SOLVAY FLUOR

SOLKANE® - INFORMATION SERVICE

Solkane®134a Thermodynamics

SOLVAY FLUOR GMBH

Technical Service - Refrigerants -

PRODUCT BULLETIN NO.: T/09.04/01/E

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1 Units and Symbols

Symbol	Unit	Meaning/Definition
A, B	[-]	parameters of the Wagner equation
C	[-]	parameter of the equation for density of boiling liquid
D	[kJ/(kg K)]	parameter of the equation for specific heat capacity in an ideal gas state
E, F, G	[-]	parameter of the Martin-Hou equation
H	[Pa s /K]	parameter of the equation for dynamic viscosity
J	[W/(m K)]	parameter of the equation for thermal conductivity of the saturated liquid
L	[W/(m K)]	parameter of the equation for thermal conductivity of the saturated vapour
K	[N/(m K)]	parameter of the equation for surface tension
M	[kJ/(kg K)]	parameter of the equation for specific heat capacity of the saturated liquid
R	[bar m^3/(kg K)]	gas constant
b	[m^3/kg)]	parameter of the Martin-Hou equation
c	[kJ/(kg K)]	specific heat capacity
e	[kJ/kg]	specific exergy
h	[kJ/kg]	specific enthalpy
k	[-]	parameter of the Martin-Hou equation
p	[bar]	pressure
r	[kJ/kg]	enthalpy of vaporization
s	[kJ/(kg K)]	specific entropy
t	[°C]	temperature
T	[K]	temperature
v	[m^3/kg]	specific volume
η	[Pa s]	dynamic viscosity
λ	[W/(m K)]	thermal conductivity
ρ	[kg/m^3]	density
σ	[N/m]	surface tension

Indices

´	liquid
´´	vapour
c	critical value
R	reduced value
i	run index
u	ambient conditions
p	isobar
v	isochor
0	ideal gas

2 Introduction

The refrigerant Solkane®134a is a long term replacement for the chlorofluorocarbon (CFC) R12. Solkane®134a (CF_3-CH_2F) has the chemical designation 1,1,1,2-tetrafluoroethane and is an isomer of R134 (see section 2.1). The physical and thermodynamic properties of Solkane®134a are very similar to those of R12. In the AFEAS programme (Alternative Fluorocarbon Environmental Acceptability Study), a study jointly financed by a series of different companies, the influence of various partly-halogenated fluorohydrocarbons (HFC) on the environment was assessed - among others Solkane®134a. According to the results, Solkane 134a has no ozone depletion potential (ODP) and has around 90% less direct influence on the greenhouse effect than R12.

Between 1987 and 1992, Solkane®134a was subjected to an intensive toxicological research programme, which was carried out within the scope of PAFT (Programme for Alternative Fluorocarbon Toxicity Testing). Based on the results, Solkane®134a was toxicologically classified as being similar to R12. The TLV for an eight hour working day is estimated as 1000 ppm. The environmental tolerance and handling of Solkane refrigerants is described in the environmental compatibility brochure[1] and material safety data sheet[1].

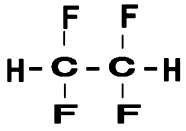
Solkane®134a is non-combustible, demonstrates good material compatibility and possesses good thermal and chemical stability.

[1] Order by fax : 0511/857-2178

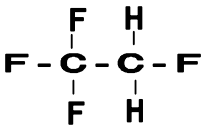
2.1 Definition of Isomers

A few refrigerants have an additional lower case letter next to the R-number in accordance with the ASHRAE nomenclature (eg R134a = 1,1,1,2-tetrafluoroethane). This letter serves to distinguish between the different isomers. Two types of isomerism among refrigerants are significant: position isomerism and chain isomerism.

Examples of position isomerism are R134a (1,1,1,2-tetrafluoroethane) and R134 (1,1,2,2-tetrafluoroethane). Refrigerant R134, because of its physical properties, is not a suitable substitute for R12. The boiling points of R134a and R134 are -26.3°C and -19.8 C respectively. The difference is due to the position of the four fluorine (F) and two hydrogen (H) atoms on the carbon (C) centres. The isomers all have the same ASHRAE number. The letters a, b, c, etc. are appended to the number to indicate the degree of asymmetry. (c would be more asymmetrical than b etc.) The most symmetrical isomers (eg R134) are not indicated by a lower case letter.



R 134

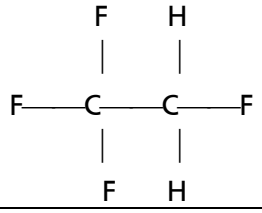


R 134a

The difference in the position of the fluorine and hydrogen atoms on the two carbon atom centres can be seen in the structural formulae above.

3 Thermophysical Values

3.1 Physical Data

Chemical name	[-]	1,1,1,2-tetrafluoroethane
Chemical formula	[-]	CH_2FCF_3
Chemical structure	[-]	
CAS No.	[-]	811-97-2
Molecular weight	[kg/kmol]	102.0
Boiling point[1]	[°C]	-26.06
Freezing point[1]	[°C]	-101
Critical temperature	[°C]	101.1
Critical pressure	[bar]	40.59
Saturated liquid density[2]	[kg/m³]	1206
Saturated vapour density[1,2]	[kg/m³]	32.35
Vapour pressure[1,2]	[bar]	6.654
Enthalpy of vaporization[2]	[kJ/kg]	177.5
Liquid thermal conductivity[2]	[W/m K]	83.51E-3
Vapour thermal conductivity[2]	[W/m K]	13.97E-3
Surface tension of liquid[2]	[N/m]	8.02E-3
Specific heat capacity of liquid[2]	[kJ/(kgK)]	1.425
Specific heat capacity of vapour[1,2]	[kJ/(kgK)]	1.011
Liquid viscosity[2]	[Pa s]	0.1974E-3
Saturated vapour viscocity[2]	[Pa s]	0.01193E-3
Flammability limit in air[1]	[Vol.-%]	none[3]

[1] at 1.013 bar
[2] at 25°C
[3] according to DIN 51649 and UL 2128

3.2 Basis of Thermodynamic Calculation

The thermodynamic calculation equations have been adapted to ISO/DIS 17584, as at 12/2003. They fulfil this standard with the exception of the thermal capacities in a saturated state of $0.60 < T_R < 0.96$ and in an overheated state of 0.05MPa < p < 2.5MPa and T_{max} = 500K.

The Wagner equation

$$\ln p_R = \left(A_1(1-T_R) + A_2(1-T_R)^{B_1} + A_3(1-T_R)^{B_2} + A_4(1-T_R)^{B_3} + A_5(1-T_R)^{B_4} + A_6\right)/T_R \quad (1)$$

where $T_R = \frac{T}{T_c}$ and $p_R = \frac{p}{p_c}$

was chosen to describe the vapour pressure. The constants and values for the critical pressure p_C and the critical pressure T_C are as follows:

A_1	[-]	-7.7069E+00	B_1	[-]	1.5158
A_2	[-]	2.4932E+00	B_2	[-]	1.9907
A_3	[-]	-2.9212E+00	B_3	[-]	4.3798
A_4	[-]	-3.8684E+00	B_4	[-]	1.7461
A_5	[-]	4.6898E-01	T_c	[K]	374.21
A_6	[-]	-8.3360E-05	p_c	[bar]	40.59

The density of the boiling liquid is described by the equation

$$\rho'_R = 1 + C_1(1-T_R)^{1/3} + C_2(1-T_R)^{2/3} + C_3(1-T_R) + C_4(1-T_R)^{4/3} \quad (2)$$

where $\rho'_R = \frac{\rho'}{\rho_c}$

The constants and the value for the critical density are:

C_1	[-]	1.732277	C_4	[-]	1.056144
C_2	[-]	1.348322	ρ_c	[kg/m³]	511.90
C_3	[-]	-1.251446			

The specific heat capacity under ideal gas conditions is represented by the equation

$$c_p{}^0 = D_1 + D_2T + D_3T^2 + D_4T^3 + D_5/T \quad (3)$$

The coefficients are:

D_1	[kJ/(kg K)]	2.49202E-01	D_3	[kJ/(kg K³)]	-1.65650E-06
D_2	[kJ/(kg K²)]	2.45251E-03	D_4	[kJ/kg]	8.91048E-10
D_5	[kJ/kg]	-6.96764E+00			

The equation of state according to Martin-Hou is

$$p = \frac{RT}{z} + \frac{E_1 + F_1 T + G_1 e^{-kT_R}}{z^2} + \frac{E_2 + F_2 T + G_2 e^{-kT_R}}{z^3} + \frac{E_3}{z^4} + \frac{E_4 + F_4 T + G_4 e^{-kT_R}}{z^5} \qquad (4)$$

where $z = v - b$

and is a good representation of the pvT relationship for Solkane 134a. The coefficients of the equation are:

E_1	[-]	-1.40114E-03	F_2	[-]	-2.78860E-09
E_2	[-]	2.19433E-06	F_4	[-]	1.02574E-14
E_3	[-]	-6.73580E-10	G_1	[-]	-2.69555E-02
E_4	[-]	-4.66800E-12	G_2	[-]	2.67772E-05
F_1	[-]	1.63714E-06	G_4	[-]	1.69513E-10
b	[m³/kg]	2.99628E-04	K	[-]	5.475
R	[bar m³/(kg K)]	8.14892E-04			

The equation for specific heat capacity under ideal gas conditions (3) and the thermal equation of state (4) form the basis of the specific enthalpy and entropy calculation. Applying generally valid thermodynamic relationships the equation is transformed to

$$h = h_0 + (pv - RT) + D_1 T + D_2 \frac{T^2}{2} + D_3 \frac{T^3}{3} + D_4 \ln T + \frac{E_1}{z} + \frac{E_2}{2z^2} + \frac{E_3}{3z^3} + \frac{E_4}{4z^4} + e^{-k \cdot T_R} \cdot (1 + k \cdot T_R) \cdot \left(\frac{G_1}{z} + \frac{G_2}{2z^2} + \frac{G_4}{4z^4} \right) \qquad (5)$$

and

$$s = s_0 + R \ln\left(\frac{zp_1}{RT}\right) + D_1 \cdot \ln T + D_2 T + D_3 \frac{T^2}{2} - \frac{D_4}{T} - \left(\frac{F_1}{z} + \frac{F_2}{2z^2} + \frac{F_4}{4z^4} \right) + \frac{k}{T_c} e^{-k \cdot T_R} \left(\frac{G_1}{z} + \frac{G_2}{2z^2} + \frac{G_4}{4z^4} \right) \qquad (6)$$

where $z = v - b$ and p_1 = 1.013 bar.

The Clausius - Clapeyron equation was used to generate thermodynamic data in the wet vapour range.

$$\frac{dp}{dT} = \frac{1}{T} \cdot \frac{h'' - h'}{v'' - v'} \qquad (7)$$

Rearranging equation (7) gives

$$h' = h'' - \frac{dp}{dT} \cdot T \cdot (v'' - v') \qquad (8)$$

The intergration constants h_0 und s_0 are found by letting

$h'_{(t = 0\ °C)}$= 200.0 kJ/kg
$s'_{(t = 0\ °C)}$= 1.000 kJ/(kgK)

to be

h_0 = 295.57 kJ/kg
s_0 = -0.2037 kJ/(kg K)

If neither the kinetic nor the potential energies are taken into account, the specific exergy may be found by the following equation:

$$e = h - h_u - T_u(s - s_u) \tag{9}$$

where the subscript u indicates ambient conditions.
The saturation pressure of the substance at Tu = 290 K serves as the reference pressure.
Applying the preconditions mentioned above, the constants h_u and s_u are found to be as follows:

h_u=223.17 kJ/kg
s_u=1.081 kJ/(kg K).

