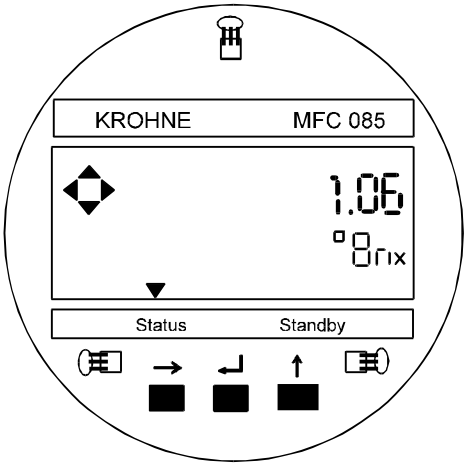
KROHNE

CORIMASS

Instruction Manual
for
MFC 081 / 085

Concentration Measurement



Contents

1. Introduction

The standard MFC 081 and 085 Mass Flow Converters enable the direct measurement of the overall mass flow, mass total, density, and temperature of the process fluid passing through the flow tube. From the mass flow and density measurements it is then possible to calculate additional values for volume flow and volume total.

If the process fluid is a mixture of two components, then, given data on those components, it is possible to **infer**, from the measured density, what the proportions of those components must be. Clearly, if the two components have the same (or similar,) individual densities then the mixture will also have the same density regardless of the relative proportions of the components. Hence no concentration calculations will be possible for this case. As the difference between the component densities increases, it then becomes easier to accurately determine the relative proportions of the components.

The MFC081 and 085 converters are available with enhanced software which can calculate the concentrations of the solid/solute components within various mixtures. Typical mixtures include:

solid / liquid suspensions or slurries
oil / water emulsions
dissolved solids in water or other solvent.

Owing to the diverse physical and chemical properties of such a range of mixtures no one concentration equation can fit all cases. Hence five different versions of concentration software are available.

General Concentration
This is a freely programmable algorithm for mixtures of two immiscible components, (oil / water emulsions or solid / liquid slurries). It can also be used for most other mixtures but the range of accurate measurements can be limited.

Brix
Concentration of **sucrose in pure water** measured in °BRIX

Baumé Rational
Baumé Commercial
Concentration of **sucrose in pure water** measured in °BAUMÉ. There are two slightly different versions of this scale with the “COMMERCIAL” version used more in the USA and “RATIONAL” in Europe.

Sodium hydroxide, NaOH, Concentration
Concentration of aqueous sodium hydroxide, (NaOH), solutions.

All these different software versions provide measurements for Concentration, (in units of °Brix, °Baumé or as a percentage by mass). They also provide a Solute Flow Rate so that the mass flow rate of the solid / solute can be displayed. In addition the GENERAL CONCENTRATION option provides a concentration by volume display.

Please Note:
The concentration measurements can only be as good as the density measurement from which they are derived. For best performance it is recommended that the process should be operated at a stable temperature and the density measurements should be site calibrated at that temperature. Any sudden changes in temperature should be avoided.

2. Definitions

2.1 Concentration by Volume (C_V)

A mixture with total volume, V_T, contains a volume, V_S, of one component. The concentration by volume, C_V, of that component is:

$$C_V = \frac{V_S}{V_T} \times 100\%$$

Note: V_S, V_T and hence C_V will vary with temperature.

2.2 Concentration by Mass (C_M)

A mixture or solution with total mass, M_T, contains mass, M_S, of one component. The concentration by mass, C_M, of that component is:

$$C_M = \frac{M_S}{M_T} \times 100\%$$

Masses M_S, M_T and hence C_M do **not** vary with temperature.

2.3 Brix

Brix is the **concentration by mass** of sucrose in pure water. A 10% solution has a Brix value of 10°Brix. A solution's Brix value does **not** vary with temperature. If a 100 g solution contains 10 g of sucrose it will still contain 10 g whether the temperature is 10, 20 or 30°C

The Brix option provides the following:
Sucrose Concentration C_{BX} °BRIX
Sucrose Mass Flow or BRIX RATE

C_{BX} is defined by:

$$C_{BX} = \frac{M_{SUCROSE}}{M_{SUCROSE} + M_{WATER}} * 100$$

Where: $M_{SUCROSE}$ = mass of sucrose
M_{WATER} = mass of water

The BRIX RATE, (mass flow rate of sucrose) is given by :

$$\text{BRIX RATE} = \frac{C_{BX}}{100} * \dot{m}$$

where: $\dot{m}$ is the mass flow of the total solution.

2.4 Baumé

This is another concentration scale for aqueous sucrose. It is based on the specific gravity of sucrose solutions, d_{15}^{15}, relative to water at 60°F, measured at 60°F. The concentration is then given by:

$$Conc. = K_B \left(1 - \frac{1}{d_{15}^{15}}\right) {}^{\circ}Be$$

There are actually two Baumé scales:
Baumé Commercial (US) K_B = 145.0
Baumé Rational K_B = 144.3

2.5 Specific Gravity, d_Y^X

This is the density of a substance measured at X°C relative to the density of water at Y°C.
Example:

At 20°C water has a density= 0.9982 g/cm^3
At 4°C water has a density = 0.99997 g/cm^3
At 20°C a 10% sucrose solution has a density = 1.0381 g/cm^3

So, for the sucrose solution:

$$d_{20}^{20} = \frac{1.0381}{0.9982} = 1.03997$$

$$d_{4}^{20} = \frac{1.0381}{0.99997} = 1.03813$$

3. Programming the Converter

3.1 Menu Variations for Concentration Systems

Table 3.1.1 below shows how the menus for the MFC081 / 085 converters vary with the different concentration options. The main difference from the standard software is in the Fct. 1.2 and 3.2 menus. This is to allow the optional display of the new measured values. For General Concentration systems menus Fct. 3.10.1 to 3.10.7 are available to allow the input of product specific data.

Table 3.1.1
Menu Variations for Concentration systems

	Concentration Option				
Submenu	**NONE**	**BRIX**	**BAUMÉ**	**GEN. CONC.**	**NaOH**
Fct. 1.2.9 / 3.2.9	not available	BRIX RATE	SOLUTE.FLOW	SOLUTE.FLOW	SOLUTE.FLOW
Fct. 1.2.10 / 3.2.10	not available	BRIX	BAUME	CONC.BY.MASS	CONC.BY.MASS
Fct. 1.2.11 / 3.2.11	not available	not available	not available	CONC.BY. VOL.	not available
Fct. 3.10.0	not available	not available	not available	CONC. MEAS.	not available
Fct. 3.10.1	not available	not available	not available	SOLUTE R20	not available
Fct. 3.10.2	not available	not available	not available	SOLUTE K1	not available
Fct. 3.10.3	not available	not available	not available	SOLUTE K2	not available
Fct. 3.10.4	not available	not available	not available	LIQUID	not available
Fct. 3.10.5	not available	not available	not available	LIQUID R20*	not available
Fct. 3.10.6	not available	not available	not available	LIQUID K1*	not available
Fct. 3.10.7	not available	not available	not available	LIQUID K2*	not available

*Only available if Fct. 3.10.4 LIQUID is set to NON WATER

3.2 Displaying Concentration and Solute Flow Values

Table 3.2 shows the measured values available for display on the converter with the concentration systems. All options have a Concentration by Mass display, (in units of °Brix, °Baumé or just as a percentage), and a solid flow rate display. The General Concentration option also has a percentage by volume display.

The control of these displays are basically the same for all systems, please refer to the Standard operating manual. Using NaOH as an example, starting from measuring mode:

Key	Line 1	Line 2	Comments
→↑↑	Fct. 3.(0)	INSTALL	
→↑	Fct. 3.(2).0	DISPLAY	
→↑x8	Fct. 3.2.(9)	SOLUTE.FLOW	
→		(OFF)	Display disabled
↑	00000.000	(g)/min	Display enabled, use ↑ key to select mass units
↑	00000.000	(kg)/min	
→	00000.000	kg/(min)	Use the ↑ key to select time units
→	00000(.)000	kg/min	Use the ↑ key move the decimal point
↑	000000(.)00	kg/min	
↵	Fct. 3.2.(9)	SOLUTE.FLOW	
↑	Fct. 3.2.(10)	CONC.BY.MASS	
→		(OFF)	Display disabled
↑	000000.00	(PERCENT M)	Display enabled
↵	Fct. 3.2.(10)	CONC.BY.MASS	
↵x4			Exit menus and save changes

Table 3.2.1 Measurement Display variations for Concentration systems

Concentration Option				
NONE	**BRIX**	**BAUMÉ**	**GEN. CONC.**	**NaOH**
MASS FLOW	**MASS FLOW**	**MASS FLOW**	**MASS FLOW**	**MASS FLOW**
MASS TOTAL	**MASS TOTAL**	**MASS TOTAL**	**MASS TOTAL**	**MASS TOTAL**
DENSITY	**DENSITY**	**DENSITY**	**DENSITY**	**DENSITY**
TEMPERATURE	**TEMPERATURE**	**TEMPERATURE**	**TEMPERATURE**	**TEMPERATURE**
VOLUME FLOW	VOLUME FLOW	VOLUME FLOW	VOLUME FLOW	VOLUME FLOW
VOLUME TOTAL	VOLUME TOTAL	VOLUME TOTAL	VOLUME TOTAL	VOLUME TOTAL
	BRIX	BAUME	PERCENT M.	PERCENT M.
	SUCROSE FLOW	SUCROSE FLOW	PERCENT V.	SOLID FLOW
			SOLID FLOW	

BOLD type indicates displays that are permanently enabled. All other displays must be specifically enabled in the corresponding Fct 1.2 or 3.2 menu.

3.3 Output of Concentration Values

Tables 3.3.1,3.3.2 and 3.3.3 show the additional output functions that are available with the different concentration options. These may be programmed in the normal way as described in the Standard Operating manual.

Table 3.3.1 Current Output Function Variations for Concentration systems

Concentration Option				
NONE	**BRIX**	**BAUMÉ**	**GEN. CONC.**	**NaOH**
OFF	OFF	OFF	OFF	OFF
MASS FLOW	MASS FLOW	MASS FLOW	MASS FLOW	MASS FLOW
DENSITY	DENSITY	DENSITY	DENSITY	DENSITY
TEMPERATUR.	TEMPERATUR.	TEMPERATUR.	TEMPERATUR.	TEMPERATUR.
VOL. FLOW	VOL. FLOW	VOL. FLOW	VOL. FLOW	VOL. FLOW
DIRECTION	BRIX RATE	SOLUTE. FLOW	SOLUTE. FLOW	SOLUTE. FLOW
	BRIX	BAUME	CONC.BY.MASS	CONC.BY.MASS
	DIRECTION	DIRECTION	CONC.BY VOL	DIRECTION
			DIRECTION	

Table 3.3.2 Pulse Output Function Variations for Concentration systems

Concentration Option				
NONE	**BRIX**	**BAUMÉ**	**GEN. CONC.**	**NaOH**
OFF	OFF	OFF	OFF	OFF
MASS FLOW	MASS FLOW	MASS FLOW	MASS FLOW	MASS FLOW
MASS TOTAL	MASS TOTAL	MASS TOTAL	MASS TOTAL	MASS TOTAL
DENSITY	DENSITY	DENSITY	DENSITY	DENSITY
TEMPERATUR.	TEMPERATUR.	TEMPERATUR.	TEMPERATUR.	TEMPERATUR.
VOL. FLOW	VOL. FLOW	VOL. FLOW	VOL. FLOW	VOL. FLOW
VOL. TOTAL	VOL. TOTAL	VOL. TOTAL	VOL. TOTAL	VOL. TOTAL
DIRECTION	BRIX RATE	SOLUTE. FLOW	SOLUTE. FLOW	SOLUTE. FLOW
	SUC. TOTAL	SOL. TOTAL	SOL. TOTAL	SOL. TOTAL
	BRIX	BAUME	CONC.BY.MASS	CONC.BY.MASS
	DIRECTION	DIRECTION	CONC.BY VOL	DIRECTION
			DIRECTION	

Table 3.3.3 Alarm Output Function Variations for Concentration systems

Concentration Option				
NONE	**BRIX**	**BAUMÉ**	**GEN. CONC.**	**NaOH**
OFF	OFF	OFF	OFF	OFF
MASS FLOW	MASS FLOW	MASS FLOW	MASS FLOW	MASS FLOW
MASS TOTAL	MASS TOTAL	MASS TOTAL	MASS TOTAL	MASS TOTAL
DENSITY	DENSITY	DENSITY	DENSITY	DENSITY
TEMPERATUR.	TEMPERATUR.	TEMPERATUR.	TEMPERATUR.	TEMPERATUR.
VOL. FLOW	VOL. FLOW	VOL. FLOW	VOL. FLOW	VOL. FLOW
VOL. TOTAL	VOL. TOTAL	VOL. TOTAL	VOL. TOTAL	VOL. TOTAL
DIRECTION	BRIX RATE	SOLUTE. FLOW	SOLUTE. FLOW	SOLUTE. FLOW
SEVERE ERR.	BRIX	BAUME	CONC.BY.MASS	CONC.BY.MASS
ALL MSG.	DIRECTION	DIRECTION	CONC.BY VOL	DIRECTION
I1 SAT	SEVERE ERR.	SEVERE ERR.	DIRECTION	SEVERE ERR.
P1 SAT	ALL MSG.	ALL MSG.	SEVERE ERR.	ALL MSG.
ANY OP. SAT.	I1 SAT	I1 SAT	ALL MSG.	I1 SAT
	P1 SAT	P1 SAT	I1 SAT	P1 SAT
	ANY OP. SAT.	ANY OP. SAT.	P1 SAT	ANY OP. SAT.
			ANY OP. SAT.	

