

# Property Library for Helium

## LibHe

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## Property Functions

Functional Dependence	Function Name	Call from Fortran program	Property or Function	Unit of the result
$a = f(p, t, x)$	a_ptx_He	APTXXHE(P,T,X)	Thermal diffusivity	m <sup>2</sup> /s
$c_p = f(p, t, x)$	cp_ptx_He	CPPTXHE(P,T,X)	Specific isobaric heat capacity	kJ/(kg K)
$c_v = f(p, t, x)$	cp_ptx_He	CVPTXHE(P,T,X)	Specific isochoric heat capacity	kJ/(kg K)
$\eta = f(p, t, x)$	eta_ptx_He	ETAPTXXHE(P,T,X)	Dynamic viscosity	Pa s
$h = f(p, t, x)$	h_ptx_He	HPTXXHE(P,T,X)	Specific enthalpy	kJ/kg
$\kappa = f(p, t, x)$	kappa_ptx_He	KAPPTXXHE(P,T,X)	Isentropic exponent	-
$\lambda = f(p, t, x)$	lambda_ptx_He	LAMPTXXHE(P,T,X)	Thermal conductivity	W/(m K)
$\mu = f(p, t, x)$	mue_ptx_He	MUEPTXXHE(P,T,X)	Joule-Thomson Coefficient	K/bar
$\nu = f(p, t, x)$	ny_ptx_He	NYPTXXHE(P,T,X)	Kinematic viscosity	m <sup>2</sup> /s
$p_{\text{mel}} = f(t)$	pmel_t_He	PMELTHE(T)	Melting pressure from temperature	bar
$p_s = f(t)$	ps_t_He	PSTHE(T)	Vapor pressure from temperature	bar
$Pr = f(p, t, x)$	Pr_ptx_He	PRPTXXHE(P,T,X)	Prandtl-Number	-
$\rho = f(p, t, x)$	rho_ptx_He	RHOPTXXHE(P,T,X)	Density	kg/m <sup>3</sup>
$s = f(p, t, x)$	s_ptx_He	SPTXXHE(P,T,X)	Specific entropy	kJ/(kg K)
$t = f(p, h)$	t_ph_He	TPHHE(P,H)	Backward function: Temperature from pressure and enthalpy	°C
$t = f(p, s)$	t_ps_He	TPSHE(P,S)	Backward function: Temperature from pressure and entropy	°C
$t_{\text{mel}} = f(p)$	tmel_p_He	TMELPHE(P)	Melting temperature from pressure	°C
$t_s = f(p)$	ts_p_He	TSPHE(P)	Saturation temperature from pressure	°C
$v = f(p, t, x)$	v_ptx_He	VPTXXHE(P,T,X)	Specific volume	m <sup>3</sup> /kg
$w = f(p, t, x)$	w_ptx_He	WPTXXHE(P,T,X)	Isentropic speed of sound	m/s <sup>2</sup>
$x = f(p, h)$	x_ph_He	XPHHE(P,H)	Backward function: Vapor fraction from pressure and enthalpy	kg/kg
$x = f(p, s)$	x_ps_He	XPSHE(P,S)	Backward function: Vapor fraction from pressure and entropy	kg/kg

**Units:**                     $t$  in °C  
                                   $p$  in bar  
                                   $x$  in (kg of saturated steam)/(kg wet steam)

### Details on the vapor fraction $x$

The wet steam region is calculated automatically by the subprograms. For this purpose the following fixed details on the vapor fraction  $x$  are to be considered:

If the state point to be calculated is located in the single-phase region (liquid or superheated steam)  $x = -1$  must be entered as a pro-forma value. Here the backward functions will also result in  $x = -1$ .

If the state point to be calculated is located in the two phase region (wet steam), either the value 0 or 1 has to be entered for  $x$  ( $x = 0$  for boiling liquid,  $x = 1$  for saturated steam). Here the backward functions will result in  $x = 0$  or  $x = 1$ .

If the state point to be calculated is located in the two phase region, it is adequate to enter either the given value for  $t$  and  $p = -1000$ , or the given value for  $p$  and  $t = -1000$ , plus the value for  $x$  between 0 and 1. When calculating wet steam and  $p$  and  $t$  and  $x$  are entered as given values, the program will consider  $p$  and  $t$  to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the quantity of the chosen function to be calculated results in  $-1000$ .

Wet steam region:

Temperature range from  $t_t = -270.9732$  °C bis  $t_c = -267.9485$  °C

Pressure range from  $p_t = 0.04856476$  bar bis  $p_c = 2.274751$  bar

### Values on the triple point and on the critical point

By means of McCarty's equation of state the exact values of the critical and the triple point have been calculated as follows:

Critical point:             $t_c = -267.9485$  °C  
                                   $p_c = 2.27475064473337$  bar

Triple point:              $t_t = -270.9732$  °C  
                                   $p_t = 0.048564759143234$  bar

**Range of validity**

Temperature range: from  $t_{\text{mel}}(p)$  to 1226.85 °C at  $p \geq p_t = 0.04856476$  bar  
and  
from  $t_t = -270.9732$  °C to 1226.85 °C at  $p < p_t = 0.04856476$  bar

Pressure range: from 0.001 bar to 1000 bar

**Reference state**

$h = h' = 0$  and  $s = s' = 0$

at  $p = p_n = 1.01325$  bar (Standard atmospheric pressure)

and  $t = t_s(p_n) = -268.92$  °C

**Hint!**

If the input values are located outside the range of validity, the result of the calculated function will always be -1000. Please find more exact details on every function and its corresponding range of validity in the enclosed program documentation in Chapter 3.