Honeywell Genetron® AZ-50 & 404A

Properties, Uses, Storage, and Handling

Honeywell

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Introduction

Genetron® AZ-50® refrigerant (an azeotropic mixture of HFC-125 and HFC-143a, assigned R-507 by ASHRAE) was developed by Honeywell to serve as a long-term substitute for the refrigerant R-502. This patented, environmentally safe, non-ozone-depleting substitute possesses similar energy efficiency and capacity characteristics to R-502 and has an intrinsically low toxicity. Genetron AZ-50 has higher energy efficiency than other R-502 alternatives, due in part to superior heat transfer characteristics. Genetron AZ-50 is an excellent refrigerant choice for low- and medium-temperature refrigeration applications.

Genetron® 404A is a refrigerant blend made up of HFC-125, HFC-143a, and HFC-134a and assigned the refrigerant number R-404A by ASHRAE. Like Genetron AZ-50, Genetron 404A is a non-ozone-depleting long-term alternative to R-502 that is well suited for low- and medium-temperature refrigeration applications.

Applications

In commercial refrigeration, Genetron AZ-50 and Genetron 404A serve a wide range of applications including supermarket freezer cases, reach-in coolers, display cases, transport refrigeration, and ice machines. These refrigerants may also be used to replace R-502 in a number of specialty applications.

Genetron AZ-50 and Genetron 404A are suitable for both new equipment and retrofitting existing R-502 commercial refrigeration systems. Generally, there will be few, if any, equipment changes necessary to optimize the performance of Genetron AZ-50 or Genetron 404A refrigerants in these applications. For retrofitting commercial systems, refer to bulletin G525-100, Genetron Refrigeration Retrofit Guidelines.

Physical Properties AZ-50

Chemical Name		Pentafluoroethane/ 1,1,1-Trifluoroethane
Appearance		Clear, colorless gas with a faint ethereal odor
Molecular Formula (composition, wt%)		CHF_2CF_3 (50%) CH_3CF_3 (50%)
Molecular Weight		98.9
Boiling Point	@ 1 ATM	-52.1°F
	@ 1.01 bar	-46.8°C
Freezing Point Range	@ 1 ATM	-177.7 to -181.3 °F
	@ 1.01 bar	-116.5 to 118.5 °C
Critical Temperature*		159.11°F 70.617°C
Critical Pressure*		537.37 (Psia) 3705 (kPa)
Critical Volume*		0.0326 (ft^3/lb) 0.002 (m^3/kg)
Critical Density*		30.637 (lb/ft^3) 490.77 (kg/m^3)
Vapor Density at boiling point		0.3487 (lb/ft^3) 5.585 (kg/m^3)
Liquid Density		65.42 (lb/ft^3) 1048.0 (kg/m^3)
Liquid Heat Capacity at constant pressure		0.37 (Btu/lb•°F) 1.54 (kJ/kg•K)
Vapor Heat Capacity at constant pressure		
	@ 1 ATM	0.208 (Btu/lb•°F)
	@ 1.01 bar	0.8700 (kJ/kg•K)
Heat of Vaporization at boiling point		84.72 (Btu/lb) 196.95 (kJ/kg)
Vapor Pressure		186.02 (Psia) 1283 (kPa)
Liquid Thermal Conductivity		0.0369 (Btu/hr•ft•°F) 0.0639 (W/m•K)
Vapor Thermal Conductivity		0.0104 (Btu/hr•ft•°F) 0.0180 (W/m•K)
Liquid Viscosity		0.3087 (lb_m/ft•hr) 127.6 (µPa•s)
Vapor Viscosity		0.0353 (lb_m/ft•hr) 14.58 (µPa•s)
% Volatiles by volume		100
Flammability Limits in Air @ 1 ATM (vol. %)		None
Ozone Depletion Potential (ODP)		0.00
ASHRAE Safety Group Classification		A1

* NIST Refprop 7

Note: All measurements are at 77° (25°C) unless otherwise noted.

Physical Properties 404A

Chemical Name	Pentafluoroethane/ 1,1,1-Trifluoroethane/ 1,1,1,2-Tetrafluoroethane
Appearance	Clear, colorless gas with a faint ethereal odor
Molecular Formula (composition, wt %)	CHF_2CF_3 (44%) CH_3CF_3 (52%) CH_2FCF_3 (4%)
Molecular Weight	97.6
Boiling Point @ 1 ATM @ 1.01 bar	-51.2°F -46.2°C
Freezing Point Range @ 1 ATM @ 1.01 bar	 Not Measured Not Measured
Critical Temperature* 72.046°C	161.68°F
Critical Pressure*	540.82 (Psia) 3728.9 (kPa)
Critical Volume*	0.0329 (ft^3/lb) 0.002 (m^3/kg)
Critical Density*	30.373 (lb/ft^3) 486.53 (kg/m^3)
Vapor Density at boiling point	0.3423 (lb/ft^3) 5.48 (kg/m^3)
Liquid Density	65.18 (lb/ft^3) 1044 (kg/m^3)
Liquid Heat Capacity at constant pressure	 0.37 (Btu/lb•°F) 1.54 (kJ/kg•K)
Vapor Heat Capacity at constant pressure @ 1 ATM @ 1.01 bar	 0.210 (Btu/lb•°F) 0.8773 (kJ/kg•K)
Heat of Vaporization at boiling point	86.45 (Btu/lb) 200.94 (kJ/kg)
Vapor Pressure	165.3 (Psia) 1241 (kPa)
Liquid Thermal Conductivity	0.0375 (Btu/hr•ft•°F) 0.0649 (W/m•K)
Vapor Thermal Conductivity	0.0104 (Btu/hr•ft•°F) 0.0180 (W/m•K)
Liquid Viscosity	0.3130 (lb_m/ft•hr) 129.3 (µPa•s)
Vapor Viscosity	0.0349 (lb_m/ft•hr) 14.41 (µPa•s)
% Volatiles by volume	100
Flammability Limits in Air @ 1 ATM (vol. %)	 None
Ozone Depletion Potential (ODP)	0
ASHRAE Safety Group Classification	A1

* NIST Refprop 7

Note: All measurements are at 77° (25°C) unless otherwise noted.

AZ-50 Pressure vs. Temperature

Temp. (°F)	Pressure (psig)	Temp. (°C)	Pressure bar-gauge
-60	5.8 *	-50	-0.15
-55	2.2 *	-47.5	-0.03
-50	0.9	-45	0.09
-45	3.0	-42.5	0.23
-40	5.4	-40	0.38
-35	8.1	-37.5	0.54
-30	11.0	-35	0.72
-25	14.1	-32.5	0.91
-20	17.6	-30	1.12
-15	21.4	-27.5	1.35
-10	25.5	-25	1.59
-5	30.0	-22.5	1.85
0	34.8	-20	2.14
5	40.0	-17.5	2.44
10	45.7	-15	2.76
15	51.7	-12.5	3.11
20	58.2	-10	3.49
25	65.2	-7.5	3.88
30	72.7	-5	4.31
35	80.7	-2.5	4.76
40	89.2	0	5.23
45	98.3	2.5	5.74
50	107.9	5	6.28
55	118.2	7.5	6.85
60	129.1	10	7.45
65	140.6	12.5	8.09
70	152.8	15	8.76
75	165.8	17.5	9.46
80	179.5	20	10.21
85	193.9	22.5	10.99
90	209.1	25	11.82
95	225.2	27.5	12.68
100	242.1	30	13.59
105	259.9	32.5	14.54
110	278.6	35	15.54
115	298.3	37.5	16.59
120	318.9	40	17.69
125	340.7	42.5	18.83
130	363.5	45	20.03
135	387.5	47.5	21.29
140	412.7	50	22.60
145	439.2	52.5	23.97
150	467.2	55	25.41
		57.5	26.91
		60	28.48
		62.5	30.12
		65	31.84

* "Hg Vac

404A Pressure vs. Temperature

Temp. (°F)	Bubble Pressure (psig)	Dew Pressure (psig)	Temp. (°C)	Bubble Pressure bar-gauge	Dew Pressure bar-gauge
-60.0	6.4 *	7.3 *	-50	-0.17	-0.20
-55.0	2.9 *	3.9 *	-47.5	-0.06	-0.09
-50.0	0.5	0.1 *	-45	0.06	0.03
-45.0	2.6	2.0	-42.5	0.20	0.16
-40.0	4.9	4.3	-40	0.34	0.30
-35.0	7.5	6.8	-37.5	0.50	0.46
-30.0	10.3	9.6	-35	0.68	0.63
-25.0	13.4	12.7	-32.5	0.86	0.81
-20.0	16.8	16.0	-30	1.07	1.01
-15.0	20.5	19.7	-27.5	1.29	1.23
-10.0	24.6	23.6	-25	1.53	1.47
-5.0	28.9	27.9	-22.5	1.78	1.72
0.0	33.7	32.6	-20	2.06	1.99
5.0	38.8	37.7	-17.5	2.36	2.29
10.0	44.3	43.1	-15	2.68	2.60
15.0	50.2	49.0	-12.5	3.02	2.94
20.0	56.6	55.3	-10	3.38	3.30
25.0	63.4	62.1	-7.5	3.77	3.68
30.0	70.7	69.3	-5	4.18	4.09
35.0	78.6	77.1	-2.5	4.62	4.53
40.0	86.9	85.4	0	5.09	4.99
45.0	95.8	94.2	2.5	5.59	5.49
50.0	105.3	103.6	5	6.11	6.01
55.0	115.3	113.6	7.5	6.67	6.56
60.0	126.0	124.2	10	7.26	7.15
65.0	137.3	135.5	12.5	7.88	7.77
70.0	149.3	147.4	15	8.54	8.42
75.0	162.0	160.1	17.5	9.23	9.11
80.0	175.4	173.4	20	9.96	9.83
85.0	189.5	187.5	22.5	10.73	10.60
90.0	204.5	202.4	25	11.54	11.40
95.0	220.2	218.1	27.5	12.38	12.25
100.0	236.8	234.6	30	13.27	13.13
105.0	254.2	252.1	32.5	14.21	14.06
110.0	272.5	270.4	35	15.19	15.04
115.0	291.8	289.6	37.5	16.21	16.06
120.0	312.1	309.9	40	17.28	17.14
125.0	333.3	331.2	42.5	18.41	18.26
130.0	355.6	353.5	45	19.58	19.43
135.0	379.1	377.0	47.5	20.81	20.66
140.0	403.7	401.7	50	22.10	21.95
145.0	429.6	427.7	52.5	23.44	23.29
150.0	456.8	455.1	55	24.84	24.70
			57.5	26.31	26.16
			60	27.84	27.70
			62.5	29.44	29.31
			65	31.12	30.99

