Honeywell Genetron® 407C

Properties, Uses, Storage, and Handling

Honeywell

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Introduction

Honeywell's Genetron® 407C (a ternary blend of HFC-32/HFC-125/HFC-134a, assigned R-407C by ASHRAE) serves as a non-ozone-depleting replacement for HCFC-22 in various air-conditioning applications, as well as in most refrigeration systems.

Since Genetron® 407C is a close match to HCFC-22, it also serves as a retrofit fluid in applications where HCFC-22 is generally used.

Applications

Unitary Air Conditioning

Genetron® 407C can serve as a non-ozone-depleting replacement for HCFC-22 in residential and light commercial air-conditioning systems. It has a capacity comparable to HCFC-22 making it easier to use in existing equipment designs. Some equipment modifications will be required when retrofitting these systems to Genetron® 407C.

Chillers

Genetron® 407C can serve as a replacement for HCFC-22 in positive displacement chillers without flooded heat-exchangers. Because Genetron® 407C is a blend with a temperature glide, it is not recommended for use in chillers with a flooded evaporator.

Commercial Refrigeration

Genetron® 407C may be used to replace HCFC-22 in existing medium-temperature commercial refrigeration systems, including supermarket display cases and reach-in coolers.

Physical Properties

Chemical Name	Difluoromethane/Pentafluoroethane/ Tetrafluoroethane	
Molecular Formula	$CH_2F_2/CHF_2CF_3/CH_2FCF_3$	
Appearance		Colorless
Molecular Weight		86.2
Bubble Point Temperature	@ 1 ATM	-46.5°F
	@ 101.3 kPa	-43.6°C
Dew Point Temperature	@ 1 ATM	-33.9°F
	@ 101.3 kPa	-36.6°C
Bubble Point Pressure†		172.6 (Psia)
		1190 (kPa)
Dew Point Pressure†		147.9 (Psia)
		1020 (kPa)
Critical Temperature**		186.86°F
		86.034°C
Critical Pressure**		671.49 (Psia)
		4629.8 (kPa)
Critical Volume**		0.0331 (ft^3/lb)
		0.0021 (m^3/kg)
Critical Density**		30.23 (lb/ft^3)
		484.23 (kg/m^3)
Vapor Density	@ 1 ATM	0.289 (lb/ft^3)
	@101.3 kPa	4.630 (kg/m^3)
Liquid Density†		71.01 (lb/ft^3)
		1137 (kg/m^3)
Liquid Heat Capacity at constant pressure†		0.37 (Btu/lb °F)
		1.54 (KJ/kg K)
Vapor Heat Capacity at constant pressure†		0.20 (Btu/lb °F)
		0.837 (KJ/kg K)
Heat of Vaporization	@ 1 ATM	107.16 (Btu/lb)
at boiling point	@101.3 kPa	249.08 (KJ/kg)
Liquid Thermal Conductivity†		0.0472 (Btu/hr ft °F)
		81.7 (mW/m°K)
Vapor Thermal Conductivity†		0.0083 (Btu/hr ft °F)
		14.3 (mW/m °K)
Liquid Viscosity†		0.3281 (lb_m/ft hr)
		135.58 (µPa sec)
Vapor Viscosity†		0.0310 (lb_m/ft hr)
		12.82 a (µPa sec)
Flammability Limits in Air (vol%)		None *
Ozone Depletion Potential (ODP)		0.00
ASHRAE Safety Group Classification		A1

* Based on ASHRAE Standard 34 with match ignition.
** Based on NIST Refprop 7.
† All data are at 77°F (25°C) unless otherwise noted.

Specifications

Assay (Min. Wt. % of HFC-32/125/134a):	99.7%
Moisture (Max. Wt. %):	0.0010
High-boiling Residue (Max. Vol. %):	0.01
Chloride (Max. Wt. %):	0.0001
Total Acidity (Max. Wt. %):	0.0001
Non-condensibles in vapor phase (Max. Vol. %):	1.5

Servicing Considerations

Genetron® 407C is a ternary blend of HFC-32/HFC-125/HFC-134a. This product can generally be used to successfully retrofit existing HCFC-22 systems.

Unlike pure fluids and azeotropes, blends boil and condense at varying temperatures for a given pressure. The range over which the temperature varies is referred to as temperature glide. Genetron® 407C has moderately high temperature glides between about 9°F and 13°F, depending upon pressure.