3.3 Transport Properties

3.3.1 Dynamic Viscosity of Saturated Liquid

The viscosity of the saturated liquid of Solkane 134a was measured within the temperature range -50 to 60 °C. The following regression equation is valid for the liquid phase:

$$\ln\left(\frac{\eta'}{10^{-3}}\right) = H_0 + H_1 t + H_2 t^2 + H_3 t^3 \qquad (10)$$

t is in °C and η' in 10^{-3} Pa s. The coeffients are:

H_0	=	-1.29909	[Pa s]	H_2 =	4.9223 x10-6 [Pa s/K^2]
H_1	=	-0.0129286	[Pa s/K]	H_3 =	-1.9860 x10-7 [Pa s/K^3]

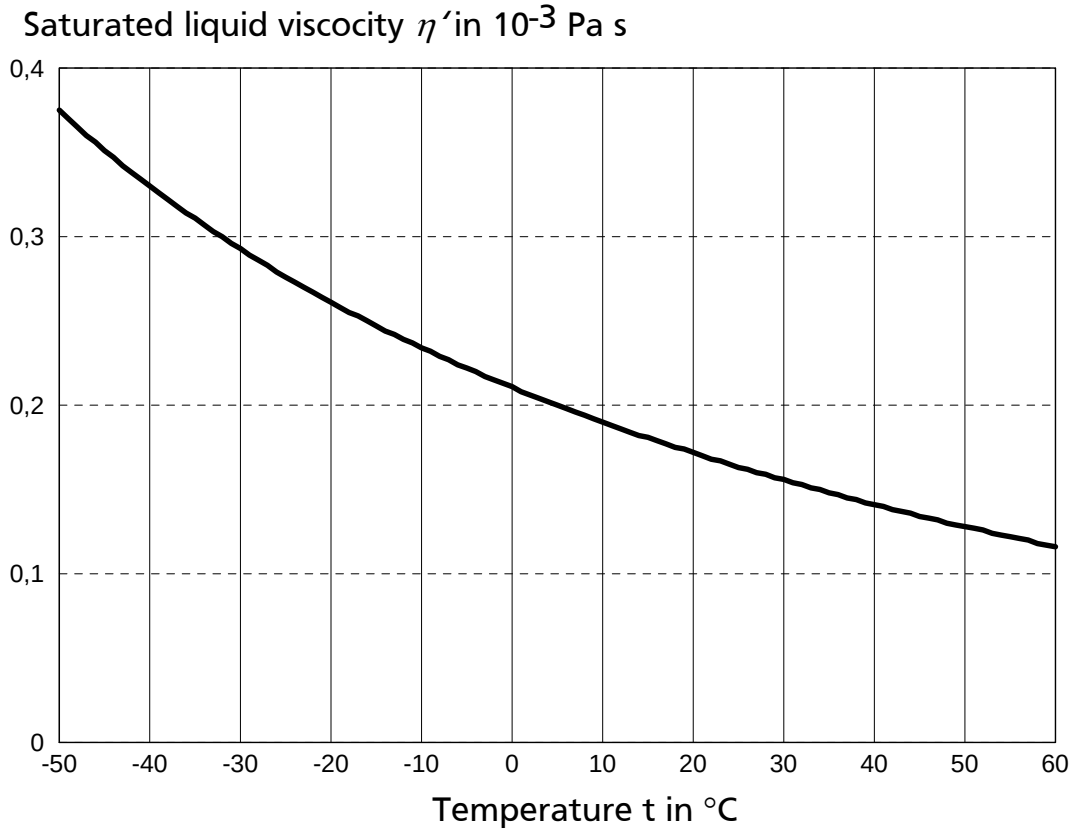


Figure 1: **Dynamic saturated liquid viscocity**

3.3.2 Dynamic Viscosity of Saturated and Superheated Vapour

The viscosity of the saturated and superheated vapour of Solkane®134a was measured in a temperature range of -50 to 50°C. The data can be represented by the following equations

$$\eta = \eta_0 + \Delta\eta \tag{11}$$

with

$$\eta_0 = 2.6696 \times 10^{-2} \times \frac{(MT)^{\frac{1}{2}}}{\sigma^2 \Omega_\eta T^*}, \qquad T^* = \frac{kT}{\varepsilon} \text{ and}$$

$$\Omega(T^*) = \exp[0.45667 - 0.53955(\ln(T^*) + 0.187265(\ln T^*)^2 - 0.03629(\ln T^*)^3 + 0.00241(\ln T^*)^4]$$

(12 a-c)

$$\Delta\eta = T_R^{2.2}\left[\ln(1.65 + \rho_{R0}^{0.8})\right]^{1.6}\left[e^{\left(1-\frac{0.78}{T_c}\right)\cdot\rho_{r0}} - 1\right](F \cdot z_c \cdot \zeta)^{-1}$$

$$z_c = \frac{p_c V_c}{R T_c} \quad \text{and} \quad \rho_{R0} = \frac{\rho - \rho_0}{\rho_c} \text{ and } F = 1 \text{ for R134a as a light polar agent.} \tag{12 d-f}$$

In equation (12) the constants are as follows:

R the universal gas constant	= 8314	[J kmol^{-1} K^{-1}]
ρ_c the critical density	= 515.30	[kg/m^3]
ρ_0 the density at 1.013bar and temperature as defined by T		[kg/m^3]
T_c the critical temperature	= 374.205	[K]

The constants of equation (11) where determined to be

ζ = 39721 [1/(Pa s)]
σ = 0.5067 [nm]
ε/k = 277.74 [K]

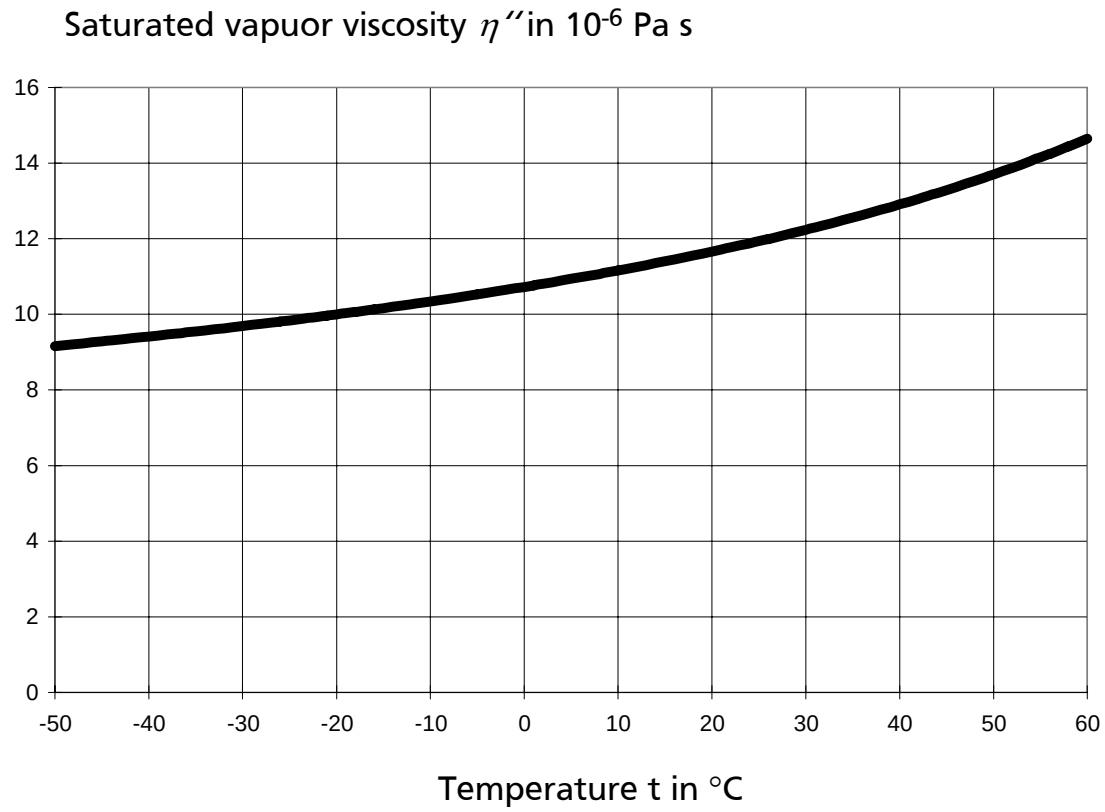


Figure 2: **Dynamic viscosity of saturated vapour**

3.3.3 Thermal Conductivity of Saturated Liquid

The thermal conductivity of saturated liquid can be expressed with the regression equation

$$\lambda' = J_0 + J_1 t \qquad (13)$$

where t is in °C und λ' in 10^{-3} W/(mK). The coefficients of the equation are:

J_0 = 94.21 [10^{-3}W/(m K)] J_1 = -0.42784 [10^{-3}W/(m K^2)]

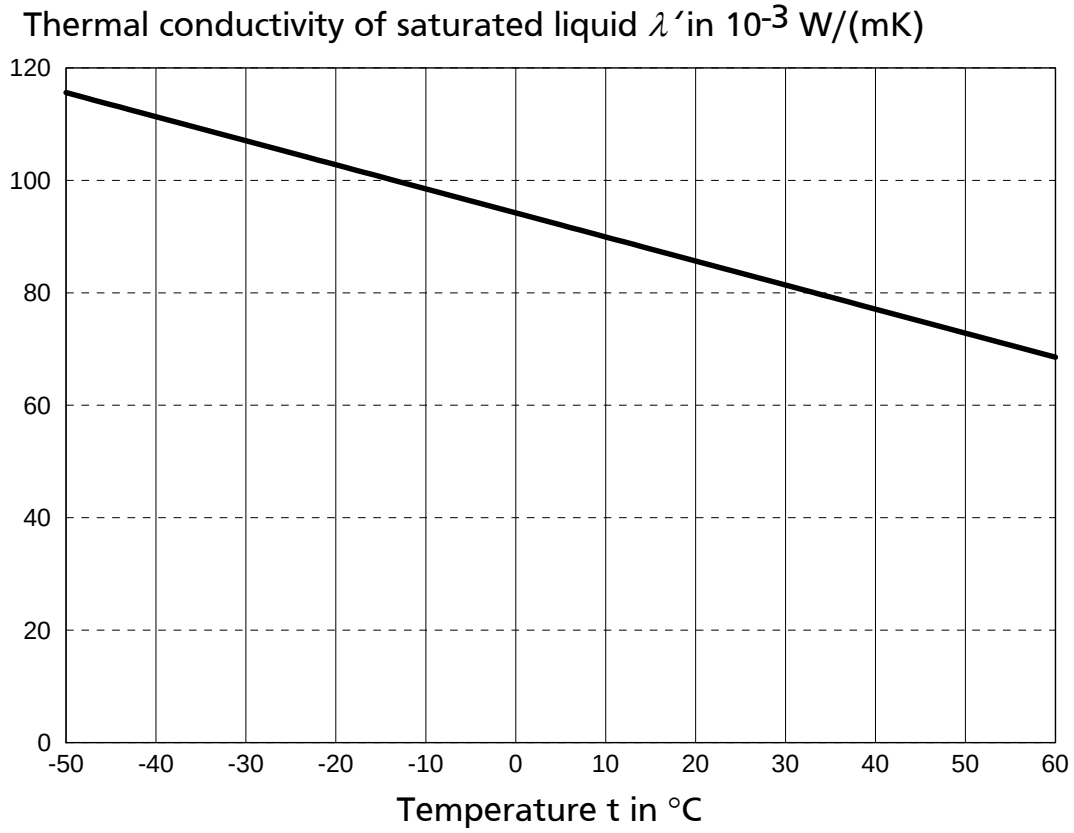


Figure 3: Thermal Conductivity of Saturated Liquid

3.3.4 Thermal Conductivity of Saturated Vapour

The thermal conductivity of saturated vapour can be expressed using the regression equation

$$\lambda'' = L_0 + L_1 t + L_2 t^2 \qquad (14)$$

where t is in °C und λ'' in 10^{-3} W/(m K). The coefficients of the equation are as follows:

