Honeywell Genetron® AZ-20

Properties, Uses, Storage, and Handling

Honeywell

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Introduction

Genetron® AZ-20® (an azeotropic mixture of HFC-32/HFC-125, assigned R-410A by ASHRAE), has been developed by Honeywell to serve as a long-term, non-ozone-depleting replacement for HCFC-22 in a variety of new-equipment applications.

Genetron AZ-20 has a significantly higher capacity and pressure than HCFC-22 and an intrinsically low toxicity. Because it behaves like an azeotrope, Genetron AZ-20 is easy to service in the field.

Genetron AZ-20 is patented and has been recognized by Underwriters' Laboratory as practically non-flammable.

Applications

Unitary Air Conditioning

Genetron AZ-20 is the ideal non-ozone-depleting, long-term replacement for HCFC-22 in new residential and light commercial unitary air conditioning systems. In new unitary systems optimized for its use, with either scroll or reciprocating compressors, Genetron AZ-20 has shown in tests to have a 5-to-6 percent higher Energy Efficiency Rating (EER) than HCFC-22.

Genetron AZ-20 also has a higher capacity and pressure than HCFC-22, enabling the design of smaller, more compact air-conditioning equipment.

Chillers

Genetron AZ-20 serves as an excellent replacement for HCFC-22 in new chillers, particularly positive displacement chillers. It also may serve as a retrofit fluid for replacing HCFC-22 in some existing chillers with components approved for high pressure, especially those with flooded heat-exchangers. Honeywell recommends contacting the original chiller equipment manufacturer before carrying out any retrofit.

Commercial Refrigeration

Genetron AZ-20 may be used as a replacement for HCFC-22 in new medium-temperature commercial refrigeration systems, including supermarket display cases and reach-in coolers.

Servicing Considerations

Genetron AZ-20 is a 50/50 (wt. %) mixture of HFC-32/125. Genetron AZ-20 exhibits azeotropic behavior with temperature glides that are less than 0.3°F (0.2°C) over the operating range.

When compared with a zeotrope, an azeotropic mixture such as Genetron AZ-20 will not suffer significant segregation in a system and will not materially change its composition due to a leak. As a result, servicing a system that uses an azeotropic mixture is similar to servicing a system that uses a pure fluid.

Physical Properties

Chemical Name	Difluoromethane/ Pentafluoroethane
Molecular Formula	CH2F2/CHF2CF3
Appearance	Colorless
Molecular Weight	72.6
Boiling Point @ 1 ATM (101.3 kPa)	-60.6°F -51.5°C
Freezing Point	-247°F -155°C
Critical Temperature[a]	160.444°F 71.358°C
Critical Pressure[a]	711.06 (Psia) 49.03 (bar)
Critical Volume[a]	0.0349 (ft^3/lb) 0.0022 (m^3/kg)
Critical Density[a]	28.69 (lb/ft^3) 459.53 (kg/m^3)
Vapor Density at Boiling Point	0.26 (lb/ft^3) 4.17 (kg/m^3)
Liquid Density[†]	66.09 (lb/ft^3) 1059 (kg/m^3)
Liquid Heat Capacity[†] (at constant pressure)	0.41 (Btu/lb°F) 1.71 (kJ/kg•K)
Vapor Heat Capacity[†] @ 1 ATM	0.17 (Btu/lb°F) 0.70 (kJ/kg•K)
Heat of Vaporization at Boiling Point @ 1 ATM (101.3 kPa)	117.43 (Btu/lb) 272.97 (kJ/kg)
Vapor Pressure[†]	239.59 (Psia) 16.52 (bar)
Liquid Thermal Conductivity[†]	0.0534 (Btu/hr ft°F) 0.0924 (W/m•K)
Vapor Thermal Conductivity[†]	0.0091 (Btu/hr ft°F) 0.0157 (W/m•K)
Liquid Viscosity[†]	0.2825 (lbm/ft hr) 116.73 (lbm/ft hr)
Vapor Viscosity[†]	0.0351 (lbm/ft hr) 14.50 (lbm/ft hr)
% Volatiles by Volume	99.99
Solubility of Water in AZ-20 (wt. %)	0.28
Flammability Limits in Air (vol. %)*	None
Ozone Depletion Potential (ODP)	0.00
ASHRAE Safety Group Classification	A1/A1

[a] Refprop v7.01 (NIST)

* ASTM E681-85 match ignition, ambient conditions

[†] All measurements are at 77° (25°C) unless otherwise noted.

Product Specifications

Assay (Min. Wt % of HFC-32/125)	99.7%
Moisture (Max. Wt. %)	0.0010
Non-Volatile Residue (Max. Vol. %)	0.01
Chloride (Max. Wt. %)	0.0001
Total Acidity (Max. mg KOH/gm)	0.0015
Non-condensibles in vapor phase (Max. Vol. %)	1.5

Pressure vs. Temperature

Temp. °F	Pressure Psig	Temp. °C	Pressure bar-gauge
-40	10.7	-40	0.74
-35	14.0	-37.5	0.95
-30	17.7	-35	1.17
-25	21.8	-32.5	1.42
-20	26.2	-30	1.68
-15	31.0	-27.5	1.97
-10	36.3	-25	2.28
-5	42.0	-22.5	2.62
0	48.2	-20	2.98
5	54.9	-17.5	3.37
10	62.2	-15	3.79
15	70.0	-12.5	4.24
20	78.4	-10	4.72
25	87.4	-7.5	5.23
30	97.0	-5	5.77
35	107.3	-2.5	6.35
40	118.4	0	6.97
45	130.1	2.5	7.63
50	142.6	5	8.32
55	156.0	7.5	9.06
60	170.1	10	9.84
65	185.1	12.5	10.66
70	201.1	15	11.53
75	217.9	17.5	12.45
80	235.8	20	13.42
85	254.6	22.5	14.44
90	274.5	25	15.51
95	295.5	27.5	16.64
100	317.6	30	17.83
105	340.9	32.5	19.07
110	365.4	35	20.37
115	391.2	37.5	21.74
120	418.3	40	23.18
125	446.8	42.5	24.68
130	476.8	45	26.25
135	508.3	47.5	27.90
140	541.4	50	29.62
145	576.3	52.5	31.42
150	613.0	55	33.30
		57.5	35.27
		60	37.33
		62.5	39.49
		65	41.75