Using Brix as an example, starting from measuring mode:

Key	Line 1	Line 2	Comments
→↑↑	Fct. 3.(0)	INSTALL	
→↑↑	Fct. 3.(3).0	CUR.OUTP.I	
→	Fct. 3.3.(1)	FUNCTION I	
→↑xn		(BRIX)	Press the ↑ key as required to select BRIX
↵↑	Fct. 3.3.(2)	RANGE I	
→↑xn		4-20mA	Use the ↑ key select the range.
↵↑	Fct. 3.3.(3)	MIN BRIX	
→	(0)0.00	°BRIX	
→↑x4	(4).00	°BRIX	Edit the value to 4.0
↵↑	Fct. 3.3.(4)	MAX BRIX	
→	(0)100.00	°BRIX	
→↑x9	(0)00.00	°BRIX	
→↑x2	(2)0.00	°BRIX	Edit the value to 20.00
↵↵	Fct. 3.(3).0	CUR.OUTP.I	Current output now set 4-20°Brix = 4-20mA Note: The Brix display need not be enabled first in order to set the output to Brix.
↑	Fct. 3.(4).0	PULS.OUTP.P	
→	Fct. 3.4.(1)	FUNCTION P	
→↑xn		(SOL. TOTAL)	Use the ↑ key to select the desired function. The SOL. TOTAL function sends a series of pulses each one representing a preset mass of the solute.
↵↑	Fct. 3.4.(2)	PULSE/MASS	
→	1.000	I. P. = (g)	Edit the this number and units to select the desired mass per pulse value.
↵↑	Fct. 3.4.(3)	PULSE.WIDTH	
→	(0)0.4	mSec	Edit to set the desired minimum pulse width
↵↵	Fct. 3.(4).0	PULS.OUTP.P	With these settings the output will give one 0.4ms pulse for every 1.0g of solute measured.
↑	Fct. 3.(5).0	ALARM.OUT.A	
→	Fct. 3.5.(1)	FUNCTION A	
→↑xn		BRIX	Use the ↑ key to select the desired function
↵↑↑	Fct. 3.5.(3)	MIN. LIMIT	
→	(0)0.00	°BAUME	Edit the lower alarm limit
→↑x4	(4).00	°BAUME	
↵↑	Fct. 3.5.(4)	MAX. LIMIT	
→	(0)100.00	°BAUME	Edit the upper alarm limit
→↑x9	(0)00.000	°BAUME	
→↑	(1)0.000	°BAUME	
↵	Fct. 3.5.(4)	MAX. LIMIT	
↵x4			Save changes. The alarm will now be active if the Brix value is outside the range 4-10 Brix

4. General Concentration

4.1 Mixtures Of Two Immiscible Non Compressible Components

Immiscible means the two components do not mix or interact with each other. Typical examples are oil/water emulsions or solid/liquid suspensions. For these cases, if you have V_S volume of one component and V_C of the other, then on mixing, the total volume V_T is :

$$V_T = V_S + V_C$$

Also for the masses :

$$M_T = M_S + M_C$$

Also the densities of the components ρ_S, ρ_C and the mixture ρ_M are related by :

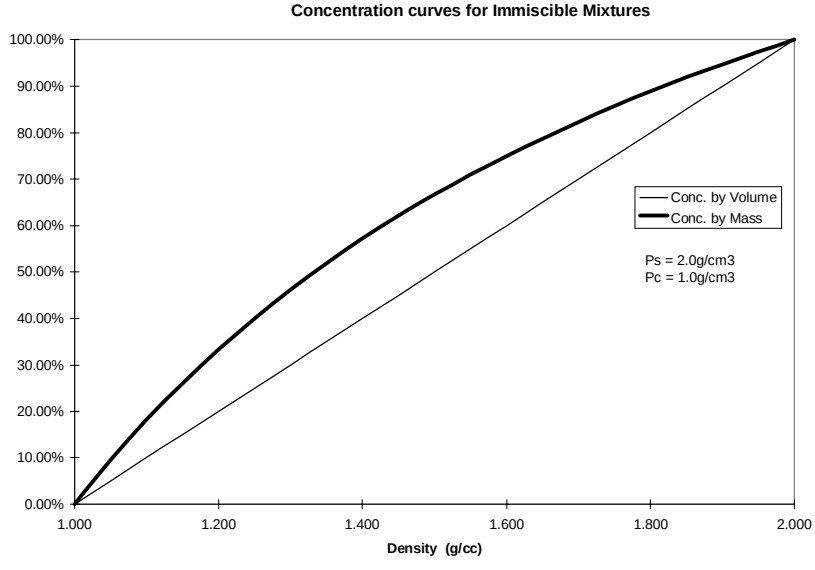
$$\rho_S = \frac{M_S}{V_S},\ \rho_C = \frac{M_C}{V_C} \text{ and } \rho_M = \frac{M_T}{V_T}$$

It can be shown that :

$$C_V = \frac{\rho_M - \rho_C}{\rho_S - \rho_C} \times 100\% \qquad \textit{Equation 1}$$

$$C_M = \frac{\rho_S}{\rho_M} \cdot \frac{\rho_M - \rho_C}{\rho_S - \rho_C} \times 100\% \qquad \textit{Equation 2}$$

The figure below shows graphically these two equations for the case ρ_S=2.0 and ρ_C=1.0. As can be seen, the C_V curve is linear whilst the C_M curve is not.



It is these two equations that are used in the MFC081/085's general concentration algorithm. ρ_M is measured directly by the meter and ρ_S and ρ_C are known for the components in question.

However, ρ_S and ρ_C vary with temperature, T. This is compensated for by using the following equation for both ρ_S and ρ_C.

$$\rho = \rho_{20} + K_1 (T-20) + K_2 (T-20)^2 \qquad \textit{Equation 3}$$

where: ρ_{20}, K_1 and K_2 are input by the customer for each component.

These parameters are entered via the Fct. 3.10 menus.

Menu	Comments
Fct. 3.10.1 SOLUTE R20	ρ_{20} for the solid component
Fct. 3.10.2 SOLUTE K1	K_1 for the solid component
Fct. 3.10.3 SOLUTE K2	K_2 for the solid component
Fct. 3.10.4 LIQUID	Select either WATER or NON WATER If WATER is selected then ρ_C is taken from an internal lookup table of water's density versus temperature. If NON WATER is selected then ρ_C is calculated from Equation 3 using the parameters in menus 3.10.5 to 3.10.7
Fct. 3.10.5 LIQUID R20	ρ_{20} for the liquid component
Fct. 3.10.6 LIQUID K1	K_1 for the liquid component
Fct. 3.10.7 LIQUID K2	K_2 for the liquid component

Having computed the concentrations it is possible to estimate the flow rate of the individual components. If $\dot{m}$ is the total measured mass flow rate of the mixture, then the flow rate of the solid/solute, $\dot{m}$, is given by :

$$\dot{m} = \frac{C_M}{100} \cdot \dot{m} \qquad \textit{Equation 4}$$

4.2 Concentration Of Miscible Liquids

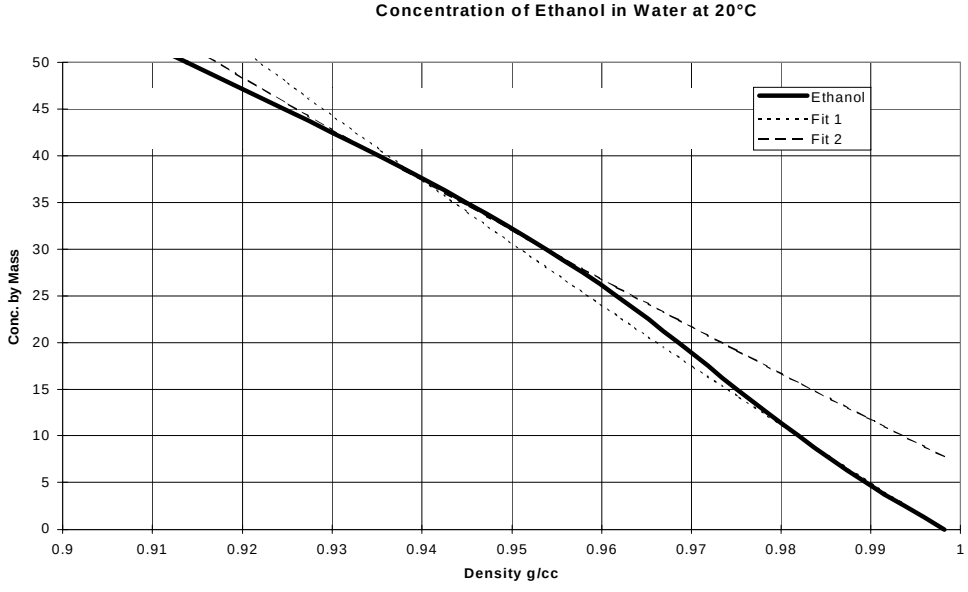
When two liquids mix or dissolve together they are said to be miscible. The two components may also have a strong chemical interaction. For such mixtures volumes do not add.

$$V_T \neq V_S + V_C$$

Consequently equations 1 and 2 above only approximate to the true behaviour of the mixture. The accuracy of this approximation varies from mixture to mixture and each case must be individually assessed. Normally it is possible to achieve a good fit, although this may only be over a limited range of densities.

Consider a mixture of ethanol and water as shown in the figure below. Clearly the true characteristic does not follow the ideal case of the previous section. Ignoring temperature compensation, ($K_1 = K_2 = 0$) the concentration software may be programmed with one of the following data sets.

	Fit 1	Fit 2
SOLUTE R20	0.85659 g/cm^3	0.83678 g/cm^3
LIQUID R20	0.99812 g/cm^3	1.01477 g/cm^3



As can be seen Fit 1 matches the characteristic from about 0 to 12% ethanol, whereas Fit 2 matches the range 28 to 43%. Note, for these cases, although the liquid carrier is water it is necessary to set the Liquid type (Fct. 3.10.4) to NON WATER so that the curves can be adjusted for best fit.

4.3 Determining the General Concentration Parameters

Case 1: Solid suspensions in water.
For these cases the solid particles tend to have a density much greater than that of water and their density can usually be considered not to vary significantly with temperature. Therefore set:

Menu	Setting	Comments
Fct. 3.10.1 SOLUTE R20	Density of the dry solid	
Fct. 3.10.2 SOLUTE K1	0	No temperature correction necessary
Fct. 3.10.3 SOLUTE K2	0	
Fct. 3.10.4 LIQUID	WATER	

This is the simplest case. There are some exceptions where the density of the dry solid differs greatly from its apparent density when wet. Starch is one such substance, in this case the starch will actually absorb water when wet.

Case 2: Solid suspensions in other liquids
As for Case 1 the dry solid density can be input in the same manner. However the converter needs to know how the liquid carrier's density varies with temperature. If the process always operates at the same temperature it is acceptable to input the carrier's density at that temperature into Fct. 3.10.5 LIQUID R20, and to set Fct. 3.10.6 and 3.10.7 to zero. However errors will result if the process is then operated at a different temperature.

If the density of the carrier is known only at two different temperatures then only a linear compensation is possible.

	Temperature °C	Density
1st Point	T_1	ρ_1
2nd Point	T_2	ρ_2

Set: Fct. 3.10.4 LIQUID = NON WATER
Fct. 3.10.7 LIQUID K2 = 0
Fct. 3.10.6 LIQUID K1 = $\dfrac{\rho_1 - \rho_2}{T_1 - T_2}$
Fct. 3.10.5 LIQUID R20 = $\rho_1 - K_1(T_1 - 20)$

To fully fit the temperature compensation equation to the real fluid three different temperature / density points are required; (ρ_1,T_1), (ρ_2,T_2), and (ρ_3,T_3). This gives a set of three equations with three unknowns to be solved simultaneously.

$$\rho_1 = \rho_{20} + K_1(T_1 - 20) + K_2(T_1 - 20)^2$$
$$\rho_2 = \rho_{20} + K_1(T_2 - 20) + K_2(T_2 - 20)^2$$
$$\rho_3 = \rho_{20} + K_1(T_3 - 20) + K_2(T_3 - 20)^2$$

Manual solution of these equations is possible, especially if one of the temperatures T_1,T_2 or T_3 = 20°C. However this is tedious and mistakes are easily made. It is recommended that the Microsoft Excel™ spread sheet file CONC4.XLT should be used to solve these equations automatically.