L_0 = 11.804 [10^{-3} W/(m K)]
L_1 = 0.0805 [10^{-3} W/(m K^2)]
L_2 = 1.33741 x10-4 [10^{-3} W/(m K^3)]

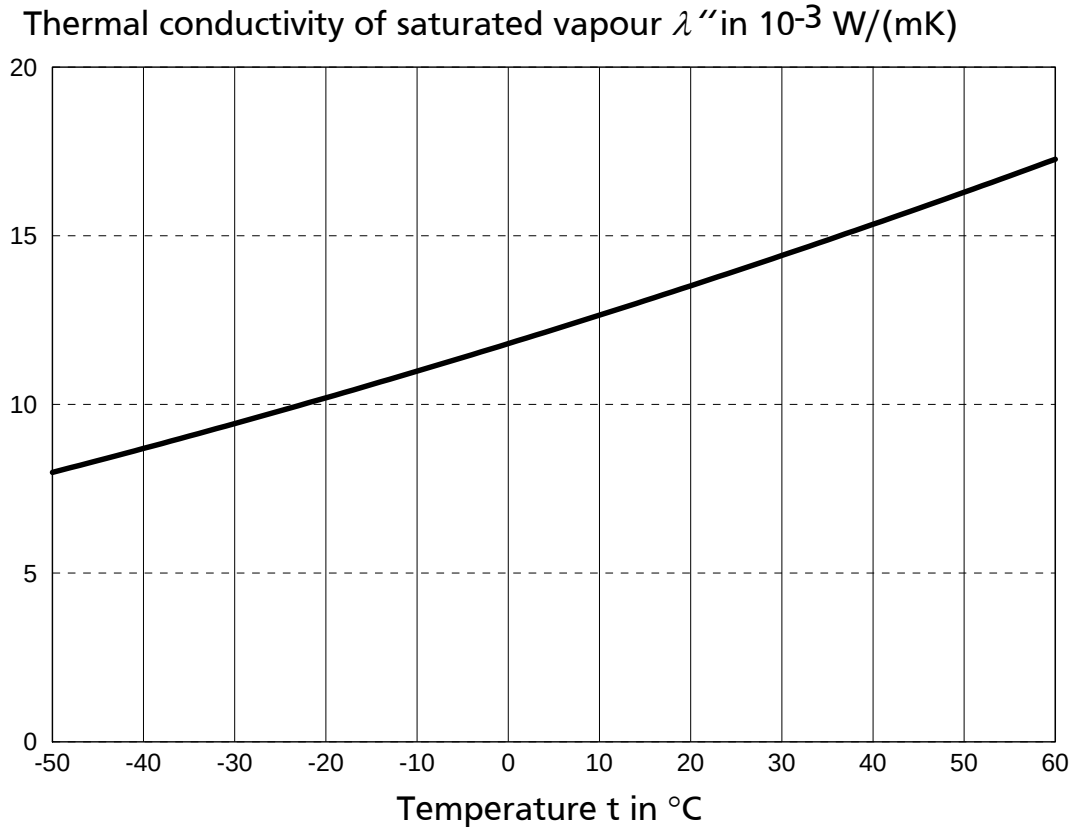


Figure 4: **Thermal conductivity of saturated vapour**

3.3.5 Surface Tension

The surface tension of the liquid can be expressed using the regression equation

$$\sigma = K_0 + K_1 t + K_2 t^2 + K_3 t^3 \qquad (15)$$

where t is in °C und σ in 10^{-3}N/m. The coefficients of the equation are:

K_0 = 11.4860 [10^{-3} N/m] K_2 = 1.3133 x10^{-4} [10^{-3} N/(mK^2)]
K_1 = -0.14267 [10^{-3} N/(mK)] K_3 = 1.1697 x10^{-6} [10^{-3} N/(mK^3)]

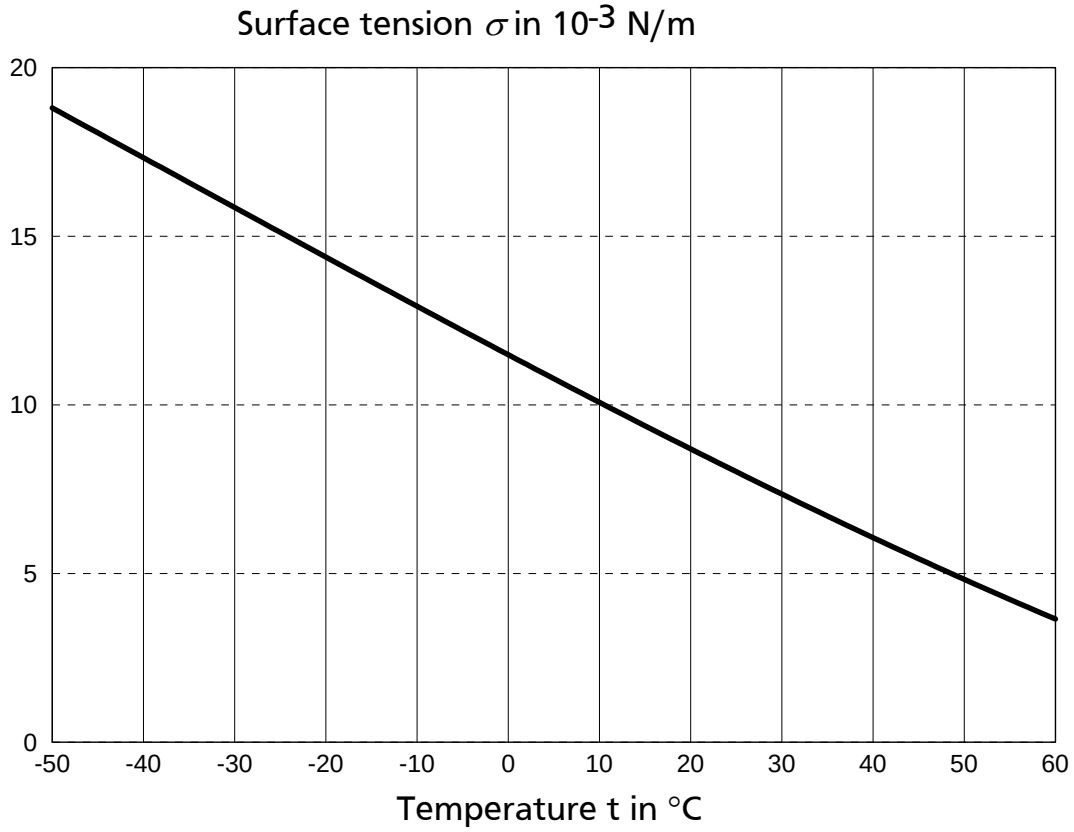


Figure 5: Surface tension

3.3.6 Specific Heat Capacity of Saturated Liquid

The specific heat capacity of saturated fluid can be expressed using the equation

$$c'_p = M_0 + M_1\left(1-T_R\right)^{1/9} + M_2\left(1-T_R\right)^{2/9} + M_3\left(1-T_R\right)^{3/9} + M_4\left(1-T_R\right)^{6/9} \quad (16)$$

where $T_R = \frac{T}{T_c}$, c'_p is in kJ/(kg K) and T is in K. The coefficients of the equation are as follows:

M_0 =	395.19033 [kJ/(kg K)]	M_3 =	-1120.361 [kJ/(kg K)]
M_1 =	-1588.637 [kJ/(kg K)]	M_4 =	81.256634 [kJ/(kg K)]
M_2 =	2233.8111 [kJ/(kg K)]	T_c =	374.205 [K]

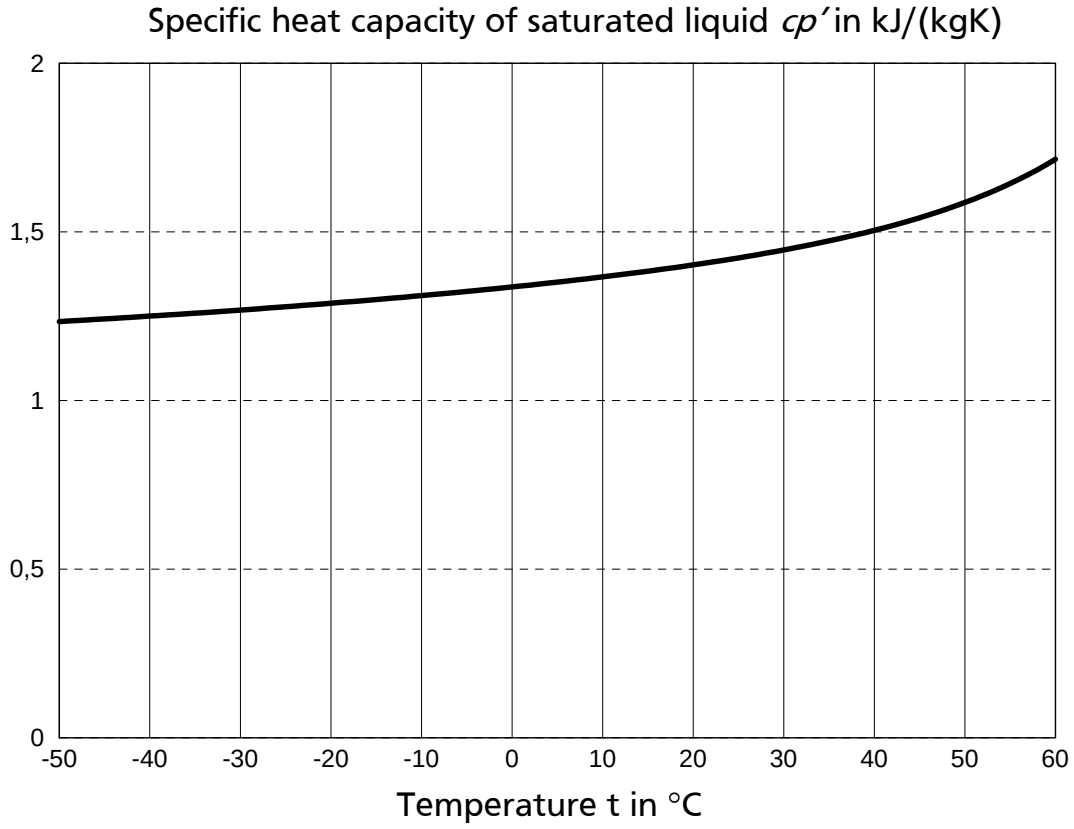


Figure 6: Specific heat capacity of saturated liquid

4 Compatibility of Materials

4.1 Elastomeres

The compatibility of materials with Solkane®134a was checked according to DIN 8944 using various selected elastomers. The extraction tests, which were carried out on the elastomers usually used in refrigeration technology CR, NBR and H-NBR, showed only slight swelling and yielded negligible amounts of extract. Fluorinated rubbers (types FKM and FPM) are not recommended because of their considerable swelling and blistering when used with Solkane®134a. Ethylenepropylenediene rubber is only to be recommended where the presence of mineral oil in the refrigeration cycle can be excluded. The effect of the lubricant which is used must not be ignored. Recommendations made by the lubricant and compressor manufacturers must be followed.

