Honeywell Genetron® 134a

Properties, Uses, Storage, and Handling

GENERAFRIO
LIDERES EN SISTEMAS DE AIRE ACONDICIONADO Y REFRIGERACION

Honeywell

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Introduction

Genetron® 134a (1,1,1,2-tetrafluoroethane) is a non-ozone-depleting, environmentally safer refrigerant developed by Honeywell to replace CFCs and HCFCs in several air-conditioning and refrigeration applications. It possesses similar energy efficiency and capacity characteristics as CFC-12, has an intrinsically low toxicity, and is recognized as a superior long-term solution in many applications.

This document is meant to provide engineers, technicians, and mechanics with basic Genetron 134a properties, plus application and handling information to facilitate safe and efficient usage.

Applications

Stationary Refrigeration and Air-Conditioning

Genetron 134a can be used in refrigeration applications including supermarket cases, walk-in coolers, beverage dispensers, vending machines, water coolers and home refrigerators. Genetron 134a is also used in centrifugal chillers. Genetron 134a is suitable for both new equipment and for retrofitting existing CFC-12 commercial refrigeration systems. Generally, there will be few equipment design changes necessary to optimize the performance of Genetron 134a in these applications.

For further information on retrofitting, your Genetron refrigerants distributor or your Honeywell sales or technical representative can provide you with the most up-to-date retrofit literature. We also recommend consulting the original equipment manufacturer before performing any retrofit.

Automotive Air-Conditioning

Several automobile and truck manufacturers have selected Genetron 134a for the initial charge in their new vehicles. Additionally, retrofit kits for converting CFC-12 systems to Genetron 134a are widely available. Honeywell is also proud to offer Genetron 134aUV, a special formulation of Genetron 134a and a refrigerant-soluble dye that fluoresces when exposed to ultraviolet light. Genetron 134aUV was developed specifically for automotive mechanics who wanted a solution for making leak detection in cars and trucks easier, faster, and less expensive.

Aerosol and Foam-Blowing Applications

Genetron 134a is used as a propellant in many specialty aerosol products and may be used as a blowing agent for rigid-foam insulation. Additional information on the use of Genetron 134a in aerosol and foam applications is available through your Honeywell sales or technical representative.

Physical Properties

Chemical Name		1,1,1,2-tetrafluoroethane
Appearance		Clear, colorless gas with a faint ethereal odor
Molecular Formula		CH_2FCF_3
Molecular Weight		102.03
Boiling Point	@ 1 ATM	-14.9°F
	@ 14.3 kPa	-25.9°C
Freezing Point	@ 1 ATM	-141.9°F
	@ 101.3 kPa	-96.6°C
Critical Temperature*		213.91°F 101.06°C
Critical Pressure*		588.75 psia 4059.3 kPa
Critical Volume*		0.031 ft^3/lb 0.00195 kg/m^3
Critical Density*		31.957 (lb/ft^3) 511.9 (kg/m^3)
Vapor Density at Boiling Point		0.328 (lb/ft^3) 5.26 (kg/m^3)
Liquid Density		75.33 (lb/ft^3) 1207.0 (kg/m^3)
Liquid Heat Capacity		0.341 (Btu/lb•°F) 1.425 (kJ/kg•°K)
Vapor Heat Capacity at constant pressure		
	@ 1 ATM	0.203 Btu/lb•°F)
	@ 101.3 kPa	0.851 (kJ/kg•°K)
Heat of Vaporization at Boiling Point		93.3 (Btu/lb) 216.98 (kJ/kg)
Vapor Pressure		96.51 (Psia) 665.0 (kPa)
Liquid Thermal Conductivity		0.0469 (Btu/hr•ft•°F) 81.1 (W/m•°K)
Vapor Thermal Conductivity		0.0080 (Btu/hr•ft•°F) 13.8 (W/m•°K)
Liquid Viscosity		0.472 (lbm/ft•h) 194.9 (m Pa•s)
Vapor Viscosity		0.0283 (lbm/ft•h) 11.7 (m Pa•s)
% Volatiles by Volume		100
Solubility of Genetron 134a in water (wt. %)		0.15
Solubility of water in Genetron 134a		0.11
Flammability Limits in Air (vol. %)		None
Auto Ignition Temperature		1418°F 770°C
Ozone Depletion Potential (ODP)		0
Global Warming Potential (relative to CO_2 - 100 yr. time horizon)		1300

* NIST Refprop 7

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

Specifications – Refrigeration Grade

Assay (min. wt. % of all Genetron 134a Isomers)	99.8%
Moisture (max. wt. %)	0.0010
High-boiling Residue, maximum volume percent	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 134a	CFC-12
Evaporating Pressure		
psig	9.10	11.7
kPa absolute	164	182
Condensing Pressure		
psig	97.0	93.2
kPa absolute	770	744
Compression Ratio	4.69	4.09
Compressor Discharge Temperature		
°F	97.9	100.1
°C	36.6	37.8
Temperature of Suction Gas		
°F	5	5
°C	-15	-15
Specific Volume of Suction Vapor		
cu. ft./lb	1.93	1.47
m3/kg	0.12	0.09
Latent Heat of Vaporization		
Btu/lb	90.1	68.8
kJ/kg	208.5	160.0
Net Refrigeration Effect		
Btu/lb	63.6	50.3
kJ/kg	147.9	117.0
Coefficient of Performance (C.O.P.)	4.61	4.70
Horsepower per ton of Refrigeration	1.02	1.00
Refrigerant Circulated per ton		
lbs/min.	3.15	3.98
per kw(g/s)	6.78	8.56
Compressor Suction Gas Volume		
per ton (cu. in./min.)	6.08	5.85
per kw (l/s)	0.82	0.79
Liquid Circulated per ton		
cu. in./min.	73.3	85.2
per kw (mL/s)	5.70	6.62

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

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

Pressure vs. Temperature

Temp. °F	Pressure (psig)	Temp. °C	Pressure (bar-gauge)
-40	14.8 ("Hg Vac)	-40.0	-0.50
-35	12.5 ("Hg Vac)	-37.5	-0.43
-30	9.8 ("Hg Vac)	-35.0	-0.35
-25	6.9 ("Hg Vac)	-32.5	-0.26
-20	3.7 ("Hg Vac)	-30.0	-0.17
-15	0.1 ("Hg Vac)	-27.5	-0.06
-10	1.9	-25.0	0.05
-5	4.1	-22.5	0.18
0	6.5	-20.0	0.32
5	9.1	-17.5	0.47
10	11.9	-15.0	0.63
15	15.0	-12.5	0.81
20	18.4	-10.0	1.00
25	22.1	-7.5	1.20
30	26.1	-5.0	1.42
35	30.4	-2.5	1.66
40	35.0	0.0	1.92
45	40.1	2.5	2.19
50	45.4	5.0	2.49
55	51.2	7.5	2.80
60	57.4	10.0	3.14
65	64.0	12.5	3.49
70	71.1	15.0	3.87
75	78.7	17.5	4.28
80	86.7	20.0	4.71
85	95.2	22.5	5.16
90	104.3	25.0	5.64
95	113.9	27.5	6.15
100	124.2	30.0	6.69
105	135.0	32.5	7.26
110	146.4	35.0	7.86
115	158.4	37.5	8.49
120	171.2	40.0	9.16
125	184.6	42.5	9.85
130	198.7	45.0	10.59
135	213.6	47.5	11.36
140	229.2	50.0	12.17
145	245.7	52.5	13.02
150	262.9	55.0	13.91
		57.5	14.83
		60.0	15.81
		62.5	16.83
		65.0	17.90