Should a PC running Microsoft Excel™ version 5 or later not be available the solution of these equations is as follows:

$$K_2 = \frac{\rho_1(T_3 - T_2) + \rho_2(T_1 - T_3) + \rho_3(T_2 - T_1)}{T_3^{\,2}(T_2 - T_1) + T_2^{\,2}(T_1 - T_3) + T_1^{\,2}(T_3 - T_2)}$$

$$K_1 = \frac{\rho_1 - \rho_2 - K_2(T_1 - 20)^2 + K_2(T_2 - 20)^2}{T_1 - T_2}$$

$$\rho_{20} = \rho_1 - K_1(T_1 - 20) - K_2(T_1 - 20)^2$$

Case 3: Oil Water Emulsions
For this case the oil should be treated as the “solid” component, and the LIQUID (Fct. 3.10.4) should be set to WATER. The calculation of the oil’s density parameters (Fct. 3.10.1 - 3) are calculated in the same way as described for the liquid carrier in Case 2 above.

Case 4: Dissolved solids.

To program the converter for this case two density / concentration points are required at three different temperatures. The three temperatures should cover the normal operating range of the process and the concentration points should be chosen to match the normal operating span of concentrations over which maximum accuracy is required.

Temp. /°C	Conc. by Mass /%	Density /g/cm^3
T_1	C_{11}	ρ_{11}
	C_{21}	ρ_{21}
T_2	C_{12}	ρ_{12}
	C_{22}	ρ_{22}
T_3	C_{13}	ρ_{13}
	C_{23}	ρ_{23}

This data should then be input into the Microsoft Excel™ CONC4.XLT spread sheet which will then proceed to calculate the settings for the 3.10 menus. Manual solution of the equations is possible but the Excel method is preferable as it will also produce tables and charts so the algorithm can be compared against real data and adjustments quickly made if necessary.

To solve manually, ρ_S and ρ_C values must be calculated for each of the temperatures, T_1, T_2 and T_3, using the equations:

$$\rho_{Cn} = \frac{\rho_{1n}\rho_{2n}\left(C_{1n} - C_{2n}\right)}{\rho_{1n}C_{1n} - \rho_{2n}C_{2n}}$$

$$\rho_{Sn} = \frac{C_{1n}\rho_{1n}\rho_{cn}}{C_{1n}\rho_{1n} - 100\left(\rho_{1n} - \rho_{cn}\right)}$$

for temperature T_n

With three temperature / ρ_C points the Liquid ρ_{20} , K_1 and K_2 values can be calculated as detailed for Case 2. The Solute ρ_{20} , K_1 and K_2 values can then be calculated in the same way from the three ρ_S values.

Example: Aqueous Sodium Chloride Solution (NaCl).

The process operates between 10 to 30°C and is required to measure NaCl concentrations between 5 and 15% by mass.

Enter the raw data (bold) into the table below then for each temperature calculate ρ_c and ρ_s using the above equations.

Temp. /°C	Conc. by Mass /%	Density /g/cm^3	ρ_c	ρ_s
10	**5.52** **14.9**	**1.040473** **1.112023**	1.002565	2.9473856
20	**5.52** **14.9**	**1.037835** **1.107953**	1.0006212	2.8540898
30	**5.52** **14.9**	**1.034454** **1.103516**	0.9977574	2.7906384

Transfer the ρ_c and ρ_s into the table below and calculate the ρ_{20}, K1 and K2 values for each using the equations of Case 2:

	Density	Temp.	K_2	K_1	ρ_{20}
Liquid	ρ_1 = **1.002565** ρ_2 = **1.0006212** ρ_3 = **0.9977574**	10 20 30	-0.0000046	-0.0002404	1.000621
Solid	ρ_1 = **2.9473856** ρ_2 = **2.8540898** ρ_3 = **2.7906384**	10 20 30	+0.0001492	-0.0078374	2.85409

Program these values into the converter. For this example the fit of the concentration algorithm, over the range 3 to 17%, is accurate to better than ±0.1

4.4 Entering the data into the converter

Having calculated the necessary parameters they must now be entered into the converter. In performing the ρ_{20}, K_1, K_2 calculations it does not matter which density units are used, (g/cm^3, kg/m^3, lb/US Gallon etc), provided all data is then entered in those units.

For an example consider an oil / water emulsion where the oil has densities of 650.0, 648.5, and 647.3 kg/m^3 at temperatures 10, 20 and 30°C respectively. From this data:

ρ_{20} = 648.5 kg/m^3
K_1 = -0.135 kg/m^3/°C
K_2 = 0.0015 kg/m^3/°C^2

Beginning from measuring mode:

Key	Line 1	Line 2	Comments
→↑↑	Fct. (3).0	INSTALL	
→↑x9	Fct. 3.(10).0	CONC. MEAS.	
→	Fct. 3.10.(1)	SOLUTE R20	
→	+4.0000000	(g)/cm^3	Use ↑ to select mass units.
↑	+4.0000000	(kg)/cm^3	
→	+4.0000000	kg/(cm^3)	Use ↑ to select volume units.
↑x3	+4.0000000	kg/(m^3)	Units set here must match those used in calculations
→	+(4).0000000	kg/m^3	Enter the calculated value
↑↑	+(6).0000000	kg/m^3	
→	+6(.)0000000	kg/m^3	
↑↑	+600(.)00000	kg/m^3	
→↑x5	+600.(5)0000	kg/m^3	
→x8	+6(0)0.50000	kg/m^3	
↑x4	+6(4)0.50000	kg/m^3	
→↑x8	+64(8).50000	kg/m^3	
↵↑	Fct. 3.10.(2)	SOLUTE K1	
→	(+)0.0000000	/°C	Enter K1 as calculated
↑	(-)0.0000000	/°C	
→→→↑	-0.(1)000000	/°C	
→↑x3	-0.1(3)000000	/°C	
→↑x5	-0.13(5)0000	/°C	
↵↑	Fct. 3.10.(3)	SOLUTE K2	Enter K2 as calculated
→	(+)0.0000000	/°C2	
→x5	+0.00(0)0000	/°C2	
↑	+0.00(1)0000	/°C2	
→↑x5	+0.001(5)000	/°C2	
↵↑	Fct. 3.10.(4)	LIQUID	
→		(NON WATER)	Select the carrier as water.
↑		(WATER)	
↵	Fct. 3.10.(4)	LIQUID	
↵x4			Save changes and return to measurements.

5. Practical Considerations when using Concentration Measurements

5.1 Accuracy of Concentration Estimation

The results of the concentration estimation depend on the accuracy of the density measurements and on the "fit" of the algorithm used to infer the concentration value. Of the two factors the density measurement itself is obviously the most critical. In order to assess the effect of inaccuracies in the density measurement it is necessary to consider the amount density will change over a given range of interest..

For instance, it is required to measure concentrations in the range 5 to 10% by mass. Over this range density varies from 1.018 to 1.038 g/cm^3, a change of 0.020 g/cm^3. If the density accuracy of the flow meter is ±0.002g/cm^3 , then , assuming that the variation of density with concentration is linear, the approximate accuracy of the measurement will be:

$$\pm\frac{\text{Change in Concentration}}{\text{Change in Density}}\times\text{Density Accuracy} = \pm\frac{5}{0.02}\times 0.002 = \pm 0.5$$

Obviously this simple calculation takes no account of temperature, or of the fit of the algorithm, but it very quickly gives an indication of what is achievable with any given density meter.

There are other factors which also limit the ability of the meter to read an accurate density figure.

- **Air / Gas Inclusions**. If the process fluid has a significant gas content this will cause the Coriolis meter to under-read density. This is not a fault of the meter but a problem with the application. If it is not possible to prevent air getting into the fluid various measures can be taken to try to minimise the effect. The meter should be installed vertically to prevent air collecting within it (this may not help with bent tube instruments). Try pressurising the line to try to collapse any air bubbles.
- **Temperature Shocks**. Corimass meters have temperature compensation for their density measurements, and can cope with slowly changing temperatures. If however the meter is subjected to a rapid change in the temperature, then temporary errors in the density reading may result, whilst the whole instrument achieves a new thermal equilibrium. Such errors can persist for several minutes after the initial shock.
- **Response Time**. Corimass meters display a "steady state" density value. They cannot track fast changes in density. If the fluid passing through the meter has a sudden change in density, then the meter, owing to internal filtering will take about 30 seconds before the density reading settles to the new value.

To ensure a good density measurement :

a) Ensure meter is properly installed and clamped.
b) The product must be free from air bubbles (see above).
c) Site calibrate the density measurement, preferably at the process' normal operating temperature, as described in the standard operating manual.

5.2 Brix Measurements

Many industries use the Brix scale to monitor/control the sucrose content in their product(s).

Typically, they will use a refractrometer to do this. A small sample of the product is taken from the line and placed on the refractrometer. The refractrometer then measures the refractive index of the sample.

The refractive index of sucrose solutions varies with both concentration and temperature. Modern refractrometers also measure temperature, and can then display a **inferred** Brix value, based on the assumption that the sample it measured was just a solution of sucrose in water. This whole process is an off-line procedure and can be very inconvenient. In-line refractrometers are available, but these are notoriously unreliable and need frequent cleaning and maintenance.

In practice very few companies work with pure sucrose solutions, but they still use a refractrometer to measure Brix! In the case of soft drinks manufacturers their product will contain many other components in addition to sucrose (maybe glucose, fructose, fruit acids, proteins, suspended particulates etc.). Many of these other components may affect the product's overall refractive index. Consequently, the refractrometer reading becomes only an approximation to the actual sugar content.

Coriolis mass flowmeters measure density and temperature. From these measurements, and the known characteristics of sucrose solutions, a Brix value can be calculated. As with the refractrometer, if there are any other components present in the product, then the displayed Brix value will be only an approximation. This approximation can not be expected to match exactly the refractrometer's approximation. This is because the impurities will not necessary have the same effect on refractive index as they do on density. Solid particles in the product will not effect how light is refracted passing thorough the rest of the liquid, but they will effect its density.

If this situation is not acceptable then the GENERAL CONCENTRATION option could be used instead. Its parameters should be set so that the 'PERCENT M' display mimics the refractrometer. This requires that the product be fully characterised as described in Section 4.3 Case 4.

5.3 Sodium Hydroxide, (NaOH), Concentration

The NaOH algorithm fits the true characteristics of the product to one decimal place (±0.1). However the range of the fit is limited to 10 to 40°C and 0 to 50% solutions. This is not a great problem for the Titanium MFM 4085 G series flow meters, as higher concentrations and temperature would corrode the flow tube. (Zirconium meters and the stainless steel are fully resistant to attack by Sodium Hydroxide).