Transport Properties

Thermal Conductivity and Viscosity

	Thermal Conductivity Btu/hr ft °F		Viscosity lb_m/ft hr	
Temp. °F	**Liquid**	**Vapor**	**Liquid**	**Vapor**
45	0.0590	0.0076	0.3549	0.0316
77	0.0534	0.0091	0.2825	0.0351
110	0.0477	0.0120	0.2196	0.0398

	Thermal Conductivity mW/m•K		Viscosity mP•s	
Temp. °C	Liquid	Vapor	Liquid	Vapor
5	103.4	12.8	150.87	12.92
25	92.4	15.7	116.73	14.50
50	79.1	24.1	81.80	17.43

English (T in °F)

Liquid Thermal Conductivity, (Btu/hr ft °F)

$\lambda_{AZ\text{-}20} = 0.0002T + 0.0675$

Vapor Thermal Conductivity, (Btu/hr ft °F)

$\lambda_{AZ\text{-}20} = 5.0 \times 10^{-11} T^4 - 4.0 \times 10^{-9} T^3 - 5.0 \times 10^{-8} T^2 + 4.0 \times 10^{-5} T + 0.0064$

Liquid Viscosity, (lb_m/ft hr)

$\eta = 0.502e - 0.0078T$

Vapor Viscosity, (lb_m/ft hr)

$\eta = 4.0 \times 10^{-9} T^3 - 7.0 \times 10^{-8} T^2 + 6.0 \times 10^{-5} T + 0.0283 -$

SI (T in °C)

Liquid Thermal Conductivity, (mW/m•K)

$\lambda_{AZ\text{-}20} - 0.5529T + 106.7$

Vapor Thermal Conductivity, (mW/m•K)

$\lambda_{AZ\text{-}20} = 1.0 \times 10^{-6} T^4 + 6.0 \times 10^{-6} T^3 - 0.0007T^2 + 0.1037T + 12.658$

Liquid Viscosity, (mPa•s)

$\eta = 0.0122T^2 - 2.2759T + 163.33$

Vapor Viscosity, (mPa•s)

$\eta = 1.0 \times 10^{-5} T^3 + 0.0003T^2 + 0.0523T + 12.632$

Surface Tension

Temp. °C	Temp. °F	s, dyne/cm
-40.0	-40.0	15.622
-35.0	-31.0	14.754
-30.0	-22.0	13.895
-25.0	-13.0	13.046
-20.0	-4.0	12.208
-15.0	5.0	11.380
-10.0	14.0	10.564
-5.0	23.0	9.760
0.0	32.0	8.969
5.0	41.0	8.192
10.0	50.0	7.429
15.0	59.0	6.681
20.0	68.0	5.949
25.0	77.0	5.235
30.0	86.0	5.539
35.0	95.0	3.864
40.0	104.0	3.212
45.0	113.0	2.585
50.0	122.0	1.987
55.0	131.0	1.423
60.0	140.0	0.901

$$s = -51.226 \frac{T}{T_C} + 49.826$$

T in Kelvin or °Rankine

Heat Transfer and Pressure Drop Characteristics

A number of researchers from tubing, system, and refrigerant manufacturers and universities have conducted studies on the heat transfer and pressure drop characteristics of Genetron® AZ-20® R-410A. The table below summarizes results from seven different sources. The results indicate a consistent increase in the evaporation heat transfer coefficient averaging 40% higher than R-22. Condensation values are similar to R-22. The pressure drop is significantly less than R-22 in both evaporation and condensation, averaging close to 40% lower in both cases. For additional information on these results, please contact Genetron Refrigerants Technical Service.

Heat Transfer Information — Inside Tube

								Results (Relative to R-22)			
							Mass Flux	Evaporation		Condensation	
Source	Cond.	Evap.	ΔP	Tube	Oil	Dia.	(klb/ft^2-hr)	h	ΔP	h	ΔP
1	Yes	Yes	Yes	Smooth	0%	3/8" O.D.	118-414	23 to 63%	-20 to -38%	2 to 6%	-25 to -45%
2	Yes	Yes	Yes	Smooth	0%	3/8" O.D.	150-600	50 to 70%	-55 to -70%	-30 to 0%	-50 to -60%
	Yes	Yes	Yes	Enhan.	0%	3/8" O.D.	150-600	30 to 50%	-50 to -60%	5 to 20%	-40 to 0%
3	Yes	Yes	Yes	Smooth	0%	3/8" O.D.	75-300	35 to 40%	-20 to -25%	7%	-30 to -35%
	Yes	Yes	Yes	Enhan.	0%	3/8" O.D.	75-300	20 to 35%	-20 to -25%	3 to 8%	-30 to -35%
4	Yes	Yes	Yes	Smooth	0%	0.268" I.D.	75- 260	20 to 50%	-20 to -50%	-20 to 0%	–
5	Yes	No	No	Smooth	0%	0.315" I.D.	120-360	–	–	15 to 20%	–
	Yes	No	No	Smooth	2.6%	0.315" I.D.	120-360	–	–	4 to 8%	–
	Yes	No	No	Smooth	5.4%	0.315" I.D.	120-360	–	–	-2 to 2%	–
6	Yes	No	Yes	Smooth	0%	3/8" O.D.	90-450	–	–	0 to 17%	-40 to -50%
	Yes	No	Yes	Enhan.	0%	3/8" O.D.	90-450	–	–	-4 to 9%	-30 to -50%
	Yes	No	Yes	Enhan.	0%	5/16" O.D.	180-450	–	–	23 to 45%	-41 to-45%
	Yes	No	Yes	Enhan.	0%	5/8" O.D.	90-300	–	–	2 to 27%	-23 to -42%
7	Yes	No	No	Enhan.	0%	3/8" O.D.	120-600	–	–	-5 to 15%	–
	Yes	No	No	Enhan.	1%	3/8" O.D.	120-600	–	–	-15 to 15%	–

Electrical Properties

Breakdown Voltage and Dielectric Strength

Breakdown Voltage volts	Temp. °F	Pressure psia	d (Gap) inches
9580	45	145	0.02
17000	77	239	0.02
28100	110	380	0.02
55400	45	145	0.10
92500	77	239	0.10
148300	110	380	0.10

Breakdown Voltage volts	Temp. °F	Pressure psia	d (Gap) inches
8600	5	931	0.05
16700	25	1649	0.05
32600	50	3058	0.05
50700	5	931	0.25
91200	25	1649	0.25
170900	50	3058	0.25