Lubricants

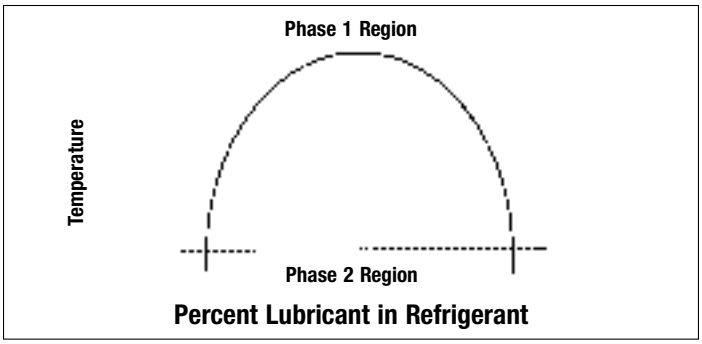
Genetron® 134a is being used with polyalkylene glycol (PAG) and with polyol ester lubricants. Most automotive original equipment manufacturers have chosen specific PAG lubricants for their systems. For non-automotive applications, most compressor manufacturers are recommending specific polyol ester lubricants. Check with the equipment manufacturer for the recommended lubricants for their system.

Miscibility in Lubricants

Polyol esters and PAGs 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 miscibilities can vary widely. Miscibility is the ability of the refrigerant/lubricant mixture to form a single liquid phase.

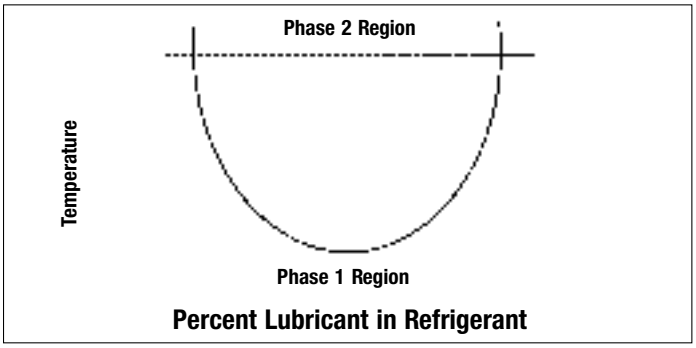
Many commercial polyol esters provide miscibility with Genetron 134a down to low temperatures. The Genetron 134a polyol ester lubricant miscibility curve is usually — but not always — convex (upward). The refrigerant/lubricant mixture is immiscible at low temperatures and becomes miscible as the mixture is heated. Such mixtures exhibit upper critical solution temperatures. The upper critical solution temperature is the temperature above which the refrigerant mixture will remain miscible over the entire concentration range.

Miscibility Genetron 134a and Polyol Ester Lubricant



For Genetron 134a and PAGs, lower critical solution temperatures are typically found. The Genetron 134a/PAG mixture is usually miscible at lower temperatures, and becomes immiscible as the temperature is raised. For Genetron 134a/PAG mixtures, the lower critical solution temperature usually decreases with the increase in viscosity for groups of similar PAGs. The user should consult the lubricant manufacturer or call a Genetron® technical representative for more detailed information.

Miscibility Genetron 134a and PAG Lubricant



Copper Plating

Copper plating occurs when copper transfers from copper surfaces through the refrigerant/oil mixture to steel surfaces in the compressor. In some cases, this can affect clearance volumes in the compressor.

Laboratory sealed tube copper plating tests have been conducted for Genetron 134a with PAGs and polyol esters. As shown in the table below, the Genetron 134a/PAG tests were done at 300°F (149°C) for up to four months. Laboratory test results for Genetron 134a with PAGs indicated that this system produces less copper plating than the CFC 12/mineral oil system. This was found for both wet and dry systems. Tests under field conditions have indicated that copper plating can be a concern when the system is wet.

Copper plating for Genetron 134a as compared with CFC-12

System	Months	Total μ g/Cu
Genetron 134a/PAG/5000 ppm water	2	208
Genetron 134a/PAG/5000 ppm water	4	390
Genetron 134a/Mineral oil/5000 ppm water	2	591
CFC-12/Mineral oil/5000 ppm water	4	1143
Genetron 134a/Dry PAG	2	170
Genetron 134a/Dry PAG	4	174
CFC-12/Dry mineral oil	2	806
CFC-12/Dry mineral oil	4	1247

Tests also were done with Genetron 134a and polyol ester lubricants. They were conducted at temperatures between 300°F (149°C) and 400°F (204°C) for periods of two to four weeks. The lubricants were Castro1 SW 32 and Mobil EAL 22. They contained amounts of water that varied from 50 to 600 ppm. Visual observation revealed no copper plating after two weeks.

These laboratory tests indicate that, in the presence of fairly high concentrations of water and pure materials, refrigerant and oils do not cause copper plating. However, actual field systems experience wear and may contain other materials that promote

copper plating and may produce results that are different from laboratory tests. The laboratory tests are useful in pointing out that the refrigerant and lubricants alone may not be responsible for copper plating.

Stability with Metals

The overall stability of Genetron 134a is very good for virtually all applications where CFC-12 is suitable. Genetron 134a is compatible with steel, copper, aluminum and brass.

The stability of refrigerant/oil mixtures is determined using the ASHRAE 97 sealed-tube method. Studies were conducted using sealed tubes of Genetron 134a with both PAG and polyol ester lubricants. The refrigerant/oil mixture was studied in the presence of three metals: valve steel, copper and aluminum. The testing was conducted at a temperature of about 200°F to 400°F (93°C to 204°C) for one to four weeks and was judged through both visual observation and measuring the fluoride concentration produced in the tube.

On the basis of these tests, it is clear that Genetron 134a with either PAGs and polyol esters is as stable as CFC-12 with mineral oil. A typical example of such a test with polyol esters is shown in the table below. Copper, steel and aluminum are stable with Genetron 134a and the polyol esters studied. The stability of the refrigerant, as shown by the fluoride produced and the Genetron 134a purity, is excellent.

Stability of Genetron 134a with Polyol Ester Lubricants and Metals

Lubricant	Copper	Aluminum	Steel	Fluoride	Purity Genetron 134a
Mobil EAL 22	N.C.*	N.C.	N.C.	10mg	N.C.
Castrol SW 32	N.C.	N.C.	N.C.	10mg	N.C.