AZ-50 and 404A Refrigeration Grade Specifications

AZ-50 Assay (min. wt. % of all Fluorocarbons)	99.5
404A Assay (min. wt. % of all Fluorocarbons)	99.7
Moisture (max. wt. %)	0.0010
High-boiling Residue (max. vol. %)	0.01
Chloride (max. wt. %)	0.0001
Total Acidity (max. wt. %)	0.0001
Non-Condensibles in Vapor Phase (max. vol. %)	1.5

Performance Data

	Genetron AZ-50	R-502	R-404A
Evaporating Pressure			
psig	40.6	35.4	38.7
bar-gauge	2.80	2.44	26.7
Condensing Pressure			
psig	197.8	176.3	192.1
bar-gauge	13.64	12.15	13.25
Compression Ratio			
	3.84	3.81	3.87
	3.85	3.82	3.88
Compressor Discharge Temperature			
°F	94.9	99.7	96.19
°C	35.0	37.6	35.7
Temperature of Suction Gas			
°F	5.0	5.0	5.0
°C	-15.0	-15.0	-15.0
Specific Volume of Suction Vapor			
ft^3/lb	0.81	0.81	0.86
m^3/kg	0.051	0.051	0.054
Latent Heat of Vaporization			
Btu/lb	74.8	67.4	76.4
kJ/kg	173.9	156.7	177.7
Net Refrigeration Effect			
Btu/lb	47.4	45.5	49.3
kJ/kg	110.4	106.0	114.5
Coefficient of Performance (C.O.P.)	4.19	4.39	4.23
Horsepower per ton of Refrigeration	1.13	1.07	1.11
Refrigerant Circulated			
per ton (lb/min)	4.22	4.39	4.06
per kW (g/s)	9.05	9.44	8.74
Compressor Suction Gas Volume			
per ton (ft^3/min)	3.42	3.55	3.48
per kW (l/s)	0.46	0.48	0.47
Liquid Circulated			
per ton (in^3/min)	114.1	102.0	109.8
per kW (mL/s)	8.87	8.03	8.56

English Units: The data above indicates performance at Standard Ton Conditions (5°F evaporating and 86°F condensing). 100% isentropic efficiency.

SI Units: The data above at cooling load=1kW (-15°C evaporating and 30°C condensing)

Genetron® 404A vs. Genetron 507

Although Genetron® AZ-50® and Genetron 404A can be used in the same applications, there are some differences between the two refrigerants that may influence product selection.

– AZ-50 is an azeotrope demonstrating 0.1°F or less temperature glide.

– R-404A is a blend and must be liquid charged using a throttling device in the manifold hose.

– **Thermodynamic capacity:** R-507 is slightly higher than R-404A.

– **System capacity:** R-507 typically about 3% higher than R-404A.

– **Compressor efficiency:** R-507 is 1-2% higher than R-404A.

– **System efficiency:** R-507 is about 3-4% higher than R-404A. Field test data has ranged from 2-7%.

– The refrigerant-side heat transfer coefficient is higher for R-507 than R-404A. The presence of R-134a in R-404A increases mass transfer resistance that results in a decline in heat transfer.

Lubricants

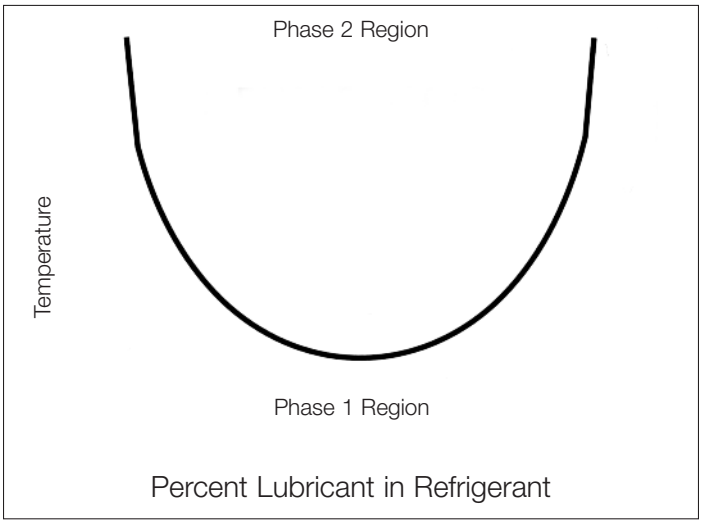
Compressor lubricants used must be miscible with Genetron AZ-50 and Genetron 404A. Polyol ester lubricants are most commonly used. Most compressor manufacturers recommend specific polyol ester lubricants. Check with the equipment manufacturer for the recommended lubricants for their system.

Miscibility in Lubricants

Polyol ester lubricants are available in a wide viscosity range from as low as 15 centistokes (cs) to more than 220 cs at 104°F (40°C). Their range of miscibility with Genetron AZ-50 or Genetron 404A can vary widely. Miscibility is the ability of the refrigerant/lubricant mixture to form a single liquid phase.

Many commercial polyol esters provide miscibility with Genetron AZ-50 and Genetron 404A down to low temperatures. As shown in the following figure, the miscibility curve for Genetron AZ-50 or Genetron 404A with polyol ester lubricant is often concave. The refrigerant/lubricant mixture is miscible at low temperatures and becomes immiscible at higher temperatures. These mixtures exhibit lower critical solution temperatures. The lower critical solution temperature is the temperature below which the refrigerant mixtures remain miscible over the entire concentration range.

Miscibility Genetron AZ-50 or Genetron 404A and Polyol Ester Lubricant



Stability with Metals

The stability of Genetron AZ-50 and Genetron 404A is very good for virtually all applications where R-502 is suitable. Genetron AZ-50 and Genetron 404A are compatible with steel, copper, aluminum and brass.

The stability of refrigerant/lubricant mixtures was determined for Genetron AZ-50 using the ASHRAE 97 sealed-tube method. Studies were conducted using sealed tubes of Genetron AZ-50 with polyol ester lubricants in the presence of three metal coupons (valve steel, copper and aluminum) for 14 days at 400°F (204°C). The stability was evaluated through both visual observation and measurement of the fluoride concentration produced in the tube.

On the basis of several tests, it is clear that Genetron AZ-50 is stable with polyol esters. A typical example of such tests is shown in the following table. Copper, steel and aluminum are stable with Genetron AZ-50 and the polyol esters studied. The stability of the refrigerant, as shown by the fluoride produced and the purity of the Genetron AZ-50 determined by chromatographic analysis, is excellent.

Genetron 404A is made up of the components HFC-125, HFC-143a and HFC-134a. The stability of Genetron 404A can be characterized based on the stability of its refrigerant components, in this case, by the known stability of Genetron AZ-50 and Genetron 134a.

Stability of Genetron® AZ-50® with Polyol Ester Lubricants and Metals

Lubricant	Lubricant Appearance	Copper	Aluminum	Steel	Fluoride (µS)	AZ-50 Purity
Mobil EAL 22	N.C.	N.C.	N.C.	Very light copper color for the portion immersed in the liquid.	12	N.C.
Mobil EAL 32	N.C.	N.C.	N.C.	N.C.	<10	N.C.
Castrol SW 32	N.C.	N.C.	N.C.	Slight black spots in the vapor phase region. Portion immersed in liquid is unchanged.	13	N.C.

*N.C. = No Change
Note: Test performed at 400°F (204°C) for 14 days

Chlorinated Materials and Refrigerants

There are three situations in which Genetron AZ-50 or Genetron 404A and compressor lubricants may come into contact with chlorinated materials. These instances are:

1. A chlorinated solvent is used to clean or flush the system.
2. A system is retrofitted from R-502, or
3. R-502 is accidentally charged into a system that contains Genetron AZ-50 or Genetron 404A.

It is recommended that chlorinated materials not be introduced into systems that used Genetron AZ-50 or Genetron 404A with polyol ester lubricants. While performing retrofits, the service technician should follow appropriate retrofit guidelines to help assure that residual chlorinated compounds are minimized. Genetron AZ-50 or Genetron 404A alone is chemically compatible with chlorinated materials. However, the polyol ester lubricants used can be incompatible with chlorinated materials. Chlorinated materials should not be introduced in to Genetron AZ-50 or Genetron 404A systems that use polyol ester lubricants without prior consultation with the equipment manufacturer.

Genetron AZ-50 or Genetron 404A Mixtures with R-502

The mixing of Genetron AZ-50 or Genetron 404A with R-502 should be avoided. The HFC-125 in Genetron AZ-50 or Genetron 404A can form an azeotrope with the CFC-115 component in R-502. Separation of HFC-125, HFC-143a, CFC-115, and HCFC-22 becomes difficult as a result. This will make recycling and reclamation very difficult or expensive, especially if it is desired to recover the original products.

Equipment

Compatibility: Plastics and Elastomers

Honeywell, in conjunction with the leading OEMs, has conducted materials testing to evaluate the compatibility of Genetron AZ-50 with materials used in refrigerant applications. The following list is a condensed sampling of the testing that has been performed to date. The information on this list is a first-level ranking of the compatibility of the materials. (Note: the compatibility of any specific material will be dependent on its formulation and history.) The ranking, although based on limited sampling can serve as a useful guide. Due to the similarity of Genetron® AZ-50® and Genetron 404A, the table below can also serve as a useful guide to the expected compatibility of Genetron 404A.

