KCE
ThermoFluidProperties

Property Library for Humid Gas Mixtures

LibHuGas

Property Functions

Function	Function Name	Call of Fortran Program	Property or Function	Unit
$a = f(p,t)$	a_ptcomp_HuGas	= a_pTcomp_HuGas(p,T,type,comp)	Thermal diffusivity	m^2/s
$c_p = f(h,s)$	cp_hscomp_HuGas	= cp_hscomp_HuGas(h,s,type,comp)	Backward function: Specific isobaric heat capacity from enthalpy and entropy	$kJ/(kg \cdot K)$
$c_p = f(p,h)$	cp_phcomp_HuGas	= cp_phcomp_HuGas(p,h,type,comp)	Backward function: Specific isobaric heat capacity from pressure and enthalpy	$kJ/(kg \cdot K)$
$c_p = f(p,s)$	cp_pscomp_HuGas	= cp_pscomp_HuGas(p,s,type,comp)	Backward function: Specific isobaric heat capacity from pressure and entropy	$kJ/(kg \cdot K)$
$c_p = f(p,t)$	cp_ptcomp_HuGas	= cp_pTcomp_HuGas(p,T,type,comp)	Specific isobaric heat capacity	$kJ/(kg \cdot K)$
$c_p = f(t,s)$	cp_tscomp_HuGas	= cp_Tscomp_HuGas(T,s,type,comp)	Backward function: Specific isobaric heat capacity from temperature and entropy	$kJ/(kg \cdot K)$
$c_v = f(p,t)$	cv_ptcomp_HuGas	= cv_pTcomp_HuGas(p,T,type,comp)	Specific isochoric heat capacity	$kJ/(kg \cdot K)$
$\eta = f(p,t)$	Eta_ptcomp_HuGas	= eta_pTcomp_HuGas(p,T,type,comp)	Dynamic viscosity	$Pa \cdot s$
$h = f(p,s)$	h_pscomp_HuGas	= h_pscomp_HuGas(p,s,type,comp)	Backward function: Specific enthalpy from pressure and entropy	kJ/kg
$h = f(p,t)$	h_ptcomp_HuGas	= h_pTcomp_HuGas(p,T,type,comp)	Specific Enthalpy	kJ/kg
$h = f(t,s)$	h_tscomp_HuGas	= h_Tscomp_HuGas(T,s,type,comp)	Backward function: Specific enthalpy from temperature and entropy	kJ/kg
$\kappa = f(p,s)$	Kappa_pscomp_HuGas	= kappa_pscomp_HuGas(p,s,type,comp)	Backward function: Isentropic exponent from pressure and entropy	-

Function	Function Name	Call of Fortran Program	Property or Function	Unit
$\kappa = \mathrm{f}(p,t)$	Kappa_ptcomp_HuGas	= kappa_pTcomp_HuGas(p,T,type,comp)	Isentropic exponent	-
$\lambda = \mathrm{f}(p,t)$	Lambda_ptcomp_HuGas	= lambda_pTcomp_HuGas(p,T,type,comp)	Thermal conductivity	$\mathrm{W/(m \cdot K)}$
M	M_comp_HuGas	= M_comp_HuGas(type,comp)	Molar mass	kg/kmol
$\nu = \mathrm{f}(p,t)$	Ny_ptcomp_HuGas	= ny_pTcomp_HuGas(p,T,type,comp)	Kinematic viscosity	$\mathrm{m^2/s}$
$p = \mathrm{f}(h,s)$	p_hscomp_HuGas	= p_hscomp_HuGas(h,s,type,comp)	Backward function: Pressure from enthalpy and entropy	bar
$p = \mathrm{f}(t,s)$	p_tscomp_HuGas	= p_Tscomp_HuGas(T,s,type,comp)	Backward function: Pressure from temperature and entropy	bar
$p_{\mathrm{dsat}} = \mathrm{f}(p,t)$	pdsat_pt_HuGas	= pdsat_pT_HuGas(p,T)	Saturation pressure of water in mixture	bar
$\varphi = \mathrm{f}(p,t)$	Phi_ptcomp_HuGas	= phi_pTcomp_HuGas(p,T,type,comp)	Relative humidity	%
$\mathrm{Pr} = \mathrm{f}(p,t)$	Pr_ptcomp_HuGas	= Pr_pTcomp_HuGas(p,T,type,comp)	Prandtl number	-
$\psi_{\mathrm{wl}} = \mathrm{f}(p,t)$	Psiwl_ptcomp_HuGas	= psiwl_pTcomp_HuGas(p,T,type,comp)	Mole fraction of water (liquid)	kmol/kmol
$\psi_{\mathrm{wsat}} = \mathrm{f}(p,t)$	Psiwsat_ptcomp_HuGas	= psiwsat_pTcomp_HuGas(p,T,type,comp)	Mole fraction of water of the saturated gas	kmol/kmol
R	R_comp_HuGas	= R_comp_HuGas(type,comp)	Gas constant	$\mathrm{kJ/(kg \cdot K)}$
Region = f(h,s)	Region_hscomp_HuGas	= Region_hscomp_HuGas(h,s,type,comp)	Region from given enthalpy and entropy	-
Region = f(p,h)	Region_phcomp_HuGas	= Region_phcomp_HuGas(p,h,type,comp)	Region from given pressure and enthalpy	-
Region = f(p,s)	Region_pscomp_HuGas	= Region_pscomp_HuGas(p,s,type,comp)	Region from given pressure and entropy	-