*N.C. = no change Note: Testing performed at 400°F (204°C) for 2 weeks

Chlorinated Materials and Refrigerants

There are three situations in which Genetron 134a and its associated lubricants might come into contact with chlorinated materials and refrigerants. They occur when:

1. A chlorinated solvent is used to clean or flush the system;

2. A system is retrofitted from CFC-12 to Genetron® 134a, or

3. CFC-12 is accidentally charged into a system that contains Genetron 134a.

It is recommended that chlorinated materials not be introduced into systems that use Genetron 134a with PAG or polyol ester lubricants. While performing retrofits, the service technician should follow appropriate retrofit guidelines to help ensure that residual chlorinated compounds are minimized. Genetron 134a alone is chemically compatible with all chlorinated materials. However, the PAG and polyol ester lubricants used with Genetron 134a are typically not compatible with all chlorinated materials. Chlorinated materials should not be introduced into Genetron 134a systems that use polyol ester or PAG lubricants without prior consultation with the equipment manufacturer.

Genetron 134a/CFC-12

Compatibility tests have been conducted to determine the compatibility of PAG lubricants and Genetron 134a spiked with varying levels of CFC-12. These tests show that up to about 0.5% CFC-12 can be present in the Genetron 134a before the decomposition of the PAG lubricant can be visually observed (test method involves observing color changes when the refrigerant oil mixture is at 400°F (204°C) for one week). At 300°F (149°C), up to 5% weight CFC-12 can be present in Genetron 134a before decomposition is observed.

In the case of polyol ester lubricants in wet systems, hydrolysis of the ester can be accelerated by hydrochloric acid from the breakdown of CFC-12. This can increase corrosion in the system. Some polyol esters are much less susceptible to this problem. The user should consult the compressor manufacturer for more information.

A second concern with respect to CFC-12 in Genetron 134a is that these two materials form an azeotrope whose pressure is higher than that of either component. The pressure in any system containing these two materials may be higher than expected, and could result in performance problems. Moreover, the difficulty in separating this azeotropic mixture will make recycling and reclamation difficult.

Equipment

Compatibility: Plastics and Elastomers

With the introduction of Genetron 134a, Honeywell in conjunction with other industry leaders, has conducted materials testing to evaluate the compatibility of materials used in refrigerant applications. The following list is a condensed sampling of the testing that has been performed to date. (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.

Materials Compatibility

Material	Genetron 134a	Genetron 134a/PAG	Genetron 134a/ Polyol Esters
Ethylene Propylene Diene Terpolymer	S	S	S
Ethylene-Propylene copolymer	S	S	S
Chlorosulfonated Polyethylene	S	Us	Us
Polyisoprene	S	Su	U
Chlorinated Polyethylene	Su	Su	Us
Neoprene (Chloroprene)	S	S	Su
Epichlorohydrin	S	Su	Us
Polyvinylidene fluoride and copolymer of vinylidene fluoride and hexafluoropropylene	U	S	Us
Silicone	Us	S	Su
Polyurethane	S	U	Su
Nitrile	Su	Su	Su
H-NBR	S	Su	S
Butyl rubber	S	S	Su
Natural rubber	Su	U	U
Polysulfide	S	U	U
Nylon	S	Su	Su
Polytetrafluoroethylene	S	S	S
PEEK	S	S	S
ABS	S	U	U
Polypropylene	Su	Su	S
Polyphenylene sulfide	Su	U	Su
Polyethylene terephthalate	S	U	S
Polysulfone	S	Us	S
Polyimide	S	Su	Su
Polyetherimide	S	Su	S
Polyphthalamide	S	U	U
Polyamideimide	S	S	S
Acetal	S	U	U
Phenolic	S	S	Su
Epoxy resin	S	S	S

Note: S: Suitable, Su: Suitable with some exceptions, U: unsuitable, Us: Unsuitable with some exceptions. 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

Polyethylene Terephthalate (PET)

PET is used in hermetic compressors as slot liners and as electrical insulation. It may be embrittled in the presence of moisture and as a result of prolonged contact with PAGs. PET is compatible with most polyol esters.

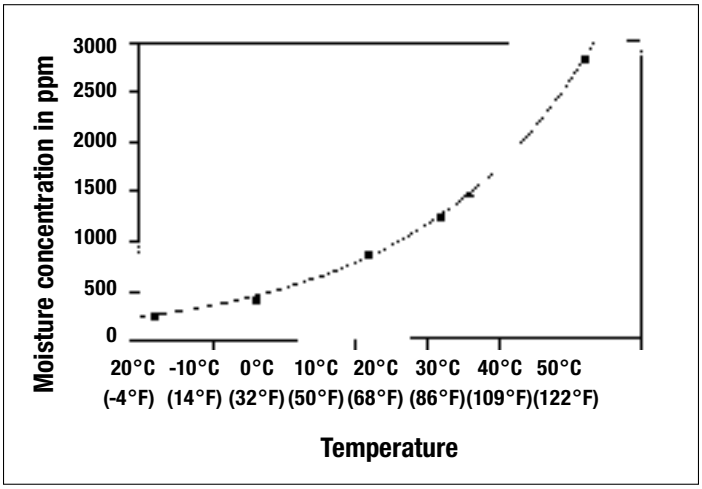
Desiccants

There are three common types of desiccant materials that are used in making driers. They are molecular sieves, alumina and silica gel. Under some conditions the molecular sieve XH5, commonly used with CFC-12, is incompatible with Genetron 134a. Molecular sieves XH7 and XH9 are recommended by UOP (a major molecular sieve manufacturer) for use with Genetron 134a. In addition, each drier manufacturer has developed driers and filters that are compatible with Genetron 134a. Such driers can include all three types of drier materials.

Solubility of Water in Genetron 134a

The solubility of water in Genetron 134a is shown in the graph below. This solubility is comparable to that of water in HCFC-22.

Solubility of Water in Genetron 134a



Safety

Toxicity

Genetron® 134a can be safely used in all of its intended applications, based on a review data developed by the Program for Alternative Fluorocarbon Toxicity Testing (PAFT I), an international consortium of which Honeywell is a charter member. However, the end-user should read the Material Safety Data Sheet (MSDS) before using Genetron 134a.

Inhalation

The American Industrial Hygiene Association (AIHA) has established a Workplace Environmental Exposure Level (WEEL) of 1000 parts per million (8- and 12-hour Time-Weighted Average) for Genetron 134a. Inhalation of the product's vapor may cause irritation. Vapor inhalation at high concentrations may result in asphyxiation or cardiac arrhythmia. If vapors are inhaled at high concentrations, cardiac irregularities and possibly cardiac arrest could occur. Under these conditions the heart may become sensitized. Do not give epinephrine (adrenaline) if over-exposure to Genetron 134a is suspected. When concentrations of Genetron 134a reach levels which reduce oxygen to 12-14% by displacement, symptoms of asphyxiation will occur. An individual exposed to high concentrations of Genetron 134a must be given medical attention immediately. Adequate ventilation must be provided at all times.