Appendix 1 Table of Brix Values Versus Density And Temperature

Density g/cc	Temperature 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
0.958	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.960	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.52
0.962	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	1.07
0.964	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.61	1.62
0.966	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	1.15	2.17
0.968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.74	1.69	2.72
0.970	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.37	1.28	2.23	3.26
0.972	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.91	1.81	2.77	3.79
0.974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.59	1.44	2.35	3.30	4.33
0.976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30	1.12	1.98	2.88	3.84	4.86
0.978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.84	1.66	2.51	3.41	4.37	5.39
0.980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.58	1.37	2.19	3.04	3.94	4.89	5.92
0.982	-	-	-	-	-	-	-	-	-	-	-	-	-	0.38	1.11	1.90	2.71	3.56	4.46	5.42	6.45
0.984	-	-	-	-	-	-	-	-	-	-	-	-	0.21	0.91	1.64	2.42	3.24	4.09	4.99	5.94	6.97
0.986	-	-	-	-	-	-	-	-	-	-	-	0.07	0.74	1.44	2.17	2.95	3.77	4.61	5.51	6.46	7.49
0.988	-	-	-	-	-	-	-	-	-	-	-	0.61	1.27	1.97	2.69	3.47	4.29	5.13	6.03	6.98	8.00
0.990	-	-	-	-	-	-	-	-	-	-	0.51	1.13	1.80	2.50	3.22	4.00	4.81	5.65	6.54	7.50	8.52
0.992	-	-	-	-	-	-	-	-	-	0.46	1.03	1.66	2.33	3.02	3.74	4.52	5.33	6.17	7.06	8.01	9.03
0.994	-	-	-	-	-	-	-	-	0.46	0.99	1.56	2.19	2.85	3.54	4.26	5.03	5.85	6.68	7.57	8.52	9.54
0.996	-	-	-	-	-	-	0.08	0.51	0.99	1.51	2.08	2.71	3.37	4.06	4.78	5.55	6.36	7.19	8.09	9.03	10.05
0.998	-	-	-	-	-	0.25	0.60	1.03	1.51	2.03	2.60	3.23	3.89	4.58	5.29	6.07	6.87	7.71	8.59	9.54	10.55
1.000	0.03	-	0.00	0.12	0.46	0.77	1.12	1.56	2.03	2.55	3.12	3.75	4.41	5.10	5.81	6.58	7.39	8.22	9.10	10.04	11.06
1.002	0.53	0.50	0.52	0.65	0.98	1.29	1.64	2.08	2.55	3.07	3.64	4.27	4.93	5.61	6.32	7.09	7.90	8.72	9.61	10.55	11.56
1.004	1.03	1.01	1.04	1.18	1.49	1.80	2.16	2.59	3.07	3.59	4.16	4.78	5.44	6.13	6.83	7.60	8.40	9.23	10.11	11.05	12.05
1.006	1.53	1.52	1.56	1.71	2.01	2.31	2.67	3.11	3.59	4.10	4.67	5.30	5.96	6.64	7.34	8.11	8.91	9.73	10.61	11.55	12.55
1.008	2.03	2.02	2.07	2.23	2.52	2.83	3.18	3.62	4.10	4.62	5.18	5.81	6.47	7.15	7.85	8.61	9.41	10.23	11.11	12.05	13.04
1.010	2.52	2.53	2.58	2.75	3.03	3.34	3.70	4.13	4.61	5.13	5.69	6.32	6.98	7.65	8.36	9.12	9.92	10.73	11.61	12.54	13.54
1.012	3.02	3.03	3.09	3.27	3.53	3.84	4.21	4.64	5.12	5.64	6.20	6.83	7.48	8.16	8.86	9.62	10.42	11.23	12.11	13.03	14.03
1.014	3.51	3.53	3.60	3.79	4.04	4.35	4.71	5.15	5.63	6.14	6.71	7.33	7.99	8.67	9.36	10.12	10.92	11.73	12.60	13.52	14.51
1.016	4.00	4.03	4.10	4.30	4.54	4.85	5.22	5.66	6.14	6.65	7.22	7.84	8.49	9.17	9.86	10.62	11.41	12.23	13.09	14.01	15.00
1.018	4.48	4.52	4.61	4.81	5.04	5.36	5.72	6.16	6.64	7.15	7.72	8.34	9.00	9.67	10.36	11.12	11.91	12.72	13.58	14.50	15.48
1.020	4.97	5.02	5.11	5.32	5.54	5.86	6.23	6.67	7.14	7.66	8.22	8.84	9.50	10.17	10.86	11.61	12.40	13.21	14.07	14.99	15.96
1.022	5.45	5.51	5.61	5.82	6.04	6.36	6.73	7.17	7.65	8.16	8.72	9.34	9.99	10.66	11.35	12.11	12.90	13.70	14.56	15.47	16.44
1.024	5.94	6.00	6.10	6.32	6.54	6.85	7.22	7.67	8.15	8.66	9.22	9.84	10.49	11.16	11.85	12.60	13.39	14.19	15.05	15.95	16.92
1.026	6.42	6.49	6.60	6.82	7.03	7.35	7.72	8.17	8.64	9.15	9.72	10.34	10.99	11.65	12.34	13.09	13.87	14.67	15.53	16.43	17.39
1.028	6.90	6.97	7.09	7.32	7.53	7.85	8.22	8.66	9.14	9.65	10.21	10.83	11.48	12.15	12.83	13.58	14.36	15.16	16.01	16.91	17.87
1.030	7.37	7.46	7.58	7.82	8.02	8.34	8.71	9.16	9.63	10.14	10.71	11.32	11.97	12.64	13.32	14.07	14.85	15.64	16.49	17.39	18.34
1.032	7.85	7.94	8.07	8.31	8.51	8.83	9.20	9.65	10.13	10.63	11.20	11.81	12.46	13.12	13.81	14.55	15.33	16.12	16.97	17.86	18.81
1.034	8.32	8.42	8.56	8.80	9.00	9.32	9.69	10.14	10.62	11.12	11.69	12.30	12.95	13.61	14.29	15.03	15.81	16.60	17.45	18.33	19.28
1.036	8.80	8.90	9.04	9.29	9.48	9.81	10.18	10.63	11.11	11.61	12.18	12.79	13.43	14.10	14.78	15.52	16.29	17.08	17.92	18.80	19.74
1.038	9.27	9.38	9.52	9.78	9.97	10.29	10.67	11.11	11.59	12.10	12.66	13.28	13.92	14.58	15.26	16.00	16.77	17.55	18.39	19.27	20.21
1.040	9.74	9.86	10.00	10.26	10.45	10.78	11.16	11.60	12.08	12.59	13.15	13.76	14.40	15.06	15.74	16.48	17.25	18.03	18.86	19.74	20.67
1.042	10.20	10.33	10.48	10.74	10.93	11.26	11.64	12.08	12.56	13.07	13.63	14.24	14.88	15.54	16.22	16.95	17.72	18.50	19.33	20.21	21.13
1.044	10.67	10.80	10.96	11.22	11.41	11.74	12.12	12.57	13.05	13.55	14.11	14.72	15.36	16.02	16.70	17.43	18.20	18.97	19.80	20.67	21.59
1.046	11.14	11.27	11.43	11.70	11.89	12.22	12.60	13.05	13.53	14.03	14.59	15.20	15.84	16.50	17.17	17.90	18.67	19.44	20.27	21.13	22.05
1.048	11.60	11.74	11.91	12.18	12.37	12.70	13.08	13.53	14.01	14.51	15.07	15.68	16.32	16.97	17.65	18.37	19.14	19.91	20.73	21.59	22.50
1.050	12.06	12.21	12.38	12.65	12.84	13.17	13.56	14.00	14.48	14.99	15.55	16.16	16.79	17.45	18.12	18.85	19.61	20.38	21.20	22.05	22.95

Density g/cc	Temperature																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1.052	12.52	12.68	12.85	13.12	13.31	13.65	14.03	14.48	14.96	15.46	16.03	16.63	17.26	17.92	18.59	19.31	20.07	20.84	21.66	22.51	23.41
1.054	12.98	13.14	13.31	13.59	13.79	14.12	14.51	14.95	15.43	15.94	16.50	17.10	17.74	18.39	19.06	19.78	20.54	21.30	22.12	22.97	23.86
1.056	13.44	13.60	13.78	14.06	14.26	14.59	14.98	15.43	15.91	16.41	16.97	17.58	18.21	18.86	19.53	20.25	21.00	21.76	22.57	23.42	24.31
1.058	13.89	14.06	14.24	14.53	14.72	15.06	15.45	15.90	16.38	16.88	17.44	18.04	18.67	19.33	19.99	20.71	21.46	22.22	23.03	23.87	24.75
1.060	14.35	14.52	14.71	14.99	15.19	15.53	15.92	16.37	16.85	17.35	17.91	18.51	19.14	19.79	20.46	21.18	21.92	22.68	23.49	24.32	25.20
1.062	14.80	14.98	15.17	15.45	15.66	16.00	16.39	16.84	17.31	17.82	18.38	18.98	19.61	20.26	20.92	21.64	22.38	23.14	23.94	24.77	25.64
1.064	15.25	15.44	15.63	15.91	16.12	16.46	16.85	17.30	17.78	18.29	18.84	19.44	20.07	20.72	21.38	22.10	22.84	23.59	24.39	25.22	26.09
1.066	15.70	15.89	16.08	16.37	16.58	16.93	17.32	17.77	18.25	18.75	19.31	19.91	20.53	21.18	21.84	22.55	23.30	24.05	24.84	25.67	26.53
1.068	16.15	16.34	16.54	16.83	17.04	17.39	17.78	18.23	18.71	19.21	19.77	20.37	20.99	21.64	22.30	23.01	23.75	24.50	25.29	26.11	26.97
1.070	16.60	16.79	16.99	17.28	17.50	17.85	18.24	18.69	19.17	19.68	20.23	20.83	21.45	22.10	22.76	23.47	24.20	24.95	25.74	26.55	27.41
1.072	17.04	17.24	17.45	17.74	17.96	18.31	18.70	19.15	19.63	20.14	20.69	21.29	21.91	22.55	23.21	23.92	24.65	25.40	26.18	27.00	27.84
1.074	17.49	17.69	17.90	18.19	18.42	18.77	19.16	19.61	20.09	20.59	21.15	21.74	22.36	23.01	23.67	24.37	25.10	25.85	26.63	27.44	28.28
1.076	17.93	18.14	18.35	18.64	18.87	19.22	19.62	20.07	20.55	21.05	21.61	22.20	22.82	23.46	24.12	24.82	25.55	26.29	27.07	27.88	28.71
1.078	18.37	18.58	18.79	19.09	19.33	19.68	20.08	20.52	21.00	21.51	22.06	22.65	23.27	23.91	24.57	25.27	26.00	26.74	27.51	28.31	29.15
1.080	18.81	19.03	19.24	19.53	19.78	20.13	20.53	20.98	21.46	21.96	22.52	23.11	23.72	24.36	25.02	25.72	26.44	27.18	27.95	28.75	29.58
1.082	19.25	19.47	19.68	19.98	20.23	20.58	20.98	21.43	21.91	22.41	22.97	23.56	24.17	24.81	25.47	26.16	26.89	27.62	28.39	29.18	30.01
1.084	19.69	19.91	20.13	20.42	20.68	21.03	21.43	21.88	22.36	22.87	23.42	24.01	24.62	25.26	25.91	26.61	27.33	28.06	28.83	29.62	30.43
1.086	20.13	20.35	20.57	20.86	21.12	21.48	21.88	22.33	22.81	23.32	23.87	24.46	25.07	25.71	26.36	27.05	27.77	28.50	29.26	30.05	30.86
1.088	20.56	20.79	21.01	21.30	21.57	21.93	22.33	22.78	23.26	23.76	24.32	24.90	25.51	26.15	26.80	27.49	28.21	28.94	29.70	30.48	31.29
1.090	21.00	21.22	21.45	21.74	22.02	22.37	22.78	23.23	23.70	24.21	24.76	25.35	25.96	26.59	27.24	27.93	28.65	29.37	30.13	30.91	31.71
1.092	21.43	21.66	21.88	22.18	22.46	22.82	23.22	23.67	24.15	24.66	25.21	25.79	26.40	27.03	27.68	28.37	29.08	29.80	30.56	31.34	32.13
1.094	21.86	22.09	22.32	22.61	22.90	23.26	23.67	24.11	24.59	25.10	25.65	26.23	26.84	27.47	28.12	28.81	29.52	30.24	30.99	31.76	32.56
1.096	22.29	22.53	22.75	23.05	23.34	23.70	24.11	24.56	25.04	25.54	26.09	26.67	27.28	27.91	28.56	29.24	29.95	30.67	31.42	32.19	32.98
1.098	22.72	22.96	23.19	23.48	23.78	24.14	24.55	25.00	25.48	25.98	26.53	27.11	27.72	28.35	29.00	29.68	30.38	31.10	31.84	32.61	33.40
1.100	23.14	23.39	23.62	23.91	24.22	24.58	24.99	25.44	25.92	26.42	26.97	27.55	28.15	28.79	29.43	30.11	30.81	31.53	32.27	33.03	33.81
1.102	23.57	23.81	24.05	24.34	24.65	25.02	25.43	25.88	26.35	26.86	27.41	27.99	28.59	29.22	29.86	30.54	31.24	31.95	32.69	33.45	34.23
1.104	23.99	24.24	24.48	24.77	25.09	25.46	25.87	26.31	26.79	27.30	27.85	28.42	29.02	29.65	30.30	30.97	31.67	32.38	33.12	33.87	34.65
1.106	24.42	24.67	24.91	25.20	25.52	25.89	26.30	26.75	27.23	27.73	28.28	28.86	29.46	30.08	30.73	31.40	32.10	32.80	33.54	34.29	35.06
1.108	24.84	25.09	25.33	25.62	25.96	26.32	26.74	27.18	27.66	28.17	28.72	29.29	29.89	30.51	31.16	31.83	32.52	33.23	33.96	34.71	35.47
1.110	25.26	25.51	25.76	26.05	26.39	26.76	27.17	27.62	28.09	28.60	29.15	29.72	30.32	30.94	31.58	32.26	32.95	33.65	34.38	35.12	35.88
1.112	25.68	25.94	26.18	26.47	26.82	27.19	27.60	28.05	28.52	29.03	29.58	30.15	30.74	31.37	32.01	32.68	33.37	34.07	34.79	35.54	36.30
1.114	26.10	26.36	26.60	26.89	27.24	27.62	28.03	28.48	28.95	29.46	30.01	30.58	31.17	31.80	32.43	33.10	33.79	34.49	35.21	35.95	36.70
1.116	26.52	26.78	27.02	27.31	27.67	28.04	28.46	28.91	29.38	29.89	30.44	31.01	31.60	32.22	32.86	33.52	34.21	34.91	35.63	36.36	37.11
1.118	26.93	27.19	27.44	27.73	28.10	28.47	28.89	29.33	29.81	30.32	30.86	31.43	32.02	32.64	33.28	33.95	34.63	35.32	36.04	36.77	37.52
1.120	27.35	27.61	27.86	28.15	28.52	28.90	29.31	29.76	30.24	30.75	31.29	31.86	32.45	33.07	33.70	34.36	35.04	35.74	36.45	37.18	37.93
1.122	27.76	28.03	28.28	28.57	28.94	29.32	29.74	30.18	30.66	31.17	31.71	32.28	32.87	33.49	34.12	34.78	35.46	36.15	36.86	37.59	38.33
1.124	28.18	28.44	28.69	28.99	29.37	29.74	30.16	30.61	31.08	31.59	32.13	32.70	33.29	33.91	34.54	35.20	35.87	36.56	37.27	38.00	38.73
1.126	28.59	28.85	29.11	29.40	29.79	30.17	30.58	31.03	31.51	32.02	32.56	33.12	33.71	34.32	34.96	35.61	36.29	36.97	37.68	38.40	39.14
1.128	29.00	29.27	29.52	29.81	30.21	30.59	31.00	31.45	31.93	32.44	32.98	33.54	34.12	34.74	35.37	36.03	36.70	37.38	38.09	38.81	39.54
1.130	29.41	29.68	29.93	30.23	30.62	31.01	31.42	31.87	32.35	32.86	33.40	33.96	34.54	35.16	35.79	36.44	37.11	37.79	38.49	39.21	39.94
1.132	29.82	30.09	30.34	30.64	31.04	31.42	31.84	32.29	32.76	33.27	33.81	34.37	34.96	35.57	36.20	36.85	37.52	38.20	38.90	39.61	40.34
1.134	30.22	30.50	30.75	31.05	31.46	31.84	32.26	32.70	33.18	33.69	34.23	34.79	35.37	35.98	36.61	37.26	37.93	38.60	39.30	40.01	40.73
1.136	30.63	30.90	31.16	31.46	31.87	32.25	32.67	33.12	33.60	34.11	34.64	35.20	35.78	36.40	37.02	37.67	38.33	39.01	39.70	40.41	41.13
1.138	31.03	31.31	31.57	31.86	32.28	32.67	33.09	33.53	34.01	34.52	35.06	35.62	36.19	36.81	37.43	38.08	38.74	39.41	40.10	40.81	41.53
1.140	31.44	31.71	31.98	32.27	32.69	33.08	33.50	33.95	34.42	34.93	35.47	36.03	36.60	37.21	37.84	38.48	39.14	39.81	40.50	41.21	41.92
1.142	31.84	32.12	32.38	32.68	33.10	33.49	33.91	34.36	34.84	35.35	35.88	36.44	37.01	37.62	38.24	38.89	39.54	40.22	40.90	41.60	42.31
1.144	32.24	32.52	32.79	33.08	33.51	33.90	34.33	34.77	35.25	35.76	36.29	36.85	37.42	38.03	38.65	39.29	39.95	40.61	41.30	42.00	42.71