English

Dielectric Strength 50.8 kV/inch @ 1 atm, 77°F

Breakdown Voltage*, volts = $-1876 + 3952\ P_{(psia)}{}^{d}{}_{(inches)}$

SI

Dielectric Strength 20.0 kV/cm@101.3 kPa, 25°C

Breakdown Voltage*, volts = $-1876 + 226\ P_{(kPa)}{}^{d}{}_{(cm)}$

*equations derived from measurements per ASTM D2477

Materials Compatibility

The stability of Genetron® AZ-20® R-410A with metals is excellent. Laboratory testing has shown that Genetron AZ-20 is compatible with steel, copper, aluminum and brass. The stability of refrigerant/oil mixtures is determined using the ASHRAE 97 sealed tube method. AZ-20 was studied with several lubricants. The tests were conducted in the presence of steel, copper and aluminum. The time of the exposure was two weeks, with the temperature of the exposure being 400°F (204°C). The stability was judged by both visual observation and measuring the fluoride concentration in the tubes.

A typical example of the results of such tests with three different lubricants is shown. The visual appearance of the metals and the lubricant is unchanged. In addition, the amount of fluoride produced in the tube is just barely above the background concentration. This indicates that the lubricant, metals and the refrigerant are compatible under the extreme conditions of the tests.

Stability with Polyol Ester Lubricants and Metals

Lubricant	Lubricant Appearance	Copper	Aluminum	Steel	Fluoride (μg)	AZ-20 Purity
Mobil Eal 22	No Change	No Change	No Change	No Change	5	No Change
Mobil Eal 32	No Change	No Change	No Change	No Change	6	No Change
Castrol SW 32	No Change	No Change	No Change	No Change	10	No Change

Note: Test performed at 400°F (204°C) for 14 days.

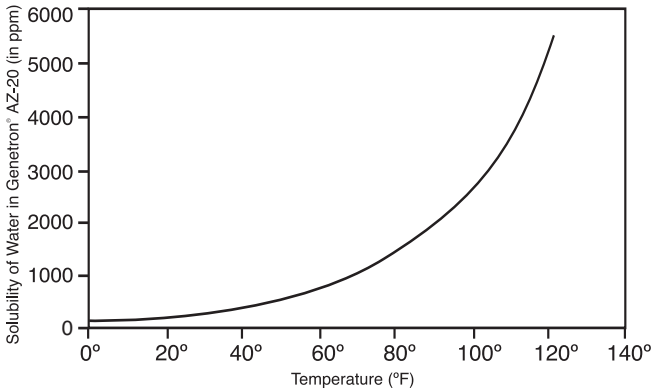
Chlorinated Materials and Refrigerants

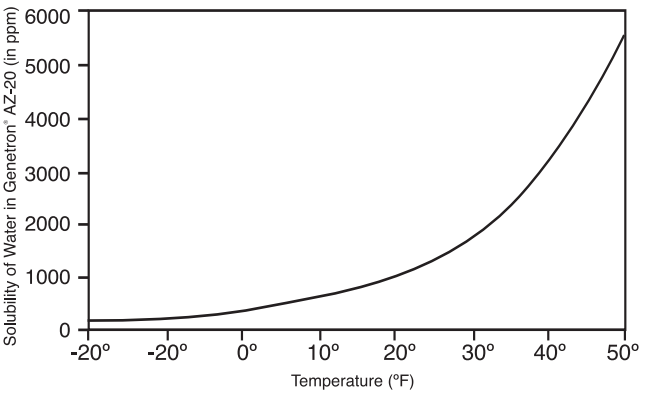
Honeywell does not recommend the use of chlorinated solvents to clean refrigeration systems or components.

Desiccants

Desiccant driers compatible with Genetron AZ-20 are commercially available from several drier manufacturers. Individual drier manufacturers should be contacted for specific recommendations.

Solubility of Water in Genetron® AZ-20®





Compatibility with Plastics and Elastomers

The table below is a summary of materials compatibility data resulting from tests performed by Honeywell and other worldwide organizations.

Since there are many different grades and formulations of these materials, we recommend that compatibility testing be performed on the specific grade of materials under consideration when designing new systems.

This data should be used only as a guide to the compatibility of materials with Genetron® AZ-20® R-410A.

The rankings in the table below should be used with caution since they are judgements based on limited samplings. Customers should consult with the manufacturer or conduct further independent testing.

Summary of Materials Compatibility: Plastics and Elastomers

Material	AZ-20
Ethylene-Propylene Diene Terpolymer	S
Ethylene-Propylene Copolymer	S
Chlorosulfonated Polyethylene	S
Chlorinated Polyethylene	D
Neoprene (Chloroprene)	S
Epichlorohydrin	D
Fluorinated Rubbers	U
Silicone	D
Polyurethane	D
Nitriles	D
H-NBR	D
Butyl Rubber	D
Polysulfide	S
Nylon	S
Polytetrafluoroethylene	S
PEEK	S
ABS	U
Polypropylene	D
Polyphenyl Sulfide	U
Polyethylene Terephthalate	D
Polysulfone	D
Polyimide	S
Polyetherimide	S
Polyphthalamide	D
Polyamideimide	S
Acetal	D
Phenolic	S

S: Suitable
D: Suitability dependent on formulation
U: Unsuitable

Lubricants

As with other HFC's, miscible lubricants such as polyol ester lubricants are recommended for use with Genetron AZ-20. Many polyol ester lubricants are commercially available. Castrol SW 32 and Mobil EAL 32 are two polyol ester lubricants that were tested by Honeywell. Within a temperature range of -40°F to 140°F (-40°C to 60°C) and a concentration up to 50% lubricant, these two lubricants exhibited complete miscibility with Genetron AZ-20.

Honeywell does not recommend specific lubricants. The compressor and lubricant manufacturers should be consulted for a specific recommendation.

Safety

Honeywell recommends reading the MSDS before using Genetron AZ-20. Any Genetron MSDS can be obtained through our MSDS request line at 1-973-455-3680 or downloaded from www.genetron.com.

Toxicity

Genetron AZ-20 can be safely used in all of its intended applications when handled in accordance to the Material Safety Data Sheet (MSDS). This is based on data developed by the Program for Alternative Fluorocarbon Toxicity Testing (PAFTs, III and V), an international consortium of which Honeywell is a charter member. The conclusion was reached after review of all toxicity results, which confirmed the intrinsically low toxicity of the components. Honeywell recommends reading the MSDS before using Genetron AZ-20.

