressure and Temperature.

In the case which they do not correspond with these properties, the program will make an iterative procedure until it obtain the solution.

Allowable units.

The units accepted by the program are showed on table 1.

Table 1. allowable units for properties

PROPERTY	ALLOWABLE UNITS
P: Pressure	<i>bar - psi - Mpa - atm - torr - mmHg - inHg - inH₂O - Pa - kPa</i>
T: Temperature	<i>°C - °F - K - °R</i>
v: Specific volume	$\frac{m^3}{kg} - \frac{ft^3}{lb} - \frac{cm^3}{kg} - \frac{in^3}{lb} - \frac{l}{kg} - \frac{gal}{lb}$
u: Internal energy	$\frac{kJ}{kg} - \frac{Btu}{lb} - \frac{cal}{g}$
h: Enthalpy	$\frac{kJ}{kg} - \frac{Btu}{lb} - \frac{cal}{g}$
s: Entropy	$\frac{kJ}{kg \cdot K} - \frac{Btu}{lb \cdot ^\circ R} - \frac{cal}{g \cdot K}$
x: Quality	-

Installation

- Download the file onto your calculator and put the content on the stack.
- Type the number of the port in which you want to store the library in. (should be 0)
- Press STO to store the library in that port.
- press ON-C, to finish installation of the library.
- Purge the variable containing the library.

Examples

- Superheated steam at 700 psi and 680°F is expanded at constant entropy to 140 psi. What is the final enthalpy?



Enter 700 and select psi as unit.

```

VaporHP - V0.9
* P: 700.      psi
  T: 680.      °F
  V: 5.53101212422E-2 m³/kg
  U: 2832.66101972 kJ/kg
  H: 3099.605923 kJ/kg
  S: 6.51461356882 kJ/kg·K
  X: "SUPERHEATED" Reg: 2.
Unit of Temperature?
[CHOOS] [CANCL] [OK]
    
```

Enter 680 and select °F as unit.

```

VaporHP - V0.9
* P: 700.      psi
  T: 680.      °F
  V: 5.53101212422E-2 m³/kg
  U: 2832.66101972 kJ/kg
  H: 3099.605923 kJ/kg
  S: 6.51461356882 kJ/kg·K
  X: "SUPERHEATED" Reg: 2.
Entropy?
[EDIT] [CANCL] [OK]
    
```

Select the field entropy and press enter

```

VaporHP - V0.9
* P: 700.      psi
  T: 680.      °F
  V: 5.53101212422E-2 m³/kg
  U: 2832.66101972 kJ/kg
  H: 3099.605923 kJ/kg
  * S: 6.51461356882 kJ/kg·K
  X: "SUPERHEATED" Reg: 2.
Entropy?
[EDIT] [CANCL] [OK]
    
```

The field entropy is selected. A mark will appear by it.

```

VaporHP - V0.9
* P: 700.      psi
  T: 680.      °F
  V: 5.53101212422E-2 m³/kg
  U: 2832.66101972 kJ/kg
  H: 3099.605923 kJ/kg
  * S: 6.51461356882 kJ/kg·K
  X: "SUPERHEATED" Reg: 2.
Pressure?
[EDIT] [CANCL] [OK]
    
```

Select again the field pressure

```

VaporHP - V0.9
* P: 140.      psi
  T: 353.039290776 °F
  V: .197324117283 m³/kg
  U: 2548.02345181 kJ/kg
  H: 2738.49371736 kJ/kg
  * S: 6.51461356882 kJ/kg·K
  X: .981546126533 Reg: 4.
Unit of Pressure?
[CHOOS] [CANCL] [OK]
    
```

Enter 140 and select units as psi

```

VaporHP - V0.9
* P: 140.      psi
  T: 353.039290776 °F
  V: .197324117283 m³/kg
  U: 2548.02345181 kJ/kg
  H: 1177.3403772 Btu/lb
  * S: 6.51461356882 kJ/kg·K
  X: .981546126533 Reg: 4.
Unit of Enthalpy?
[CHOOS] [CANCL] [OK]
    
```

Change the units

The final enthalpy is $1177.34 \frac{kJ}{kg}$

- What are the specific volume, enthalpy, and entropy of steam having a quality of 90% at 400 psi?

```
VaporHP - V0.9
* P: 400.          psi
T:                °C
V:                m^3/kg
U:                kJ/kg
H:                kJ/kg
S:                kJ/kg·K
X:                Reg:
Unit of Pressure?
[CHOOS] [CANCL] [OK]
```