Density g/cc	Temperature																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1.146	32.64	32.92	33.19	33.48	33.92	34.31	34.73	35.18	35.66	36.17	36.70	37.25	37.83	38.43	39.05	39.69	40.35	41.01	41.70	42.39	43.10
1.148	33.04	33.32	33.59	33.89	34.33	34.72	35.14	35.59	36.06	36.57	37.11	37.66	38.23	38.84	39.46	40.09	40.74	41.41	42.09	42.78	43.49
1.150	33.44	33.72	33.99	34.29	34.74	35.13	35.55	36.00	36.47	36.98	37.51	38.07	38.64	39.24	39.86	40.49	41.14	41.81	42.49	43.18	43.88
1.152	33.84	34.12	34.39	34.69	35.14	35.53	35.96	36.40	36.88	37.39	37.92	38.47	39.04	39.64	40.26	40.89	41.54	42.20	42.88	43.57	44.26
1.154	34.23	34.52	34.79	35.09	35.54	35.94	36.36	36.81	37.28	37.79	38.32	38.87	39.44	40.04	40.66	41.29	41.93	42.60	43.27	43.96	44.65
1.156	34.63	34.92	35.19	35.49	35.95	36.34	36.76	37.21	37.68	38.19	38.72	39.27	39.84	40.44	41.05	41.69	42.33	42.99	43.66	44.34	45.04
1.158	35.02	35.31	35.59	35.89	36.35	36.74	37.17	37.61	38.09	38.60	39.13	39.67	40.24	40.84	41.45	42.08	42.72	43.38	44.05	44.73	45.42
1.160	35.42	35.71	35.98	36.28	36.75	37.14	37.57	38.01	38.49	39.00	39.53	40.07	40.64	41.24	41.85	42.48	43.11	43.77	44.44	45.12	45.81
1.162	35.81	36.10	36.38	36.68	37.15	37.54	37.97	38.41	38.89	39.40	39.93	40.47	41.04	41.63	42.24	42.87	43.50	44.16	44.82	45.50	46.19
1.164	36.20	36.49	36.77	37.07	37.54	37.94	38.37	38.81	39.29	39.80	40.32	40.87	41.43	42.03	42.63	43.26	43.89	44.55	45.21	45.89	46.57
1.166	36.59	36.88	37.16	37.47	37.94	38.34	38.76	39.21	39.68	40.19	40.72	41.26	41.83	42.42	43.03	43.65	44.28	44.93	45.59	46.27	46.95
1.168	36.98	37.27	37.55	37.86	38.33	38.73	39.16	39.61	40.08	40.59	41.12	41.66	42.22	42.81	43.42	44.04	44.67	45.32	45.98	46.65	47.33
1.170	37.37	37.66	37.95	38.25	38.73	39.13	39.56	40.00	40.48	40.98	41.51	42.05	42.61	43.20	43.81	44.43	45.06	45.70	46.36	47.03	47.71
1.172	37.76	38.05	38.34	38.64	39.12	39.52	39.95	40.40	40.87	41.38	41.90	42.44	43.00	43.59	44.19	44.81	45.44	46.09	46.74	47.41	48.09
1.174	38.14	38.44	38.72	39.03	39.51	39.92	40.34	40.79	41.26	41.77	42.30	42.84	43.39	43.98	44.58	45.20	45.83	46.47	47.12	47.79	48.46
1.176	38.53	38.82	39.11	39.42	39.91	40.31	40.74	41.18	41.66	42.16	42.69	43.23	43.78	44.37	44.97	45.58	46.21	46.85	47.50	48.17	48.84
1.178	38.91	39.21	39.50	39.81	40.30	40.70	41.13	41.57	42.05	42.55	43.08	43.61	44.17	44.76	45.35	45.97	46.59	47.23	47.88	48.54	49.21
1.180	39.30	39.59	39.89	40.20	40.68	41.09	41.52	41.96	42.44	42.94	43.46	44.00	44.56	45.14	45.74	46.35	46.97	47.61	48.26	48.92	49.59
1.182	39.68	39.98	40.27	40.59	41.07	41.48	41.91	42.35	42.82	43.33	43.85	44.39	44.94	45.53	46.12	46.73	47.35	47.99	48.63	49.29	49.96
1.184	40.06	40.36	40.66	40.97	41.46	41.86	42.29	42.74	43.21	43.72	44.24	44.77	45.33	45.91	46.50	47.11	47.73	48.36	49.01	49.66	50.33
1.186	40.44	40.74	41.04	41.36	41.84	42.25	42.68	43.13	43.60	44.10	44.62	45.16	45.71	46.29	46.88	47.49	48.11	48.74	49.38	50.04	50.70
1.188	40.82	41.12	41.42	41.74	42.23	42.64	43.07	43.51	43.98	44.49	45.01	45.54	46.09	46.67	47.26	47.87	48.48	49.11	49.75	50.41	51.07
1.190	41.20	41.50	41.80	42.12	42.61	43.02	43.45	43.90	44.37	44.87	45.39	45.92	46.47	47.05	47.64	48.25	48.86	49.49	50.13	50.78	51.44
1.192	41.58	41.88	42.18	42.51	42.99	43.40	43.83	44.28	44.75	45.26	45.77	46.31	46.85	47.43	48.02	48.62	49.23	49.86	50.50	51.15	51.81
1.194	41.96	42.26	42.56	42.89	43.38	43.79	44.22	44.66	45.13	45.64	46.15	46.69	47.23	47.81	48.39	49.00	49.60	50.23	50.87	51.51	52.17
1.196	42.33	42.64	42.94	43.27	43.76	44.17	44.60	45.04	45.52	46.02	46.53	47.07	47.61	48.19	48.77	49.37	49.98	50.60	51.24	51.88	52.54
1.198	42.71	43.01	43.32	43.65	44.14	44.55	44.98	45.42	45.90	46.40	46.91	47.44	47.99	48.56	49.14	49.74	50.35	50.97	51.60	52.25	52.90
1.200	43.08	43.39	43.70	44.03	44.51	44.93	45.36	45.80	46.27	46.78	47.29	47.82	48.36	48.94	49.52	50.11	50.72	51.34	51.97	52.61	53.27
1.202	43.46	43.76	44.07	44.41	44.89	45.30	45.73	46.18	46.65	47.15	47.67	48.20	48.74	49.31	49.89	50.49	51.09	51.71	52.34	52.98	53.63
1.204	43.83	44.14	44.45	44.79	45.27	45.68	46.11	46.56	47.03	47.53	48.04	48.57	49.11	49.68	50.26	50.85	51.45	52.07	52.70	53.34	53.99
1.206	44.20	44.51	44.83	45.16	45.64	46.06	46.49	46.94	47.41	47.91	48.42	48.94	49.49	50.05	50.63	51.22	51.82	52.44	53.06	53.70	54.35
1.208	44.57	44.88	45.20	45.54	46.02	46.43	46.86	47.31	47.78	48.28	48.79	49.32	49.86	50.42	51.00	51.59	52.19	52.80	53.43	54.06	54.71
1.210	44.94	45.25	45.57	45.91	46.39	46.81	47.24	47.68	48.16	48.66	49.17	49.69	50.23	50.79	51.37	51.96	52.55	53.17	53.79	54.42	55.07
1.212	45.31	45.63	45.94	46.29	46.76	47.18	47.61	48.06	48.53	49.03	49.54	50.06	50.60	51.16	51.73	52.32	52.92	53.53	54.15	54.78	55.43
1.214	45.68	46.00	46.32	46.66	47.14	47.55	47.98	48.43	48.90	49.40	49.91	50.43	50.97	51.53	52.10	52.69	53.28	53.89	54.51	55.14	55.78
1.216	46.05	46.36	46.69	47.04	47.51	47.92	48.35	48.80	49.27	49.77	50.28	50.80	51.34	51.90	52.46	53.05	53.64	54.25	54.87	55.50	56.14
1.218	46.41	46.73	47.06	47.41	47.88	48.29	48.72	49.17	49.64	50.14	50.65	51.17	51.70	52.26	52.83	53.41	54.00	54.61	55.23	55.85	56.49
1.220	46.78	47.10	47.43	47.78	48.24	48.66	49.09	49.54	50.01	50.51	51.01	51.53	52.07	52.63	53.19	53.78	54.36	54.97	55.58	56.21	56.85
1.222	47.15	47.47	47.79	48.15	48.61	49.03	49.46	49.91	50.38	50.88	51.38	51.90	52.44	52.99	53.55	54.14	54.72	55.33	55.94	56.56	57.20
1.224	47.51	47.83	48.16	48.52	48.98	49.40	49.83	50.28	50.75	51.24	51.75	52.27	52.80	53.35	53.92	54.50	55.08	55.68	56.29	56.92	57.55
1.226	47.87	48.20	48.53	48.89	49.35	49.76	50.19	50.64	51.11	51.61	52.11	52.63	53.16	53.71	54.28	54.86	55.44	56.04	56.65	57.27	57.90
1.228	48.24	48.56	48.89	49.26	49.71	50.13	50.56	51.01	51.48	51.97	52.48	52.99	53.52	54.08	54.64	55.21	55.79	56.39	57.00	57.62	58.25
1.230	48.60	48.92	49.26	49.63	50.07	50.49	50.92	51.37	51.84	52.34	52.84	53.35	53.89	54.44	54.99	55.57	56.15	56.75	57.35	57.97	58.60
1.232	48.96	49.28	49.62	49.99	50.44	50.86	51.29	51.74	52.21	52.70	53.20	53.72	54.25	54.79	55.35	55.93	56.50	57.10	57.71	58.32	58.95
1.234	49.32	49.65	49.99	50.36	50.80	51.22	51.65	52.10	52.57	53.06	53.56	54.08	54.61	55.15	55.71	56.28	56.86	57.45	58.06	58.67	59.29
1.236	49.68	50.01	50.35	50.73	51.16	51.58	52.01	52.46	52.93	53.42	53.92	54.44	54.96	55.51	56.06	56.64	57.21	57.80	58.41	59.02	59.64
1.238	50.04	50.37	50.71	51.09	51.52	51.94	52.37	52.82	53.29	53.78	54.28	54.79	55.32	55.87	56.42	56.99	57.56	58.15	58.75	59.37	59.98