When dealing with blends, pressure-temperature tables are presented in an unconventional manner. Two pressures are listed for each temperature: the dew pressure and the bubble pressure. The dew pressure is used for determining the system pressure when the refrigerant is in a saturated vapor or superheated condition (i.e., on the suction and discharge sides of the compressor). The bubble pressure is used for determining the system pressure when the refrigerant is in a saturated liquid or subcooled condition (i.e., at the inlet to the expansion valve or capillary tube).

Genetron® 407C must be the only liquid charged into a system to ensure proper refrigerant composition and system performance. (See Retrofit Procedures for more information.)

If a significant leak develops in a system containing Genetron® 407C and a noticeable change in system performance occurs, recover the remaining charge and re-charge the system to ensure that the proper composition is in the system.

Materials Compatibility

Compatibility with Metals

Genetron® 407C is compatible with copper, steel and aluminum as determined using the ASHRAE 97 sealed tube method. The method comprised sealing the refrigerant and metals into glass tubes, which were put in an oven at 200°C for one week. After one week, there were no visual changes in the contents of the tubes. The amount of fluoride generated in the tubes was barely above the background level. The conclusion of the study is that Genetron® 407C is stable in the presence of metals over the normal operating temperature range.

Pressure vs. Temperature

Temp. (°F)	Temp. (°C)	Bubble Pressure (psig)	Dew Pressure (psig)	Temp. (°C)	Bubble Pressure bar-gauge	Dew Pressure bar-gauge
-40	-40.0	2.7	4.6 *	-40	0.2	-0.2
-35	-37.2	5.1	0.9 *	-38	0.3	-0.1
-30	-34.4	7.7	1.6	-36	0.4	0.0
-25	-31.7	10.6	3.9	-34	0.6	0.1
-20	-28.9	13.7	6.5	-32	0.7	0.2
-15	-26.1	17.2	9.3	-30	0.9	0.4
-10	-23.3	20.9	12.3	-28	1.0	0.5
-5	-20.6	25	15.7	-26	1.2	0.6
0	-17.8	29.5	19.4	-24	1.4	0.8
5	-15.0	34.3	23.5	-22	1.6	1.0
10	-12.2	39.5	27.9	-20	1.8	1.1
15	-9.4	45.2	32.7	-18	2.0	1.3
20	-6.7	51.2	37.9	-16	2.2	1.5
25	-3.9	57.7	43.5	-14	2.5	1.7
30	-1.1	64.7	49.6	-12	2.8	1.9
35	1.7	72.2	56.1	-10	3.0	2.2
40	4.4	80.2	63.2	-8	3.3	2.4
45	7.2	88.8	70.7	-6	3.6	2.7
50	10.0	97.9	78.8	-4	4.0	3.0
55	12.8	107.6	87.5	-2	4.3	3.3
60	15.6	117.9	96.8	0	4.7	3.6
65	18.3	128.9	106.7	2	5.0	3.9
70	21.1	140.5	117.3	4	5.4	4.3
75	23.9	152.8	128.5	6	5.9	4.6
80	26.7	165.8	140.5	8	6.3	5.0
85	29.4	179.6	153.2	10	6.7	5.4
90	32.2	194.1	166.7	12	7.2	5.9
95	35.0	209.4	181	14	7.7	6.3
100	37.8	225.5	196.1	16	8.2	6.8
105	40.6	242.4	212.1	18	8.8	7.3
110	43.3	260.3	229	20	9.4	7.8
115	46.1	279	246.9	22	10.0	8.3
120	48.9	298.6	265.8	24	10.6	8.9
125	51.7	319.2	285.7	26	11.2	9.5
130	54.4	340.7	306.6	28	11.9	10.1
135	57.2	363.3	328.8	30	12.6	10.7
140	60.0	387	352.1	32	13.3	11.4
145	62.8	411.7	376.6	34	14.0	12.1
150	65.6	437.5	402.5	36	14.8	12.8
				38	15.6	13.6
				40	16.5	14.4
				42	17.3	15.2
				44	18.2	16.1
				46	19.2	17.0
				48	20.1	17.9
				50	21.1	18.9
				52	22.2	19.9
				54	23.2	20.9
				56	24.4	22.0
				58	25.5	23.1
				60	26.7	24.3
				62	27.9	25.5
				64	29.2	26.7
				66	30.5	28.0
				68	31.8	29.4

Chlorinated Materials and Refrigerants

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

The following are three situations in which Genetron® 407C and its associated lubricant might come into contact with chlorinated materials and refrigerants:

– A chlorinated solvent is used to clean or flush the system

– An HCFC-22 system is retrofitted with Genetron® 407C

– HCFC-22 or another chlorinated refrigerant is accidentally charged into a system that contains Genetron® 407C

Desiccants

Several desiccant driers compatible with Genetron® 407C are commercially available. Individual drier manufacturers should be contacted for specific recommendations.