Skin and Eye Contact

Genetron 134a vapors can irritate the skin and eyes. In liquid form, it can freeze skin or eyes on contact. If skin contact should occur, flush the exposed area with lukewarm water until all the chemical is removed. If there is evidence of frostbite, soak in lukewarm water. Should eye contact occur, immediately flush with large amounts of luke-warm water for at least 15 minutes, lifting eyelids occasionally to facilitate irrigation. Seek medical attention as soon as possible.

Leaks

If a release of Genetron 134a 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. Unprotected 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 134a and air, oxygen or other oxidizing materials. Leak-checking can be performed safely with a mixture of Genetron 134a and nitrogen.

Flammability

According to ASHRAE Standard 34, Genetron 134a 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, Genetron 134a has no flame limits, and is therefore non-flammable (Green Label).

Since Genetron 134a is non-flammable, Honeywell believes 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 134a or any other similar product.

Combustibility

Although Genetron 134a is non-flammable at ambient temperatures and atmospheric pressure, tests have shown it to be combustible at pressures as low as 5.5 psig (38 kPag) and a temperature of 350°F (177°C) when mixed with air concentrations generally greater than 60 percent by volume. At lower temperatures, higher pressures are required for combustibility.

Because of this combustibility potential under pressure, Genetron 134a and air, oxygen or other oxidizing materials should never be mixed in tanks or supply lines, or allowed to accumulate in storage tanks, vessels or systems for any purpose. Leak-checking should never be done with a mixture of Genetron 134a and air, oxygen or other oxidizing materials. Leak-checking can be performed safely with a mixture of Genetron 134a and nitrogen.

Thermal Stability

It is important to avoid exposing Genetron 134a to very high temperatures. When exposed to high temperatures, such as those found in flames, Genetron 134a vapors will decompose. This may produce toxic and irritating compounds. Pungent odors released will irritate the nose and throat and generally force evacuation of the area.

Genetron 134a is stable under normal operating conditions. Contact with certain red-hot metals may result in exothermic reactions and yield toxic and/or corrosive decomposition products. Specific materials to avoid include abraded aluminum surfaces and active metals such as sodium, potassium, calcium, powdered aluminum, magnesium and zinc.

Storage and Handling

Genetron® 134a cylinders must be clearly marked and kept in cool, dry and properly ventilated storage areas away from heat, flames, corrosive chemicals, fumes, explosives and otherwise protected from damage. Under no circumstances should anything be put into an empty cylinder. Empty returnable cylinders should be returned to Honeywell or your Genetron Wholesaler. Disposable JugsTM should be disposed of in an environmentally acceptable manner in accordance with applicable laws and regulations.

Keep cylinders of Genetron 134a out of direct sunlight, particularly in warm weather. Genetron 134a liquid expands significantly when heated, thereby reducing the amount of vapor space left in the cylinder. Once the cylinder becomes liquid-full, any further rise in temperature can cause the cylinder pressure relief device to activate potentially resulting in serious personal injury.

Never allow cylinder to get warmer than 125°F (52°C).

Cylinders should always be raised above dirt or damp floors to prevent rusting. This can be done by using a platform or parallel rails. All containers must be secured in place by means of a rack, chain or rope so they cannot tip, roll or accidentally strike each other or any other object. If a cylinder valve is broken off, rapid escape of the high pressure contents will propel the cylinder which could cause 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, assuring that proper design and operation satisfies the required pressure rating and also avoids corrosive external conditions, over-heating or over-filling. 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 134a 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 134a. 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

Leak detectors can be used for pinpointing specific leaks or for monitoring an entire room on a continuous basis. Leak detection is important for refrigerant conservation, equipment protection and performance, reduction of emissions and protection of those coming in contact with the system. No leak testing should be performed with Genetron 134a and air, oxygen or other oxidizing materials in a system.

Types of Detectors

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.

With regard to selectivity, there are three categories of leak detectors: nonselective, halogen-selective or compound- selective. In general, the complexity and cost of a leak detector increases as its specificity increases. Fluorescent dyes approved for use by the equipment manufacturer can be added to systems 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 would 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 150psig in order to perform a leak check. Pressure can be restored for leak checking by adding Genetron® 134a 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 or a mixture of refrigerant and nitrogen, an electronic leak detector can be used. The leak detector must be capable of detecting a hydrofluorocarbon (HFC) refrigerant. Older leak detectors designed for R-22 (or other HCFCs) 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 the 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 134a 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

Commercial Refrigeration

Commercial refrigeration applications where Genetron 134a is a suitable retrofit refrigerant include supermarket cases, walk-in coolers, beverage machines, and water coolers. The use of Genetron® 134a should be limited to applications where the evaporator temperature is above -10°F (-23°C).

Automotive Air-Conditioning Systems

Genetron 134a is a retrofit refrigerant replacing CFC-12 in automobile air-conditioning systems. Many automobile manufacturers are introducing retrofit kits that can utilize Genetron 134a, enabling system conversions.

Commercial Air-Conditioning Systems

Genetron 134a is a viable retrofit fluid for centrifugal chillers running CFC-12. We recommend consulting the original equipment manufacturer before performing any retrofit.

Home Appliances

Genetron 134a can replace CFC-12 in home refrigerators. Consult the original equipment manufacturer before performing any retrofit.

Retrofit Lubricants

Genetron 134a is not a “drop in” replacement for CFC-12. Mineral oils and alkylbenzene lubricants are immiscible with Genetron 134a and must therefore be replaced with either PAG or polyol ester lubricants. Consult the original equipment manufacturer for the recommended lubricants.

Retrofit Procedures

Retrofit procedures have been developed to help technicians perform successful retrofits of CFC-12 systems utilizing positive-displacement (reciprocating, rotary, scroll or screw) compressors with Genetron 134a. However, these procedures should not be used as a substitute for the equipment manufacturer’s specific recommendations.

For further information on retrofitting with Genetron 134a, refer to “Refrigeration Retrofit Guidelines”, G-525-100.

Environmental Considerations

Reclamation

The Clean Air Act Amendments of 1990 require mandatory recycling and reclamation of Genetron 134a during maintenance, service or repair of air-conditioning and refrigeration equipment. Your Genetron Wholesaler offers a refrigerant reclamation program for Genetron 134a.

Waste

Genetron 134a 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.

If discarded unused, Genetron 134a is not considered a "hazardous waste" by the Resource Conservation and Recovery Act (RCRA). Because Genetron 134a is considered to have minimum biodegradability, care should be taken to avoid releases to the environment.

The disposal of Genetron 134a 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.