Function	Function Name	Call of Fortran Program	Property or Function	Unit
Region = f(*p*,*t*)	Region_ptcomp_HuGas	= Region_pTcomp_HuGas(p,T,type,comp)	Region from given pressure and temperature	-
Region = f(*t*,*s*)	Region_tscomp_HuGas	= Region_Tscomp_HuGas(T,s,type,comp)	Region from given temperature and entropy	-
$\rho = f(p,t)$	Rho_ptcomp_HuGas	= rho_pTcomp_HuGas(p,T,type,comp)	Density	kg/m^3
$s = f(p,h)$	s_phcomp_HuGas	= s_phcomp_HuGas(p,h,type,comp)	Backward function: Specific entropy from pressure and specific enthalpy	$kJ/(kg \cdot K)$
$s = f(p,t)$	s_ptcomp_HuGas	= s_pTcomp_HuGas(p,T,type,comp)	Entropy	$kJ/(kg \cdot K)$
$\sigma_w = f(t)$	Sigmaw_t_HuGas	= sigmaw_T_HuGas(T)	Surface tension of water	N/m
$t = f(h,s)$	t_hscomp_HuGas	= T_hscomp_HuGas(h,s,type,comp)	Backward function: Temperature from enthalpy and entropy	°C
$t = f(p,h)$	t_phcomp_HuGas	= T_phcomp_HuGas(p,h,type,comp)	Backward function: Temperature from pressure and enthalpy	°C
$t = f(p,s)$	t_pscomp_HuGas	= T_pscomp_HuGas(p,s,type,comp)	Backward function: Temperature from pressure and entropy	°C
$t_{w,dew} = f(p)$	twdew_pcomp_HuGas	= Twdew_pcomp_HuGas(p,type,comp)	Dew point temperature of water	°C
$u = f(p,t)$	u_ptcomp_HuGas	= u_pTcomp_HuGas(p,T,type,comp)	Specific internal energy	kJ/kg
$v = f(h,s)$	v_hscomp_HuGas	= v_hscomp_HuGas(h,s,type,comp)	Backward function: Specific volume from enthalpy and entropy	m^3/kg

Function	Function Name	Call of Fortran Program	Property or Function	Unit
$v = \mathrm{f}(p,h)$	v_phcomp_HuGas	= v_phcomp_HuGas(p,h,type,comp)	Backward function: Specific volume from pressure and enthalpy	m^3/kg
$v = \mathrm{f}(p,s)$	v_pscomp_HuGas	= v_pscomp_HuGas(p,s,type,comp)	Backward function: Specific volume from pressure and entropy	m^3/kg
$v = \mathrm{f}(p,t)$	v_ptcomp_HuGas	= v_pTcomp_HuGas(p,T,type,comp)	Specific volume	m^3/kg
$v = \mathrm{f}(t,s)$	v_tscomp_HuGas	= v_Tscomp_HuGas(T,s,type,comp)	Backward function: Specific volume from temperature and entropy	m^3/kg
$w = \mathrm{f}(p,t)$	w_ptcomp_HuGas	= w_pTcomp_HuGas(p,T,type,comp)	Isentropic speed of sound	m/s
x_w	xw_comp_HuGas	= xw_comp_HuGas(type,comp)	Humidity ratio (Absolute humidity)	g_{water}/kg_{gas}