Materials Compatibility

Material	Genetron AZ-50	Genetron AZ-50 Polyol Ester
Ethylene-Propylene Diene terpolymer	S	S
Ethylene-Propylene copolymer	S	S
Chlorosulfonated Polyethylene	S	U
Polyisoprene	D	U
Chlorinated Polyethylene	S	U
Neoprene (Chloroprene)	S	D
Epichlorohydrin	D	U
Polyvinylidene fluoride and copolymer of vinylidene fluoride and hexafluoropropylene	U	U
Silicone	U	D
Polyurethane	D	D
Nitriles	D	D
H-NBR	D	S
Butyl rubber	D	S
Polysulfide	S	U
Nylon	S	D
Polytetrafluoroethylene	S	S
PEEK	S	S
ABS	D	U
Polypropylene	D	D
Polyphenylene sulfide	D	D
Polyethylene terephthalate	S	S
Polysulfone	S	S
Polyimide	S	D
Polyetherimide	S	S
Polyphthalamide	D	U
Polyamideimide	D	S
Acetal	S	U
Phenolic	S	D
Epoxy Laminate	S	S

Note: S: Suitable D: Suitability dependant on formulation
U: Unsuitable

In either case, rankings should be used with caution since they are judgements based on limited sampling. Customers should consult the manufacturer or do further independent testing

Desiccants

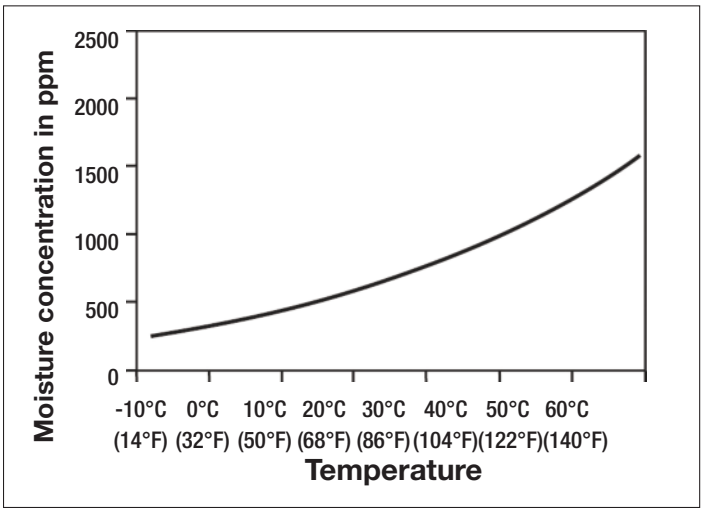
Three common types of desiccant materials are used in making driers. They are molecular sieves, alumina and silica gel. Molecular sieves XH7 and XH9 are recommended by UOP (a major molecular sieve manufacturer) for use with Genetron AZ-50. Similarly, Genetron 404A is compatible with XH7 and XH9. In addition, each drier manufacturer has developed driers and filters that are compatible with Genetron AZ-50 and Genetron 404A. Such driers can include all three types of drier materials.

Solubility of Water in Genetron AZ-50

The solubility of water in Genetron AZ-50 is shown in the graph below. The solubility of water in Genetron AZ-50 is comparable to that of water in R-502. Although not shown, the solubility of water in Genetron 404A would be comparable to that of water in Genetron AZ-50.

Safety

Solubility of Water in Genetron AZ-50



Honeywell recommends reading the MSDS before using any Genetron refrigerant. Any Genetron MSDS can be downloaded from www.genetron.com.

Toxicity

Genetron AZ-50 and Genetron 404A can be safely used in all of their intended applications based on data developed by Honeywell. This conclusion was reached after review of all toxicity results confirming the intrinsically low toxicity of these refrigerants. However, the end-user should read the Material Safety Data Sheet (MSDS) before using any Genetron refrigerant.

Inhalation

Genetron AZ-50 and Genetron 404A are of a low order of acute toxicity in animals. Vapor inhalation at high concentrations may result in asphyxiation or cardiac arrhythmia. If vapors are inhaled at high concentrations, cardiac irregularities and potentially cardiac arrest could occur. Under these circumstances, the heart may become sensitized. Do not administer adrenaline (epinephrine) if over-exposure to Genetron AZ-50 or Genetron 404A is suspected. These refrigerants are heavier than air and may displace oxygen. When concentrations of Genetron AZ-50 or Genetron 404A in air reach levels that reduce oxygen content to 14-16% by volume, symptoms of asphyxiation will occur. An individual exposed to high concentrations of Genetron AZ-50 or Genetron 404A must be given medical attention immediately. As with most refrigerants, adequate ventilation must be provided at all times.

Skin and Eye Contact

Genetron AZ-50 and Genetron 404A vapors have little or no effect on the skin and eyes. In liquid form, they can freeze skin or eyes on contact. If contact with the skin should occur, flush the exposed area with lukewarm water for 15 minutes to ensure the chemical is removed. If there is evidence of frostbite, soak affected area in lukewarm water. If contact with the eyes should occur, immediately flush with large amounts of lukewarm water for at least 15 minutes, occasionally lifting the eyelid to facilitate the flushing process. Seek medical attention immediately.

Leaks

Should a release of Genetron AZ-50 or Genetron 404A occur, the area must be evacuated immediately. Protected personnel should de-energize or remove any ignition sources and address the leak, if without risk. Vapors may concentrate near the floor, displacing available oxygen. Once the area is evacuated, it must be ventilated with blowers or fans to circulated the air at floor level. Unprotected personnel should not be allowed to return to the area until the air has been tested and determined safe.

Flammability

As defined by the U.S. Department of Transportation (DOT) regulations, flash point determinations do not apply to Genetron® AZ-50® and Genetron 404A. These refrigerants have no flame limits and DOT considers them non-flammable (Green Label). Underwriters' Laboratories® (UL) recognizes Genetron AZ-50 and Genetron 404A as practically non-flammable. According to ASHRAE Standard 34, Genetron AZ-50 and Genetron 404A are classified in Safety Group A1. Since these refrigerants do not have flash points and are non-flammable, Honeywell believes that standard industrial-type electrical installations may be used. It is essential to review and comply with all local building codes and other applicable regulations and laws when using Genetron AZ-50 or Genetron 404A.

Combustibility

Genetron AZ-50 and Genetron 404A are HFC refrigerants and are non-flammable at ambient temperatures and atmospheric pressures. However, when mixed with air, HFCs can be combustible at higher pressures and temperatures. Because of this combustibility potential under pressure, Genetron AZ-50 or

Genetron 404A and air should never be mixed in tanks or supply lines, or allowed to accumulate in storage tanks. Leak checking should never be done with mixtures of HFC refrigerants and air. Leak checking can be performed safely with a mixture of refrigerant and dry nitrogen. Anyone using or handling these refrigerants should first carefully review the Material Safety Data Sheet (MSDS).

Thermal Stability

Genetron AZ-50 and Genetron 404A are stable under normal operating conditions; however, it is important to avoid exposing these refrigerants to very high temperatures. When exposed to high temperatures, such as those found in flames or red-hot surfaces, the materials can decompose to produce toxic and corrosive compounds. Pungent odors released will irritate the nose and throat and generally force evacuation of the area. Contact with certain red-hot metals may result in exothermic or explosive reactions. Specific materials to avoid include freshly abraded aluminum surfaces and active metals such as sodium, potassium, aluminum, magnesium and zinc.

Storage and Handling

An important handling practice that must be followed for Genetron 404A is to ensure that all transfers be executed by using liquid charging instead of vapor charging. This practice will help minimize compositional changes.

Genetron AZ-50 and Genetron 404A cylinders must be clearly marked and kept in a cool, dry and properly ventilated storage area away from heat, flames, corrosive chemicals, fumes, explosives and be otherwise protected from damage. Disposable Jugs™ should be discarded in an environmentally safe manner in accordance with all laws and regulations.

Empty cylinders should be returned to Honeywell or your Genetron Wholesaler. Under no circumstance should anything be put into the empty cylinder. Prior to disposal, cylinder contents should be recovered to an internal pressure of 0 psig or less. Once empty, properly close the cylinder valve and replace the valve cap.

Keep cylinders out of direct sunlight, especially in warm weather.

Genetron AZ-50 and Genetron 404A liquid expand significantly when heated, reducing the amount of vapor space left in the cylinder. Once the cylinder becomes liquid-full, any further rise in temperature can cause it to burst, potentially resulting in serious personal injury.

NEVER ALLOW A CYLINDER TO GET WARMER THAN 125°F (55°C).

Always store cylinders above dirt or damp floors to prevent rusting, using a platform or parallel rails. SECURE CYLINDERS IN PLACE BY MEANS OF A RACK,CHAIN OR ROPE TO PREVENT THEM FROM TIPPING, FALLING, ROLLING OR ACCIDENTALLY STRIKING EACH OTHER OR ANY OTHER OBJECT. If the cylinder valve is broken off, rapid escape of the high-pressure contents will propel the cylinder, which could potentially result in serious injury. Keep cylinder caps in place until the cylinder is in use.

The storage area should be away from corrosive chemicals or fumes to avoid damaging effects on the cylinder and threaded areas of the valve. Follow similar precautions for bulk storage and transport systems, ensuring that proper design and operation satisfies the required pressure rating and also avoids external corrosive conditions, overheating or overfilling.

Maintenance

A thorough pre-job review must be done to determine the respiratory protection requirements, as well as any other safety equipment needed. Maintenance in areas where Genetron® AZ-50® or Genetron 404A has accumulated should be performed only after confirming that work area concentrations are below the permissible exposure level (PEL). This may be determined using a vapor-in-air analyzer capable of measuring the amount of airborne Genetron AZ-50 or Genetron 404A. These vapors are heavier than air and can accumulate at floor level. When vapor concentrations are above the PEL, the area should be ventilated to reduce the vapor concentration to below the PEL before entry. Ventilate the area using fans and other air movers as necessary. If entry must be made to areas where vapor concentrations are above the PEL, appropriate respiratory protection should be used.

Federal occupational health and safety agencies often have legal requirements and guidelines for proper selection and use of respiratory protection. It is often the responsibility of the employer to ensure the safety of the employees performing the maintenance. Be sure to comply with applicable laws and guidelines for proper selection and use of respiratory protection. If the airborne concentration of refrigerant is unknown or at a particular threshold, the law may require the use of supplied air respirators. Particular work team and work zone entry procedures may also apply.

Vessels, containers, transfer lines, pumps and other equipment should not be exposed to high-temperature sources (such as welding, brazing and open flames) until they have been thoroughly cleaned and found free of vapors. Exposure to these circumstances can cause fire, explosion and decomposition of refrigerant. This may result in the formation of toxic or corrosive compounds. Potential sources for further vapor releases should also be eliminated if possible.