Packaging

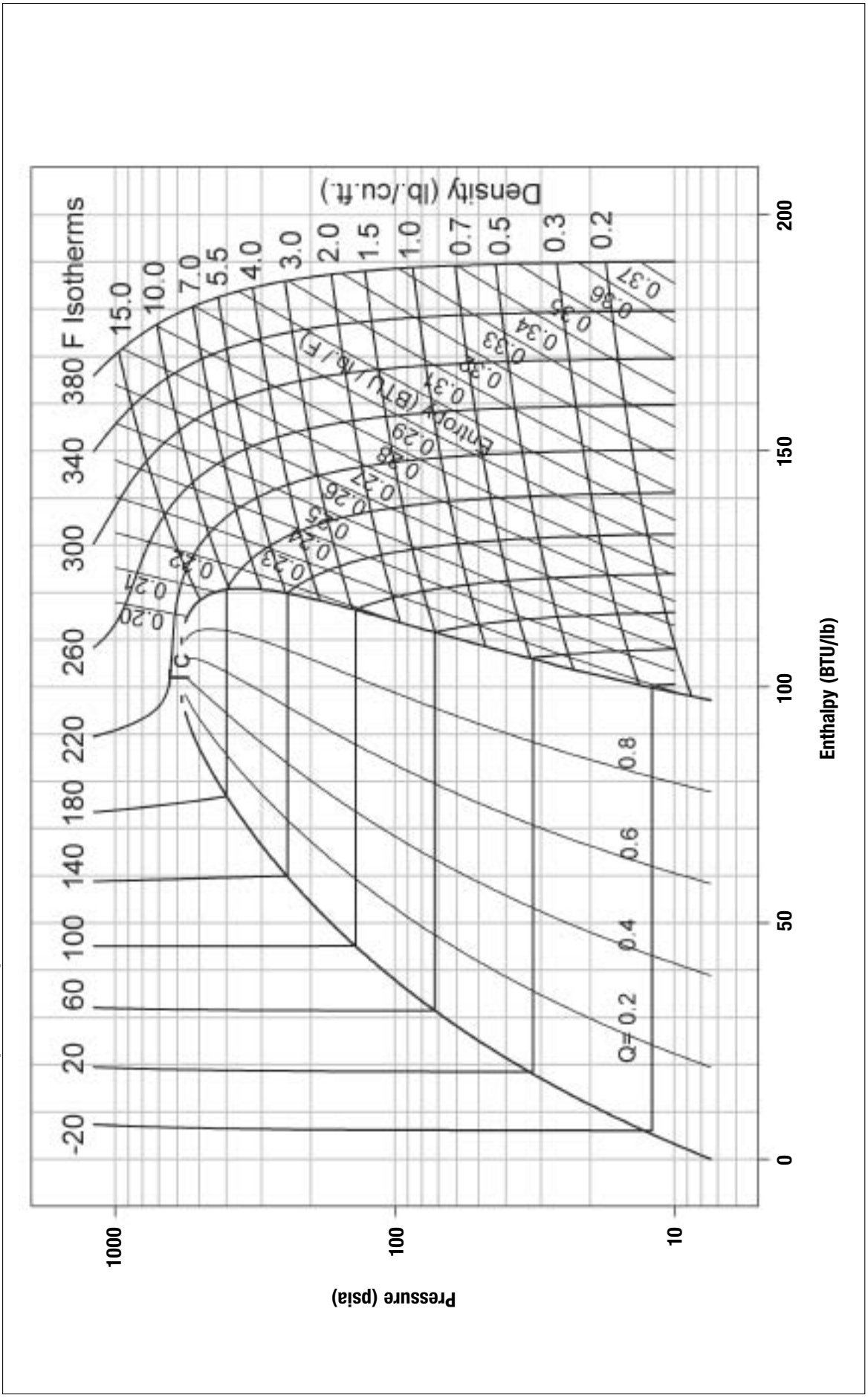
Genetron 134a is available in a variety of containers equipped with standard valve outlets. They include 30-lb non-refillable cylinders, 125-lb. returnable cylinders, one ton (1750-lb.) returnable tanks, bulk tank trailers and isotanks.

In addition, the 30-lb. non-refillable cylinder is available with a 1/2" – 16 ACME (CGA-167) valve outlet specifically designed for automotive air-conditioning service equipment. Please specify the necessary valve when ordering.