Density g/cc	Temperature																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1.240	50.39	50.73	51.07	51.46	51.88	52.30	52.73	53.18	53.65	54.14	54.64	55.15	55.68	56.22	56.77	57.34	57.91	58.50	59.10	59.71	60.33
1.242	50.75	51.09	51.44	51.82	52.24	52.66	53.09	53.54	54.01	54.50	55.00	55.51	56.03	56.58	57.12	57.69	58.26	58.85	59.45	60.06	60.67
1.244	51.11	51.44	51.79	52.18	52.60	53.02	53.45	53.90	54.37	54.86	55.35	55.86	56.39	56.93	57.48	58.04	58.61	59.20	59.80	60.40	61.01
1.246	51.46	51.80	52.15	52.54	52.95	53.37	53.81	54.26	54.72	55.21	55.71	56.22	56.74	57.28	57.83	58.39	58.96	59.55	60.14	60.74	61.35
1.248	51.82	52.16	52.51	52.90	53.31	53.73	54.16	54.61	55.08	55.57	56.06	56.57	57.10	57.63	58.18	58.74	59.31	59.89	60.48	61.09	61.70
1.250	52.17	52.51	52.87	53.27	53.67	54.09	54.52	54.97	55.44	55.92	56.42	56.93	57.45	57.98	58.53	59.09	59.66	60.24	60.83	61.43	62.03
1.252	52.52	52.87	53.23	53.63	54.02	54.44	54.87	55.32	55.79	56.28	56.77	57.28	57.80	58.33	58.88	59.44	60.00	60.58	61.17	61.77	62.37
1.254	52.88	53.22	53.58	53.98	54.37	54.79	55.23	55.68	56.14	56.63	57.12	57.63	58.15	58.68	59.22	59.78	60.35	60.93	61.51	62.11	62.71
1.256	53.23	53.57	53.94	54.34	54.73	55.15	55.58	56.03	56.50	56.98	57.47	57.98	58.50	59.03	59.57	60.13	60.69	61.27	61.85	62.45	63.05
1.258	53.58	53.93	54.29	54.70	55.08	55.50	55.93	56.38	56.85	57.33	57.83	58.33	58.85	59.38	59.92	60.47	61.03	61.61	62.19	62.78	63.38
1.260	53.93	54.28	54.65	55.06	55.43	55.85	56.28	56.73	57.20	57.68	58.17	58.68	59.20	59.73	60.26	60.82	61.38	61.95	62.53	63.12	63.72
1.262	54.28	54.63	55.00	55.41	55.78	56.20	56.63	57.08	57.55	58.03	58.52	59.03	59.54	60.07	60.61	61.16	61.72	62.29	62.87	63.46	64.05
1.264	54.63	54.98	55.35	55.77	56.13	56.55	56.98	57.43	57.90	58.38	58.87	59.37	59.89	60.42	60.95	61.50	62.06	62.63	63.21	63.79	64.38
1.266	54.97	55.33	55.70	56.12	56.48	56.90	57.33	57.78	58.25	58.73	59.22	59.72	60.24	60.76	61.29	61.84	62.40	62.97	63.54	64.13	64.71
1.268	55.32	55.68	56.05	56.48	56.82	57.25	57.68	58.13	58.59	59.07	59.56	60.06	60.58	61.10	61.64	62.19	62.74	63.31	63.88	64.46	65.04
1.270	55.67	56.03	56.40	56.83	57.17	57.59	58.03	58.48	58.94	59.42	59.91	60.41	60.92	61.45	61.98	62.53	63.08	63.64	64.22	64.79	65.37
1.272	56.01	56.37	56.75	57.18	57.52	57.94	58.37	58.82	59.29	59.76	60.25	60.75	61.27	61.79	62.32	62.86	63.42	63.98	64.55	65.12	65.70
1.274	56.36	56.72	57.10	57.53	57.86	58.28	58.72	59.17	59.63	60.11	60.60	61.10	61.61	62.13	62.66	63.20	63.75	64.32	64.88	65.46	66.03
1.276	56.70	57.06	57.45	57.88	58.21	58.63	59.06	59.51	59.98	60.45	60.94	61.44	61.95	62.47	63.00	63.54	64.09	64.65	65.22	65.79	66.36
1.278	57.05	57.41	57.80	58.23	58.55	58.97	59.40	59.86	60.32	60.80	61.28	61.78	62.29	62.81	63.33	63.88	64.42	64.98	65.55	66.12	66.68
1.280	57.39	57.75	58.14	58.58	58.89	59.32	59.75	60.20	60.66	61.14	61.62	62.12	62.63	63.15	63.67	64.21	64.76	65.32	65.88	66.44	67.01
1.282	57.73	58.10	58.49	58.93	59.24	59.66	60.09	60.54	61.00	61.48	61.96	62.46	62.97	63.49	64.01	64.55	65.09	65.65	66.21	66.77	67.33
1.284	58.07	58.44	58.84	59.28	59.58	60.00	60.43	60.88	61.34	61.82	62.30	62.80	63.31	63.82	64.34	64.88	65.43	65.98	66.54	67.10	67.66
1.286	58.41	58.78	59.18	59.62	59.92	60.34	60.77	61.22	61.69	62.16	62.64	63.14	63.65	64.16	64.68	65.22	65.76	66.31	66.87	67.42	67.98
1.288	58.75	59.12	59.52	59.97	60.26	60.68	61.11	61.56	62.02	62.50	62.98	63.47	63.98	64.49	65.01	65.55	66.09	66.64	67.19	67.75	68.30
1.290	59.09	59.47	59.87	60.31	60.60	61.02	61.45	61.90	62.36	62.83	63.32	63.81	64.32	64.83	65.35	65.88	66.42	66.97	67.52	68.07	68.62
1.292	59.43	59.81	60.21	60.66	60.94	61.36	61.79	62.24	62.70	63.17	63.65	64.15	64.65	65.16	65.68	66.21	66.75	67.30	67.85	68.40	68.94
1.294	59.76	60.14	60.55	61.00	61.27	61.70	62.13	62.58	63.04	63.51	63.99	64.48	64.99	65.50	66.01	66.54	67.08	67.63	68.17	68.72	69.26
1.296	60.10	60.48	60.89	61.34	61.61	62.03	62.46	62.92	63.37	63.84	64.32	64.81	65.32	65.83	66.34	66.88	67.41	67.95	68.50	69.04	69.58
1.298	60.44	60.82	61.23	61.68	61.95	62.37	62.80	63.25	63.71	64.18	64.66	65.15	65.65	66.16	66.67	67.20	67.74	68.28	68.82	69.36	69.89
1.300	60.77	61.16	61.57	62.03	62.28	62.70	63.13	63.59	64.04	64.51	64.99	65.48	65.99	66.49	67.00	67.53	68.07	68.61	69.15	69.68	70.21
1.302	61.11	61.49	61.91	62.37	62.62	63.04	63.47	63.92	64.38	64.85	65.33	65.81	66.32	66.82	67.33	67.86	68.39	68.93	69.47	70.00	70.52
1.304	61.44	61.83	62.24	62.70	62.95	63.37	63.80	64.26	64.71	65.18	65.66	66.14	66.65	67.15	67.66	68.19	68.72	69.26	69.79	70.32	70.84
1.306	61.77	62.16	62.58	63.04	63.28	63.71	64.14	64.59	65.04	65.51	65.99	66.47	66.98	67.48	67.99	68.52	69.05	69.58	70.11	70.64	71.15
1.308	62.10	62.50	62.91	63.38	63.62	64.04	64.47	64.92	65.38	65.84	66.32	66.80	67.31	67.81	68.32	68.84	69.37	69.90	70.43	70.96	71.46
1.310	62.44	62.83	63.25	63.72	63.95	64.37	64.80	65.25	65.71	66.17	66.65	67.13	67.64	68.14	68.64	69.17	69.70	70.23	70.75	71.27	71.77
1.312	62.77	63.16	63.58	64.05	64.28	64.70	65.13	65.58	66.04	66.50	66.98	67.46	67.96	68.46	68.97	69.49	70.02	70.55	71.07	71.59	72.09
1.314	63.10	63.50	63.92	64.39	64.61	65.03	65.46	65.91	66.37	66.83	67.31	67.79	68.29	68.79	69.30	69.82	70.34	70.87	71.39	71.90	72.40
1.316	63.43	63.83	64.25	64.72	64.94	65.36	65.79	66.24	66.70	67.16	67.63	68.12	68.62	69.11	69.62	70.14	70.66	71.19	71.71	72.22	72.70
1.318	63.75	64.16	64.58	65.05	65.27	65.69	66.12	66.57	67.02	67.48	67.96	68.44	68.94	69.44	69.94	70.46	70.99	71.51	72.02	72.53	73.01
1.320	64.08	64.49	64.91	65.39	65.60	66.02	66.45	66.90	67.35	67.81	68.29	68.77	69.27	69.76	70.27	70.78	71.31	71.83	72.34	72.84	73.32
1.322	64.41	64.82	65.24	65.72	65.93	66.35	66.77	67.23	67.68	68.14	68.61	69.09	69.59	70.09	70.59	71.11	71.63	72.15	72.66	73.15	73.63
1.324	64.73	65.14	65.57	66.05	66.25	66.67	67.10	67.55	68.00	68.46	68.94	69.42	69.91	70.41	70.91	71.43	71.95	72.46	72.97	73.46	73.93
1.326	65.06	65.47	65.90	66.38	66.58	67.00	67.43	67.88	68.33	68.79	69.26	69.74	70.24	70.73	71.23	71.75	72.27	72.78	73.29	73.77	74.24
1.328	65.38	65.80	66.23	66.70	66.91	67.33	67.75	68.20	68.65	69.11	69.58	70.06	70.56	71.05	71.55	72.07	72.58	73.10	73.60	74.08	74.54
1.330	65.71	66.12	66.55	67.03	67.23	67.65	68.08	68.53	68.98	69.43	69.91	70.38	70.88	71.37	71.88	72.39	72.90	73.41	73.91	74.39	74.84
1.332	66.03	66.45	66.88	67.36	67.56	67.97	68.40	68.85	69.30	69.76	70.23	70.71	71.20	71.69	72.19	72.70	73.22	73.73	74.22	74.70	75.15