Table 1: Cold extraction tests according to DIN 8944: Solkane®134a

Elastomer		Change in weight [%]	Extract [%]
IIR	butyl rubber	-1.1	0
EPDM	ethylenepropylenediene rubber	-0.4	0
HNBR	hydrated acrylonitrilebutadiene rubber	-0.11	0
CR	chlorobutadiene rubber (Neoprene)	-0.15	0
NBR	acrylonitrilebutadiene rubber	-0.29	0
NR	natural rubber	-0.6	0
FKM	fluoro rubber	+7.3	0.1

Sample post treatment: 1h drying at 50°C
Extract post treatment: 24h drying at 100°C

4.2 Thermoplastics

Experience with CFC and H-CFC has shown that only a limited number of plastics are resistant to fluorinated refrigerants. Various plastics used in refrigeration technology were stored for 50 days at room temperature. It is vital to take the possible additional effect of the lubricants into account. The following table of values can only be used to give an idea of the effects to be expected.

Tabelle 2: Storage tests for Solkane®134a and Thermoplastics

Thermoplast	Change in weight /%			Optical changes[1]
Drying time:	-	1 h	24 h	
Hostaform S 27076	10.3	9.5	6.1	0
Hostaform S 9064	2.7	2.5	1.6	0
Hostaform C 9021 GV	0.8	0.8	0.4	0
Fortron 6165 A4 natural	0	0	0	0
Fortron 1140 L4 natural	-0.1	-0.1	-0.1	0
Hostalit Z	-0.1	-0.1	-0.1	0
Polyethylene GM 7746	0.6	0.5	0.3	0
Polyethylene GA 7260	0.5	0.4	0.2	++
Polystyrene 4000	0.5	0.3	0.1	+
Polystyrene 6600	0.8	0.7	0.4	0
Vectra A 130 + 30% Glass fibres	-0.1	-0.1	-0.1	0
Vectra C 130 + 30% Glass fibres	-0.1	-0.1	-0.1	0
Vectra A 530 + 30% Mineral content	-0.1	-0.1	-0.1	0
Vectra C 810	0	0	0	0
Vectra C 510	0	0	0	0
Polypropylene PPX 4207	0.9	0.9	0.5	0
Polypropylene PPW 1752	0.7	0.7	0.4	0
Polypropylene PPN 1060	0.5	0.4	0.3	0

[1] 0 : no change, + surface attacked, ++ surface delaminated

4.3 Metals

Solkane®134a is generally used in conjunction with lubricants (Ester oils, PAG-oils) in refrigeration technology. The combination of both these materials is compatible with the metals and joints usually found in machines and apparatus. Only zinc, magnesium, lead and aluminium alloys with more than 2% magnesium by mass should be avoided. The water content of refrigeration oil depending on oil type should especially be taken into account. Values of not more than 50 ppm are to be aimed at.

5 Refrigerant Oils

Like all fluorinated hydrocarbons, Solkane®134a is immiscible with mineral oils. Ester oil, and in automotive airconditioning systems, fully synthetic polyglycols (PAG) are used as lubricants. The solubility of these oils in Solkane®134a is a function of temperature and composition. The following diagram shows the solubility properties of various lubricants with Solkane®134a. Highly viscous lubricants tend to give large miscibility gaps.

The precise miscibility gaps of the individual oils can be obtained from the lubricant manufacturers.

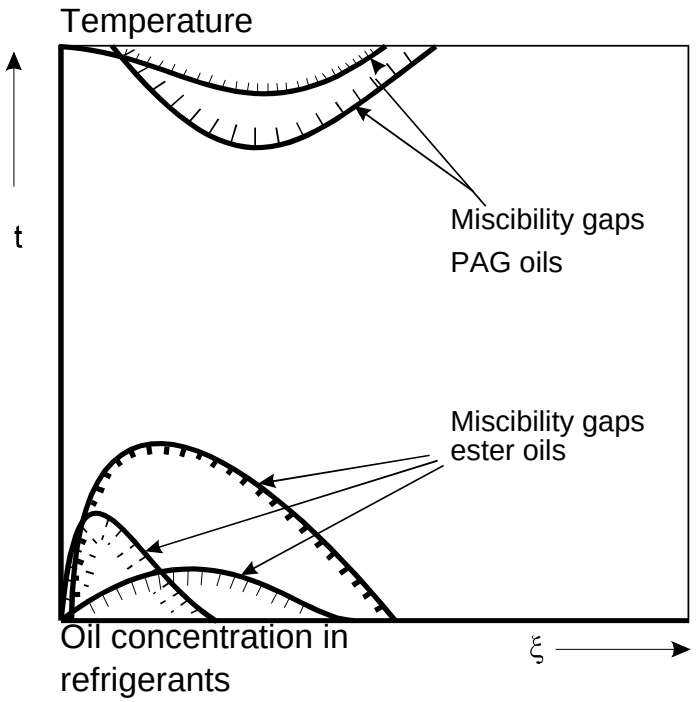


Figure 7: **An example of a depiction of miscibility gaps from different types of synthetic lubricants.**

6 Thermal Stability

Solkane®134a demonstrates a better thermal stability than the CFCs which have been used up to now. No fluoride ions were found by the Phillip test in accordance with DIN 51 593 (refrigerant + mineral oil in a U-tube for 96 h at 250°C). The product has therefore passed the Phillip test.

7 Flammability

According to DIN 51649 and UL 2182 Solkane®134a is non-flammable.

8 Toxicity

The toxicity of Solkane®134a was extensively tested between 1987 and 1994 within the scope of the PAFT programme (Programme for Alternative Fluorocarbon Toxicity Testing). The tests showed that the safety for Solkane®134a with regard to toxicity was at least as high as that for R12. The results showed that the product can be safely used in domestic, commercial and industrial refrigeration and in air conditioning technology. The usual measures which are recommended for work safety must be followed. Solvay recommends a TLV of 1000 ppm.

9 Vapour Table, Wet Vapour Range Solkane®134a

t	p´	v´	v´´	ρ´	ρ´´	h´	h´´	r	s´	s´´
[°C]	[bar]	[dm³/kg]	[dm³/kg]	[kg/dm³]	[kg/m³]	[kJ/kg]	[kJ/kg]	[kJ/kg]	[kJ/kgK]	[kJ/kgK]
-50	0.29	0.691	606.17	1.447	1.65	135.75	367.70	231.95	0.7409	1.7808
-49	0.31	0.692	574.14	1.444	1.74	136.99	368.33	231.34	0.7463	1.7790
-48	0.33	0.694	544.11	1.441	1.84	138.24	368.96	230.73	0.7518	1.7772
-47	0.35	0.695	515.95	1.438	1.94	139.49	369.60	230.11	0.7572	1.7755
-46	0.37	0.697	489.51	1.436	2.04	140.73	370.23	229.50	0.7626	1.7738
-45	0.39	0.698	464.68	1.433	2.15	141.98	370.86	228.89	0.7681	1.7722
-44	0.41	0.699	441.35	1.430	2.27	143.22	371.50	228.27	0.7735	1.7706
-43	0.44	0.701	419.41	1.427	2.38	144.47	372.13	227.66	0.7789	1.7690
-42	0.46	0.702	398.76	1.424	2.51	145.71	372.76	227.05	0.7842	1.7674
-41	0.49	0.704	379.33	1.421	2.64	146.96	373.39	226.43	0.7896	1.7659
-40	0.51	0.705	361.01	1.418	2.77	148.21	374.02	225.81	0.7950	1.7645
-39	0.54	0.706	343.76	1.415	2.91	149.46	374.66	225.20	0.8003	1.7630
-38	0.57	0.708	327.49	1.413	3.05	150.71	375.29	224.58	0.8057	1.7616
-37	0.60	0.709	312.13	1.410	3.20	151.96	375.92	223.95	0.8110	1.7602
-36	0.63	0.711	297.64	1.407	3.36	153.21	376.54	223.33	0.8163	1.7589
-35	0.66	0.712	283.95	1.404	3.52	154.47	377.17	222.70	0.8217	1.7576
-34	0.70	0.714	271.01	1.401	3.69	155.73	377.80	222.08	0.8270	1.7563
-33	0.73	0.715	258.78	1.398	3.86	156.98	378.43	221.45	0.8322	1.7551
-32	0.77	0.717	247.20	1.395	4.05	158.24	379.06	220.81	0.8375	1.7538
-31	0.80	0.718	236.25	1.392	4.23	159.51	379.68	220.18	0.8428	1.7526
-30	0.84	0.720	225.88	1.389	4.43	160.77	380.31	219.54	0.8480	1.7515
-29	0.88	0.721	216.05	1.386	4.63	162.04	380.93	218.89	0.8533	1.7503
-28	0.93	0.723	206.73	1.383	4.84	163.31	381.56	218.25	0.8585	1.7492
-27	0.97	0.725	197.90	1.380	5.05	164.58	382.18	217.60	0.8637	1.7481
-26	1.02	0.726	189.51	1.377	5.28	165.85	382.80	216.94	0.8689	1.7471
-25	1.06	0.728	181.56	1.374	5.51	167.13	383.42	216.29	0.8741	1.7460
-24	1.11	0.729	174.00	1.371	5.75	168.41	384.04	215.63	0.8793	1.7450
-23	1.16	0.731	166.82	1.368	5.99	169.69	384.66	214.96	0.8845	1.7440
-22	1.22	0.733	160.00	1.365	6.25	170.98	385.28	214.30	0.8896	1.7431
-21	1.27	0.734	153.51	1.362	6.51	172.27	385.89	213.62	0.8948	1.7421
-20	1.33	0.736	147.33	1.359	6.79	173.56	386.51	212.95	0.8999	1.7412
-19	1.39	0.738	141.46	1.356	7.07	174.85	387.12	212.27	0.9050	1.7403
-18	1.45	0.739	135.86	1.353	7.36	176.15	387.73	211.58	0.9101	1.7394
-17	1.51	0.741	130.54	1.349	7.66	177.45	388.34	210.90	0.9152	1.7385
-16	1.57	0.743	125.46	1.346	7.97	178.75	388.95	210.20	0.9203	1.7377
-15	1.64	0.744	120.62	1.343	8.29	180.06	389.56	209.51	0.9254	1.7369
-14	1.71	0.746	116.00	1.340	8.62	181.36	390.17	208.81	0.9304	1.7361
-13	1.78	0.748	111.60	1.337	8.96	182.68	390.77	208.10	0.9355	1.7353
-12	1.85	0.750	107.39	1.334	9.31	183.99	391.38	207.39	0.9405	1.7346
-11	1.93	0.752	103.38	1.331	9.67	185.31	391.98	206.67	0.9455	1.7338