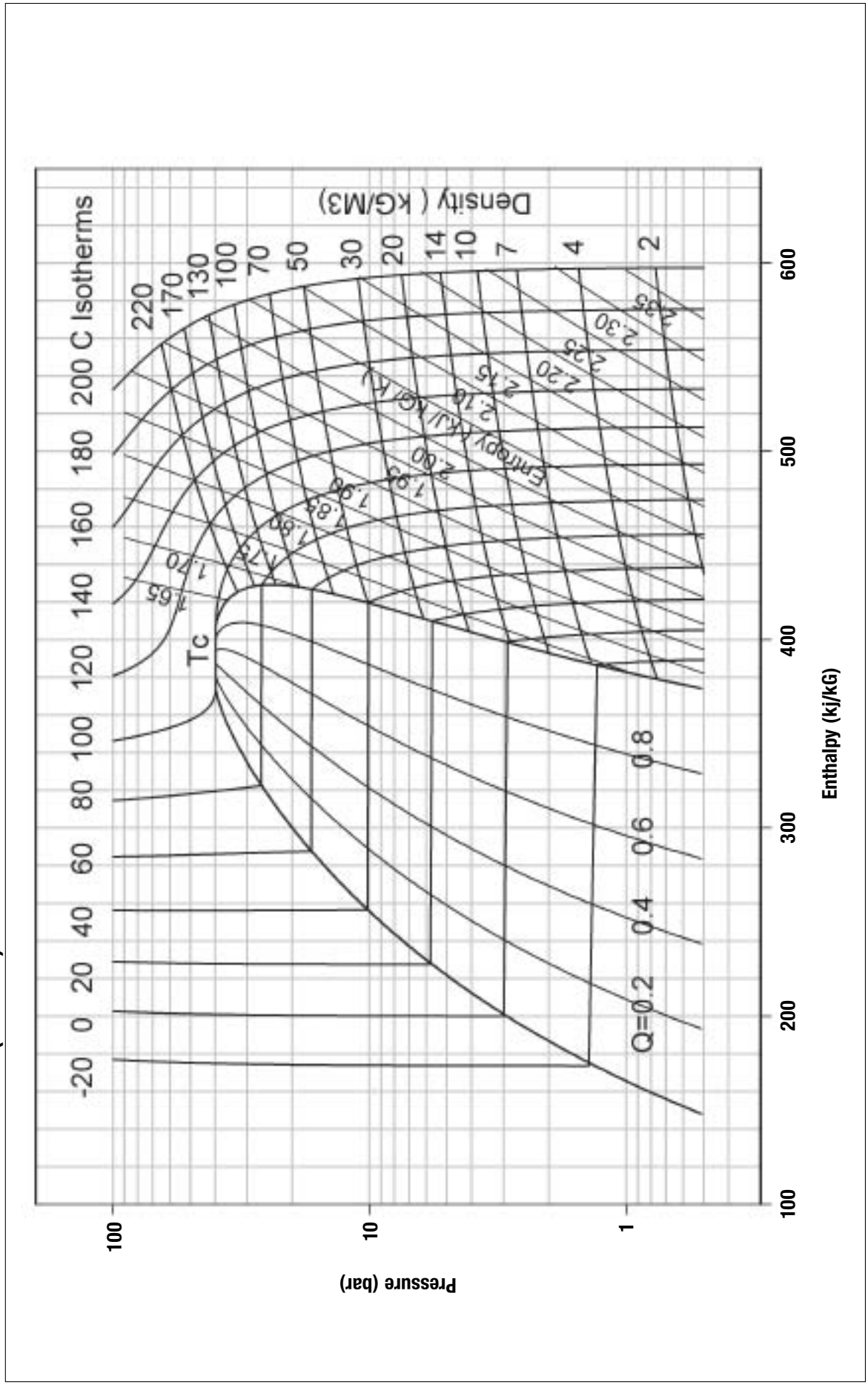
Technical Assistance

Honeywell technical specialists are available to assist customers on all phases of Genetron 134a use. The Genetron refrigerants sales staff can offer plans for safe and effective storage, handling and use of Genetron products. For further information and/or technical assistance on Genetron 134a, please contact any of our worldwide locations. Contact information for your country or region can be found on the back cover.

Genetron®134a Mollier Chart (IP Units)



Genetron®134a Mollier Chart (SI Units)



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
-40.0	7.4	88.50	5.7839	0.00	97.17	97.17	0.0000	0.2315
-38.0	7.9	88.30	5.4778	0.60	96.87	97.47	0.0014	0.2312
-36.0	8.3	88.10	5.1910	1.20	96.57	97.77	0.0028	0.2308
-34.0	8.8	87.90	4.9221	1.80	96.28	98.08	0.0043	0.2304
-32.0	9.3	87.70	4.6698	2.41	95.97	98.38	0.0057	0.2301
-30.0	9.9	87.49	4.4330	3.01	95.67	98.68	0.0071	0.2297
-28.0	10.4	87.29	4.2104	3.62	95.36	98.98	0.0085	0.2294
-26.0	11.0	87.09	4.0013	4.23	95.05	99.28	0.0099	0.2291
-24.0	11.6	86.88	3.8045	4.83	94.75	99.58	0.0113	0.2288
-22.0	12.2	86.67	3.6193	5.44	94.44	99.88	0.0127	0.2285
-20.0	12.9	86.47	3.4449	6.05	94.13	100.18	0.0141	0.2282
-18.0	13.6	86.26	3.2805	6.66	93.82	100.48	0.0154	0.2279
-16.0	14.3	86.05	3.1255	7.27	93.51	100.78	0.0168	0.2276
-14.0	15.0	85.85	2.9793	7.89	93.19	101.08	0.0182	0.2273
-12.0	15.8	85.64	2.8413	8.50	92.88	101.38	0.0196	0.2270
-10.0	16.6	85.43	2.7109	9.12	92.56	101.68	0.0209	0.2268
-8.0	17.5	85.22	2.5877	9.73	92.24	101.97	0.0223	0.2265
-6.0	18.3	85.01	2.4712	10.35	91.92	102.27	0.0237	0.2263
-4.0	19.3	84.79	2.3610	10.97	91.60	102.57	0.0250	0.2260
-2.0	20.2	84.58	2.2567	11.59	91.27	102.86	0.0264	0.2258
0.0	21.2	84.37	2.1579	12.21	90.95	103.16	0.0277	0.2256
2.0	22.2	84.15	2.0643	12.83	90.62	103.45	0.0291	0.2253
4.0	23.2	83.94	1.9756	13.45	90.29	103.74	0.0304	0.2251
6.0	24.3	83.72	1.8914	14.08	89.95	104.03	0.0317	0.2249
8.0	25.5	83.51	1.8116	14.70	89.63	104.33	0.0331	0.2247
10.0	26.6	83.29	1.7357	15.33	89.29	104.62	0.0344	0.2245
12.0	27.8	83.07	1.6637	15.96	88.95	104.91	0.0357	0.2243
14.0	29.1	82.85	1.5953	16.59	88.61	105.20	0.0371	0.2241
16.0	30.4	82.63	1.5302	17.22	88.26	105.48	0.0384	0.2239
18.0	31.7	82.41	1.4683	17.85	87.92	105.77	0.0397	0.2238
20.0	33.1	82.19	1.4094	18.48	87.58	106.06	0.0410	0.2236
22.0	34.6	81.96	1.3534	19.12	87.22	106.34	0.0423	0.2234
24.0	36.0	81.74	1.3000	19.75	86.88	106.63	0.0436	0.2232
26.0	37.6	81.51	1.2491	20.39	86.52	106.91	0.0449	0.2231
28.0	39.2	81.29	1.2006	21.03	86.16	107.19	0.0462	0.2229
30.0	40.8	81.06	1.1543	21.67	85.80	107.47	0.0476	0.2228
32.0	42.5	80.83	1.1102	22.31	85.44	107.75	0.0489	0.2226
34.0	44.2	80.60	1.0681	22.95	85.08	108.03	0.0501	0.2225
36.0	46.0	80.37	1.0279	23.60	84.71	108.31	0.0514	0.2223
38.0	47.8	80.14	0.9895	24.24	84.34	108.58	0.0527	0.2222
40.0	49.7	79.90	0.9528	24.89	83.97	108.86	0.0540	0.2221
42.0	51.7	79.67	0.9177	25.54	83.59	109.13	0.0553	0.2219
44.0	53.7	79.43	0.8842	26.19	83.21	109.40	0.0566	0.2218
46.0	55.8	79.20	0.8521	26.84	82.83	109.67	0.0579	0.2217
48.0	57.9	78.96	0.8214	27.49	82.45	109.94	0.0592	0.2216
50.0	60.1	78.72	0.7920	28.15	82.06	110.21	0.0604	0.2214
52.0	62.4	78.48	0.7638	28.81	81.66	110.47	0.0617	0.2213
54.0	64.7	78.24	0.7369	29.47	81.27	110.74	0.0630	0.2212
56.0	67.1	77.99	0.7110	30.13	80.87	111.00	0.0643	0.2211
58.0	69.6	77.75	0.6862	30.79	80.47	111.26	0.0655	0.2210
60.0	72.1	77.50	0.6625	31.45	80.07	111.52	0.0668	0.2209
62.0	74.7	77.25	0.6397	32.12	79.66	111.78	0.0681	0.2208
64.0	77.4	77.00	0.6178	32.79	79.25	112.04	0.0693	0.2207
66.0	80.1	76.75	0.5968	33.45	78.84	112.29	0.0706	0.2206
68.0	82.9	76.49	0.5766	34.13	78.41	112.54	0.0719	0.2205