When possible, maintenance or cleaning of equipment should be performed without entering the vessel. A tank or storage vessel may be a confined space. These spaces may have a configuration that can hinder activities and/or expose personnel to the risk of physical injury from entrapment, engulfment, or hazardous atmospheres. Depending on conditions and applicable regulations, a permit may be required to enter such vessels. If a tank must be entered, personnel should be required to use a formal tank entry procedure based on recognized safety principles and comply with all applicable regulations. The procedure would provide guidance for critical items such as but not limited to respiratory protection, safety equipment, work practice, and communication. Among the possible requirements of these procedures is the use of a fully qualified work team and placement of a confined space entry permit at the job site.

Leak Detection

Use leak detectors for pinpointing leaks or for monitoring an entire room on a continual basis.

Leak detectors are important for refrigerant conservation, equipment protection and performance, reduction of environmental impact, and protection of those coming in contact with the system. There are two types of leak detection systems — leak pinpointing and area monitoring. Before purchasing either type, several equipment factors should be considered, including detection limits, sensitivity, and selectivity. Regarding selectivity, there are three categories: non-selective, halogen-selective, and compound selective. In general, complexity and cost of a leak detector increase as the specificity increases. A fluorescent dye compatible with the refrigerant and lubricant may also be used in conjunction with an ultraviolet lamp to pinpoint leaks.

New installations should be checked for leaks prior to complete charging. Whenever a leak inspection is performed, check all factory and field joints throughout the system. For a system that has been in operation for some time, check for oil at joints and connections, as this may serve as an indication of a refrigerant leak at that location. This approach would not commonly be considered when leak checking a new system installation since it is much less likely that oil will have found its way to the leak. If a system has lost all or most of its refrigerant charge, the system must be pressurized to about 150 psig in order to perform a leak check. Pressure can be restored for leak checking by adding Genetron® AZ-50® or Genetron 404A using normal charging procedures or by using dry nitrogen. DO NOT USE AIR TO LEAK CHECK THE SYSTEM. At pressures above atmospheric, mixtures of air and any HCFC or HFC refrigerant will become combustible. For a system containing either refrigerant or a mixture of refrigerant and nitrogen, an electronic leak detector can be used. The leak detector must be capable of detecting a hydrofluorocabon (HFC) refrigerant. Older leak detectors designed for R-22 will not be sensitive enough to effectively detect HFC refrigerants. Halide torches cannot effectively detect HFC refrigerant leaks.

NITROGEN IS A HIGH PRESSURE GAS. REMEMBER TO USE A PRESSURE REGULATOR COMING OFF THE NITROGEN TANK TO AVOID ANY RISK OF SEVERE PERSONAL INJURY.

A simple way to test for leaks is to use a solution of soap and water. Commercial soap solutions for leak detection tend to be more effective. Apply the solution to joints and connections. Generation of bubbles will indicate a pinhole leak. Several minutes may be required to generate a bubble in the case of a very small leak. When it is suspected that essentially no refrigerant remains in the system, the above method can be used to detect leaking nitrogen gas. However, the most convenient and effective means to detect a leak when Genetron AZ-50 or Genetron 404A is in the system is to use an electronic leak detector designed for HFC refrigerants. When a leak is found, the refrigerant must be recovered and the leak repaired prior to final charging and operation. If the refrigerant charge is 50 pounds or more, the system is subject to leak repair requirements under the Refrigerant Recycling Regulations of Section 608 of the Clean Air Act Amendments of 1990. In this case, the equipment owner must keep a record of the date and type of service performed and the amount of refrigerant added.

Environmental Considerations

Genetron AZ-50 and Genetron 404A are halogenated hydrocarbons. Treatment or disposal of wastes generated by use of these products may require special consideration, depending on the nature of the wastes and the means of discharge, treatment or disposal. For more information, refer to the Disposal Considerations and Regulatory Information sections of the Material Safety Data Sheet (MSDS).

If discarded unused, Genetron AZ-50 and Genetron 404A are not considered “hazardous waste” by the Resource Conservation and Recovery Act (RCRA). Because these refrigerants are considered to have minimum biodegradability, care should be taken to avoid releases to the environment. The disposal of Genetron AZ-50 and Genetron 404A may be subject to federal, state and local regulations. Users should conduct disposal operations in compliance with applicable federal, state and local laws and regulations. Appropriate regulatory agencies also should be consulted before discharging or disposing of waste materials.

Reclamation

The Clean Air Act Amendments of 1990 require mandatory recycling and reclamation of Genetron AZ-50 and Genetron 404A during maintenance, service or repair of air-conditioning and refrigeration equipment. Refrigerant that is too contaminated for reuse must be properly disposed of or reclaimed. In the U.S., reclamation can only be performed at an EPA (Environmental Protection Agency) approved reclamation facility before it may be resold to another party. Most Genetron refrigerant wholesalers will accept recovered Genetron AZ-50 and Genetron 404A for reclamation.

Retrofitting

Applications where Genetron AZ-50 or Genetron 404A are suitable retrofit replacement refrigerants include supermarket display cases, walk-in coolers, ice machines and other specialty applications.

Long-term vs. Interim Replacements

Where feasible, Genetron AZ-50 or Genetron 404A are the preferred retrofit replacements for R-502 in most OEM applications. In some cases, however, retrofitting with these refrigerants may be difficult because nearly all of the mineral oil in the system must be removed. For these instances, interim blends such as Genetron HP80 or Genetron 408A may be suitable options. These interim blends contain hydrochlorofluorocarbon (HCFC) refrigerants that have been shown to be ozone-depleting chemicals.

Technicians and end-users should keep in mind that future regulations may further restrict the use of HCFC-containing refrigerants and dictate the ultimate use of non-chlorine containing refrigerants such as Genetron® AZ-50® or Genetron 404A for servicing R-502 equipment.

Retrofit Lubricants

Genetron AZ-50 and Genetron 404A are not “drop-in” replacements for R-502. Mineral oils and alkylbenzene lubricants are immiscible with these refrigerants and therefore must be replaced with a miscible lubricant such as polyol ester lubricant. Consult the original equipment manufacturer for the recommended lubricant.

Retrofit Procedures

Retrofit procedures have been developed by Honeywell to help technicians perform successful retrofits of R-502 systems utilizing positive-displacement (reciprocating, rotary, scroll or screw) compressors with Genetron AZ-50 or Genetron 404A. However, these should not be used as substitutes for the equipment manufacturer’s specific recommendations. For further information on retrofitting with Genetron AZ-50 and Genetron 404A, refer to the Genetron Refrigeration Retrofit Guidelines bulletin G525-100.

Packaging

Genetron AZ-50 and Genetron 404A are available in a variety of containers including 24-lb. and 25-lb. disposable cylinders (404A and AZ-50 respectively), 100-lb. returnable cylinders, and one ton (1750-lb.) returnable tanks. Bulk tank trailers and isotanks are also available. Consult your Sales Representative if a larger container is required.

Technical Assistance

Honeywell technical specialists and sales representatives are available to assist customers with regard to all aspects relating to Genetron AZ-50 and Genetron 404A, including handling, use, storage, and applications design. For further information and/or technical assistance with Genetron refrigerants, contact:

Honeywell
Genetron Refrigerants
P.O. Box 1053
Morristown, NJ 07962-1053
Or call us at 1-800-631-8138

Available Literature

Honeywell has a wide range of literature available including MSDS sheets, retrofitting procedures, product specifications and product descriptions. For more information, call Honeywell at (800) 631-8138 or visit the Genetron web site at www.genetron.com. Most literature is also available through your local Genetron refrigerant wholesaler.