Inhalation

Honeywell has established an occupational exposure limit (8 hour time-weighted average) of 1000 ppm for Genetron AZ-20. Inhalation of the product's vapor may cause irritation. Vapor inhalation at high concentrations may result in asphyxiation or the heart may become sensitized, causing cardiac arrhythmia. Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be used with special caution only in situations of emergency life support. Treatment of overexposure to Genetron AZ-20 should be directed at the control of symptoms.

When concentrations of Genetron AZ-20 reach levels which reduce oxygen to 14-16% by displacement, symptoms of asphyxiation will occur. An individual exposed to high concentrations of Genetron AZ-20 must be given medical attention immediately. Adequate ventilation must be provided at all times.

Skin and Eye Contact

Genetron® AZ-20® R-410A vapors can irritate the skin and eyes. In liquid form, it can freeze skin or eyes on contact. If contact with skin should occur, flush the exposed area with lukewarm water until all of the chemical is removed. If there is evidence of frostbite, bathe in lukewarm water. Should eye contact occur, immediately flush with large amounts of lukewarm water for at least 15 minutes, lifting eyelids occasionally to facilitate irrigation. Seek medical attention as soon as possible.

Leaks

If a large release of Genetron AZ-20 vapor occurs, the area should be evacuated immediately. Protected personnel should de-energize or remove any ignition sources and address leak, if without risk. Vapors may concentrate near the floor, displacing available oxygen. Once the area is evacuated, it must be ventilated using blowers or fans to circulate the air at floor-level. Unpro-tected personnel should not return to the area until the air has been tested and determined safe. Leak checking should never be done with a mixture of Genetron AZ-20 and air, oxygen or other oxidizers. Leak checking can be performed safely using a mixture of Genetron AZ-20 and nitrogen.

Flammability

According to ASHRAE Standard 34, Genetron AZ-20 is classified in safety group A1, i.e., it is non-flammable at 1 Atm. pressure (101.3 kPa) and 64°F (18°C). As defined by the U.S. Department of Transportation (DOT) regulations, flash-point determinations do not apply to Genetron AZ-20. It has no flame limits, and DOT considers it non-flammable (Green Label).

In addition, Underwriters' Laboratory has recognized Genetron AZ-20 as practically non-flammable.

Since Genetron AZ-20 does not have a flash point and is 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-20 or any other similar product.

Combustibility

Although Genetron AZ-20 is non-flammable at ambient temperatures and atmospheric pressures, it can become combustible under pressure when mixed with air.

Because of this combustibility potential under pressure, Genetron AZ-20 and air, oxygen or other oxidizers should never be mixed in tanks or supply lines, or allowed to accumulate in storage tanks. Leak-checking should never be done with a mixture of Genetron AZ-20 and air, oxygen or other oxidizers. Leak-checking can be performed safely with a mixture of Genetron AZ-20 and nitrogen.

Thermal Stability

It is important to avoid exposing Genetron AZ-20 to very high temperatures. When exposed to high temperatures, such as those found in flames, Genetron AZ-20 vapors will decompose. This will produce toxic and irritating compounds. Pungent odors released will irritate the nose and throat and generally force evacuation of the area.

Genetron AZ-20 is stable under normal operating conditions. Contact with certain red-hot metals may result in exothermic or explosive reactions and yield toxic and/or corrosive decomposition products. Specific materials to avoid include freshly abraded aluminum surfaces and active metals such as sodium, potassium, calcium, powdered aluminum, magnesium and zinc.

Storage and Handling

Bulk and Cylinder

Genetron AZ-20 has a higher vapor pressure compared to most of the current refrigerants, particularly Genetron 22 (HCFC-22). For this reason, Genetron AZ-20 must be handled with careful attention to the design pressure rating of the handling equipment. All storage shipping containers — cylinders, storage tanks, tank trailers or tank cars — must be specifically designed to handle Genetron AZ-20.

Another important handling practice that must be followed for Genetron AZ-20 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-20 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 of Genetron® AZ-20® R-410A out of direct sunlight, especially in warm weather. Genetron AZ-20 expands 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 (52°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.

If a cylinder leak is detected, contact Honeywell for guidance.

Maintenance

A thorough pre-job review must be done to determine respiratory protection requirements, as well as any other safety equipment needed. Maintenance in areas where Genetron AZ-20 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-20. 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. Leaks detectors are important for refrigerant conservation, equipment protection and performance, reduction of emissions and protection of those coming in contact with the system.

Leak testing should not be performed using mixtures of air and Genetron® AZ-20®. There are two types of leak detectors — leak pinpointers and area monitors. 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. Fluorescent dye approved by the equipment manufacturer can be added to system to help 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-20 R-410A 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 Genetron AZ-20 R-410A, like R-22, will become combustible.) For a system containing either all 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 can not 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-20® 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.

Retrofitting Existing Systems

Genetron AZ-20 is the long-term non-ozone-depleting replacement for HCFC-22 in new equipment due to its many favorable performance characteristics. However, the performance properties which make it the replacement for HCFC-22 in new equipment — higher capacity and higher pressure — make it difficult to be used in existing systems designed for HCFC-22. In most cases, mandatory changes would include compressors and thermostatic expansion valves. Condensers and other high-pressure-side components may also require replacement. Depending on the applicable design standard for pressure-containing components and the particular design, even low-pressure-side components may require changing. Provided local building codes permit, and equipment manufacturers approve, it may be possible to retain the indoor coil and inter-connecting lines.

When converting an existing R-22 residential air-conditioning system to Genetron AZ-20 R-410A, the condensing unit will have to be replaced with one designed for R-410A. If the expansion device is a short tube orifice, it can typically be modified using a kit available from the manufacturer. An R-22 thermostatic expansion valve (TXV) must be replaced with an R-410A TXV. It is also important to install a compatible liquid-line filter drier. If water or acid need to be removed, consult the equipment manufacturer's application information or service manual. Confirm with the equipment manufacturer that the existing indoor coil is suitable–some existing indoor coils (capillary tube or pre-1980's design) are not acceptable for use with Genetron AZ-20. Indoor sections must be UL approved for appropriate service pressure ratings. The service pressure rating for Genetron AZ-20 is 235 psig. Indoor coils listed for R-22 heat pump applications would meet or exceed this rating. In most cases, existing line sets can be used.