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
70.0	85.8	76.24	0.5572	34.80	78.00	112.80	0.0731	0.2204
72.0	88.8	75.98	0.5386	35.47	77.57	113.04	0.0744	0.2203
74.0	91.8	75.72	0.5207	36.15	77.14	113.29	0.0756	0.2202
76.0	94.9	75.46	0.5035	36.83	76.71	113.54	0.0769	0.2201
78.0	98.1	75.20	0.4870	37.51	76.27	113.78	0.0781	0.2200
80.0	101.4	74.94	0.4710	38.20	75.82	114.02	0.0794	0.2199
82.0	104.7	74.67	0.4557	38.88	75.38	114.26	0.0806	0.2198
84.0	108.2	74.40	0.4410	39.57	74.92	114.49	0.0819	0.2197
86.0	111.7	74.13	0.4268	40.26	74.47	114.73	0.0831	0.2196
88.0	115.3	73.86	0.4131	40.95	74.01	114.96	0.0844	0.2195
90.0	119.0	73.58	0.3999	41.65	73.54	115.19	0.0856	0.2194
92.0	122.8	73.31	0.3872	42.34	73.07	115.41	0.0869	0.2193
94.0	126.7	73.03	0.3749	43.04	72.60	115.64	0.0881	0.2193
96.0	130.6	72.74	0.3631	43.74	72.12	115.86	0.0894	0.2192
98.0	134.7	72.46	0.3517	44.45	71.62	116.07	0.0906	0.2191
100.0	138.9	72.17	0.3407	45.15	71.14	116.29	0.0919	0.2190
102.0	143.1	71.88	0.3301	45.86	70.64	116.50	0.0931	0.2189
104.0	147.4	71.59	0.3198	46.58	70.13	116.71	0.0944	0.2188
106.0	151.9	71.29	0.3099	47.29	69.63	116.92	0.0956	0.2187
108.0	156.4	70.99	0.3004	48.01	69.11	117.12	0.0969	0.2186
110.0	161.1	70.69	0.2911	48.73	68.59	117.32	0.0981	0.2185
112.0	165.8	70.39	0.2822	49.45	68.06	117.51	0.0994	0.2184
114.0	170.7	70.08	0.2735	50.18	67.52	117.70	0.1006	0.2183
116.0	175.6	69.77	0.2652	50.91	66.98	117.89	0.1019	0.2182
118.0	180.7	69.45	0.2571	51.65	66.43	118.08	0.1031	0.2181
120.0	185.9	69.14	0.2493	52.38	65.88	118.26	0.1044	0.2180
122.0	191.1	68.81	0.2417	53.12	65.31	118.43	0.1056	0.2179
124.0	196.5	68.49	0.2344	53.87	64.74	118.61	0.1069	0.2178
126.0	202.0	68.16	0.2273	54.61	64.16	118.77	0.1081	0.2177
128.0	207.7	67.83	0.2204	55.36	63.58	118.94	0.1094	0.2175
130.0	213.4	67.49	0.2137	56.12	62.97	119.09	0.1106	0.2174
132.0	219.3	67.15	0.2073	56.88	62.37	119.25	0.1119	0.2173
134.0	225.2	66.80	0.2010	57.64	61.76	119.40	0.1131	0.2172
136.0	231.3	66.45	0.1949	58.41	61.13	119.54	0.1144	0.2170
138.0	237.6	66.09	0.1890	59.18	60.50	119.68	0.1157	0.2169
140.0	243.9	65.73	0.1833	59.95	59.86	119.81	0.1169	0.2167
142.0	250.4	65.36	0.1778	60.73	59.20	119.93	0.1182	0.2166
144.0	257.0	64.99	0.1724	61.52	58.53	120.05	0.1195	0.2164
146.0	263.7	64.61	0.1671	62.31	57.85	120.16	0.1207	0.2163
148.0	270.6	64.22	0.1620	63.11	57.16	120.27	0.1220	0.2161
150.0	277.6	63.83	0.1571	63.91	56.46	120.37	0.1233	0.2159

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
-40.0	51	1418	0.3611	148.14	225.86	374.00	0.7956	1.7643
-39.0	54	1415	0.3438	149.40	225.24	374.64	0.8010	1.7629
-38.0	57	1412	0.3276	150.66	224.61	375.27	0.8063	1.7615
-37.0	60	1409	0.3122	151.92	223.98	375.90	0.8117	1.7602
-36.0	63	1406	0.2977	153.18	223.36	376.54	0.8170	1.7588
-35.0	66	1403	0.2840	154.44	222.73	377.17	0.8223	1.7575
-34.0	70	1400	0.2711	155.71	222.09	377.80	0.8276	1.7563
-33.0	73	1397	0.2589	156.98	221.45	378.43	0.8329	1.7550
-32.0	77	1394	0.2473	158.25	220.81	379.06	0.8381	1.7538
-31.0	80	1391	0.2363	159.52	220.17	379.69	0.8434	1.7526
-30.0	84	1388	0.2259	160.79	219.53	380.32	0.8486	1.7515
-29.0	88	1385	0.2161	162.07	218.88	380.95	0.8538	1.7503
-28.0	93	1382	0.2068	163.34	218.23	381.57	0.8591	1.7492
-27.0	97	1379	0.1980	164.62	217.58	382.20	0.8642	1.7482
-26.0	102	1376	0.1896	165.90	216.92	382.82	0.8694	1.7471
-25.0	106	1373	0.1816	167.19	216.26	383.45	0.8746	1.7461
-24.0	111	1370	0.1741	168.47	215.60	384.07	0.8798	1.7451
-23.0	116	1367	0.1669	169.76	214.93	384.69	0.8849	1.7441
-22.0	122	1364	0.1601	171.05	214.27	385.32	0.8900	1.7432
-21.0	127	1361	0.1536	172.34	213.60	385.94	0.8951	1.7422
-20.0	133	1358	0.1474	173.64	212.91	386.55	0.9002	1.7413
-19.0	139	1355	0.1415	174.93	212.24	387.17	0.9053	1.7404
-18.0	145	1352	0.1359	176.23	211.56	387.79	0.9104	1.7396
-17.0	151	1349	0.1306	177.53	210.87	388.40	0.9155	1.7387
-16.0	157	1346	0.1255	178.83	210.19	389.02	0.9205	1.7379
-15.0	164	1343	0.1207	180.14	209.49	389.63	0.9256	1.7371
-14.0	171	1340	0.1161	181.44	208.80	390.24	0.9306	1.7363
-13.0	178	1337	0.1117	182.75	208.10	390.85	0.9356	1.7355
-12.0	185	1333	0.1074	184.07	207.39	391.46	0.9407	1.7348
-11.0	193	1330	0.1034	185.38	206.68	392.06	0.9457	1.7341
-10.0	201	1327	0.0996	186.70	205.96	392.66	0.9506	1.7334
-9.0	209	1324	0.0959	188.02	205.25	393.27	0.9556	1.7327
-8.0	217	1321	0.0924	189.34	204.53	393.87	0.9606	1.7320
-7.0	225	1318	0.0891	190.66	203.81	394.47	0.9656	1.7313
-6.0	234	1314	0.0859	191.99	203.07	395.06	0.9705	1.7307
-5.0	243	1311	0.0828	193.32	202.34	395.66	0.9754	1.7300
-4.0	253	1308	0.0799	194.65	201.60	396.25	0.9804	1.7294
-3.0	262	1305	0.0771	195.98	200.86	396.84	0.9853	1.7288
-2.0	272	1301	0.0744	197.32	200.11	397.43	0.9902	1.7282
-1.0	282	1298	0.0718	198.66	199.36	398.02	0.9951	1.7276
0.0	293	1295	0.0693	200.00	198.60	398.60	1.0000	1.7271
1.0	304	1291	0.0669	201.34	197.85	399.19	1.0049	1.7265
2.0	315	1288	0.0647	202.69	197.08	399.77	1.0098	1.7260
3.0	326	1285	0.0625	204.04	196.30	400.34	1.0146	1.7255
4.0	338	1281	0.0604	205.40	195.52	400.92	1.0195	1.7250
5.0	350	1278	0.0584	206.75	194.74	401.49	1.0243	1.7245
6.0	362	1275	0.0564	208.11	193.95	402.06	1.0292	1.7240
7.0	375	1271	0.0546	209.47	193.16	402.63	1.0340	1.7235
8.0	388	1268	0.0528	210.84	192.36	403.20	1.0388	1.7230
9.0	401	1264	0.0511	212.21	191.55	403.76	1.0437	1.7226
10.0	415	1261	0.0494	213.58	190.74	404.32	1.0485	1.7221
11.0	429	1257	0.0479	214.95	189.93	404.88	1.0533	1.7217
12.0	443	1254	0.0463	216.33	189.10	405.43	1.0581	1.7212
13.0	458	1250	0.0449	217.71	188.27	405.98	1.0629	1.7208
14.0	473	1247	0.0435	219.09	187.44	406.53	1.0677	1.7204