Vapour Table, Wet Vapour Range Solkane®134a

t	p´	v´	v´´	ρ´	ρ´´	h´	h´´	r	s´	s´´
[°C]	[bar]	[dm³/kg]	[dm³/kg]	[kg/dm³]	[kg/m³]	[kJ/kg]	[kJ/kg]	[kJ/kg]	[kJ/kgK]	[kJ/kgK]
-10	2.01	0.753	99.54	1.327	10.05	186.63	392.58	205.95	0.9505	1.7331
-9	2.09	0.755	95.88	1.324	10.43	187.95	393.18	205.23	0.9555	1.7324
-8	2.17	0.757	92.38	1.321	10.82	189.28	393.78	204.50	0.9605	1.7317
-7	2.25	0.759	89.03	1.318	11.23	190.61	394.37	203.77	0.9655	1.7310
-6	2.34	0.761	85.83	1.315	11.65	191.94	394.97	203.03	0.9705	1.7304
-5	2.43	0.763	82.76	1.311	12.08	193.27	395.56	202.29	0.9754	1.7297
-4	2.53	0.765	79.83	1.308	12.53	194.61	396.15	201.54	0.9804	1.7291
-3	2.62	0.766	77.02	1.305	12.98	195.95	396.74	200.79	0.9853	1.7285
-2	2.72	0.768	74.33	1.301	13.45	197.30	397.32	200.03	0.9902	1.7279
-1	2.82	0.770	71.75	1.298	13.94	198.64	397.91	199.27	0.9951	1.7273
0	2.93	0.772	69.28	1.295	14.43	200.00	398.49	198.49	1.0000	1.7267
1	3.04	0.774	66.91	1.291	14.95	201.35	399.07	197.72	1.0049	1.7262
2	3.15	0.776	64.64	1.288	15.47	202.70	399.65	196.95	1.0098	1.7256
3	3.26	0.778	62.46	1.285	16.01	204.06	400.22	196.16	1.0146	1.7251
4	3.38	0.780	60.36	1.281	16.57	205.42	400.80	195.38	1.0195	1.7246
5	3.50	0.782	58.35	1.278	17.14	206.79	401.37	194.58	1.0243	1.7241
6	3.62	0.785	56.42	1.275	17.72	208.15	401.94	193.78	1.0292	1.7236
7	3.75	0.787	54.57	1.271	18.33	209.52	402.50	192.98	1.0340	1.7231
8	3.88	0.789	52.79	1.268	18.94	210.90	403.07	192.17	1.0388	1.7226
9	4.01	0.791	51.08	1.264	19.58	212.27	403.63	191.36	1.0436	1.7221
10	4.15	0.793	49.43	1.261	20.23	213.65	404.19	190.54	1.0484	1.7217
11	4.29	0.795	47.84	1.257	20.90	215.03	404.74	189.71	1.0532	1.7212
12	4.43	0.798	46.32	1.254	21.59	216.42	405.30	188.88	1.0580	1.7208
13	4.58	0.800	44.85	1.250	22.29	217.80	405.85	188.04	1.0627	1.7204
14	4.73	0.802	43.44	1.247	23.02	219.19	406.39	187.20	1.0675	1.7200
15	4.88	0.804	42.08	1.243	23.76	220.58	406.94	186.35	1.0723	1.7196
16	5.04	0.807	40.77	1.240	24.53	221.98	407.48	185.50	1.0770	1.7192
17	5.21	0.809	39.51	1.236	25.31	223.38	408.02	184.64	1.0818	1.7188
18	5.37	0.811	38.30	1.232	26.11	224.78	408.55	183.77	1.0865	1.7184
19	5.54	0.814	37.12	1.229	26.94	226.18	409.08	182.90	1.0912	1.7180
20	5.72	0.816	35.99	1.225	27.78	227.59	409.61	182.02	1.0960	1.7176
21	5.90	0.819	34.91	1.221	28.65	229.00	410.14	181.14	1.1007	1.7172
22	6.08	0.821	33.85	1.218	29.54	230.41	410.66	180.25	1.1054	1.7169
23	6.27	0.824	32.84	1.214	30.45	231.83	411.18	179.35	1.1101	1.7165
24	6.46	0.826	31.86	1.210	31.39	233.25	411.69	178.44	1.1148	1.7162
25	6.65	0.829	30.91	1.206	32.35	234.67	412.20	177.53	1.1195	1.7158
26	6.85	0.832	30.00	1.202	33.33	236.09	412.71	176.61	1.1242	1.7155
27	7.06	0.834	29.12	1.199	34.34	237.52	413.21	175.69	1.1289	1.7151
28	7.27	0.837	28.27	1.195	35.38	238.96	413.71	174.75	1.1336	1.7148
29	7.48	0.840	27.44	1.191	36.44	240.39	414.20	173.81	1.1383	1.7144

Vapour Table, Wet Vapour Range Solkane®134a

t	p´	v´	v´´	ρ′	ρ″	h´	h´´	r	s´	s´´
[°C]	[bar]	[dm³/kg]	[dm³/kg]	[kg/dm³]	[kg/m³]	[kJ/kg]	[kJ/kg]	[kJ/kg]	[kJ/kgK]	[kJ/kgK]
30	7.70	0.842	26.65	1.187	37.53	241.83	414.69	172.86	1.1429	1.7141
31	7.93	0.845	25.88	1.183	38.64	243.27	415.18	171.91	1.1476	1.7138
32	8.15	0.848	25.13	1.179	39.79	244.72	415.66	170.94	1.1523	1.7134
33	8.39	0.851	24.41	1.175	40.96	246.17	416.14	169.97	1.1570	1.7131
34	8.63	0.854	23.72	1.171	42.16	247.62	416.61	168.99	1.1616	1.7128
35	8.87	0.857	23.04	1.167	43.40	249.08	417.07	168.00	1.1663	1.7124
36	9.12	0.860	22.39	1.163	44.66	250.54	417.54	167.00	1.1710	1.7121
37	9.37	0.863	21.76	1.159	45.96	252.01	417.99	165.99	1.1757	1.7118
38	9.63	0.866	21.15	1.155	47.29	253.48	418.44	164.97	1.1804	1.7114
39	9.90	0.869	20.55	1.150	48.66	254.95	418.89	163.94	1.1850	1.7111
40	10.17	0.872	19.98	1.146	50.06	256.43	419.33	162.90	1.1897	1.7107
41	10.44	0.876	19.42	1.142	51.49	257.91	419.76	161.85	1.1944	1.7104
42	10.72	0.879	18.88	1.138	52.97	259.40	420.19	160.79	1.1991	1.7100
43	11.01	0.882	18.36	1.133	54.48	260.90	420.61	159.72	1.2038	1.7097
44	11.30	0.886	17.85	1.129	56.03	262.40	421.03	158.63	1.2085	1.7093
45	11.60	0.889	17.36	1.125	57.62	263.90	421.44	157.54	1.2132	1.7090
46	11.90	0.893	16.88	1.120	59.25	265.41	421.84	156.43	1.2179	1.7086
47	12.21	0.896	16.41	1.116	60.92	266.93	422.24	155.31	1.2226	1.7082
48	12.53	0.900	15.96	1.111	62.64	268.45	422.63	154.17	1.2273	1.7078
49	12.85	0.904	15.53	1.107	64.40	269.98	423.01	153.02	1.2320	1.7075
50	13.18	0.908	15.10	1.102	66.21	271.52	423.38	151.86	1.2367	1.7071
51	13.51	0.911	14.69	1.097	68.07	273.07	423.75	150.68	1.2415	1.7066
52	13.85	0.915	14.29	1.093	69.98	274.62	424.10	149.49	1.2462	1.7062
53	14.20	0.919	13.90	1.088	71.94	276.18	424.45	148.28	1.2510	1.7058
54	14.55	0.923	13.52	1.083	73.95	277.74	424.79	147.05	1.2557	1.7053
55	14.92	0.928	13.15	1.078	76.02	279.32	425.12	145.81	1.2605	1.7049
56	15.28	0.932	12.80	1.073	78.15	280.90	425.44	144.54	1.2653	1.7044
57	15.66	0.936	12.45	1.068	80.34	282.49	425.76	143.26	1.2701	1.7039
58	16.04	0.941	12.11	1.063	82.59	284.10	426.06	141.96	1.2749	1.7034
59	16.42	0.945	11.78	1.058	84.90	285.71	426.35	140.64	1.2797	1.7029
60	16.82	0.950	11.46	1.053	87.28	287.33	426.63	139.30	1.2845	1.7024
61	17.22	0.955	11.15	1.047	89.72	288.96	426.90	137.94	1.2894	1.7018
62	17.63	0.960	10.84	1.042	92.24	290.60	427.15	136.55	1.2942	1.7012
63	18.04	0.965	10.54	1.037	94.84	292.26	427.40	135.14	1.2991	1.7006
64	18.47	0.970	10.26	1.031	97.51	293.92	427.63	133.71	1.3040	1.7000
65	18.90	0.975	9.97	1.026	100.27	295.60	427.84	132.25	1.3089	1.6994
66	19.34	0.980	9.70	1.020	103.11	297.29	428.05	130.76	1.3138	1.6987
67	19.78	0.986	9.43	1.014	106.04	298.99	428.24	129.25	1.3188	1.6980
68	20.24	0.992	9.17	1.008	109.06	300.71	428.41	127.70	1.3237	1.6973
69	20.70	0.998	8.91	1.002	112.19	302.44	428.57	126.13	1.3287	1.6965