Be certain to follow the equipment manufacturer's procedures for pumpdown and recovery of the original R-22 charge and for installation of the new condensing unit, expansion device, and liquid-line filter drier. For a residential air-conditioning retrofit where indoor coil and lines stay, it is important to drain residual mineral oil or alkylbenzene oil from the system. Systems charged with R-410A can tolerate a small mineral oil residual. Pay particular attention to low spots in the suction-line and evaporator where oil may have accumulated. Never leave a system open to atmosphere for more that 15 minutes.

A miscible lubricant such as polyol ester (POE) lubricant must be used with Genetron AZ-20 R-410A refrigerant. Refer to the equipment manufacturer for a list of approved lubricants since lubricants are not always interchangeable. POE lubricant readily absorbs moisture; therefore, care should be taken to minimize exposure of the lubricant to the atmosphere. Use a pump to transfer lubricant; do not pour. In an air-conditioning system, a filter drier can be used to effectively remove moisture from POE lubricant; A VACUUM PUMP WILL NOT WORK.

After the new condensing unit, expansion device, and liquid-line filter drier have been installed, evacuate the system to 500 microns to insure that air and liquid water are effectively removed from the system. Once a system is under vacuum, do not open to the atmosphere. Break vacuum using Genetron AZ-20 or if a triple evacuation method is being used, break vacuum using 2-3 psig dry nitrogen. Once certain that there are no leaks, weigh-in the refrigerant charge using a dial-a-charge designed for Genetron AZ-20 or a digital scale.

Charge Optimization

Standard superheat and subcooling procedure can be used to optimize the refrigerant charge. Fixed restrictor-type metering devices require charge optimization using the superheat method. A system charged with Genetron AZ-20 and equipped with an R-410A TXV (thermostatic expansion valve) requires use

of the subcooling method for refrigerant charge optimization. Do not use an R-22 TXV with Genetron AZ-20.

For a typical 3/8-inch outer diameter liquid line, long line applications will require approximately 0.50 oz. of refrigerant per foot of additional length. Charging units with long refrigerant lines must be done carefully since pressure and temperature changes occur more slowly. Add or remove refrigerant in small increments (about 5% by weight of the original system charge) and allow the system to stabilize between each.

LIQUID CHARGE USING A COMMERCIAL METERING DEVICE IN THE MANIFOLD HOSE. CHARGE INTO THE SUCTION LINE.

Consult Honeywell's Genetron® AZ-20® (R-410A) Air-Conditioning System Charging and Recovery Guidelines (publication G-525-083) for more detailed information on charge optimization.

Filter Driers

Liquid-line filter driers must have rated working pressures of no less than 600psig. Honeywell recommends the use of a liquid-line filter drier. Be certain not to install a suction-line drier in the liquid-line. The filter drier should be approved for R-410A refrigerant. Remove a filter drier from the system by using a tubing cutter. Do not unsweat a filter drier since heat will release moisture and contaminants from the drier into the system.

Environmental Considerations

Genetron AZ-20 is a halogenated hydrocarbon. Treatment or disposal of wastes generated by use of this product 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 Material Safety Data Sheet (MSDS).

If discarded unused, Genetron AZ-20 is not considered a "hazardous waste" by the Resource Conservation and Recovery Act (RCRA). Because Genetron AZ-20 is considered to have minimum biodegradability, care should be taken to avoid releases to the environment.

The disposal of Genetron AZ-20 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.

Refrigerant Recovery, Recycling and Reclamation

In the United States, amendments to the 1990 Clean Air Act require mandatory recycling and reclamation of refrigerants during maintenance, servicing or repair of air-conditioning or refrigeration equipment. This includes HFC (hydrofluorocarbon) refrigerants such as Genetron AZ-20. The venting of refrigerants to the atmosphere is prohibited. The recovery or recycling device must be EPA approved. Recycled refrigerant may only be returned to the equipment from which it was removed or used in other equipment owned by the same person.

IT IS VERY IMPORTANT TO MAKE CERTAIN THAT THE RECYCLE OR RECOVERY EQUIPMENT USED IS DESIGNED FOR R-410A. The pressure of Genetron AZ-20 refrigerant is approximately 60% (1.6 times) greater than that of R-22. Pressure gauges require a range up to 800 psig high-side and 250 psig low-side with a 550 psig low-side retard. Hoses need an 800 psig service pressure rating. Recovery cylinders require a 400 psig service pressure rating — DO NOT PUT GENETRON® AZ-20® R-410A IN A 300 PSIG RATED CYLINDER. DOT 4BA400 and DOT 4BW400 vessels are acceptable.

Refrigerant that is too contaminated for reuse must be properly disposed of or reclaimed. Reclamation can only be performed at an EPA (Environmental Protection Agency) approved reclamation facility. Most Genetron refrigerant wholesalers will accept recovered Genetron AZ-20 for reclamation.

Packaging

Genetron AZ-20 is available in a variety of containers. They include 25-lb disposable Jugs™, 100-lb returnable cylinders and one ton (1450-lb) returnable tanks. Bulk tank trailers and isotanks are available. Consult your Genetron Sales Representative if a larger container is required.

Available Literature/Technical Assistance

Honeywell has a wide range of literature available for all of its environmentally safer Genetron products, covering such topics as reclamation, retrofitting guidelines, product specifications and physical properties. In addition, Honeywell technical specialists are available to assist you in all aspects of using Genetron AZ-20 — handling and storage and applications assistance. For further information, please write us at:

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

Thermodynamic Table — English Units

Temp °F	Pressure psia	Liquid Density lb/ft^3	Vapor volume ft^3/lb	Enthalpy H_{liq} Btu/lb	Enthalpy Dh Btu/lb	Enthalpy H_{vap} Btu/lb	Entropy S_{liq} Btu/lb °F	Entropy S_{vap} Btu/lb °F
-60	14.9	84.1928	3.7914	-6.60	117.29	110.69	-0.0161	0.2775
-58	15.8	83.9740	3.5965	-5.95	116.89	110.94	-0.0144	0.2766
-56	16.7	83.7544	3.4136	-5.29	116.47	111.18	-0.0128	0.2758
-54	17.6	83.5341	3.2418	-4.63	116.06	111.43	-0.0112	0.2750
-52	18.6	83.3130	3.0803	-3.97	115.64	111.67	-0.0096	0.2742
-50	19.7	83.0912	2.9285	-3.31	115.23	111.92	-0.0080	0.2734
-48	20.7	82.8686	2.7856	-2.65	114.81	112.16	-0.0064	0.2726
-46	21.8	82.6452	2.6511	-1.99	114.38	112.39	-0.0048	0.2718
-44	23.0	82.4210	2.5243	-1.33	113.96	112.63	-0.0032	0.2710
-42	24.2	82.1959	2.4048	-0.66	113.53	112.87	-0.0016	0.2703
-40	25.5	81.9700	2.2921	0.00	113.10	113.10	0.0000	0.2696
-38	26.8	81.7432	2.1857	0.67	112.66	113.33	0.0016	0.2688
-36	28.1	81.5155	2.0853	1.33	112.23	113.56	0.0031	0.2681
-34	29.5	81.2869	1.9903	2.00	111.79	113.79	0.0047	0.2674
-32	31.0	81.0573	1.9006	2.67	111.35	114.02	0.0063	0.2667
-30	32.5	80.8268	1.8157	3.34	110.91	114.25	0.0078	0.2660
-28	34.1	80.5952	1.7353	4.01	110.46	114.47	0.0094	0.2653
-26	35.7	80.3627	1.6592	4.68	110.01	114.69	0.0109	0.2646
-24	37.4	80.1291	1.5870	5.36	109.55	114.91	0.0125	0.2640
-22	39.2	79.8945	1.5187	6.03	109.10	115.13	0.0140	0.2633
-20	41.0	79.6588	1.4538	6.71	108.63	115.34	0.0155	0.2627
-18	42.9	79.4219	1.3923	7.39	108.17	115.56	0.0171	0.2620
-16	44.9	79.1839	1.3339	8.07	107.70	115.77	0.0186	0.2614
-14	46.9	78.9447	1.2784	8.75	107.23	115.98	0.0201	0.2608
-12	49.0	78.7044	1.2256	9.43	106.75	116.18	0.0216	0.2601
-10	51.2	78.4628	1.1755	10.11	106.28	116.39	0.0231	0.2595
-8	53.4	78.2199	1.1278	10.80	105.79	116.59	0.0246	0.2589
-6	55.7	77.9757	1.0823	11.48	105.31	116.79	0.0261	0.2583
-4	58.1	77.7302	1.0391	12.17	104.82	116.99	0.0276	0.2577
-2	60.6	77.4834	0.9979	12.86	104.33	117.19	0.0291	0.2571
0	63.1	77.2351	0.9587	13.55	103.83	117.38	0.0306	0.2566
2	65.8	76.9854	0.9213	14.25	103.32	117.57	0.0321	0.2560
4	68.5	76.7342	0.8856	14.94	102.82	117.76	0.0336	0.2554
6	71.3	76.4816	0.8516	15.64	102.31	117.95	0.0351	0.2548
8	74.2	76.2273	0.8191	16.34	101.79	118.13	0.0366	0.2543
10	77.1	75.9715	0.7880	17.04	101.27	118.31	0.0381	0.2537
12	80.2	75.7140	0.7584	17.74	100.75	118.49	0.0395	0.2532
14	83.3	75.4549	0.7300	18.45	100.21	118.66	0.0410	0.2526
16	86.6	75.1940	0.7029	19.15	99.68	118.83	0.0425	0.2521
18	89.9	74.9314	0.6770	19.86	99.14	119.00	0.0440	0.2516
20	93.4	74.6669	0.6522	20.57	98.60	119.17	0.0454	0.2510
22	96.9	74.4006	0.6285	21.29	98.04	119.33	0.0469	0.2505
24	100.5	74.1324	0.6057	22.00	97.49	119.49	0.0484	0.2500
26	104.3	73.8621	0.5840	22.72	96.93	119.65	0.0498	0.2494
28	108.1	73.5899	0.5631	23.44	96.36	119.80	0.0513	0.2489
30	112.1	73.3156	0.5431	24.16	95.79	119.95	0.0527	0.2484
32	116.1	73.0391	0.5239	24.89	95.21	120.10	0.0542	0.2479
34	120.3	72.7604	0.5055	25.62	94.62	120.24	0.0557	0.2474
36	124.6	72.4794	0.4878	26.35	94.03	120.38	0.0571	0.2469
38	129.0	72.1961	0.4708	27.08	93.43	120.51	0.0586	0.2463
40	133.5	71.9104	0.4546	27.82	92.83	120.65	0.0600	0.2458
42	138.1	71.6223	0.4389	28.56	92.21	120.77	0.0615	0.2453
44	142.9	71.3315	0.4239	29.30	91.60	120.90	0.0629	0.2448
46	147.7	71.0382	0.4094	30.04	90.98	121.02	0.0644	0.2443
48	152.7	70.7422	0.3955	30.79	90.34	121.13	0.0658	0.2438