Parameter

p - Pressure *p* of mixture in bar
t - Temperature *t* in °C
type - Type of composition:
type = 0 for compostion in mole fractions
type = 1 for compostion in mass fractions
comp(1:8) - Mole or mass fractions of components

Parameter for using Fortran Functions of LibHuGas

p - Pressure *p* of mixture in bar
T - Temperature *t* in °C

For input of composition in mass fractions use the function set_comp_mass_HuGas or

For input of composition in mole fractions use the function set_comp_mol_HuGas.

This composition will be stored in a Common Block and will be used for all calculations after that.

This will continue to occur unless the composition is changed by calling set_comp_mol_HuGas or set_comp_mass_HuGas again.

In order to know what composition is stored, it can be called by

using get_comp_mass_HuGas or get_comp_mol_HuGas.

Range of Validity

Temperature: *t* = - 70 °C ... 3026.15 °C
Pressure of mixture: *p* = 0.01 bar ... 1000 bar

Mixture Components

Nr.	Symbol	Name of mixture component
0	Dummy	
1	Ar	Argon
2	Ne	Neon
3	N_2	Nitrogen
4	O_2	Oxygen
5	CO	Carbon Monoxide
6	CO_2	Carbon Dioxide
7	H_2O	Water
8	SO_2	Sulfur dioxide

Values of the Region Functions

Region	Description
0	Out of range of validity
1	Dry gas mixture
2	Unsaturated humid gas mixture
3	Liquid fog
4	Ice fog
5	Liquid-ice fog at 0.01 °C exactly
6	Pure liquid water
7	Pure water-wet steam
8	Pure steam
10	The CO2 in the gas mixture would be partly liquid. Calculation is terminated.
11	The SO2 in the gas mixture would be partly liquid. Calculation is terminated.

Reference States of LibHuGas

Fluid	t_0 [°C]	p_0 [bar]	h_0 [kJ/kg]	s_0 [kJ/(kg K)]	u_0 [kJ/kg]
Argon	0	1.01325	0	0	-56.79766
Neon	0	1.01325	0	0	-112.5436
Nitrogen	0	1.01325	0	0	-81.03459
Oxygen	0	1.01325	0	0	-70.90573
Carbon monoxide	0	1.01325	0	0	-81.08139
Carbon dioxide	0	1.01325	0	0	-51.25686
Water	0.01	0.00611657	$0.611872 \cdot 10^{-3}$	0	0
Sulfur dioxide	0	1.01325	0	0	-35.45001

Conversion to the Reference State of Water to t_0 = 0 °C

$h = h_{\mathrm{HuGas}} - \xi_{\mathrm{H_2O}} \cdot 2500.914579$ kJ/kg

$u = u_{\mathrm{HuGas}} - \xi_{\mathrm{H_2O}} \cdot 2500.914579$ kJ/kg

$s = s_{\mathrm{HuGas}} - \xi_{\mathrm{H_2O}} \cdot 9.155493408$ (kJ/kgK)

Conversion to the Reference States of the Publications

$z_{\mathrm{Publication}} = z_{\mathrm{LibHuGas}} + \Delta z$ where $z \equiv h,s,u$

Fluid	t_0 [°C]	p_0 [bar]	Δh [kJ/kg]	Δs [kJ/(kg K)]	Δu [kJ/kg]	Reference
Argon	25	1.01325	-13.23564	$-4.6203961 \cdot 10^{-2}$	-13.23564	[27]
Neon	0	1.01325	0	0	0	-
Nitrogen	25	1.01325	283.2331	6.744095	283.2331	[28]
Oxygen	25	1	-23.20175	$-8.448914 \cdot 10^{-2}$	-23.20175	[29]
Carbon monoxide	0	1.01325	0	0	0	-
Carbon dioxide	25	1.01325	-21.90979	$-7.564382 \cdot 10^{-2}$	-21.90979	[30]
Water	0.01	0.00611657	0	0	0	[31]
Sulfur dioxide	0	1.01325	0	0	0	-