Density g/cc	Temperature																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1.334	66.35	66.77	67.20	67.68	67.88	68.30	68.72	69.17	69.62	70.08	70.55	71.03	71.52	72.01	72.51	73.02	73.54	74.04	74.54	75.01	75.45
1.336	66.67	67.10	67.53	68.01	68.20	68.62	69.05	69.50	69.95	70.40	70.87	71.35	71.84	72.33	72.83	73.34	73.85	74.36	74.85	75.32	75.75
1.338	67.00	67.42	67.85	68.33	68.53	68.94	69.37	69.82	70.27	70.72	71.19	71.67	72.16	72.65	73.15	73.66	74.17	74.67	75.16	75.62	76.05
1.340	67.32	67.74	68.17	68.65	68.85	69.26	69.69	70.14	70.59	71.04	71.51	71.98	72.48	72.97	73.47	73.97	74.48	74.98	75.47	75.93	76.35
1.342	67.63	68.06	68.50	68.97	69.17	69.59	70.01	70.46	70.91	71.36	71.83	72.30	72.80	73.28	73.78	74.29	74.80	75.29	75.78	76.23	76.65
1.344	67.95	68.38	68.82	69.29	69.49	69.91	70.33	70.78	71.22	71.68	72.14	72.62	73.11	73.60	74.10	74.60	75.11	75.61	76.08	76.54	76.94
1.346	68.27	68.70	69.14	69.61	69.81	70.23	70.65	71.10	71.54	71.99	72.46	72.94	73.43	73.92	74.41	74.92	75.42	75.92	76.39	76.84	77.24
1.348	68.59	69.02	69.45	69.93	70.13	70.55	70.97	71.42	71.86	72.31	72.78	73.25	73.74	74.23	74.73	75.23	75.74	76.23	76.70	77.14	77.54
1.350	68.90	69.34	69.77	70.25	70.45	70.86	71.29	71.73	72.18	72.63	73.09	73.57	74.06	74.55	75.04	75.54	76.05	76.54	77.01	77.44	77.83
1.352	69.22	69.65	70.09	70.56	70.77	71.18	71.61	72.05	72.49	72.94	73.41	73.88	74.37	74.86	75.36	75.86	76.36	76.85	77.31	77.74	78.13
1.354	69.53	69.97	70.40	70.88	71.08	71.50	71.92	72.37	72.81	73.26	73.72	74.20	74.69	75.17	75.67	76.17	76.67	77.16	77.62	78.04	78.42
1.356	69.85	70.28	70.72	71.19	71.40	71.82	72.24	72.68	73.12	73.57	74.04	74.51	75.00	75.49	75.98	76.48	76.98	77.46	77.92	78.34	78.72
1.358	70.16	70.60	71.03	71.50	71.72	72.13	72.55	73.00	73.44	73.89	74.35	74.82	75.31	75.80	76.29	76.79	77.29	77.77	78.23	78.64	79.01
1.360	70.47	70.91	71.35	71.82	72.03	72.45	72.87	73.31	73.75	74.20	74.66	75.13	75.62	76.11	76.61	77.10	77.60	78.08	78.53	78.94	79.30
1.362	70.78	71.22	71.66	72.13	72.35	72.76	73.18	73.63	74.07	74.51	74.97	75.45	75.93	76.42	76.92	77.41	77.91	78.39	78.83	79.24	79.59
1.364	71.09	71.54	71.97	72.44	72.66	73.08	73.50	73.94	74.38	74.82	75.29	75.76	76.25	76.73	77.23	77.72	78.22	78.69	79.14	79.54	79.88
1.366	71.40	71.85	72.28	72.74	72.98	73.39	73.81	74.25	74.69	75.13	75.60	76.07	76.56	77.04	77.54	78.03	78.52	79.00	79.44	79.84	80.17
1.368	71.71	72.16	72.59	73.05	73.29	73.70	74.12	74.56	75.00	75.44	75.91	76.38	76.86	77.35	77.85	78.34	78.83	79.30	79.74	80.13	80.46
1.370	72.02	72.47	72.90	73.36	73.60	74.02	74.44	74.88	75.31	75.75	76.22	76.69	77.17	77.66	78.15	78.65	79.14	79.61	80.04	80.43	80.75
1.372	72.33	72.77	73.20	73.66	73.91	74.33	74.75	75.19	75.62	76.06	76.52	77.00	77.48	77.97	78.46	78.96	79.44	79.91	80.34	80.72	81.04
1.374	72.64	73.08	73.51	73.96	74.23	74.64	75.06	75.50	75.93	76.37	76.83	77.30	77.79	78.27	78.77	79.26	79.75	80.21	80.64	81.02	81.33
1.376	72.94	73.39	73.82	74.27	74.54	74.95	75.37	75.81	76.24	76.68	77.14	77.61	78.10	78.58	79.08	79.57	80.05	80.52	80.94	81.31	81.62
1.378	73.25	73.69	74.12	74.57	74.85	75.26	75.68	76.11	76.55	76.99	77.45	77.92	78.40	78.89	79.38	79.87	80.36	80.82	81.24	81.61	81.90
1.380	73.55	74.00	74.42	74.87	75.16	75.57	75.99	76.42	76.85	77.29	77.75	78.22	78.71	79.19	79.69	80.18	80.66	81.12	81.54	81.90	82.19
1.382	73.85	74.30	74.72	75.16	75.47	75.88	76.30	76.73	77.16	77.60	78.06	78.53	79.01	79.50	79.99	80.49	80.97	81.42	81.83	82.19	82.47
1.384	74.16	74.60	75.02	75.46	75.77	76.19	76.60	77.04	77.47	77.91	78.36	78.83	79.32	79.80	80.30	80.79	81.27	81.72	82.13	82.48	82.76
1.386	74.46	74.90	75.32	75.76	76.08	76.49	76.91	77.34	77.77	78.21	78.67	79.14	79.62	80.11	80.60	81.09	81.57	82.02	82.43	82.77	83.04
1.388	74.76	75.20	75.62	76.05	76.39	76.80	77.22	77.65	78.08	78.52	78.97	79.44	79.93	80.41	80.91	81.40	81.87	82.32	82.72	83.06	83.33
1.390	75.06	75.50	75.92	76.35	76.70	77.11	77.52	77.95	78.38	78.82	79.27	79.74	80.23	80.71	81.21	81.70	82.18	82.62	83.02	83.36	83.61
1.392	75.36	75.80	76.22	76.64	77.00	77.41	77.83	78.26	78.68	79.12	79.58	80.05	80.53	81.01	81.51	82.00	82.48	82.92	83.32	83.65	83.90
1.394	75.65	76.10	76.51	76.93	77.31	77.72	78.13	78.56	78.99	79.43	79.88	80.35	80.83	81.32	81.82	82.30	82.78	83.22	83.61	83.93	84.18
1.396	75.95	76.39	76.80	77.22	77.62	78.03	78.44	78.87	79.29	79.73	80.18	80.65	81.13	81.62	82.12	82.61	83.08	83.52	83.90	84.22	84.46
1.398	76.25	76.69	77.10	77.50	77.92	78.33	78.74	79.17	79.59	80.03	80.48	80.95	81.43	81.92	82.42	82.91	83.38	83.81	84.20	84.51	84.74
1.400	76.54	76.98	77.39	77.79	78.23	78.63	79.05	79.47	79.89	80.33	80.78	81.25	81.73	82.22	82.72	83.21	83.68	84.11	84.49	84.80	85.02
1.402	76.84	77.28	77.68	78.08	78.53	78.94	79.35	79.77	80.19	80.63	81.08	81.55	82.03	82.52	83.02	83.51	83.98	84.41	84.78	85.09	85.31
1.404	77.13	77.57	77.97	78.36	78.83	79.24	79.65	80.07	80.49	80.93	81.38	81.85	82.33	82.82	83.32	83.81	84.27	84.70	85.08	85.38	85.59
1.406	77.42	77.86	78.25	78.64	79.14	79.54	79.95	80.37	80.79	81.23	81.68	82.15	82.63	83.12	83.62	84.11	84.57	85.00	85.37	85.66	85.87
1.408	77.71	78.15	78.54	78.92	79.44	79.85	80.25	80.67	81.09	81.53	81.97	82.45	82.93	83.41	83.92	84.41	84.87	85.29	85.66	85.95	86.15
1.410	78.00	78.44	78.83	79.20	79.74	80.15	80.56	80.97	81.39	81.82	82.27	82.74	83.23	83.71	84.22	84.71	85.17	85.59	85.95	86.23	86.43
1.412	78.29	78.73	79.11	79.48	80.04	80.45	80.86	81.27	81.68	82.12	82.57	83.04	83.52	84.01	84.51	85.00	85.46	85.88	86.24	86.52	86.71
1.414	78.58	79.01	79.39	79.75	80.34	80.75	81.16	81.57	81.98	82.42	82.86	83.34	83.82	84.31	84.81	85.30	85.76	86.18	86.53	86.81	86.99
1.416	78.87	79.30	79.67	80.03	80.64	81.05	81.45	81.87	82.28	82.71	83.16	83.63	84.12	84.60	85.11	85.60	86.06	86.47	86.82	87.09	87.27
1.418	79.16	79.58	79.95	80.30	80.94	81.35	81.75	82.16	82.57	83.01	83.45	83.93	84.41	84.90	85.41	85.89	86.35	86.76	87.11	87.38	87.55
1.420	79.44	79.86	80.23	80.57	81.24	81.65	82.05	82.46	82.87	83.30	83.75	84.22	84.71	85.19	85.70	86.19	86.65	87.06	87.40	87.66	87.83
1.422	79.73	80.15	80.51	80.84	81.54	81.94	82.35	82.76	83.16	83.60	84.04	84.52	85.00	85.49	86.00	86.49	86.94	87.35	87.69	87.94	88.10
1.424	80.01	80.43	80.78	81.11	81.84	82.24	82.65	83.05	83.46	83.89	84.33	84.81	85.29	85.78	86.29	86.78	87.23	87.64	87.98	88.23	88.38
1.426	80.29	80.70	81.06	81.38	82.14	82.54	82.94	83.35	83.75	84.19	84.62	85.10	85.59	86.08	86.59	87.08	87.53	87.93	88.27	88.51	88.66

Density g/cc	Temperature																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1.428	80.58	80.98	81.33	81.64	82.44	82.84	83.24	83.64	84.04	84.48	84.92	85.40	85.88	86.37	86.88	87.37	87.82	88.22	88.55	88.79	88.94
1.430	80.86	81.26	81.60	81.91	82.73	83.13	83.53	83.93	84.33	84.77	85.21	85.69	86.17	86.66	87.17	87.67	88.11	88.51	88.84	89.08	89.22
1.432	81.14	81.53	81.87	82.17	83.03	83.43	83.83	84.23	84.63	85.06	85.50	85.98	86.46	86.95	87.47	87.96	88.41	88.80	89.13	89.36	89.50
1.434	81.41	81.81	82.14	82.43	83.32	83.72	84.12	84.52	84.92	85.35	85.79	86.27	86.76	87.24	87.76	88.25	88.70	89.09	89.41	89.64	89.78
1.436	81.69	82.08	82.41	82.69	83.62	84.02	84.42	84.81	85.21	85.64	86.08	86.56	87.05	87.54	88.05	88.55	88.99	89.38	89.70	89.92	90.05
1.438	81.97	82.35	82.67	82.95	83.91	84.31	84.71	85.10	85.50	85.93	86.36	86.85	87.34	87.83	88.34	88.84	89.28	89.67	89.99	90.21	90.33
1.440	82.24	82.62	82.93	83.20	84.21	84.61	85.00	85.39	85.79	86.22	86.65	87.14	87.63	88.12	88.63	89.13	89.57	89.96	90.27	90.49	90.61
1.442	82.52	82.89	83.20	83.45	84.50	84.90	85.30	85.68	86.07	86.51	86.94	87.43	87.92	88.41	88.92	89.42	89.86	90.25	90.56	90.77	90.89
1.444	82.79	83.16	83.46	83.71	84.80	85.19	85.59	85.97	86.36	86.80	87.23	87.72	88.20	88.70	89.21	89.71	90.15	90.54	90.84	91.05	91.17
1.446	83.06	83.43	83.72	83.96	85.09	85.49	85.88	86.26	86.65	87.08	87.51	88.00	88.49	88.98	89.50	90.01	90.44	90.82	91.13	91.33	91.45
1.448	83.33	83.69	83.97	84.20	85.38	85.78	86.17	86.55	86.94	87.37	87.80	88.29	88.78	89.27	89.79	90.30	90.73	91.11	91.41	91.61	91.73
1.450	83.60	83.95	84.23	84.45	85.68	86.07	86.46	86.84	87.22	87.66	88.08	88.58	89.07	89.56	90.08	90.59	91.02	91.40	91.69	91.90	92.01
1.452	83.87	84.21	84.48	84.70	85.97	86.36	86.75	87.13	87.51	87.94	88.37	88.86	89.35	89.85	90.37	90.88	91.31	91.68	91.98	92.18	92.29
1.454	84.14	84.47	84.74	84.94	86.26	86.65	87.04	87.42	87.79	88.23	88.65	89.15	89.64	90.13	90.66	91.17	91.60	91.97	92.26	92.46	92.57
1.456	84.41	84.73	84.99	85.18	86.55	86.94	87.33	87.70	88.08	88.51	88.93	89.43	89.93	90.42	90.95	91.45	91.88	92.26	92.54	92.74	92.85
1.458	84.67	84.99	85.24	85.42	86.84	87.23	87.62	87.99	88.36	88.80	89.22	89.72	90.21	90.71	91.23	91.74	92.17	92.54	92.83	93.02	93.13
1.460	84.94	85.25	85.48	85.66	87.13	87.52	87.91	88.27	88.64	89.08	89.50	90.00	90.50	90.99	91.52	92.03	92.46	92.83	93.11	93.30	93.41
1.462	85.20	85.50	85.73	85.89	87.42	87.81	88.19	88.56	88.93	89.36	89.78	90.29	90.78	91.28	91.80	92.32	92.74	93.11	93.39	93.58	93.69
1.464	85.46	85.75	85.97	86.12	87.71	88.10	88.48	88.84	89.21	89.65	90.06	90.57	91.06	91.56	92.09	92.61	93.03	93.40	93.67	93.86	93.97
1.466	85.72	86.00	86.21	86.36	88.00	88.39	88.77	89.13	89.49	89.93	90.34	90.85	91.35	91.84	92.37	92.89	93.32	93.68	93.96	94.14	94.25
1.468	85.98	86.25	86.45	86.59	88.28	88.67	89.05	89.41	89.77	90.21	90.62	91.13	91.63	92.13	92.66	93.18	93.60	93.96	94.24	94.42	94.54
1.470	86.24	86.50	86.69	86.81	88.57	88.96	89.34	89.69	90.05	90.49	90.90	91.41	91.91	92.41	92.94	93.47	93.89	94.25	94.52	94.70	94.82
1.472	86.50	86.75	86.93	87.04	88.86	89.25	89.62	89.97	90.33	90.77	91.18	91.70	92.20	92.69	93.23	93.75	94.17	94.53	94.80	94.98	95.11
1.474	86.75	86.99	87.16	87.26	89.15	89.53	89.91	90.26	90.61	91.05	91.45	91.98	92.48	92.97	93.51	94.04	94.45	94.81	95.08	95.27	95.39
1.476	87.01	87.23	87.39	87.48	89.43	89.82	90.19	90.54	90.89	91.33	91.73	92.26	92.76	93.26	93.79	94.32	94.74	95.09	95.36	95.55	95.68
1.478	87.26	87.48	87.62	87.70	89.72	90.10	90.48	90.82	91.17	91.60	92.01	92.53	93.04	93.54	94.07	94.61	95.02	95.38	95.64	95.83	95.96
1.480	87.51	87.71	87.85	87.92	90.00	90.39	90.76	91.10	91.45	91.88	92.28	92.81	93.32	93.82	94.35	94.89	95.30	95.66	95.92	96.11	96.25
1.482	87.76	87.95	88.08	88.13	90.29	90.67	91.04	91.38	91.72	92.16	92.56	93.09	93.60	94.10	94.64	95.18	95.59	95.94	96.20	96.39	96.54
1.484	88.01	88.19	88.30	88.35	90.57	90.95	91.32	91.66	92.00	92.44	92.83	93.37	93.88	94.38	94.92	95.46	95.87	96.22	96.49	96.67	96.82
1.486	88.26	88.42	88.53	88.56	90.86	91.24	91.61	91.94	92.28	92.71	93.10	93.65	94.16	94.65	95.20	95.74	96.15	96.50	96.77	96.96	97.11
1.488	88.50	88.65	88.75	88.77	91.14	91.52	91.89	92.21	92.55	92.99	93.38	93.92	94.44	94.93	95.48	96.03	96.43	96.78	97.05	97.24	97.40
1.490	88.75	88.88	88.97	88.97	91.43	91.80	92.17	92.49	92.83	93.26	93.65	94.20	94.71	95.21	95.75	96.31	96.71	97.06	97.33	97.52	97.69
1.492	88.99	89.11	89.18	89.18	91.71	92.09	92.45	92.77	93.10	93.54	93.92	94.47	94.99	95.49	96.03	96.59	97.00	97.34	97.61	97.80	97.99
1.494	89.23	89.34	89.40	89.38	91.99	92.37	92.73	93.04	93.37	93.81	94.19	94.75	95.27	95.77	96.31	96.87	97.28	97.62	97.89	98.09	98.28
1.496	89.47	89.56	89.61	89.58	92.27	92.65	93.01	93.32	93.65	94.08	94.46	95.02	95.55	96.04	96.59	97.15	97.56	97.90	98.16	98.37	98.57
1.498	89.71	89.79	89.82	89.78	92.56	92.93	93.28	93.60	93.92	94.35	94.73	95.30	95.82	96.32	96.86	97.43	97.84	98.18	98.44	98.65	98.87
1.500	89.95	90.01	90.02	89.97	92.84	93.21	93.56	93.87	94.19	94.63	95.00	95.57	96.10	96.59	97.14	97.71	98.12	98.46	98.72	98.94	99.17
1.502	90.19	90.23	90.23	90.17	93.12	93.49	93.84	94.15	94.46	94.90	95.27	95.84	96.37	96.87	97.42	97.99	98.40	98.73	99.00	99.22	99.46
1.504	90.42	90.44	90.43	90.36	93.40	93.77	94.12	94.42	94.73	95.17	95.54	96.12	96.65	97.14	97.69	98.27	98.67	99.01	99.28	99.51	99.76
1.506	90.66	90.66	90.63	90.55	93.68	94.05	94.40	94.69	95.00	95.44	95.80	96.39	96.92	97.42	97.97	98.55	98.95	99.29	99.56	99.79	-
1.508	90.89	90.87	90.83	90.73	93.96	94.32	94.67	94.96	95.27	95.71	96.07	96.66	97.20	97.69	98.24	98.83	99.23	99.57	99.84	-	-
1.510	91.12	91.08	91.03	90.92	94.24	94.60	94.95	95.24	95.54	95.98	96.33	96.93	97.47	97.96	98.51	99.11	99.51	99.85	-	-	-
1.512	91.35	91.29	91.22	91.10	94.52	94.88	95.22	95.51	95.81	96.24	96.60	97.20	97.74	98.24	98.79	99.39	99.79	-	-	-	-
1.514	91.57	91.50	91.41	91.28	94.80	95.16	95.50	95.78	96.08	96.51	96.86	97.47	98.02	98.51	99.06	99.67	-	-	-	-	-
1.516	91.80	91.70	91.60	91.45	95.07	95.43	95.77	96.05	96.34	96.78	97.13	97.74	98.29	98.78	99.33	99.94	-	-	-	-	-
1.518	92.02	91.90	91.79	91.63	95.35	95.71	96.05	96.32	96.61	97.04	97.39	98.01	98.56	99.05	99.60	-	-	-	-	-	-
1.520	92.25	92.10	91.97	91.80	95.63	95.99	96.32	96.59	96.88	97.31	97.65	98.28	98.83	99.32	99.87	-	-	-	-	-	-