Select the field pressure and enter 400 psi.

```
VaporHP - V0.9
* P: 400.          psi
T:                °C
V:                m^3/kg
U:                kJ/kg
H:                kJ/kg
S:                kJ/kg·K
X:                Reg:
Quality?
[EDIT] [CANCL] [OK]
```

Select the field quality, x.

```
VaporHP - V0.9
* P: 400.          psi
T: 229.237128985  °C
V: 6.53851890986E-2 m^3/kg
U: 2440.96357822  kJ/kg
H: 2621.29558198  kJ/kg
S: 5.85692501707  kJ/kg·K
X: .9             Reg: 4.
Pressure?
[EDIT] [CANCL] [OK]
```

Enter 0.9 on the field quality.

```
VaporHP - V0.9
* P: 400.          psi
T: 229.237128985  °C
V: 1.04737025678  ft^3/lb
U: 1049.42802159  Btu/lb
H: 1126.95424849  Btu/lb
S: 1.39890250718  Btu/lb·°R
X: .9             Reg: 4.
Unit of Entropy?
[CHOOS] [CANCL] [OK]
```

Change the units.

$$v = 1.0474 \frac{ft^3}{lb}, h = 1126.9542 \frac{Btu}{lb}, s = 1.3989 \frac{Btu}{lb \cdot ^\circ R}$$

Command reference

P T →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	P: Pressure	<i>bar</i>	Real
: 1 :	T: Temperature	<i>°C</i>	Real
P T →			
: 7 :	P: Pressure	<i>bar</i>	Real
: 6 :	T: Temperature	<i>°C</i>	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

P v →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	P: Pressure	<i>bar</i>	Real
: 1 :	v: Specific volume	$\frac{m^3}{kg}$	Real
P v →			
: 7 :	P: Pressure	<i>bar</i>	Real
: 6 :	T: Temperature	<i>°C</i>	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

P u →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	P: Pressure	<i>bar</i>	Real
: 1 :	u: Internal energy	$\frac{kJ}{kg}$	Real
P u →			
: 7 :	P: Pressure	<i>bar</i>	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

P h →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	P: Pressure	<i>bar</i>	Real
: 1 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
P h →			
: 7 :	P: Pressure	<i>bar</i>	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

P s →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	P: Pressure	<i>bar</i>	Real
: 1 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
P s →			
: 7 :	P: Pressure	<i>bar</i>	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

P x →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	P: Pressure	<i>bar</i>	Real
: 1 :	x: Quality	-	Real
P x →			
: 7 :	P: Pressure	<i>bar</i>	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	h: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real

T v →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	T: Temperature	$^{\circ}C$	Real
: 1 :	v: Specific volume	$\frac{m^3}{kg}$	Real
T v →			
: 7 :	P: Pressure	bar	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

T u →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	T: Temperature	$^{\circ}C$	Real
: 1 :	u: Internal energy	$\frac{kJ}{kg}$	Real
T u →			
: 7 :	P: Pressure	bar	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

T h →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	T: Temperature	$^{\circ}C$	Real
: 1 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
T h →			
: 7 :	P: Pressure	bar	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

T s →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	T: Temperature	$^{\circ}C$	Real
: 1 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
T s →			
: 7 :	P: Pressure	bar	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real/String

T x →

LEVEL	PROPERTY	UNITS	DATA TYPE
: 2 :	T: Temperature	$^{\circ}C$	Real
: 1 :	x: Quality	-	Real
T x →			
: 7 :	P: Pressure	bar	Real
: 6 :	T: Temperature	$^{\circ}C$	Real
: 5 :	v: Specific volume	$\frac{m^3}{kg}$	Real
: 4 :	u: Internal energy	$\frac{kJ}{kg}$	Real
: 3 :	h: Enthalpy	$\frac{kJ}{kg}$	Real
: 2 :	s: Entropy	$\frac{kJ}{kg \cdot K}$	Real
: 1 :	x: Quality	-	Real

Program characteristics

Calculator: Hp49G/G+
 # Library: 1199
 Checksum: 4F69 h
 Bytes: 37067.5

Contact

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