Vapour Table, Wet Vapour Range Solkane®134a

t	p´	v´	v´´	ρ´	ρ´´	h´	h´´	r	s´	s´´
[°C]	[bar]	[dm³/kg]	[dm³/kg]	[kg/dm³]	[kg/m³]	[kJ/kg]	[kJ/kg]	[kJ/kg]	[kJ/kgK]	[kJ/kgK]
70	21.17	1.004	8.66	0.996	115.41	304.18	428.71	124.52	1.3337	1.6957
71	21.65	1.010	8.42	0.990	118.75	305.94	428.83	122.88	1.3387	1.6949
72	22.13	1.016	8.18	0.984	122.20	307.72	428.93	121.21	1.3438	1.6940
73	22.63	1.023	7.95	0.978	125.77	309.51	429.01	119.50	1.3489	1.6931
74	23.13	1.030	7.72	0.971	129.47	311.32	429.07	117.76	1.3539	1.6921
75	23.64	1.037	7.50	0.964	133.30	313.14	429.11	115.97	1.3590	1.6911
76	24.16	1.044	7.28	0.958	137.28	314.99	429.13	114.14	1.3642	1.6901
77	24.69	1.052	7.07	0.951	141.42	316.85	429.12	112.27	1.3693	1.6890
78	25.23	1.060	6.86	0.944	145.71	318.73	429.08	110.35	1.3745	1.6878
79	25.78	1.068	6.66	0.936	150.19	320.64	429.02	108.38	1.3797	1.6866
80	26.33	1.077	6.46	0.929	154.85	322.56	428.93	106.37	1.3850	1.6852
81	26.90	1.086	6.26	0.921	159.71	324.50	428.80	104.30	1.3903	1.6839
82	27.47	1.095	6.07	0.913	164.79	326.47	428.64	102.17	1.3955	1.6824
83	28.06	1.105	5.88	0.905	170.11	328.46	428.44	99.98	1.4009	1.6809
84	28.65	1.116	5.69	0.896	175.69	330.47	428.19	97.72	1.4062	1.6792
85	29.26	1.127	5.51	0.888	181.54	332.51	427.91	95.40	1.4116	1.6775
86	29.87	1.138	5.33	0.879	187.71	334.57	427.57	93.01	1.4170	1.6756
87	30.50	1.151	5.15	0.869	194.22	336.66	427.19	90.53	1.4225	1.6736
88	31.14	1.164	4.97	0.859	201.11	338.77	426.74	87.97	1.4280	1.6715
89	31.78	1.178	4.80	0.849	208.42	340.91	426.23	85.31	1.4335	1.6692
90	32.44	1.193	4.63	0.838	216.21	343.08	425.64	82.56	1.4391	1.6667
91	33.11	1.210	4.45	0.827	224.56	345.28	424.97	79.69	1.4447	1.6641
92	33.79	1.228	4.28	0.814	233.54	347.52	424.20	76.69	1.4503	1.6611
93	34.49	1.248	4.11	0.801	243.26	349.78	423.33	73.55	1.4560	1.6579
94	35.19	1.270	3.94	0.788	253.90	352.07	422.31	70.24	1.4617	1.6544
95	35.91	1.295	3.76	0.772	265.66	354.40	421.13	66.73	1.4675	1.6504
96	36.64	1.324	3.59	0.755	278.91	356.76	419.73	62.96	1.4733	1.6459
97	37.39	1.358	3.40	0.736	294.32	359.16	417.99	58.84	1.4791	1.6405

10 Vapour Table, Superheated Range Solkane®134a

0.293bar -50°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-50	606.17	367.70	1.7808
-45	620.71	371.27	1.7966
-40	635.20	374.88	1.8123
-35	649.63	378.54	1.8278
-30	664.01	382.24	1.8432
-25	678.35	385.98	1.8584
-20	692.64	389.76	1.8735
-15	706.90	393.59	1.8885
-10	721.13	397.46	1.9033
-5	735.33	401.38	1.9181
0	749.50	405.33	1.9327
5	763.65	409.34	1.9472
10	777.77	413.38	1.9616
15	791.88	417.47	1.9759
20	805.96	421.60	1.9901
25	820.03	425.77	2.0042
30	834.11	429.98	2.0183

0.66bar -35°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-35	283.95	377.17	1.7576
-30	290.68	380.96	1.7733
-25	297.36	384.78	1.7889
-20	304.00	388.64	1.8043
-15	310.61	392.53	1.8195
-10	317.17	396.46	1.8346
-5	323.70	400.44	1.8495
0	330.21	404.45	1.8643
5	336.69	408.49	1.8790
10	343.15	412.58	1.8936
15	349.58	416.71	1.9081
20	356.00	420.88	1.9224
25	362.40	425.09	1.9366
30	368.78	429.34	1.9508
35	375.15	433.63	1.9648
40	381.50	437.95	1.9787
45	387.84	442.32	1.9926

1.016bar -26°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-26	189.51	382.80	1.7471
-25	190.42	383.58	1.7502
-20	194.92	387.51	1.7659
-15	199.39	391.48	1.7814
-10	203.81	395.47	1.7967
-5	208.20	399.50	1.8119
0	212.57	403.57	1.8269
5	216.90	407.66	1.8418
10	221.21	411.80	1.8565
15	225.50	415.97	1.8711
20	229.77	420.18	1.8856
25	234.02	424.42	1.9000
30	238.26	428.70	1.9142
35	242.47	433.02	1.9283
40	246.68	437.38	1.9424
45	250.87	441.77	1.9563
50	255.05	446.21	1.9701

1.327bar -20°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-20	147.33	386.51	1.7412
-15	150.87	390.53	1.7569
-10	154.37	394.59	1.7725
-5	157.83	398.67	1.7879
0	161.27	402.78	1.8031
5	164.67	406.93	1.8181
10	168.05	411.10	1.8330
15	171.41	415.31	1.8477
20	174.74	419.55	1.8623
25	178.06	423.83	1.8768
30	181.36	428.14	1.8911
35	184.64	432.49	1.9053
40	187.91	436.87	1.9194
45	191.17	441.29	1.9334
50	194.41	445.75	1.9473
55	197.65	450.24	1.9611
60	200.87	454.77	1.9748

0.39bar -45°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-45	464.68	370.86	1.7722
-40	475.76	374.50	1.7879
-35	486.77	378.18	1.8036
-30	497.74	381.90	1.8190
-25	508.66	385.66	1.8343
-20	519.55	389.47	1.8495
-15	530.39	393.31	1.8646
-10	541.21	397.20	1.8795
-5	551.99	401.13	1.8943
0	562.74	405.10	1.9089
5	573.47	409.12	1.9235
10	584.18	413.17	1.9379
15	594.87	417.27	1.9523
20	605.54	421.41	1.9665
25	616.19	425.59	1.9807
30	626.83	429.81	1.9947
35	637.45	434.08	2.0087

0.843bar -30°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-30	225.88	380.31	1.7515
-25	231.24	384.17	1.7672
-20	236.55	388.06	1.7827
-15	241.83	391.99	1.7981
-10	247.07	395.96	1.8133
-5	252.28	399.96	1.8284
0	257.46	404.00	1.8433
5	262.61	408.07	1.8581
10	267.74	412.18	1.8727
15	272.85	416.33	1.8872
20	277.94	420.52	1.9017
25	283.01	424.75	1.9160
30	288.06	429.01	1.9301
35	293.10	433.32	1.9442
40	298.12	437.66	1.9582
45	303.13	442.04	1.9721
50	308.14	446.46	1.9859

1.112bar -24°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-24	174.00	384.04	1.7450
-20	177.33	387.20	1.7576
-15	181.44	391.19	1.7732
-10	185.53	395.20	1.7886
-5	189.57	399.25	1.8038
0	193.59	403.33	1.8189
5	197.58	407.44	1.8338
10	201.55	411.58	1.8486
15	205.49	415.77	1.8632
20	209.42	419.98	1.8777
25	213.32	424.24	1.8921
30	217.21	428.53	1.9064
35	221.08	432.86	1.9206
40	224.94	437.22	1.9346
45	228.79	441.62	1.9486
50	232.62	446.07	1.9624
55	236.45	450.54	1.9762

1.446bar -18°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-18	135.86	387.73	1.7394
-15	137.83	390.17	1.7489
-10	141.09	394.25	1.7645
-5	144.30	398.35	1.7800
0	147.49	402.48	1.7952
5	150.64	406.64	1.8103
10	153.77	410.83	1.8253
15	156.88	415.06	1.8401
20	159.96	419.31	1.8547
25	163.03	423.60	1.8692
30	166.07	427.92	1.8836
35	169.11	432.28	1.8979
40	172.13	436.67	1.9120
45	175.13	441.10	1.9260
50	178.13	445.57	1.9399
55	181.11	450.07	1.9538
60	184.08	454.61	1.9675

0.512bar -40°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-40	361.01	374.02	1.7645
-35	369.59	377.73	1.7802
-30	378.10	381.48	1.7958
-25	386.57	385.27	1.8112
-20	395.00	389.10	1.8265
-15	403.39	392.97	1.8416
-10	411.75	396.87	1.8566
-5	420.08	400.82	1.8715
0	428.37	404.81	1.8862
5	436.65	408.84	1.9008
10	444.90	412.91	1.9153
15	453.13	417.02	1.9297
20	461.34	421.17	1.9440
25	469.53	425.37	1.9582
30	477.71	429.60	1.9723
35	485.87	433.88	1.9862
40	494.02	438.19	2.0001

0.927bar -28°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-28	206.73	381.56	1.7492
-25	209.68	383.89	1.7587
-20	214.57	387.80	1.7743
-15	219.42	391.75	1.7897
-10	224.23	395.73	1.8050
-5	229.00	399.74	1.8201
0	233.75	403.79	1.8351
5	238.47	407.88	1.8499
10	243.17	412.00	1.8646
15	247.85	416.16	1.8791
20	252.50	420.35	1.8936
25	257.14	424.59	1.9079
30	261.76	428.86	1.9221
35	266.36	433.17	1.9362
40	270.96	437.52	1.9502
45	275.54	441.91	1.9641
50	280.10	446.34	1.9779

1.216bar -22°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-22	160.00	385.28	1.7431
-20	161.53	386.87	1.7494
-15	165.35	390.87	1.7650
-10	169.12	394.91	1.7805
-5	172.86	398.97	1.7958
0	176.57	403.06	1.8109
5	180.25	407.19	1.8259
10	183.91	411.35	1.8407
15	187.54	415.55	1.8554
20	191.15	419.78	1.8700
25	194.75	424.04	1.8844
30	198.33	428.34	1.8987
35	201.89	432.68	1.9129
40	205.44	437.05	1.9270
45	208.98	441.46	1.9409
50	212.50	445.91	1.9548
55	216.01	450.40	1.9686

1.573bar -18°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-16	125.46	388.95	1.7377
-15	126.07	389.77	1.7409
-10	129.10	393.87	1.7566
-5	132.09	398.00	1.7722
0	135.05	402.15	1.7875
5	137.98	406.33	1.8027
10	140.89	410.54	1.8177
15	143.77	414.78	1.8325
20	146.63	419.05	1.8472
25	149.47	423.36	1.8618
30	152.29	427.69	1.8762
35	155.10	432.06	1.8905
40	157.89	436.46	1.9046
45	160.67	440.90	1.9187
50	163.44	445.38	1.9327
55	166.19	449.89	1.9465
60	168.94	454.43	1.9603

Vapour Table, Superheated Range Solkane®134a

1.708bar -14°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-14	116.00	390.17	1.7361
-10	118.26	393.48	1.7488
-5	121.05	397.63	1.7644
0	123.81	401.80	1.7798
5	126.54	406.00	1.7951
10	129.24	410.23	1.8101
15	131.92	414.49	1.8250
20	134.58	418.77	1.8398
25	137.21	423.09	1.8544
30	139.83	427.44	1.8688
35	142.44	431.82	1.8832
40	145.02	436.24	1.8974
45	147.60	440.69	1.9115
50	150.16	445.17	1.9255
55	152.71	449.69	1.9394
60	155.26	454.25	1.9531
65	157.79	458.84	1.9668

2.169bar -8°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-8	92.38	393.78	1.7317
-5	93.76	396.33	1.7412
0	96.02	400.58	1.7570
5	98.26	404.86	1.7725
10	100.46	409.15	1.7878
15	102.64	413.47	1.8029
20	104.80	417.82	1.8179
25	106.93	422.19	1.8326
30	109.05	426.58	1.8473
35	111.15	431.01	1.8617
40	113.24	435.47	1.8761
45	115.31	439.95	1.8903
50	117.37	444.47	1.9044
55	119.41	449.02	1.9184
60	121.45	453.61	1.9322
65	123.48	458.23	1.9460
70	125.50	462.88	1.9597