AZ-50 (R-507) Thermodynamic Table — English Units

Temp (°F)	Vapor Pressure (psia)	Liquid Volume (ft^3/lb)	Liquid Density (lb/ft^3)	Enthalpy Enthalpy (Btu/lb)	Vapor DH (Btu/lb)	Liquid Enthalpy (Btu/lb)	Vapor Entropy (Btu/lb-F)	Entropy (Btu/lb-F)
-60	11.8	3.5108	83.05	-5.95	85.92	79.97	-0.0145	0.2005
-58	12.5	3.3320	82.84	-5.36	85.62	80.26	-0.0130	0.2001
-56	13.2	3.1640	82.62	-4.77	85.32	80.55	-0.0116	0.1998
-54	14.0	3.0063	82.41	-4.18	85.01	80.83	-0.0101	0.1995
-52	14.7	2.8580	82.19	-3.58	84.70	81.12	-0.0086	0.1991
-50	15.6	2.7184	81.97	-2.99	84.40	81.41	-0.0072	0.1988
-48	16.4	2.5871	81.76	-2.39	84.08	81.69	-0.0057	0.1985
-46	17.3	2.4634	81.54	-1.80	83.78	81.98	-0.0043	0.1982
-44	18.2	2.3468	81.32	-1.20	83.46	82.26	-0.0029	0.1979
-42	19.1	2.2369	81.10	-0.60	83.15	82.55	-0.0014	0.1976
-40	20.1	2.1332	80.88	0.00	82.83	82.83	0.0000	0.1974
-38	21.1	2.0352	80.66	0.60	82.51	83.11	0.0014	0.1971
-36	22.2	1.9426	80.44	1.20	82.19	83.39	0.0028	0.1968
-34	23.3	1.8552	80.21	1.81	81.86	83.67	0.0043	0.1966
-32	24.5	1.7724	79.99	2.41	81.55	83.96	0.0057	0.1963
-30	25.7	1.6941	79.77	3.02	81.22	84.24	0.0071	0.1961
-28	26.9	1.6200	79.54	3.63	80.88	84.51	0.0085	0.1959
-26	28.2	1.5497	79.31	4.24	80.55	84.79	0.0099	0.1956
-24	29.5	1.4831	79.09	4.85	80.22	85.07	0.0113	0.1954
-22	30.9	1.4200	78.86	5.46	79.89	85.35	0.0127	0.1952
-20	32.3	1.3601	78.63	6.07	79.55	85.62	0.0141	0.1950
-18	33.8	1.3032	78.40	6.69	79.20	85.89	0.0155	0.1948
-16	35.3	1.2491	78.16	7.30	78.87	86.17	0.0168	0.1946
-14	36.9	1.1978	77.93	7.92	78.52	86.44	0.0182	0.1944
-12	38.5	1.1490	77.70	8.54	78.17	86.71	0.0196	0.1942
-10	40.2	1.1025	77.46	9.16	77.82	86.98	0.0210	0.1940
-8	42.0	1.0584	77.23	9.78	77.47	87.25	0.0223	0.1939
-6	43.8	1.0163	76.99	10.40	77.12	87.52	0.0237	0.1937
-4	45.6	0.9762	76.75	11.03	76.75	87.78	0.0251	0.1935
-2	47.5	0.9380	76.51	11.66	76.39	88.05	0.0264	0.1934
0	49.5	0.9016	76.27	12.28	76.03	88.31	0.0278	0.1932
2	51.6	0.8669	76.02	12.91	75.67	88.58	0.0291	0.1930
4	53.7	0.8337	75.78	13.55	75.29	88.84	0.0305	0.1929
6	55.8	0.8021	75.53	14.18	74.92	89.10	0.0319	0.1927
8	58.1	0.7719	75.29	14.81	74.54	89.35	0.0332	0.1926
10	60.4	0.7430	75.04	15.45	74.16	89.61	0.0346	0.1925
12	62.8	0.7154	74.79	16.09	73.78	89.87	0.0359	0.1923
14	65.2	0.6890	74.54	16.73	73.39	90.12	0.0372	0.1922
16	67.7	0.6638	74.28	17.37	73.00	90.37	0.0386	0.1920
18	70.3	0.6396	74.03	18.02	72.60	90.62	0.0399	0.1919
20	73.0	0.6165	73.77	18.67	72.20	90.87	0.0413	0.1918
22	75.7	0.5944	73.51	19.31	71.80	91.11	0.0426	0.1917
24	78.5	0.5732	73.25	19.96	71.40	91.36	0.0439	0.1915
26	81.4	0.5528	72.99	20.62	70.98	91.60	0.0453	0.1914
28	84.4	0.5333	72.72	21.27	70.57	91.84	0.0466	0.1913
30	87.4	0.5146	72.45	21.93	70.15	92.08	0.0479	0.1912
32	90.6	0.4967	72.19	22.59	69.72	92.31	0.0492	0.1911
34	93.8	0.4795	71.91	23.25	69.30	92.55	0.0506	0.1909
36	97.1	0.4629	71.64	23.91	68.87	92.78	0.0519	0.1908
38	100.5	0.4470	71.37	24.58	68.43	93.01	0.0532	0.1907
40	103.9	0.4318	71.09	25.25	67.98	93.23	0.0545	0.1906
42	107.5	0.4171	70.81	25.92	67.54	93.46	0.0559	0.1905
44	111.2	0.4030	70.53	26.59	67.09	93.68	0.0572	0.1904
46	114.9	0.3895	70.24	27.27	66.63	93.90	0.0585	0.1903
48	118.8	0.3764	69.95	27.95	66.16	94.11	0.0598	0.1902

AZ-50 (R-507) Thermodynamic Table — English Units – continued

Temp (°F)	Vapor Pressure (psia)	Liquid Volume (ft^3/lb)	Liquid Density (lb/ft^3)	Enthalpy Enthalpy (Btu/lb)	Vapor DH (Btu/lb)	Liquid Enthalpy (Btu/lb)	Vapor Entropy (Btu/lb-F)	Entropy (Btu/lb-F)
50	122.7	0.3638	69.66	28.63	65.69	94.32	0.0611	0.1900
52	126.7	0.3518	69.37	29.31	65.22	94.53	0.0625	0.1899
54	130.9	0.3401	69.07	30.00	64.74	94.74	0.0638	0.1898
56	135.1	0.3289	68.77	30.69	64.25	94.94	0.0651	0.1897
58	139.4	0.3181	68.47	31.38	63.76	95.14	0.0664	0.1896
60	143.9	0.3076	68.16	32.08	63.26	95.34	0.0677	0.1895
62	148.4	0.2976	67.86	32.78	62.75	95.53	0.0691	0.1893
64	153.1	0.2879	67.54	33.48	62.24	95.72	0.0704	0.1892
66	157.8	0.2785	67.23	34.19	61.71	95.90	0.0717	0.1891
68	162.7	0.2695	66.91	34.90	61.18	96.08	0.0730	0.1890
70	167.7	0.2608	66.58	35.61	60.65	96.26	0.0743	0.1888
72	172.8	0.2524	66.26	36.33	60.10	96.43	0.0757	0.1887
74	178.0	0.2442	65.92	37.05	59.54	96.59	0.0770	0.1886
76	183.3	0.2364	65.59	37.77	58.99	96.76	0.0783	0.1884
78	188.8	0.2288	65.25	38.50	58.41	96.91	0.0796	0.1883
80	194.3	0.2214	64.90	39.23	57.83	97.06	0.0810	0.1881
82	200.0	0.2143	64.55	39.96	57.25	97.21	0.0823	0.1880
84	205.8	0.2074	64.20	40.70	56.65	97.35	0.0836	0.1878
86	211.8	0.2007	63.84	41.45	56.04	97.49	0.0850	0.1877
88	217.8	0.1943	63.47	42.20	55.42	97.62	0.0863	0.1875
90	224.0	0.1880	63.10	42.95	54.79	97.74	0.0876	0.1873
92	230.3	0.1820	62.72	43.71	54.15	97.86	0.0890	0.1871
94	236.8	0.1761	62.34	44.48	53.49	97.97	0.0903	0.1870
96	243.4	0.1704	61.95	45.25	52.82	98.07	0.0917	0.1868
98	250.1	0.1649	61.55	46.02	52.14	98.16	0.0930	0.1866
100	257.0	0.1595	61.14	46.80	51.45	98.25	0.0944	0.1863
102	264.0	0.1543	60.73	47.59	50.74	98.33	0.0958	0.1861
104	271.2	0.1493	60.31	48.38	50.02	98.40	0.0971	0.1859
106	278.5	0.1443	59.88	49.19	49.27	98.46	0.0985	0.1856
108	285.9	0.1396	59.44	49.99	48.52	98.51	0.0999	0.1854
110	293.5	0.1349	58.99	50.81	47.74	98.55	0.1013	0.1851
112	301.3	0.1304	58.53	51.63	46.95	98.58	0.1027	0.1848
114	309.2	0.1260	58.06	52.47	46.13	98.60	0.1041	0.1845
116	317.3	0.1217	57.57	53.31	45.29	98.60	0.1055	0.1842
118	325.5	0.1175	57.08	54.16	44.43	98.59	0.1070	0.1839
120	333.9	0.1134	56.57	55.02	43.55	98.57	0.1084	0.1835
122	342.5	0.1094	56.04	55.89	42.64	98.53	0.1099	0.1832
124	351.2	0.1055	55.50	56.77	41.70	98.47	0.1113	0.1828
126	360.1	0.1017	54.94	57.67	40.72	98.39	0.1128	0.1823
128	369.2	0.0980	54.36	58.58	39.72	98.30	0.1143	0.1819
130	378.5	0.0943	53.76	59.51	38.67	98.18	0.1158	0.1814
132	387.9	0.0907	53.14	60.45	37.58	98.03	0.1174	0.1809
134	397.6	0.0872	52.48	61.41	36.45	97.86	0.1189	0.1803
136	407.4	0.0837	51.80	62.40	35.25	97.65	0.1205	0.1797
138	417.4	0.0803	51.08	63.40	34.01	97.41	0.1222	0.1791
140	427.7	0.0769	50.32	64.44	32.68	97.12	0.1238	0.1783
142	438.1	0.0735	49.52	65.51	31.28	96.79	0.1255	0.1775
144	448.8	0.0701	48.65	66.61	29.79	96.40	0.1273	0.1766
146	459.6	0.0667	47.72	67.76	28.17	95.93	0.1291	0.1756
148	470.8	0.0632	46.69	68.98	26.39	95.37	0.1311	0.1745
150	482.1	0.0597	45.55	70.26	24.44	94.70	0.1331	0.1732