Compatibility with Plastics and Elastomers

The table to the right is a summary of materials compatibility data resulting from tests performed by Honeywell and several world-wide industry organizations. This data should be used only as a guide to the compatibility of materials with Genetron® 407C. When retrofitting existing systems to Genetron® 407C, Honeywell recommends that service technicians consult with original equipment manufacturers for their approved replacement parts. 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.

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

Lubricants

Honeywell recommends the use of lubricants having appropriate miscibility with Genetron® 407C, such as polyol ester lubricants. Many are commercially available and have been approved for use with Genetron® 407C by leading compressor manufacturers. Contact the lubricant manufacturers for their specific recommendations.

The miscibility of Genetron® 407C with two different polyol ester lubricants is shown in the table.

Miscibility of Genetron® 407C with two commercially available lubricants

Lubricant	Miscibility Limit	90% Genetron 407C 10% Polyol Ester	50% Genetron 407C 50% Polyol Ester	10% Genetron 407C 90% Polyol Ester
Mobil EAL 22	Upper	>140°F > 60°C	>140°F > 60°C	>140°F > 60°C
	Lower	<-14°F <-10°C	<-33°F <-36°C	<-33°F <-36°C
Castrol SW 32	Upper	>140°F > 60°C	>140°F > 60°C	>140°F > 60°C
	Lower	<-33°F <-36°C	<-33°F <-36°C	<-33°F <-36°C

Castrol SW 32 exhibits miscibility over the temperature range studied -33°F to 140°F (-36°C to 60°C). Mobil EAL 22 exhibits miscibility from 14°F to 140°F (-10°C to 60°C).

Summary of Materials Compatibility For Genetron® 407C Compatibility: Plastics and Elastomers

Material	Genetron® 407C
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

Safety & Toxicity

Honeywell recommends reading the MSDS before using Genetron® 407C.

Toxicity

Genetron® 407C can be safely used in all of its intended applications when handled in accordance with the Material Safety Data Sheet (MSDS). This is based on data developed by the Program for Alternative Fluorocarbon Toxicity Testing (PAFTs I, III, and V), an international consortium of which Honeywell is a charter member. This conclusion was reached after review of all toxicity results, which confirmed the intrinsically low toxicity of the substance. Honeywell recommends reading the MSDS before using Genetron® 407C.

Inhalation

Honeywell has established a PEL (permissible exposure limit) for an eight-hour day, 40-hour work-week of 1000 ppm for Genetron® 407C. 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 and only in situations of emergency life support. Treatment of overexposure to Genetron® 407C should be directed at the control of symptoms.

When concentrations of Genetron® 407C reach levels which reduce oxygen to 14–16% by displacement, symptoms of asphyxiation will occur. An individual exposed to high concentrations of Genetron® 407C must be given medical attention immediately. Adequate ventilation must be provided at all times.

Skin and Eye Contact

Genetron® 407C 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 of the chemical is removed. If there is evidence of frostbite, soak 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® 407C vapor occurs, the area should be evacuated immediately. Protected personnel should de-energize or remove any ignition sources and address the leak, if without risk. Vapors may concentrate near the floor, displacing available oxygen. Once the area is evacuated, it must be ventilated 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 to be safe. Leak-checking should never be done with a mixture of Genetron® 407C and air, oxygen or other oxidizing materials. Leak-checking can be performed safely using a mixture of Genetron® 407C and nitrogen.

Flammability

According to ASHRAE Standard 34, Genetron® 407C is classified in safety group A1, i.e., it is non-flammable at 1 atmosphere 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® 407C. It has no flame limits, and DOT considers it non-flammable (Green Label).

Since Genetron® 407C 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® 407C or any other similar product.

Combustibility

There is the potential for combustibility when Genetron® 407C is mixed with air. Because of this combustibility potential at pressures above atmospheric, Genetron® 407C and air should never be mixed in tanks or supply lines, or allowed to accumulate in storage tanks. Leak-checking should never be done with a mixture of Genetron® 407C and air. Leak-checking can be performed safely with a mixture of Genetron® 407C and nitrogen.

Thermal Stability

It is important to avoid exposing Genetron® 407C to very high temperatures. When exposed to high temperatures, such as those found in flames, Genetron® 407C 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® 407C 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 abraded aluminum surfaces and active metals such as sodium, potassium, calcium, powdered aluminum, magnesium and zinc.