2.722bar -2°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-2	74.33	397.32	1.7279
0	75.09	399.07	1.7343
5	76.96	403.44	1.7502
10	78.79	407.83	1.7658
15	80.60	412.22	1.7812
20	82.39	416.64	1.7964
25	84.15	421.08	1.8114
30	85.89	425.53	1.8262
35	87.62	430.01	1.8409
40	89.33	434.52	1.8554
45	91.02	439.06	1.8697
50	92.70	443.62	1.8840
55	94.37	448.21	1.8981
60	96.03	452.83	1.9120
65	97.68	457.49	1.9259
70	99.32	462.17	1.9397
75	100.95	466.89	1.9533

3.377bar 4°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
4	60.36	400.80	1.7246
5	60.68	401.70	1.7278
10	62.24	406.19	1.7438
15	63.78	410.69	1.7596
20	65.28	415.20	1.7751
25	66.77	419.72	1.7904
30	68.23	424.26	1.8055
35	69.67	428.81	1.8204
40	71.10	433.38	1.8351
45	72.50	437.97	1.8496
50	73.90	442.59	1.8640
55	75.28	447.23	1.8783
60	76.66	451.90	1.8924
65	78.02	456.59	1.9064
70	79.37	461.32	1.9203
75	80.71	466.07	1.9340
80	82.05	470.86	1.9477

1.852bar -12°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-12	107.39	391.38	1.7346
-10	108.45	393.05	1.7409
-5	111.06	397.22	1.7566
0	113.64	401.42	1.7722
5	116.18	405.65	1.7875
10	118.70	409.90	1.8026
15	121.20	414.17	1.8176
20	123.67	418.48	1.8324
25	126.12	422.81	1.8471
30	128.56	427.17	1.8616
35	130.98	431.57	1.8760
40	133.38	436.00	1.8902
45	135.77	440.46	1.9043
50	138.15	444.95	1.9184
55	140.52	449.48	1.9323
60	142.87	454.05	1.9461
65	145.22	458.65	1.9598

2.343bar -6°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-6	85.83	394.97	1.7304
-5	86.26	395.82	1.7336
0	88.39	400.11	1.7494
5	90.49	404.42	1.7650
10	92.56	408.74	1.7804
15	94.60	413.08	1.7956
20	96.63	417.45	1.8107
25	98.62	421.84	1.8255
30	100.60	426.26	1.8402
35	102.57	430.70	1.8547
40	104.52	435.17	1.8691
45	106.45	439.67	1.8834
50	108.37	444.21	1.8975
55	110.28	448.77	1.9115
60	112.18	453.37	1.9254
65	114.07	458.00	1.9392
70	115.95	462.66	1.9529

2.928bar 0°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
0	69.28	398.49	1.7267
5	71.05	402.90	1.7427
10	72.79	407.32	1.7585
15	74.49	411.75	1.7740
20	76.18	416.19	1.7893
25	77.84	420.65	1.8044
30	79.48	425.13	1.8193
35	81.10	429.64	1.8340
40	82.70	434.16	1.8486
45	84.30	438.72	1.8630
50	85.87	443.30	1.8773
55	87.44	447.90	1.8914
60	88.99	452.54	1.9054
65	90.54	457.21	1.9193
70	92.07	461.90	1.9331
75	93.60	466.63	1.9468
80	95.12	471.39	1.9604

3.620bar 6°C

t	v	H	s
°C	dm³/kg	kJ/kg	kJ/kgK
6	56.42	401.94	1.7236
10	57.61	405.57	1.7365
15	59.07	410.11	1.7524
20	60.50	414.66	1.7680
25	61.91	419.21	1.7834
30	63.29	423.77	1.7986
35	64.65	428.35	1.8136
40	66.00	432.95	1.8284
45	67.33	437.56	1.8430
50	68.65	442.20	1.8575
55	69.95	446.86	1.8718
60	71.24	451.55	1.8860
65	72.53	456.26	1.9000
70	73.80	461.00	1.9139
75	75.06	465.77	1.9277
80	76.32	470.57	1.9414
85	77.56	475.39	1.9550

2.006bar -10°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-10	99.54	392.58	1.7331
-5	101.99	396.79	1.7489
0	104.41	401.02	1.7646
5	106.79	405.27	1.7800
10	109.14	409.54	1.7952
15	111.47	413.83	1.8102
20	113.78	418.16	1.8251
25	116.07	422.51	1.8398
30	118.33	426.89	1.8544
35	120.59	431.30	1.8688
40	122.82	435.74	1.8831
45	125.05	440.21	1.8973
50	127.26	444.72	1.9113
55	129.46	449.26	1.9253
60	131.64	453.84	1.9391
65	133.82	458.44	1.9529
70	136.00	463.09	1.9665

2.527bar -4°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
-4	79.83	396.15	1.7291
0	81.44	399.61	1.7419
5	83.41	403.95	1.7576
10	85.36	408.30	1.7731
15	87.28	412.67	1.7884
20	89.18	417.06	1.8035
25	91.06	421.47	1.8184
30	92.91	425.91	1.8332
35	94.75	430.37	1.8478
40	96.57	434.86	1.8622
45	98.38	439.37	1.8765
50	100.18	443.92	1.8907
55	101.96	448.50	1.9048
60	103.73	453.11	1.9187
65	105.50	457.75	1.9325
70	107.25	462.42	1.9463
75	109.00	467.13	1.9599

3.146bar 2°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
2	64.64	399.65	1.7256
5	65.64	402.32	1.7353
10	67.29	406.78	1.7512
15	68.90	411.24	1.7668
20	70.49	415.71	1.7822
25	72.06	420.20	1.7974
30	73.61	424.71	1.8124
35	75.14	429.24	1.8272
40	76.65	433.78	1.8418
45	78.14	438.36	1.8563
50	79.62	442.95	1.8706
55	81.09	447.58	1.8848
60	82.55	452.23	1.8989
65	84.00	456.91	1.9128
70	85.44	461.62	1.9267
75	86.87	466.36	1.9404
80	88.30	471.13	1.9540

3.876bar 8°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
8	52.79	403.07	1.7226
10	53.35	404.90	1.7291
15	54.74	409.49	1.7452
20	56.10	414.07	1.7609
25	57.44	418.66	1.7765
30	58.75	423.26	1.7918
35	60.05	427.87	1.8068
40	61.32	432.49	1.8217
45	62.58	437.13	1.8364
50	63.82	441.79	1.8509
55	65.05	446.47	1.8653
60	66.27	451.18	1.8795
65	67.48	455.90	1.8936
70	68.68	460.66	1.9076
75	69.87	465.44	1.9214
80	71.05	470.25	1.9352
85	72.23	475.10	1.9488

Vapour Table, Superheated Range Solkane®134a

4.146bar 10°C

T	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
10	49.43	404.19	1.7217
15	50.76	408.82	1.7379
20	52.06	413.45	1.7538
25	53.33	418.08	1.7695
30	54.58	422.71	1.7849
35	55.80	427.35	1.8001
40	57.01	432.00	1.8151
45	58.21	436.67	1.8298
50	59.38	441.35	1.8444
55	60.55	446.05	1.8589
60	61.70	450.78	1.8732
65	62.84	455.53	1.8873
70	63.97	460.30	1.9013
75	65.10	465.10	1.9152
80	66.21	469.93	1.9290
85	67.32	474.78	1.9426
90	68.42	479.66	1.9562

5.043bar 16°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
16	40.77	407.48	1.7192
20	41.69	411.31	1.7323
25	42.80	416.08	1.7484
30	43.89	420.83	1.7643
35	44.96	425.59	1.7798
40	46.00	430.34	1.7951
45	47.03	435.10	1.8102
50	48.04	439.87	1.8251
55	49.04	444.65	1.8397
60	50.02	449.45	1.8542
65	50.99	454.26	1.8686
70	51.95	459.09	1.8828
75	52.90	463.95	1.8968
80	53.85	468.82	1.9107
85	54.78	473.72	1.9245
90	55.71	478.65	1.9382
95	56.63	483.61	1.9517

6.079bar 22°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
22	33.85	410.66	1.7169
25	34.45	413.63	1.7269
30	35.42	418.55	1.7433
35	36.37	423.46	1.7593
40	37.29	428.34	1.7750
45	38.19	433.22	1.7905
50	39.07	438.10	1.8057
55	39.94	442.97	1.8207
60	40.79	447.86	1.8354
65	41.63	452.75	1.8500
70	42.46	457.66	1.8644
75	43.28	462.58	1.8787
80	44.09	467.52	1.8928
85	44.89	472.48	1.9067
90	45.68	477.46	1.9205
95	46.46	482.46	1.9342
100	47.24	487.49	1.9478

7.269bar 28°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
28	28.27	413.71	1.7148
30	28.62	415.76	1.7216
35	29.48	420.86	1.7383
40	30.31	425.92	1.7546
45	31.11	430.96	1.7705
50	31.90	435.97	1.7861
55	32.67	440.97	1.8015
60	33.42	445.97	1.8166
65	34.16	450.96	1.8315
70	34.88	455.96	1.8462
75	35.60	460.97	1.8606
80	36.30	465.99	1.8749
85	37.00	471.02	1.8891
90	37.68	476.06	1.9031
95	38.36	481.13	1.9169
100	39.03	486.21	1.9306
105	39.70	491.31	1.9442

4.430bar 12°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
12	46.32	405.30	1.7208
15	47.08	408.11	1.7306
20	48.32	412.78	1.7467
25	49.54	417.45	1.7625
30	50.73	422.12	1.7780
35	51.90	426.80	1.7933
40	53.05	431.48	1.8084
45	54.18	436.18	1.8233
50	55.30	440.89	1.8380
55	56.40	445.61	1.8525
60	57.49	450.36	1.8668
65	58.57	455.13	1.8811
70	59.64	459.92	1.8951
75	60.70	464.74	1.9091
80	61.75	469.58	1.9229
85	62.80	474.45	1.9366
90	63.83	479.35	1.9501

5.372bar 18°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
18	38.30	408.55	1.7184
20	38.73	410.49	1.7250
25	39.81	415.31	1.7413
30	40.85	420.12	1.7573
35	41.87	424.92	1.7730
40	42.87	429.72	1.7884
45	43.86	434.51	1.8036
50	44.82	439.31	1.8186
55	45.77	444.12	1.8334
60	46.70	448.95	1.8480
65	47.63	453.78	1.8624
70	48.54	458.64	1.8766
75	49.44	463.52	1.8907
80	50.34	468.41	1.9047
85	51.22	473.33	1.9185
90	52.10	478.28	1.9323
95	52.98	483.25	1.9458

6.458bar 24°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
24	31.86	411.69	1.7162
25	32.05	412.69	1.7195
30	32.99	417.69	1.7361
35	33.90	422.65	1.7524
40	34.79	427.59	1.7683
45	35.66	432.51	1.7839
50	36.51	437.43	1.7992
55	37.34	442.35	1.8143
60	38.15	447.26	1.8292
65	38.96	452.19	1.8439
70	39.75	457.12	1.8583
75	40.53	462.07	1.8727
80	41.30	467.04	1.8868
85	42.06	472.02	1.9008
90	42.81	477.02	1.9147
95	43.56	482.04	1.9284
100	44.30	487.09	1.9420