Thermodynamic Table — English Units — continued

Temp °F	Pressure psia	Liquid Density lb/ft^3	Vapor volume ft^3/lb	Enthalpy H_{liq} Btu/lb	Enthalpy Dh Btu/lb	Enthalpy H_{vap} Btu/lb	Entropy S_{liq} Btu/lb °F	Entropy S_{vap} Btu/lb °F
50	157.9	70.4433	0.3821	31.54	89.70	121.24	0.0673	0.2433
52	163.1	70.1416	0.3693	32.30	89.04	121.34	0.0687	0.2428
54	168.5	69.8370	0.3569	33.05	88.40	121.45	0.0702	0.2423
56	174.0	69.5293	0.3450	33.82	87.72	121.54	0.0716	0.2418
58	179.6	69.2184	0.3335	34.58	87.05	121.63	0.0731	0.2413
60	185.4	68.9043	0.3224	35.35	86.37	121.72	0.0745	0.2408
62	191.3	68.5869	0.3117	36.12	85.68	121.80	0.0760	0.2402
64	197.4	68.2660	0.3014	36.90	84.97	121.87	0.0774	0.2397
66	203.6	67.9415	0.2915	37.68	84.26	121.94	0.0789	0.2392
68	210.0	67.6134	0.2819	38.46	83.54	122.00	0.0803	0.2387
70	216.5	67.2814	0.2727	39.25	82.81	122.06	0.0818	0.2382
72	223.1	66.9454	0.2638	40.04	82.07	122.11	0.0833	0.2376
74	229.9	66.6054	0.2552	40.84	81.31	122.15	0.0847	0.2371
76	236.9	66.2611	0.2469	41.64	80.54	122.18	0.0862	0.2366
78	244.0	65.9125	0.2388	42.44	79.77	122.21	0.0876	0.2360
80	251.2	65.5593	0.2311	43.25	78.98	122.23	0.0891	0.2355
82	258.7	65.2013	0.2235	44.07	78.18	122.25	0.0906	0.2349
84	266.3	64.8385	0.2163	44.89	77.36	122.25	0.0920	0.2344
86	274.0	64.4705	0.2092	45.72	76.53	122.25	0.0935	0.2338
88	282.0	64.0972	0.2024	46.55	75.69	122.24	0.0950	0.2332
90	290.1	63.7184	0.1959	47.38	74.84	122.22	0.0965	0.2327
92	298.3	63.3338	0.1895	48.23	73.96	122.19	0.0980	0.2321
94	306.8	62.9431	0.1833	49.08	73.07	122.15	0.0995	0.2315
96	315.4	62.5461	0.1773	49.93	72.17	122.10	0.1010	0.2309
98	324.2	62.1424	0.1715	50.80	71.25	122.05	0.1025	0.2303
100	333.2	61.7317	0.1659	51.67	70.30	121.97	0.1040	0.2296
102	342.4	61.3136	0.1604	52.54	69.35	121.89	0.1055	0.2290
104	351.8	60.8878	0.1551	53.43	68.37	121.80	0.1070	0.2283
106	361.4	60.4537	0.1500	54.32	67.37	121.69	0.1085	0.2277
108	371.2	60.0109	0.1450	55.22	66.35	121.57	0.1101	0.2270
110	381.1	59.5588	0.1401	56.13	65.31	121.44	0.1116	0.2263
112	391.3	59.0968	0.1354	57.05	64.24	121.29	0.1132	0.2256
114	401.7	58.6242	0.1308	57.98	63.14	121.12	0.1147	0.2248
116	412.3	58.1402	0.1263	58.92	62.02	120.94	0.1163	0.2241
118	423.1	57.6438	0.1219	59.88	60.86	120.74	0.1179	0.2233
120	434.1	57.1341	0.1176	60.84	59.68	120.52	0.1195	0.2225
122	445.3	56.6098	0.1135	61.82	58.45	120.27	0.1212	0.2217
124	456.8	56.0697	0.1094	62.82	57.19	120.01	0.1228	0.2208
126	468.5	55.5121	0.1055	63.83	55.89	119.72	0.1245	0.2199
128	480.4	54.9352	0.1016	64.85	54.55	119.40	0.1261	0.2190
130	492.6	54.3368	0.0978	65.90	53.16	119.06	0.1278	0.2180
132	505.0	53.7142	0.0941	66.97	51.71	118.68	0.1296	0.2170
134	517.7	53.0645	0.0904	68.07	50.20	118.27	0.1314	0.2159
136	530.6	52.3837	0.0868	69.19	48.62	117.81	0.1332	0.2148
138	543.8	51.6673	0.0833	70.34	46.97	117.31	0.1350	0.2136
140	557.2	50.9094	0.0798	71.53	45.23	116.76	0.1369	0.2124
142	570.9	50.1027	0.0763	72.76	43.39	116.15	0.1389	0.2110
144	584.9	49.2375	0.0729	74.05	41.41	115.46	0.1409	0.2096
146	599.2	48.3009	0.0694	75.39	39.30	114.69	0.1431	0.2080
148	613.7	47.2751	0.0659	76.81	37.01	113.82	0.1453	0.2062
150	628.6	46.1339	0.0624	78.34	34.48	112.82	0.1477	0.2043

Thermodynamic Table — SI Units

Temp °F	Pressure kPa	Liquid Density kg/m^3	Vapor volume m^3/kg	Enthalpy H_{liq} kJ/kg	Enthalpy Δh kJ/kg	Enthalpy H_{vap} kJ/kg	Entropy S_{liq} kJ/kg °C	Entropy S_{vap} kJ/kg °C
-30	270	1280	0.0948	156.17	253.58	409.75	0.8318	1.8749
-29	282	1276	0.0912	157.58	252.62	410.20	0.8376	1.8725
-28	293	1273	0.0877	159.00	251.65	410.65	0.8433	1.8700
-27	305	1270	0.0843	160.42	250.67	411.09	0.8491	1.8677
-26	318	1266	0.0812	161.84	249.69	411.53	0.8548	1.8653
-25	331	1263	0.0781	163.27	248.70	411.97	0.8605	1.8629
-24	344	1259	0.0752	164.70	247.70	412.40	0.8662	1.8606
-23	357	1256	0.0725	166.13	246.70	412.83	0.8719	1.8583
-22	371	1252	0.0698	167.56	245.69	413.25	0.8776	1.8560
-21	386	1249	0.0673	169.00	244.67	413.67	0.8833	1.8538
-20	401	1245	0.0649	170.44	243.64	414.08	0.8889	1.8516
-19	416	1242	0.0626	171.88	242.61	414.49	0.8945	1.8493
-18	432	1238	0.0603	173.33	241.57	414.90	0.9002	1.8471
-17	448	1234	0.0582	174.78	240.52	415.30	0.9058	1.8450
-16	465	1231	0.0562	176.23	239.47	415.70	0.9114	1.8428
-15	482	1227	0.0542	177.69	238.40	416.09	0.9170	1.8407
-14	499	1223	0.0523	179.15	237.32	416.47	0.9226	1.8386
-13	517	1220	0.0505	180.61	236.25	416.86	0.9282	1.8365
-12	536	1216	0.0488	182.08	235.15	417.23	0.9337	1.8344
-11	555	1212	0.0472	183.55	234.05	417.60	0.9393	1.8323
-10	575	1209	0.0456	185.02	232.95	417.97	0.9449	1.8303
-9	595	1205	0.0441	186.50	231.83	418.33	0.9504	1.8282
-8	615	1201	0.0426	187.99	230.69	418.68	0.9559	1.8262
-7	637	1197	0.0412	189.47	229.56	419.03	0.9615	1.8242
-6	658	1193	0.0398	190.96	228.41	419.37	0.9670	1.8222
-5	681	1190	0.0385	192.46	227.25	419.71	0.9725	1.8202
-4	703	1186	0.0373	193.96	226.08	420.04	0.9780	1.8182
-3	727	1182	0.0361	195.46	224.91	420.37	0.9835	1.8162
-2	751	1178	0.0349	196.97	223.72	420.69	0.9890	1.8143
-1	775	1174	0.0338	198.48	222.52	421.00	0.9945	1.8123
0	801	1170	0.0327	200.00	221.31	421.31	1.0000	1.8104
1	827	1166	0.0317	201.52	220.08	421.60	1.0055	1.8084
2	853	1162	0.0307	203.05	218.85	421.90	1.0110	1.8065
3	880	1158	0.0297	204.58	217.60	422.18	1.0164	1.8046
4	908	1154	0.0288	206.12	216.34	422.46	1.0219	1.8027
5	936	1150	0.0279	207.66	215.07	422.73	1.0274	1.8007
6	965	1145	0.0270	209.21	213.78	422.99	1.0328	1.7988
7	995	1141	0.0262	210.77	212.48	423.25	1.0383	1.7969
8	1025	1137	0.0254	212.33	211.16	423.49	1.0438	1.7950
9	1057	1133	0.0246	213.89	209.84	423.73	1.0492	1.7931
10	1088	1128	0.0239	215.46	208.50	423.96	1.0547	1.7912
11	1121	1124	0.0231	217.04	207.14	424.18	1.0602	1.7893
12	1154	1120	0.0224	218.63	205.76	424.39	1.0656	1.7874
13	1188	1115	0.0218	220.22	204.37	424.59	1.0711	1.7855
14	1223	1111	0.0211	221.81	202.98	424.79	1.0765	1.7836
15	1258	1106	0.0205	223.42	201.55	424.97	1.0820	1.7816
16	1295	1102	0.0199	225.03	200.11	425.14	1.0875	1.7797
17	1332	1097	0.0193	226.64	198.67	425.31	1.0929	1.7778
18	1370	1092	0.0187	228.27	197.19	425.46	1.0984	1.7758
19	1408	1088	0.0181	229.90	195.70	425.60	1.1039	1.7739
20	1448	1083	0.0176	231.54	194.19	425.73	1.1094	1.7719
21	1488	1078	0.0171	233.19	192.66	425.85	1.1148	1.7700
22	1529	1073	0.0166	234.85	191.10	425.95	1.1203	1.7680
23	1571	1069	0.0161	236.51	189.53	426.04	1.1258	1.7660
24	1614	1064	0.0156	238.18	187.94	426.12	1.1313	1.7640