Packaging

Genetron® 407C is available in a variety of containers. They include 25-lb disposable Jugs™, 115-lb returnable cylinders and one ton (1,600 lbs.) returnable tanks. In addition, bulk shipments can be made in tank trailers and isotanks.

Storage and Handling

Bulk and Cylinder

Some special handling and storage procedures are required for

Genetron® 407C to minimize or prevent liquid compositional changes, particularly those occurring during liquid level depletion or vapor leaks from the storage container. Because these procedures and/or systems are sometimes site specific, contact a Honeywell Technical Service Representative to discuss each application.

Among the most important handling practices that must be followed for Genetron® 407C is to ensure that all transfers be executed by using liquid flow instead of vapor flow. This practice will help minimize compositional changes in the liquid phase and, as a result, provide a more consistent product.

Genetron® 407C 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. Under no circumstances should anything be put into an empty cylinder. Once empty, properly close the cylinder valve and replace the valve cap. Return empty cylinders to your Genetron® Wholesaler.

Disposable Jugs™ should be discarded in an environmentally safe manner in accordance with all laws and regulations.

Cylinders of Genetron® 407C should be kept out of direct sunlight, especially in warm weather. Liquid Genetron® 407C 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 severe 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® 407C 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® 407C. 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 specific leaks or for monitoring an entire room on a continual basis. Leak 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 with mixtures of air and Genetron® 407C. Make sure the leak detector is capable of detecting Genetron® 407C before using.

Types of Leak Detectors

There are two types of leak detectors – leak pinpointers and area monitors. Before selecting either type, several equipment factors should be considered, including detection limits, sensitivity and selectivity.

With selectivity, there are three categories of leak detectors: non-selective, 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 150 psig in order to perform a leak check. Pressure can be restored for leak checking by adding Genetron® 407C 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 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® 407C 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. For commercial refrigeration applications, 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

As the industry moves away from the use of CFCs and HCFCs, refrigerant service personnel will play a key role in the transition to HFC alternatives through retrofitting. Honeywell has prepared the following guidelines to help service technicians better understand the various technical and operational aspects of performing retrofits on air conditioning or refrigeration systems using Honeywell's Genetron® 407C.

Although the information can be helpful as a general guide, it should not be used as a substitute for the equipment manufacturer's specific recommendations. For this reason, Honeywell recommends contacting the equipment manufacturer for detailed information on retrofitting the specific equipment under consideration. Always refer to the Material Safety Data Sheet (MSDS) for safety information on the use of Genetron® 407C.

Applications

Since Genetron® 407C is a close match to HCFC-22, it also serves as a retrofit fluid in many applications where HCFC-22 is generally used, including unitary air conditioning, positive displacement chillers and commercial refrigeration.

Retrofit

Genetron® 407C can be used successfully as a retrofit fluid but may require some system modifications such as changing the lubricant. Mineral oils and alkylbenzene lubricants that have been used traditionally with HCFC-22 are immiscible with Genetron® 407C and must therefore be replaced with new lubricants. Consult the original equipment manufacturer for recommended lubricants.

Retrofit Procedures

1. Record Baseline Data

Prior to retrofitting, it is desirable to record system performance data to establish the normal operating conditions for the equip-

ment. Data should include temperature and pressure measurements throughout the system, including the evaporator, compressor suction and discharge, condenser and expansion device. These measurements will be useful when adjusting the system to Genetron® 407C during the retrofit.

2. Isolate HCFC-22 Charge

The HCFC-22 charge should be isolated from the rest of the system by pumping it down into the condensing unit or receiver. If no receiver is present, the refrigerant must be removed from the system using a certified recovery machine capable of meeting or exceeding the required levels of evacuation as specified by the U.S. EPA. The charge must be collected in a recovery cylinder.

3. Choose Compressor Lubricant

Mineral oil or alkylbenzenes are typically used as the lubricants for HCFC-22 compressors. A miscible lubricant such as a polyol ester is commonly used.

Honeywell recommends using a lubricant approved by the compressor manufacturer. Differences among the various lubricants make it difficult to assume that they are interchangeable. Check with the compressor manufacturer for the approved viscosity grade and brand of lubricant for the compressor in the system being retrofitted.

4. Drain the Lubricant

Since many small hermetic compressors do not have oil drains, it may be necessary to remove the compressor from the system to drain the lubricant. The suction line of the compressor is the best point to drain the lubricant. Using this procedure, it is possible to drain nearly 95 percent of the lubricant. Small hand-operated pumps are available which permit insertion of a tube into the compressor access port for removal of the mineral oil without removing the compressor from the system. Remember that most of the oil must be removed from the system before adding the replacement lubricant.