404A Thermodynamic Table — English Units

Temp (°F)	Bubble Pressure (Liquid) (psia)	Dew Pressure (Vapor) (psia)	Vapor Volume (ft^3/lb)	Liquid Density (lb/ft^3)	Liquid Enthalpy (Btu/lb)	Enthalpy DH (Btu/lb)	Vapor Enthalpy (Btu/lb)	Liquid Entropy ($Btu/lb-^F$)	Vapor Entropy ($Btu/lb-^F$)
-60	11.6	11.1	3.8030	82.48	-6.00	87.60	81.60	-0.01	0.2051
-58	12.2	11.7	3.6063	82.27	-5.40	87.29	81.89	-0.01	0.2047
-56	12.9	12.4	3.4217	82.06	-4.81	86.99	82.18	-0.01	0.2043
-54	13.6	13.1	3.2485	81.85	-4.21	86.68	82.47	-0.01	0.2040
-52	14.4	13.9	3.0859	81.63	-3.61	86.37	82.76	-0.01	0.2036
-50	15.2	14.6	2.9330	81.42	-3.01	86.06	83.05	-0.01	0.2033
-48	16.0	15.4	2.7893	81.20	-2.41	85.75	83.34	-0.01	0.2030
-46	16.8	16.3	2.6540	80.99	-1.81	85.44	83.63	0.00	0.2026
-44	17.7	17.1	2.5266	80.77	-1.21	85.12	83.91	0.00	0.2023
-42	18.7	18.1	2.4066	80.56	-0.60	84.80	84.20	0.00	0.2020
-40	19.6	19.0	2.2935	80.34	0.00	84.49	84.49	0.00	0.2017
-38	20.6	20.0	2.1867	80.12	0.61	84.16	84.77	0.00	0.2014
-36	21.7	21.0	2.0859	79.90	1.21	83.85	85.06	0.00	0.2011
-34	22.7	22.1	1.9908	79.68	1.82	83.52	85.34	0.00	0.2009
-32	23.9	23.2	1.9008	79.46	2.43	83.19	85.62	0.01	0.2006
-30	25.0	24.3	1.8158	79.24	3.04	82.86	85.90	0.01	0.2003
-28	26.2	25.5	1.7353	79.02	3.65	82.54	86.19	0.01	0.2001
-26	27.5	26.7	1.6591	78.80	4.27	82.20	86.47	0.01	0.1998
-24	28.8	28.0	1.5870	78.57	4.88	81.87	86.75	0.01	0.1996
-22	30.1	29.3	1.5186	78.35	5.50	81.53	87.03	0.01	0.1994
-20	31.5	30.7	1.4538	78.12	6.11	81.19	87.30	0.01	0.1991
-18	33.0	32.1	1.3922	77.90	6.73	80.85	87.58	0.02	0.1989
-16	34.5	33.6	1.3339	77.67	7.35	80.51	87.86	0.02	0.1987
-14	36.0	35.1	1.2784	77.44	7.98	80.15	88.13	0.02	0.1985
-12	37.6	36.7	1.2257	77.21	8.60	79.81	88.41	0.02	0.1983
-10	39.3	38.3	1.1756	76.98	9.22	79.46	88.68	0.02	0.1981
-8	41.0	40.0	1.1280	76.74	9.85	79.10	88.95	0.02	0.1979
-6	42.7	41.7	1.0827	76.51	10.48	78.74	89.22	0.02	0.1977
-4	44.5	43.5	1.0396	76.27	11.11	78.38	89.49	0.03	0.1975
-2	46.4	45.4	0.9985	76.04	11.74	78.02	89.76	0.03	0.1973
0	48.4	47.3	0.9593	75.80	12.37	77.65	90.02	0.03	0.1972
2	50.4	49.3	0.9220	75.56	13.00	77.29	90.29	0.03	0.1970
4	52.4	51.3	0.8864	75.32	13.64	76.91	90.55	0.03	0.1968
6	54.5	53.4	0.8525	75.08	14.28	76.53	90.81	0.03	0.1967
8	56.7	55.6	0.8200	74.84	14.92	76.16	91.08	0.03	0.1965
10	59.0	57.8	0.7891	74.59	15.56	75.78	91.34	0.03	0.1964
12	61.3	60.1	0.7595	74.35	16.20	75.39	91.59	0.04	0.1962
14	63.7	62.5	0.7313	74.10	16.84	75.01	91.85	0.04	0.1961
16	66.2	64.9	0.7043	73.85	17.49	74.61	92.10	0.04	0.1959
18	68.7	67.4	0.6784	73.60	18.14	74.22	92.36	0.04	0.1958
20	71.3	70.0	0.6537	73.35	18.79	73.82	92.61	0.04	0.1956
22	74.0	72.7	0.6300	73.09	19.44	73.42	92.86	0.04	0.1955
24	76.7	75.4	0.6074	72.84	20.10	73.00	93.10	0.04	0.1954
26	79.5	78.2	0.5857	72.58	20.75	72.60	93.35	0.05	0.1952
28	82.4	81.1	0.5649	72.32	21.41	72.18	93.59	0.05	0.1951
30	85.4	84.0	0.5449	72.06	22.07	71.76	93.83	0.05	0.1950
32	88.5	87.1	0.5258	71.79	22.74	71.33	94.07	0.05	0.1948
34	91.7	90.2	0.5074	71.53	23.40	70.91	94.31	0.05	0.1947
36	94.9	93.4	0.4898	71.26	24.07	70.47	94.54	0.05	0.1946
38	98.2	96.7	0.4729	70.99	24.74	70.04	94.78	0.05	0.1945
40	101.6	100.1	0.4567	70.72	25.41	69.60	95.01	0.05	0.1943
42	105.1	103.5	0.4411	70.44	26.09	69.14	95.23	0.06	0.1942
44	108.7	107.1	0.4261	70.17	26.76	68.70	95.46	0.06	0.1941
46	112.3	110.7	0.4117	69.89	27.44	68.24	95.68	0.06	0.1940
48	116.1	114.5	0.3978	69.60	28.12	67.78	95.90	0.06	0.1939

404A Thermodynamic Table — English Units – continued

Temp (°F)	Bubble Pressure (Liquid) (psia)	Dew Pressure (Vapor) (psia)	Vapor Volume (ft^3/lb)	Liquid Density (lb/ft^3)	Liquid Enthalpy (Btu/lb)	Enthalpy DH (Btu/lb)	Vapor Enthalpy (Btu/lb)	Liquid Entropy ($Btu/lb-^F$)	Vapor Entropy ($Btu/lb-^F$)
50	120.0	118.3	0.3845	69.32	28.81	67.31	96.12	0.06	0.1937
52	123.9	122.2	0.3716	69.03	29.50	66.83	96.33	0.06	0.1936
54	128.0	126.3	0.3593	68.74	30.19	66.35	96.54	0.06	0.1935
56	132.1	130.4	0.3474	68.45	30.88	65.87	96.75	0.07	0.1934
58	136.4	134.6	0.3359	68.16	31.58	65.37	96.95	0.07	0.1932
60	140.7	138.9	0.3249	67.86	32.28	64.87	97.15	0.07	0.1931
62	145.1	143.4	0.3142	67.55	32.98	64.36	97.34	0.07	0.1930
64	149.7	147.9	0.3039	67.25	33.68	63.86	97.54	0.07	0.1929
66	154.4	152.5	0.2940	66.94	34.39	63.34	97.73	0.07	0.1927
68	159.1	157.3	0.2845	66.63	35.10	62.81	97.91	0.07	0.1926
70	164.0	162.1	0.2753	66.31	35.82	62.27	98.09	0.07	0.1925
72	169.0	167.1	0.2664	65.99	36.54	61.73	98.27	0.08	0.1923
74	174.1	172.2	0.2578	65.67	37.26	61.18	98.44	0.08	0.1922
76	179.3	177.4	0.2495	65.34	37.99	60.62	98.61	0.08	0.1921
78	184.6	182.7	0.2414	65.01	38.72	60.05	98.77	0.08	0.1919
80	190.1	188.1	0.2337	64.68	39.45	59.48	98.93	0.08	0.1918
82	195.7	193.7	0.2262	64.34	40.19	58.89	99.08	0.08	0.1916
84	201.3	199.3	0.2189	63.99	40.93	58.30	99.23	0.08	0.1914
86	207.2	205.1	0.2119	63.64	41.68	57.69	99.37	0.09	0.1913
88	213.1	211.1	0.2051	63.28	42.43	57.08	99.51	0.09	0.1911
90	219.2	217.1	0.1985	62.92	43.18	56.46	99.64	0.09	0.1909
92	225.4	223.3	0.1921	62.56	43.95	55.81	99.76	0.09	0.1908
94	231.7	229.6	0.1859	62.18	44.71	55.17	99.88	0.09	0.1906
96	238.1	236.0	0.1799	61.80	45.48	54.51	99.99	0.09	0.1904
98	244.7	242.6	0.1741	61.42	46.26	53.83	100.09	0.09	0.1902
100	251.5	249.3	0.1685	61.03	47.04	53.15	100.19	0.09	0.1900
102	258.3	256.2	0.1630	60.63	47.83	52.45	100.28	0.10	0.1897
104	265.3	263.2	0.1577	60.22	48.62	51.74	100.36	0.10	0.1895
106	272.5	270.3	0.1526	59.81	49.42	51.01	100.43	0.10	0.1893
108	279.8	277.6	0.1475	59.38	50.23	50.26	100.49	0.10	0.1890
110	287.2	285.1	0.1427	58.95	51.05	49.49	100.54	0.10	0.1888
112	294.8	292.7	0.1379	58.51	51.87	48.71	100.58	0.10	0.1885
114	302.6	300.4	0.1333	58.05	52.70	47.91	100.61	0.10	0.1882
116	310.5	308.3	0.1288	57.59	53.54	47.09	100.63	0.11	0.1879
118	318.5	316.4	0.1245	57.12	54.38	46.26	100.64	0.11	0.1876
120	326.7	324.6	0.1202	56.63	55.24	45.39	100.63	0.11	0.1873
122	335.1	333.0	0.1160	56.13	56.11	44.50	100.61	0.11	0.1869
124	343.7	341.5	0.1120	55.61	56.99	43.58	100.57	0.11	0.1865
126	352.4	350.2	0.1080	55.08	57.88	42.64	100.52	0.11	0.1861
128	361.3	359.1	0.1041	54.53	58.78	41.66	100.44	0.11	0.1857
130	370.3	368.2	0.1003	53.96	59.70	40.65	100.35	0.12	0.1853
132	379.6	377.5	0.0966	53.37	60.63	39.60	100.23	0.12	0.1848
134	389.0	386.9	0.0930	52.76	61.58	38.51	100.09	0.12	0.1843
136	398.6	396.6	0.0894	52.12	62.54	37.38	99.92	0.12	0.1837
138	408.4	406.4	0.0858	51.46	63.53	36.19	99.72	0.12	0.1831
140	418.4	416.4	0.0823	50.75	64.54	34.94	99.48	0.12	0.1824
142	428.6	426.6	0.0789	50.02	65.58	33.63	99.21	0.13	0.1817
144	439.0	437.1	0.0754	49.23	66.65	32.23	98.88	0.13	0.1809
146	449.6	447.8	0.0720	48.39	67.76	30.74	98.50	0.13	0.1801
148	460.4	458.6	0.0686	47.49	68.91	29.14	98.05	0.13	0.1791
150	471.5	469.8	0.0651	46.50	70.12	27.40	97.52	0.13	0.1780