Density g/cc	Temperature																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1.522	92.47	92.30	92.15	91.97	95.91	96.26	96.59	96.86	97.14	97.57	97.91	98.55	99.10	99.59	-	-	-	-	-	-	-
1.524	92.69	92.50	92.33	92.13	96.18	96.54	96.87	97.13	97.41	97.84	98.17	98.81	99.37	99.86	-	-	-	-	-	-	-
1.526	92.90	92.69	92.51	92.30	96.46	96.81	97.14	97.40	97.67	98.10	98.43	99.08	99.64	-	-	-	-	-	-	-	-
1.528	93.12	92.88	92.68	92.46	96.74	97.09	97.41	97.66	97.93	98.37	98.69	99.35	99.91	-	-	-	-	-	-	-	-
1.530	93.33	93.07	92.85	92.62	97.01	97.36	97.68	97.93	98.20	98.63	98.95	99.61	-	-	-	-	-	-	-	-	-
1.532	93.54	93.25	93.02	92.78	97.29	97.63	97.95	98.20	98.46	98.89	99.21	99.88	-	-	-	-	-	-	-	-	-
1.534	93.76	93.44	93.19	92.93	97.56	97.90	98.22	98.46	98.72	99.15	99.47	-	-	-	-	-	-	-	-	-	-
1.536	93.96	93.62	93.35	93.08	97.84	98.18	98.49	98.73	98.98	99.41	99.72	-	-	-	-	-	-	-	-	-	-
1.538	94.17	93.80	93.51	93.23	98.11	98.45	98.76	98.99	99.24	99.67	99.98	-	-	-	-	-	-	-	-	-	-
1.540	94.38	93.97	93.66	93.37	98.38	98.72	99.03	99.26	99.50	99.93	-	-	-	-	-	-	-	-	-	-	-
1.542	94.58	94.15	93.82	93.52	98.66	98.99	99.30	99.52	99.76	-	-	-	-	-	-	-	-	-	-	-	-
1.544	94.78	94.32	93.97	93.66	98.93	99.26	99.56	99.78	-	-	-	-	-	-	-	-	-	-	-	-	-
1.546	94.98	94.48	94.12	93.80	99.20	99.53	99.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.548	95.18	94.65	94.26	93.93	99.47	99.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.550	95.38	94.81	94.41	94.06	99.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.552	95.57	94.97	94.55	94.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.554	95.76	95.13	94.68	94.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.556	95.95	95.29	94.82	94.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.558	96.14	95.44	94.95	94.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.560	96.33	95.59	95.08	94.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.562	96.51	95.73	95.20	94.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.564	96.69	95.88	95.32	94.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.566	96.87	96.02	95.44	95.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.568	97.05	96.16	95.55	95.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.570	97.23	96.29	95.66	95.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.572	97.40	96.42	95.77	95.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.574	97.57	96.55	95.88	95.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.576	97.74	96.68	95.98	95.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.578	97.91	96.80	96.08	95.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.580	98.08	96.92	96.17	95.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.582	98.24	97.03	96.26	95.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.584	98.40	97.15	96.35	95.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.586	98.56	97.25	96.43	95.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.588	98.71	97.36	96.51	96.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.590	98.87	97.46	96.59	96.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.592	99.02	97.56	96.66	96.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 2 Density of water as a function of temperature

Temperature in		Density in		Temperature in		Density in	
°C	°F	kg/m^3	lb/ft^3	°C	°F	kg/m^3	lb/ft^3
0	32	999.8396	62.41999	25	77	997.0468	62.24563
0.5	32.9	999.8712	62.42197	25.5	77.9	996.9176	62.23757
1	33.8	999.8986	62.42367	26	78.8	996.7861	62.22936
1.5	34.7	999.9213	62.42509	26.5	79.7	996.6521	62.22099
2	35.6	999.9399	62.42625	27	80.6	996.5159	62.21249
2.5	36.5	999.9542	62.42714	27.5	81.5	996.3774	62.20384
3	37.4	999.9642	62.42777	28	82.4	996.2368	62.19507
3.5	38.3	999.9701	62.42814	28.5	83.3	996.0939	62.18614
4	39.2	999.9720	62.42825	29	84.2	995.9487	62.17708
4.5	40.1	999.9699	62.42812	29.5	85.1	995.8013	62.16788
5	41	999.9638	62.42774	30	86	995.6518	62.15855
5.5	41.9	999.9540	62.42713	30.5	86.9	995.5001	62.14907
6	42.8	999.9402	62.42627	31	87.8	995.3462	62.13947
6.5	43.7	999.9227	62.42517	31.5	88.7	995.1903	62.12973
7	44.6	999.9016	62.42386	32	89.6	995.0322	62.11986
7.5	45.5	999.8766	62.42230	32.5	90.5	994.8721	62.10987
8	46.4	999.8482	62.42053	33	91.4	994.7100	62.09975
8.5	47.3	999.8162	62.4185	33.5	92.3	994.5458	62.08950
9	48.2	999.7808	62.41632	34	93.2	994.3796	62.07912
9.5	49.1	999.7419	62.41389	34.5	94.1	994.2113	62.06861
10	50	999.6997	62.41125	35	95	994.0411	62.05799
10.5	50.9	999.6541	62.40840	35.5	95.9	993.8689	62.04724
11	51.8	999.6051	62.40535	36	98.6	993.6948	62.03637
11.5	52.7	999.5529	62.40209	36.5	97.7	993.5187	62.02537
12	53.6	999.4975	62.39863	37	98.6	993.3406	62.01426
12.5	54.5	999.4389	62.39497	37.5	99.5	993.1606	62.00302
13	55.4	999.3772	62.39112	38	100.4	992.9789	61.99168
13.5	56.3	999.3124	62.38708	38.5	101.3	992.7951	61.98020
14	57.2	999.2446	62.38284	39	102.2	992.6096	61.96862
14.5	58.1	999.1736	62.37841	39.5	103.1	992.4221	61.95692
15	59	999.0998	62.37380	40	104	992.2329	61.94510
15.5	59.9	999.0229	62.36901	40.5	104.9	992.0418	61.93317
16	60.8	998.9432	62.36403	41	105.8	991.8489	61.92113
16.5	61.7	998.8607	62.35887	41.5	106.7	991.6543	61.90898
17	62.6	998.7752	62.35354	42	107.6	991.4578	61.89672
17.5	63.5	998.6870	62.34803	42.5	108.5	991.2597	61.88434
18	64.4	998.5960	62.34235	43	109.4	991.0597	61.87186
18.5	65.3	998.5022	62.33650	43.5	110.3	990.8581	61.85927
19	66.2	998.4058	62.33047	44	111.2	990.6546	61.84657
19.5	67.1	998.3066	62.32428	44.5	112.1	990.4494	61.83376
20	68	998.2048	62.31793	45	113	990.2427	61.82085
20.5	68.9	998.1004	62.31141	45.5	113.9	990.0341	61.80783
21	69.8	997.9934	62.30473	46	114.8	989.8239	61.79471
21.5	70.7	997.8838	62.29788	46.5	115.7	989.6121	61.78149
22	71.6	997.7716	62.29088	47	116.6	989.3986	61.76816
22.5	72.5	997.6569	62.28372	47.5	117.5	989.1835	61.75473
23	73.4	997.5398	62.27641	48	118.4	988.9668	61.74120
23.5	74.3	997.4201	62.26894	48.5	119.3	988.7484	61.72756
24	75.2	997.2981	62.26132	49	120.2	988.5285	61.71384
24.5	76.1	997.1736	62.25355	49.5	121.1	988.3069	61.70000

Temperature in		Density in	
°C	°F	kg/m^3	lb/ft^3
50	122	988.0839	61.68608
50.5	122.9	987.8592	61.67205
51	123.8	987.6329	61.65793
51.5	124.7	987.4051	61.64371
52	125.6	987.1758	61.62939
52.5	126.5	986.9450	61.61498
53	127.4	986.7127	61.60048
53.5	128.3	986.4788	61.58588
54	129.2	986.2435	61.57118
54.5	130.1	986.0066	61.55640
55	131	985.7684	61.54153
55.5	131.9	985.5287	61.52656
56	132.8	985.2876	61.51150
56.5	133.7	985.0450	61.49636
57	134.6	984.8009	61.48112
57.5	135.5	984.5555	61.46580
58	136.4	984.3086	61.45039
58.5	137.3	984.0604	61.43489
59	138.2	983.8108	61.41931
59.5	139.1	983.5597	61.40364
60	140	983.3072	61.38787
60.5	140.9	983.0535	61.37203
61	141.8	982.7984	61.35611
61.5	142.7	982.5419	61.34009
62	143.6	982.2841	61.32400
62.5	144.5	982.0250	61.30783
63	145.4	981.7646	61.29157
63.5	146.3	981.5029	61.27523
64	147.2	981.2399	61.25881
64.5	148.1	980.9756	61.24231
65	149	980.7099	61.22573
65.5	149.9	980.4432	61.20907
66	150.8	980.1751	61.19233
66.5	151.7	979.9057	61.17552
67	152.6	979.6351	61.15862
67.5	153.5	979.3632	61.14165
68	154.4	979.0901	61.12460
68.5	155.3	978.8159	61.10748
69	156.2	978.5404	61.09028
69.5	157.1	978.2636	61.07300
70	158	977.9858	61.05566
70.5	158.9	977.7068	61.03823
71	159.8	977.4264	61.02074
71.5	160.7	977.1450	61.00316
72	161.6	976.8624	60.98552
72.5	162.5	976.5786	60.96781
73	163.4	976.2937	60.95002
73.5	164.3	976.0076	60.93216
74	165.2	975.7204	60.91423
74.5	166.1	975.4321	60.89623
75	167	975.1428	60.87816
75.5	167.9	974.8522	60.86003
76	168.8	974.5606	60.84182
76.5	169.7	974.2679	60.82355
77	170.6	973.9741	60.80520
77.5	171.5	973.6792	60.78680
78	172.4	973.3832	60.76832
78.5	173.3	973.0862	60.74977
79	174.2	972.7881	60.73116
79.5	175.1	972.4890	60.71249
80	176	972.1880	60.69375