7.702bar 30°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
30	26.65	414.69	1.7141
35	27.48	419.88	1.7311
40	28.29	425.01	1.7476
45	29.07	430.10	1.7637
50	29.83	435.17	1.7795
55	30.57	440.22	1.7950
60	31.30	445.26	1.8103
65	32.01	450.30	1.8253
70	32.70	455.33	1.8401
75	33.39	460.37	1.8546
80	34.06	465.42	1.8690
85	34.73	470.47	1.8832
90	35.38	475.54	1.8973
95	36.03	480.63	1.9112
100	36.67	485.74	1.9250
105	37.31	490.86	1.9386
110	37.94	496.01	1.9522

4.729bar 14°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
14	43.44	406.39	1.7200
15	43.68	407.34	1.7233
20	44.88	412.07	1.7395
25	46.04	416.79	1.7555
30	47.18	421.50	1.7712
35	48.29	426.21	1.7866
40	49.39	430.93	1.8018
45	50.46	435.65	1.8167
50	51.52	440.39	1.8315
55	52.57	445.15	1.8461
60	53.61	449.92	1.8605
65	54.63	454.71	1.8748
70	55.64	459.52	1.8889
75	56.65	464.35	1.9029
80	57.64	469.21	1.9168
85	58.63	474.10	1.9305
90	59.61	479.01	1.9441

5.717bar 20°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
20	35.99	409.61	1.7176
25	37.03	414.50	1.7341
30	38.04	419.36	1.7503
35	39.02	424.21	1.7662
40	39.98	429.05	1.7818
45	40.92	433.89	1.7971
50	41.84	438.72	1.8122
55	42.74	443.56	1.8270
60	43.64	448.42	1.8417
65	44.52	453.28	1.8562
70	45.38	458.16	1.8705
75	46.24	463.06	1.8847
80	47.09	467.98	1.8987
85	47.93	472.92	1.9126
90	48.77	477.88	1.9264
95	49.60	482.87	1.9400
95	49.60	482.87	1.9400

6.854bar 26°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
26	30.00	412.71	1.7155
30	30.73	416.76	1.7289
35	31.61	421.79	1.7454
40	32.47	426.78	1.7614
45	33.31	431.76	1.7772
50	34.12	436.72	1.7927
55	34.92	441.68	1.8079
60	35.70	446.63	1.8229
65	36.47	451.59	1.8377
70	37.23	456.56	1.8522
75	37.97	461.54	1.8666
80	38.71	466.52	1.8809
85	39.44	471.53	1.8949
90	40.15	476.55	1.9089
95	40.87	481.60	1.9227
100	41.57	486.66	1.9363
100	41.57	486.66	1.9363

8.154bar 32°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
32	25.13	415.66	1.7134
35	25.62	418.82	1.7237
40	26.41	424.03	1.7405
45	27.17	429.19	1.7569
50	27.90	434.32	1.7729
55	28.62	439.43	1.7885
60	29.32	444.51	1.8039
65	30.00	449.59	1.8190
70	30.67	454.66	1.8339
75	31.33	459.74	1.8486
80	31.97	464.81	1.8631
85	32.61	469.90	1.8774
90	33.24	475.00	1.8915
95	33.86	480.11	1.9055
100	34.47	485.24	1.9193
105	35.08	490.38	1.9330
110	35.68	495.55	1.9466

Vapour Table, Superheated Range Solkane®134a

8.626bar 34°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
34	23.72	416.61	1.7128
35	23.87	417.68	1.7162
40	24.64	422.98	1.7333
45	25.38	428.22	1.7499
50	26.10	433.42	1.7661
55	26.79	438.58	1.7820
60	27.47	443.72	1.7975
65	28.13	448.84	1.8128
70	28.77	453.96	1.8278
75	29.41	459.07	1.8426
80	30.03	464.18	1.8572
85	30.64	469.30	1.8715
90	31.24	474.42	1.8858
95	31.84	479.56	1.8998
100	32.42	484.71	1.9137
105	33.01	489.88	1.9275
110	33.58	495.07	1.9411

10.166bar 40°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
40	19.98	419.33	1.7107
45	20.68	424.87	1.7283
50	21.35	430.31	1.7453
55	21.99	435.69	1.7618
60	22.61	441.02	1.7779
65	23.21	446.31	1.7937
70	23.79	451.58	1.8091
75	24.36	456.82	1.8243
80	24.92	462.06	1.8392
85	25.47	467.28	1.8539
90	26.01	472.51	1.8684
95	26.53	477.74	1.8827
100	27.05	482.97	1.8968
105	27.57	488.21	1.9108
110	28.07	493.47	1.9246
115	28.57	498.74	1.9383
120	29.07	504.03	1.9518

11.903bar 46°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
46	16.88	421.84	1.7086
50	17.39	426.48	1.7231
55	18.01	432.17	1.7405
60	18.59	437.76	1.7574
65	19.15	443.28	1.7739
70	19.69	448.74	1.7899
75	20.22	454.16	1.8056
80	20.73	459.55	1.8209
85	21.22	464.91	1.8360
90	21.71	470.26	1.8509
95	22.19	475.60	1.8655
100	22.65	480.94	1.8799
105	23.11	486.28	1.8941
110	23.56	491.62	1.9081
115	24.01	496.97	1.9220
120	24.45	502.33	1.9357
125	24.88	507.71	1.9493

13.854bar 52°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
52	14.29	424.10	1.7062
55	14.65	427.78	1.7175
60	15.22	433.75	1.7355
65	15.76	439.59	1.7529
70	16.28	445.33	1.7698
75	16.77	450.98	1.7861
80	17.24	456.57	1.8021
85	17.70	462.12	1.8177
90	18.15	467.63	1.8329
95	18.59	473.11	1.8479
100	19.01	478.57	1.8627
105	19.43	484.03	1.8772
110	19.84	489.48	1.8915
115	20.24	494.92	1.9056
120	20.63	500.37	1.9196
125	21.02	505.83	1.9334
130	21.41	511.30	1.9470

9.118bar 36°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
36	22.39	417.54	1.7121
40	22.99	421.85	1.7260
45	23.71	427.18	1.7428
50	24.41	432.45	1.7593
55	25.09	437.68	1.7753
60	25.74	442.87	1.7910
65	26.38	448.05	1.8065
70	27.00	453.21	1.8216
75	27.61	458.36	1.8365
80	28.21	463.51	1.8512
85	28.80	468.66	1.8657
90	29.38	473.82	1.8800
95	29.95	478.98	1.8941
100	30.51	484.16	1.9081
105	31.07	489.35	1.9219
110	31.62	494.56	1.9356
115	32.16	499.79	1.9491

10.722bar 42°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
42	18.88	420.19	1.7100
45	19.29	423.58	1.7207
50	19.95	429.13	1.7381
55	20.58	434.60	1.7549
60	21.19	440.01	1.7712
65	21.77	445.37	1.7872
70	22.34	450.69	1.8028
75	22.89	455.99	1.8181
80	23.43	461.27	1.8332
85	23.96	466.54	1.8480
90	24.48	471.80	1.8626
95	24.99	477.06	1.8770
100	25.49	482.33	1.8912
105	25.98	487.60	1.9052
110	26.47	492.88	1.9191
115	26.95	498.18	1.9328
120	27.43	503.49	1.9464

12.529bar 48°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
48	15.96	422.63	1.7078
50	16.22	425.00	1.7152
55	16.83	430.82	1.7331
60	17.40	436.52	1.7503
65	17.96	442.13	1.7670
70	18.49	447.68	1.7833
75	19.00	453.16	1.7992
80	19.50	458.61	1.8147
85	19.98	464.03	1.8300
90	20.45	469.43	1.8449
95	20.91	474.82	1.8597
100	21.36	480.19	1.8742
105	21.81	485.57	1.8885
110	22.24	490.94	1.9026
115	22.67	496.32	1.9166
120	23.10	501.71	1.9304
125	23.51	507.11	1.9440

14.555bar 54°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
54	13.52	424.79	1.7053
55	13.64	426.05	1.7092
60	14.21	432.20	1.7278
65	14.75	438.18	1.7456
70	15.26	444.03	1.7628
75	15.75	449.78	1.7794
80	16.21	455.45	1.7956
85	16.66	461.07	1.8114
90	17.10	466.64	1.8268
95	17.52	472.18	1.8420
100	17.94	477.70	1.8569
105	18.34	483.20	1.8715
110	18.74	488.69	1.8859
115	19.13	494.17	1.9002
120	19.51	499.66	1.9142
125	19.89	505.14	1.9281
130	20.26	510.64	1.9418

9.632bar 36°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
38	21.15	418.44	1.7114
40	21.44	420.64	1.7184
45	22.15	426.06	1.7356
50	22.83	431.42	1.7523
55	23.49	436.72	1.7686
60	24.12	441.98	1.7845
65	24.74	447.21	1.8001
70	25.34	452.42	1.8154
75	25.93	457.61	1.8304
80	26.51	462.80	1.8452
85	27.08	467.99	1.8598
90	27.64	473.18	1.8742
95	28.18	478.38	1.8884
100	28.73	483.58	1.9025
105	29.26	488.80	1.9163
110	29.79	494.03	1.9301
115	30.31	499.28	1.9437

11.301bar 42°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
44	17.85	421.03	1.7093
45	17.98	422.18	1.7130
50	18.63	427.86	1.7307
55	19.25	433.43	1.7478
60	19.85	438.92	1.7644
65	20.42	444.36	1.7806
70	20.98	449.75	1.7964
75	21.51	455.10	1.8119
80	22.04	460.43	1.8271
85	22.55	465.75	1.8420
90	23.05	471.05	1.8567
95	23.54	476.35	1.8712
100	24.03	481.65	1.8855
105	24.50	486.96	1.8997
110	24.97	492.27	1.9136
115	25.43	497.59	1.9274
120	25.89	502.93	1.9411

13.179bar 48°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
50	15.10	423.38	1.7071
55	15.71	429.36	1.7254
60	16.28	435.19	1.7430
65	16.83	440.91	1.7601
70	17.35	446.54	1.7766
75	17.85	452.11	1.7927
80	18.34	457.62	1.8085
85	18.81	463.10	1.8239
90	19.27	468.55	1.8390
95	19.71	473.99	1.8538
100	20.15	479.41	1.8685
105	20.58	484.82	1.8829
110	21.00	490.23	1.8971
115	21.42	495.64	1.9111
120	21.83	501.06	1.9250
125	22.23	506.49	1.9387
130	22.63	511.92	1.9523

15.282bar 54°C

t	v	h	s
°C	dm³/kg	kJ/kg	kJ/kgK
56	12.80	425.44	1.7044
60	13.25	430.51	1.7197
65	13.79	436.65	1.7380
70	14.30	442.63	1.7556
75	14.78	448.50	1.7725
80	15.24	454.26	1.7890
85	15.68	459.96	1.8050
90	16.11	465.60	1.8207
95	16.52	471.21	1.8360
100	16.93	476.78	1.8510
105	17.32	482.33	1.8658
110	17.70	487.86	1.8803
115	18.08	493.38	1.8946
120	18.45	498.90	1.9088
125	18.82	504.42	1.9227
130	19.17	509.95	1.9365
135	19.53	515.48	1.9501

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