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
15.0	488	1243	0.0421	220.48	186.59	407.07	1.0724	1.7200
16.0	504	1240	0.0408	221.87	185.74	407.61	1.0772	1.7196
17.0	521	1236	0.0395	223.26	184.89	408.15	1.0820	1.7192
18.0	537	1233	0.0383	224.66	184.03	408.69	1.0867	1.7188
19.0	554	1229	0.0371	226.06	183.16	409.22	1.0915	1.7184
20.0	572	1225	0.0360	227.47	182.28	409.75	1.0962	1.7180
21.0	590	1222	0.0349	228.88	181.39	410.27	1.1010	1.7177
22.0	608	1218	0.0339	230.29	180.50	410.79	1.1057	1.7173
23.0	627	1214	0.0328	231.70	179.61	411.31	1.1105	1.7169
24.0	646	1210	0.0319	233.12	178.70	411.82	1.1152	1.7166
25.0	665	1207	0.0309	234.55	177.78	412.33	1.1199	1.7162
26.0	685	1203	0.0300	235.97	176.87	412.84	1.1246	1.7159
27.0	706	1199	0.0291	237.40	175.94	413.34	1.1294	1.7155
28.0	727	1195	0.0283	238.84	175.00	413.84	1.1341	1.7152
29.0	748	1191	0.0274	240.28	174.05	414.33	1.1388	1.7148
30.0	770	1187	0.0266	241.72	173.10	414.82	1.1435	1.7145
31.0	793	1184	0.0259	243.17	172.13	415.30	1.1482	1.7142
32.0	815	1180	0.0251	244.62	171.16	415.78	1.1529	1.7138
33.0	839	1176	0.0244	246.08	170.18	416.26	1.1576	1.7135
34.0	863	1172	0.0237	247.54	169.18	416.72	1.1623	1.7131
35.0	887	1168	0.0230	249.01	168.18	417.19	1.1670	1.7128
36.0	912	1163	0.0224	250.48	167.17	417.65	1.1717	1.7124
37.0	937	1159	0.0218	251.95	166.15	418.10	1.1764	1.7121
38.0	963	1155	0.0211	253.43	165.12	418.55	1.1811	1.7118
39.0	990	1151	0.0205	254.92	164.07	418.99	1.1858	1.7114
40.0	1017	1147	0.0200	256.41	163.02	419.43	1.1905	1.7111
41.0	1044	1142	0.0194	257.91	161.95	419.86	1.1952	1.7107
42.0	1072	1138	0.0189	259.41	160.87	420.28	1.1999	1.7103
43.0	1101	1134	0.0183	260.91	159.79	420.70	1.2046	1.7100
44.0	1130	1129	0.0178	262.43	158.68	421.11	1.2092	1.7096
45.0	1160	1125	0.0173	263.94	157.58	421.52	1.2139	1.7092
46.0	1190	1121	0.0169	265.47	156.45	421.92	1.2186	1.7089
47.0	1221	1116	0.0164	267.00	155.31	422.31	1.2233	1.7085
48.0	1253	1112	0.0160	268.53	154.16	422.69	1.2280	1.7081
49.0	1285	1107	0.0155	270.07	153.00	423.07	1.2327	1.7077
50.0	1318	1102	0.0151	271.62	151.82	423.44	1.2375	1.7072
51.0	1351	1098	0.0147	273.18	150.62	423.80	1.2422	1.7068
52.0	1385	1093	0.0143	274.74	149.41	424.15	1.2469	1.7064
53.0	1420	1088	0.0139	276.31	148.18	424.49	1.2516	1.7059
54.0	1455	1083	0.0135	277.89	146.94	424.83	1.2563	1.7055
55.0	1492	1078	0.0131	279.47	145.68	425.15	1.2611	1.7050
56.0	1528	1073	0.0128	281.06	144.41	425.47	1.2658	1.7045
57.0	1566	1068	0.0124	282.66	143.11	425.77	1.2705	1.7040
58.0	1604	1063	0.0121	284.27	141.80	426.07	1.2753	1.7035
59.0	1642	1058	0.0118	285.88	140.48	426.36	1.2801	1.7030
60.0	1682	1053	0.0114	287.50	139.13	426.63	1.2848	1.7024
61.0	1722	1048	0.0111	289.14	137.75	426.89	1.2896	1.7019
62.0	1763	1042	0.0108	290.78	136.36	427.14	1.2944	1.7013
63.0	1804	1037	0.0105	292.43	134.95	427.38	1.2992	1.7006
64.0	1847	1031	0.0102	294.09	133.52	427.61	1.3040	1.7000
65.0	1890	1026	0.0100	295.76	132.06	427.82	1.3088	1.6993
66.0	1934	1020	0.0097	297.44	130.58	428.02	1.3137	1.6987

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Belgium
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Printed in U.S.A.
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