AZ-50 (R-507) Thermodynamic Table — SI Units

Temp (°C)	Pressure (kPa)	Vapor Volume (m^3/kg)	Liquid Density (kg/m^3)	Liquid Enthalpy (kJ/kg)	Enthalpy DH (kJ/kg)	Vapor Enthalpy (kJ/kg)	Liquid Entropy (kJ/kg-C)	Vapor Entropy (kJ/kg-C)
-50	86	0.2080	1327	135.03	199.02	334.05	0.7395	1.6314
-49	91	0.1985	1324	136.27	198.38	334.65	0.7450	1.6301
-48	95	0.1896	1321	137.51	197.74	335.25	0.7505	1.6288
-47	100	0.1811	1318	138.75	197.10	335.85	0.7560	1.6276
-46	105	0.1731	1314	139.99	196.46	336.45	0.7615	1.6264
-45	110	0.1656	1311	141.24	195.81	337.05	0.7669	1.6252
-44	115	0.1584	1308	142.48	195.17	337.65	0.7724	1.6241
-43	121	0.1516	1305	143.73	194.51	338.24	0.7778	1.6229
-42	127	0.1451	1302	144.99	193.85	338.84	0.7832	1.6219
-41	133	0.1390	1299	146.24	193.19	339.43	0.7886	1.6208
-40	139	0.1332	1296	147.49	192.54	340.03	0.7940	1.6198
-39	145	0.1277	1292	148.75	191.87	340.62	0.7993	1.6188
-38	152	0.1224	1289	150.01	191.20	341.21	0.8047	1.6178
-37	158	0.1174	1286	151.28	190.52	341.80	0.8100	1.6168
-36	165	0.1127	1283	152.54	189.84	342.38	0.8153	1.6159
-35	173	0.1082	1280	153.81	189.16	342.97	0.8207	1.6150
-34	180	0.1039	1276	155.08	188.47	343.55	0.8260	1.6141
-33	188	0.0998	1273	156.35	187.79	344.14	0.8312	1.6132
-32	196	0.0959	1270	157.63	187.09	344.72	0.8365	1.6123
-31	204	0.0922	1266	158.90	186.40	345.30	0.8418	1.6115
-30	213	0.0887	1263	160.18	185.70	345.88	0.8470	1.6107
-29	222	0.0853	1260	161.46	184.99	346.45	0.8522	1.6099
-28	231	0.0821	1257	162.75	184.28	347.03	0.8575	1.6092
-27	240	0.0790	1253	164.04	183.56	347.60	0.8627	1.6084
-26	250	0.0760	1250	165.33	182.84	348.17	0.8679	1.6077
-25	260	0.0732	1246	166.62	182.12	348.74	0.8731	1.6070
-24	270	0.0706	1243	167.92	181.38	349.30	0.8783	1.6063
-23	281	0.0680	1240	169.22	180.65	349.87	0.8834	1.6056
-22	292	0.0655	1236	170.52	179.91	350.43	0.8886	1.6049
-21	303	0.0632	1233	171.82	179.17	350.99	0.8937	1.6043
- 20	315	0.0609	1229	173.13	178.41	351.54	0.8989	1.6037
-19	326	0.0588	1226	174.44	177.66	352.10	0.9040	1.6030
-18	339	0.0567	1222	175.76	176.89	352.65	0.9091	1.6024
-17	351	0.0548	1219	177.07	176.13	353.20	0.9142	1.6018
-16	364	0.0529	1215	178.39	175.36	353.75	0.9193	1.6013
-15	377	0.0511	1212	179.72	174.57	354.29	0.9244	1.6007
-14	391	0.0493	1208	181.04	173.79	354.83	0.9295	1.6001
-13	405	0.0476	1205	182.37	173.00	355.37	0.9346	1.5996
-12	420	0.0460	1201	183.71	172.20	355.91	0.9397	1.5991
-11	434	0.0445	1198	185.05	171.39	356.44	0.9447	1.5986
-10	450	0.0430	1194	186.39	170.58	356.97	0.9498	1.5980
-9	465	0.0416	1190	187.73	169.77	357.50	0.9548	1.5975
-8	481	0.0402	1187	189.08	168.94	358.02	0.9599	1.5971
-7	498	0.0389	1183	190.43	168.11	358.54	0.9649	1.5966
-6	514	0.0377	1179	191.78	167.28	359.06	0.9699	1.5961
-5	532	0.0364	1175	193.14	166.43	359.57	0.9750	1.5956
-4	549	0.0353	1172	194.51	165.57	360.08	0.9800	1.5952
-3	567	0.0341	1168	195.87	164.71	360.58	0.9850	1.5947
-2	586	0.0331	1164	197.25	163.83	361.08	0.9900	1.5943
-1	605	0.0320	1160	198.62	162.96	361.58	0.9950	1.5938
0	624	0.0310	1156	200.00	162.07	362.07	1.0000	1.5934
1	644	0.0300	1152	201.38	161.18	362.56	1.0050	1.5929
2	665	0.0291	1148	202.77	160.28	363.05	1.0100	1.5925
3	686	0.0282	1144	204.16	159.37	363.53	1.0150	1.5921
4	707	0.0273	1141	205.56	158.44	364.00	1.0199	1.5917

AZ-50 (R-507) Thermodynamic Table — SI Units – continued

Temp (°C)	Pressure (kPa)	Vapor Volume (m^3/kg)	Liquid Density (kg/m^3)	Liquid Enthalpy (kJ/kg)	Enthalpy DH (kJ/kg)	Vapor Enthalpy (kJ/kg)	Liquid Entropy (kJ/kg-C)	Vapor Entropy (kJ/kg-C)
5	729	0.0265	1136	206.96	157.51	364.47	1.0249	1.5912
6	751	0.0257	1132	208.37	156.57	364.94	1.0299	1.5908
7	774	0.0249	1128	209.78	155.62	365.40	1.0349	1.5904
8	798	0.0242	1124	211.20	154.65	365.85	1.0398	1.5900
9	822	0.0234	1120	212.62	153.68	366.30	1.0448	1.5895
10	846	0.0227	1116	214.04	152.71	366.75	1.0498	1.5891
11	871	0.0220	1112	215.47	151.71	367.18	1.0548	1.5887
12	897	0.0214	1107	216.91	150.70	367.61	1.0597	1.5883
13	923	0.0207	1103	218.35	149.69	368.04	1.0647	1.5878
14	949	0.0201	1099	219.80	148.66	368.46	1.0696	1.5874
15	977	0.0195	1094	221.25	147.62	368.87	1.0746	1.5869
16	1004	0.0190	1090	222.71	146.57	369.28	1.0796	1.5865
17	1033	0.0184	1085	224.18	145.50	369.68	1.0845	1.5860
18	1062	0.0179	1081	225.65	144.42	370.07	1.0895	1.5856
19	1092	0.0173	1076	227.13	143.32	370.45	1.0945	1.5851
20	1122	0.0168	1072	228.61	142.22	370.83	1.0995	1.5846
21	1153	0.0163	1067	230.10	141.09	371.19	1.1044	1.5841
22	1184	0.0159	1062	231.60	139.95	371.55	1.1094	1.5836
23	1216	0.0154	1058	233.10	138.81	371.91	1.1144	1.5831
24	1249	0.0150	1053	234.61	137.64	372.25	1.1194	1.5826
25	1283	0.0145	1048	236.13	136.45	372.58	1.1244	1.5821
26	1317	0.0141	1043	237.66	135.25	372.91	1.1294	1.5815
27	1351	0.0137	1038	239.19	134.03	373.22	1.1344	1.5810
28	1387	0.0133	1033	240.73	132.79	373.52	1.1394	1.5804
29	1423	0.0129	1028	242.28	131.54	373.82	1.1444	1.5798
30	1460	0.0125	1023	243.84	130.26	374.10	1.1495	1.5792
31	1498	0.0122	1017	245.41	128.96	374.37	1.1545	1.5785
32	1536	0.0118	1012	246.98	127.65	374.63	1.1595	1.5779
33	1575	0.0115	1007	248.57	126.31	374.88	1.1646	1.5772
34	1615	0.0111	1001	250.16	124.95	375.11	1.1697	1.5765
35	1655	0.0108	995	251.77	123.56	375.33	1.1748	1.5758
36	1697	0.0105	990	253.39	122.15	375.54	1.1799	1.5750
37	1739	0.0102	984	255.01	120.72	375.73	1.1850	1.5742
38	1781	0.0099	978	256.65	119.26	375.91	1.1901	1.5734
39	1825	0.0096	972	258.30	117.77	376.07	1.1953	1.5726
40	1870	0.0093	966	259.96	116.26	376.22	1.2004	1.5717
41	1915	0.0090	960	261.64	114.71	376.35	1.2056	1.5708
42	1961	0.0088	954	263.33	113.13	376.46	1.2108	1.5698
43	2008	0.0085	947	265.03	111.51	376.54	1.2161	1.5688
44	2056	0.0083	940	266.74	109.87	376.61	1.2213	1.5678
45	2104	0.0080	934	268.48	108.18	376.66	1.2266	1.5667
46	2154	0.0078	927	270.23	106.45	376.68	1.2320	1.5655
47	2204	0.0075	920	271.99	104.69	376.68	1.2373	1.5643
48	2256	0.0073	913	273.78	102.88	376.66	1.2427	1.5631
49	2308	0.0071	905	275.58	101.02	376.60	1.2481	1.5617
50	2361	0.0068	898	277.41	99.11	376.52	1.2536	1.5603
51	2415	0.0066	890	279.26	97.14	376.40	1.2591	1.5588
52	2470	0.0064	882	281.13	95.12	376.25	1.2647	1.5573
53	2527	0.0062	874	283.03	93.02	376.05	1.2703	1.5556
54	2584	0.0060	865	284.95	90.87	375.82	1.2760	1.5538
55	2642	0.0058	856	286.91	88.63	375.54	1.2818	1.5519
56	2701	0.0056	847	288.90	86.31	375.21	1.2876	1.5499
57	2761	0.0054	837	290.93	83.90	374.83	1.2936	1.5477
58	2823	0.0052	827	293.00	81.38	374.38	1.2996	1.5454
59	2885	0.0050	817	295.11	78.75	373.86	1.3058	1.5429
60	2949	0.0048	806	297.28	75.98	373.26	1.3120	1.5401

