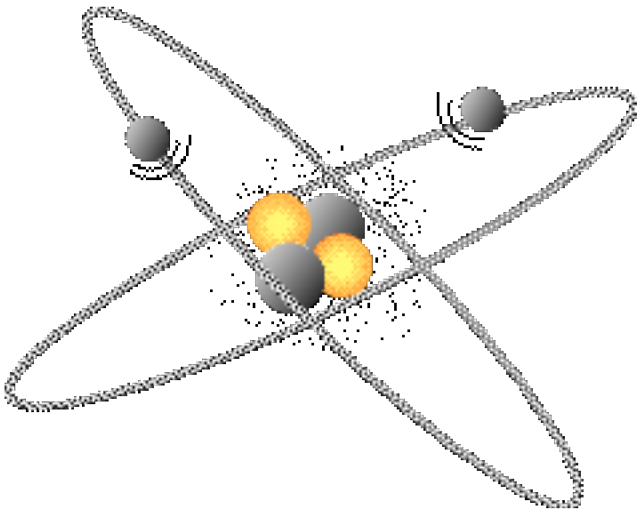
FLUIDS

Properties of fluid materials

Version 3.0
by CryoSoft

October 2002



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Introduction

Fluids is a package of routines computing Helium and Nitrogen properties as a function of Pressu***re in Pa and Temperature in K.*** The data have been generated using the Cryodata code HePak and GasPak as the smallest possible number of values over a not equally spaced Pressure-Temperature grid where they can be linearly interpolated at the requested (P,T). The data are given only after the melting ***t***emperature, special attention has been used for input values around the lambda and saturation curve, still, for physically discontinuous (e.g. density) or divergent (e.g. Cp) properties residual large errors are possible. The functions contained in the package, the property computed, its units and the call parameters are given in the table below. Remember that this package is intended for high speed and NOT for high accuracy (see later the typical accuracy achieved), as is requested by thermo-hydraulic simulation codes such as Gandalf. The list of the routines, their calling parameters and additional information is given below below. All properties are in the form of FORTRAN functions. They are accessed linking the **`fluids.a`** library.

Symbol list and physical units

Input variables

T	temperature	(K)
P	pressure	(Pa)

Output properties

K	conductivity	(W/m K)
□	density	(Kg/m^3)
H	enthalpy	(J/Kg)
S	entropy	(J/Kg K)
Grun	Gruneisen parameter	(-)
Cp	specific heat at constant pressure	(J/Kg K)
Cv	specific heat at constant volume	(J/Kg K)
SupFld	superfluid thermal conductivity	(W^3/m^5 K)
c	velocity of sound	(m/s)
Visc	viscosity	(Pa s)

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Data generation

For pressure values between 10^3 and 10^8 Pa a set of properties at different temperatures has been calculated, T ranging in the melting region as reported in the list. Below these ranges the extrema of the computed function are returned (i.e. no range checking and no error conditions), while above these the values of the perfect gas region are assumed. The data have been generated so that a linear interpolation in temperature (at constant pressure) and then in pressure will produce an error around the indicated aimed accuracy (see table below).

Helium

Within a band of ± 0.1 K around the saturation and lambda curves, a band of 2.0 K below the melting curve and again within around a box of ± 0.1 K and ± 2.5 10^4 Pa around the critical point these errors can grown considerably. In the perfect gas region the *true* value (perfect gas limit) is returned, having been fitted for conductivity and viscosity. The Gruneisen parameter has been fitted above 130 K, the viscosity above 50 K and the conductivity above 100 K. The SuperFluid Thermal Conductivity has been fitted over the whole range of temperature and it is not interpolated, outside the indicated region a value of 0 is returned.

property	T range [K]	Accuracy [%]	nr of data points in P	total nr of data points
K	2.3-1000	3	23	277
Cp	0.8-1000	2	54	3058
Cv	0.8-1000	2	20	689
□	0.8-1000	2	35	907
Grun	0.8-1000	2	50	2831
H	0.8-1000	2	25	643
S	0.8-1000	2	26	753
c	0.8-1000	2	19	319
Visc	1.2-1000	3	31	813
SupFld	superfluid region	8% of the maximum value		

Nitrogen

Within a band of ± 0.1 K around the saturation and lambda curves, a band of 2.0 K below the melting curve and again within around a box of ± 1 K and ± 2.5 10^5 Pa around the critical point these errors can grown considerably. In the perfect gas region a fitted value (perfect gas limit) is returned.

property	T range [K]	Accuracy [%]	nr of data points in P	total nr of data points
K	63.1489-2000	5	70	738
Cp	63.1489-2000	7	84	1606
Cv	63.1489-2000	7	20	202
□	63.1489-2000	5	44	432
Grun	63.1489-2000	5	40	432
H	63.1489-2000	2.5 10^3 (*)	63	674
S	63.1489-2000	5	10	54
c	63.1489-2000	5	35	349
Visc	63.1489-2000	5	112	952

(*) in [J/Kg]

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General Purpose Interface

For convenience in calling the various fluid properties we have defined a general purpose interface, consisting of functions that returns the desired property for a given fluid. Fluids are addressed via a name that is hard-coded in the general purpose interface. The general purpose interface functions are available in the **`fluids.a`** library (as the specific fluid functions). The following table gives a summary of the available functions. We refer to the previous sections for details on the calling parameters, units and ranges of validity. Properties that are not defined for some fluids are returned as zero (e.g. superfluid thermal conductivity for nitrogen).

property	Function name
ρ	`FluidDensity(Name,P,T)`
Cp	`FluidCp(Name,P,T)`
Cv	`FluidCv(Name,P,T)`
Grun	`FluidGruneisen(Name,P,T)`
K	`FluidConductivity(Name,P,T)`
c	`FluidSound(Name,P,T)`
Visc	`FluidViscosity(Name,P,T)`
S	`FluidEntropy(Name,P,T)`
H	`FluidEnthalpy(Name,P,T)`
SupFld	`SuperFluid(Name,P,T)`

saturation line	Function name
T	`FluidTSaturation(Name,P)`
P	`FluidPSaturation(Name,T)`

melting line	Function name
T	`FluidTMelting(Name,P)`
P	`FluidPMelting(Name,T)`

λ line	Function name
T	`FluidTLambda(Name,P)`
P	`FluidPLambda(Name,T)`

inverse fitting property	Function name
P(ρ,T)	`FluidPofRhoandT(Name,Rho,T)`
T(P,H)	`FluidTofPhoandH(Name,P,H)`
T(P,S)	`FluidTofPhoandS(Name,P,S)`

The fluid names are FORTRAN character strings as given in the following table.

Fluid	Name
Helium	`'Helium'`
Nitrogen	`'Nitrogen'`

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