Thermodynamic Table — SI Units — continued

Temp °F	Pressure kPa	Liquid Density kg/m^3	Vapor volume m^3/kg	Enthalpy H_{liq} kJ/kg	Enthalpy Δh kJ/kg	Enthalpy H_{vap} kJ/kg	Entropy S_{liq} kJ/kg °C	Entropy S_{vap} kJ/kg °C
25	1657	1059	0.0152	239.86	186.33	426.19	1.1368	1.7619
26	1702	1054	0.0147	241.55	184.70	426.25	1.1424	1.7599
27	1747	1048	0.0143	243.25	183.03	426.28	1.1479	1.7578
28	1794	1043	0.0139	244.96	181.35	426.31	1.1534	1.7558
29	1841	1038	0.0135	246.68	179.64	426.32	1.1590	1.7537
30	1889	1033	0.0131	248.41	177.90	426.31	1.1645	1.7515
31	1939	1027	0.0127	250.15	176.14	426.29	1.1701	1.7494
32	1989	1022	0.0123	251.90	174.35	426.25	1.1757	1.7472
33	2040	1016	0.0120	253.66	172.54	426.20	1.1813	1.7450
34	2092	1011	0.0116	255.43	170.69	426.12	1.1869	1.7428
35	2145	1005	0.0113	257.22	168.81	426.03	1.1925	1.7405
36	2199	999	0.0109	259.01	166.91	425.92	1.1982	1.7382
37	2254	993	0.0106	260.82	164.97	425.79	1.2038	1.7359
38	2310	988	0.0103	262.65	162.98	425.63	1.2095	1.7335
39	2367	981	0.0100	264.48	160.98	425.46	1.2152	1.7311
40	2426	975	0.0097	266.33	158.93	425.26	1.2210	1.7286
41	2485	969	0.0094	268.20	156.84	425.04	1.2267	1.7261
42	2545	963	0.0091	270.08	154.71	424.79	1.2325	1.7235
43	2607	956	0.0088	271.98	152.54	424.52	1.2383	1.7209
44	2670	950	0.0086	273.90	150.31	424.21	1.2442	1.7182
45	2734	943	0.0083	275.84	148.04	423.88	1.2501	1.7155
46	2799	936	0.0081	277.80	145.72	423.52	1.2560	1.7127
47	2865	929	0.0078	279.77	143.35	423.12	1.2619	1.7098
48	2932	922	0.0076	281.77	140.92	422.69	1.2680	1.7069
49	3001	914	0.0073	283.80	138.42	422.22	1.2740	1.7038
50	3071	907	0.0071	285.85	135.87	421.72	1.2801	1.7007
51	3142	899	0.0069	287.93	133.24	421.17	1.2863	1.6975
52	3214	891	0.0066	290.03	130.54	420.57	1.2926	1.6941
53	3288	883	0.0064	292.17	127.75	419.92	1.2989	1.6906
54	3363	874	0.0062	294.35	124.87	419.22	1.3053	1.6871
55	3439	865	0.0060	296.57	121.89	418.46	1.3118	1.6833
56	3517	856	0.0058	298.83	118.81	417.64	1.3184	1.6794
57	3596	847	0.0056	301.13	115.61	416.74	1.3251	1.6753
58	3676	837	0.0054	303.50	112.27	415.77	1.3319	1.6711
59	3758	826	0.0052	305.92	108.79	414.71	1.3390	1.6666
60	3842	815	0.0050	308.41	105.13	413.54	1.3461	1.6618
61	3927	804	0.0048	310.99	101.28	412.27	1.3535	1.6567
62	4013	792	0.0046	313.66	97.20	410.86	1.3612	1.6513
63	4101	778	0.0044	316.44	92.86	409.30	1.3691	1.6455
64	4191	764	0.0042	319.35	88.21	407.56	1.3775	1.6392
65	4282	748	0.0040	322.43	83.17	405.60	1.3862	1.6322

Notes

Notes

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