404A Thermodynamic Table — SI Units

Temp (°C)	Bubble Pressure (Liquid) (kPa)	Dew Pressure (Vapor) (kPa)	Vapor Volume (m^3/kg)	Liquid Density (kg/m^3)	Liquid Enthalpy (kJ/kg)	Enthalpy DH (kJ/kg)	Vapor Enthalpy (kJ/kg)	Liquid Entropy (kJ/kg-C)	Vapor Entropy (kJ/kg-C)
-50	84	81	0.2251	1318	134.59	202.92	337.51	0.7377	1.6491
-49	89	85	0.2147	1315	135.84	202.27	338.11	0.7433	1.6477
-48	93	90	0.2049	1312	137.09	201.63	338.72	0.7488	1.6463
-47	98	94	0.1956	1309	138.34	200.99	339.33	0.7543	1.6450
-46	102	99	0.1869	1306	139.59	200.34	339.93	0.7599	1.6437
-45	107	104	0.1786	1302	140.85	199.68	340.53	0.7653	1.6424
-44	113	109	0.1707	1299	142.10	199.04	341.14	0.7708	1.6412
-43	118	114	0.1633	1296	143.36	198.38	341.74	0.7763	1.6400
-42	124	119	0.1562	1293	144.62	197.72	342.34	0.7817	1.6388
-41	129	125	0.1495	1290	145.89	197.05	342.94	0.7872	1.6377
-40	135	131	0.1432	1287	147.15	196.38	343.53	0.7926	1.6365
-39	141	137	0.1372	1284	148.42	195.71	344.13	0.7980	1.6355
-38	148	143	0.1315	1281	149.69	195.04	344.73	0.8034	1.6344
-37	155	150	0.1260	1277	150.96	194.36	345.32	0.8088	1.6333
-36	161	157	0.1209	1274	152.23	193.68	345.91	0.8141	1.6323
-35	169	164	0.1160	1271	153.51	193.00	346.51	0.8195	1.6313
-34	176	171	0.1113	1268	154.79	192.31	347.10	0.8248	1.6304
-33	183	178	0.1069	1265	156.07	191.61	347.68	0.8301	1.6294
-32	191	186	0.1027	1261	157.35	190.92	348.27	0.8354	1.6285
-31	199	194	0.0986	1258	158.64	190.22	348.86	0.8407	1.6276
-30	208	202	0.0948	1255	159.93	189.51	349.44	0.8460	1.6267
-29	216	211	0.0912	1252	161.22	188.80	350.02	0.8513	1.6259
-28	225	220	0.0877	1248	162.52	188.08	350.60	0.8565	1.6250
-27	235	229	0.0843	1245	163.81	187.37	351.18	0.8618	1.6242
-26	244	238	0.0812	1242	165.11	186.64	351.75	0.8670	1.6234
-25	254	248	0.0781	1239	166.41	185.92	352.33	0.8723	1.6226
-24	264	257	0.0753	1235	167.72	185.18	352.90	0.8775	1.6219
-23	274	268	0.0725	1232	169.03	184.44	353.47	0.8827	1.6211
-22	285	278	0.0698	1229	170.34	183.70	354.04	0.8879	1.6204
-21	296	289	0.0673	1225	171.65	182.95	354.60	0.8930	1.6197
-20	307	300	0.0649	1222	172.97	182.19	355.16	0.8982	1.6190
-19	319	312	0.0626	1218	174.29	181.43	355.72	0.9034	1.6183
-18	331	324	0.0604	1215	175.61	180.67	356.28	0.9085	1.6177
-17	343	336	0.0583	1212	176.93	179.91	356.84	0.9137	1.6170
-16	356	348	0.0562	1208	178.26	179.13	357.39	0.9188	1.6164
-15	369	361	0.0543	1205	179.60	178.34	357.94	0.9240	1.6158
-14	382	374	0.0524	1201	180.93	177.56	358.49	0.9291	1.6152
-13	396	388	0.0506	1198	182.27	176.76	359.03	0.9342	1.6146
-12	410	402	0.0489	1194	183.61	175.97	359.58	0.9393	1.6140
-11	424	416	0.0472	1191	184.96	175.15	360.11	0.9444	1.6134
-10	439	431	0.0457	1187	186.31	174.34	360.65	0.9495	1.6129
-9	454	446	0.0441	1183	187.66	173.52	361.18	0.9546	1.6123
-8	470	461	0.0427	1180	189.01	172.70	361.71	0.9596	1.6118
-7	486	477	0.0413	1176	190.37	171.87	362.24	0.9647	1.6113
-6	502	494	0.0399	1172	191.74	171.02	362.76	0.9698	1.6107
-5	519	510	0.0386	1169	193.10	170.18	363.28	0.9748	1.6102
-4	537	527	0.0374	1165	194.48	169.32	363.80	0.9799	1.6097
-3	554	545	0.0362	1161	195.85	168.46	364.31	0.9849	1.6092
-2	573	563	0.0350	1158	197.23	167.59	364.82	0.9899	1.6087
-1	591	581	0.0339	1154	198.61	166.71	365.32	0.9950	1.6082
0	610	600	0.0328	1150	200.00	165.82	365.82	1.0000	1.6078
1	630	620	0.0318	1146	201.39	164.93	366.32	1.0050	1.6073
2	650	640	0.0308	1142	202.79	164.02	366.81	1.0100	1.6068
3	670	660	0.0298	1138	204.19	163.10	367.29	1.0151	1.6064
4	691	681	0.0289	1135	205.59	162.19	367.78	1.0201	1.6059
5	712	702	0.0280	1131	207.00	161.25	368.25	1.0251	1.6054

404A Thermodynamic Table — SI Units – continued

Temp (°C)	Bubble Pressure (Liquid) (kPa)	Dew Pressure (Vapor) (kPa)	Vapor Volume (m^3/kg)	Liquid Density (kg/m^3)	Liquid Enthalpy (kJ/kg)	Enthalpy DH (kJ/kg)	Vapor Enthalpy (kJ/kg)	Liquid Entropy (kJ/kg-C)	Vapor Entropy (kJ/kg-C)
6	734	724	0.0272	1127	208.41	160.32	368.73	1.0301	1.6050
7	757	746	0.0263	1123	209.83	159.37	369.20	1.0351	1.6045
8	780	769	0.0255	1119	211.26	158.40	369.66	1.0401	1.6041
9	803	792	0.0248	1115	212.68	157.43	370.11	1.0451	1.6036
10	827	816	0.0240	1110	214.12	156.45	370.57	1.0501	1.6032
11	852	840	0.0233	1106	215.56	155.45	371.01	1.0551	1.6027
12	877	865	0.0226	1102	217.00	154.45	371.45	1.0600	1.6022
13	902	890	0.0219	1098	218.45	153.44	371.89	1.0650	1.6018
14	928	916	0.0213	1094	219.90	152.42	372.32	1.0700	1.6013
15	955	943	0.0206	1089	221.36	151.38	372.74	1.0750	1.6009
16	982	970	0.0200	1085	222.83	150.32	373.15	1.0800	1.6004
17	1010	998	0.0194	1081	224.30	149.26	373.56	1.0850	1.5999
18	1039	1026	0.0189	1076	225.78	148.18	373.96	1.0900	1.5994
19	1068	1055	0.0183	1072	227.26	147.10	374.36	1.0950	1.5989
20	1097	1084	0.0178	1067	228.75	145.99	374.74	1.1000	1.5984
21	1127	1115	0.0172	1063	230.25	144.87	375.12	1.1050	1.5979
22	1158	1145	0.0167	1058	231.75	143.74	375.49	1.1100	1.5974
23	1190	1177	0.0163	1054	233.26	142.59	375.85	1.1150	1.5969
24	1222	1209	0.0158	1049	234.77	141.44	376.21	1.1200	1.5964
25	1255	1241	0.0153	1044	236.30	140.25	376.55	1.1250	1.5958
26	1288	1274	0.0149	1039	237.83	139.06	376.89	1.1300	1.5953
27	1322	1308	0.0144	1034	239.37	137.85	377.22	1.1351	1.5947
28	1357	1343	0.0140	1029	240.91	136.62	377.53	1.1401	1.5941
29	1392	1378	0.0136	1024	242.47	135.37	377.84	1.1451	1.5935
30	1428	1414	0.0132	1019	244.03	134.11	378.14	1.1502	1.5929
31	1465	1451	0.0128	1014	245.60	132.82	378.42	1.1552	1.5923
32	1503	1489	0.0125	1009	247.18	131.52	378.70	1.1603	1.5916
33	1541	1527	0.0121	1004	248.77	130.19	378.96	1.1654	1.5909
34	1580	1566	0.0118	998	250.37	128.84	379.21	1.1704	1.5903
35	1620	1605	0.0114	993	251.97	127.48	379.45	1.1755	1.5895
36	1660	1645	0.0111	988	253.59	126.08	379.67	1.1806	1.5888
37	1701	1687	0.0108	982	255.22	124.67	379.89	1.1858	1.5880
38	1743	1728	0.0105	976	256.86	123.22	380.08	1.1909	1.5872
39	1786	1771	0.0101	971	258.51	121.75	380.26	1.1961	1.5864
40	1829	1815	0.0099	965	260.17	120.26	380.43	1.2012	1.5855
41	1874	1859	0.0096	959	261.85	118.73	380.58	1.2064	1.5846
42	1919	1904	0.0093	953	263.53	117.18	380.71	1.2116	1.5837
43	1965	1950	0.0090	946	265.23	115.59	380.82	1.2169	1.5827
44	2012	1997	0.0087	940	266.95	113.97	380.92	1.2221	1.5817
45	2059	2044	0.0085	934	268.68	112.31	380.99	1.2274	1.5807
46	2108	2093	0.0082	927	270.42	110.63	381.05	1.2327	1.5796
47	2157	2142	0.0080	920	272.18	108.90	381.08	1.2381	1.5784
48	2207	2192	0.0077	913	273.96	107.12	381.08	1.2434	1.5772
49	2259	2244	0.0075	906	275.76	105.30	381.06	1.2488	1.5759
50	2311	2296	0.0072	899	277.57	103.44	381.01	1.2543	1.5746
51	2364	2349	0.0070	892	279.41	101.52	380.93	1.2598	1.5732
52	2418	2403	0.0068	884	281.27	99.55	380.82	1.2653	1.5717
53	2472	2458	0.0066	876	283.15	97.53	380.68	1.2709	1.5701
54	2528	2514	0.0064	868	285.06	95.44	380.50	1.2766	1.5685
55	2585	2571	0.0062	860	286.99	93.29	380.28	1.2823	1.5667
56	2643	2629	0.0059	851	288.96	91.05	380.01	1.2880	1.5648
57	2702	2688	0.0057	842	290.95	88.74	379.69	1.2939	1.5628
58	2762	2748	0.0055	833	292.99	86.33	379.32	1.2998	1.5607
59	2823	2809	0.0053	823	295.06	83.83	378.89	1.3059	1.5584
60	2885	2871	0.0051	813	297.18	81.22	378.40	1.3120	1.5559

Notes

Notes

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