For larger systems, the oil should be drained from multiple points in the system. Particular attention should be paid to low spots around the evaporator where lubricant often collects. The oil also should be drained from oil separators and/or suction accumulators.

5. Measuring Existing Lubricant

Measure and record the volume of lubricant removed from the system. Compare this amount with the amount recommended by the manufacturer to ensure that the majority of lubricant has been removed. This volume also will be used as a guide to determine the amount of lubricant to add in the next step.

6. Recharge Compressor with a Miscible Lubricant

Add to the compressor the same volume of miscible lubricant, for example, polyol ester, as the volume of the mineral oil drained in step 5.

7. Reinstall the Compressor

Reinstall the compressor following the standard service practices recommended by the manufacturer.

8. Recharge the HCFC-22

If the system charge was pumped into the receiver, the balance of the system should be evacuated and then the receiver valves opened. If the original charge was collected in a recovery cylinder, the system should be evacuated and then recharged with the original HCFC-22. It may be necessary to “top off” the refrigerant charge to compensate for the small amount lost in draining the lubricant.

9. Run the Compressor

Run the compressor with the new lubricant and the HCFC-22 for at least 5 hours for smaller systems and 24 hours for larger ones. Next, drain the lubricant and recharge with a new charge of lubricant. Check the lubricant that was drained to see if the residual mineral oil content is below 5%. Test kits are available from several lubricant suppliers that check for residual mineral oil content. Generally, it will require about one to three charges to get the mineral oil content down to the acceptable level.

10. Continue to Flush the System

Repeat steps 8 and 9 until the residual mineral oil content is below 5%. The lubricant that was removed from the compressors in the flushing procedure must be disposed of properly.

11. Evaluate the Expansion Device

Honeywell recommends consulting with the equipment manufacturer before retrofitting. Most HCFC-22 systems with either expansion valves or capillary tubes will operate satisfactorily with Genetron® 407C.

12. Replace the Filter Drier

Following system maintenance, a recommended service practice is to replace the filter drier. There are two types of filter driers commonly used in refrigeration equipment -- loose-fill and solid-core.

Contact your wholesaler to obtain a replacement filter drier compatible with Genetron® 407C.

13. Reconnect the System and Evacuate

Use normal service practices to reconnect and evacuate the system. To remove air and other non-condensibles, Honeywell recommends evacuating the system to a full vacuum of 1000 microns or less from both sides of the system. Attempting to evacuate a system with the pump connected to only the low side of the system will not adequately remove moisture and non-condensibles such as air. Use a good electronic gauge to measure

the vacuum. An accurate reading cannot be made with a refrigeration gauge.

14. Check for System Leaks

Check the system for leaks using normal service practices.

15. Charge System with Genetron® 407C

When charging the system with Genetron® 407C, it is important to remember that this product is a blend and not an azeotrope. For this reason, special charging procedures are required to ensure optimal system performance.

It is essential when using Genetron® 407C that the system be liquid-charged by removing only liquid from the cylinder. Never charge the system with vapor from a Genetron® 407C cylinder. Vapor-charging Genetron® 407C may result in the wrong refrigerant composition and could damage the system.

A throttling valve should be used to control the flow of refrigerant to the suction side to prevent slugs from entering the compressor. NOTE: To prevent compressor damage, do not charge liquid into the suction line of the unit.

Systems being charged with Genetron® 407C require a smaller charge size than those using HCFC-22. The charge typically will be about 95 percent by weight of the original HCFC-22 charge.

Honeywell recommends initially charging the system with 85 percent by weight of the original HCFC-22 charge. For an air conditioning application, if the original HCFC-22 charge was 10 pounds, initially charge 8.5 pounds of Genetron® 407C. If the original HCFC-22 charge was 1000 grams, initially charge 850 grams of Genetron® 407C.

16. Check System Operation

Start the system and let conditions stabilize. If the system is undercharged, add additional Genetron® 407C in increments of 5 percent by weight of the original HCFC-22 charge. For example, if the original charge was 10 pounds, charge in increments of 0.5 pounds. If the original charge was 1000 grams, charge in increments of 50 grams. Continue until desired operating conditions are achieved.

Use dew-point pressure as a reference in determining the appropriate saturated temperature for a superheat setting. To determine the saturated temperature for a subcooling calculation, use bubble-point pressure.

Compressor suction pressures for the Genetron® 407C after stabilization should be similar to that of normal system operating pressure with HCFC-22 for most applications. Compressor discharge pressures typically will be higher (5–10%) than normal system operation with HCFC-22.

It may be necessary to reset the high pressure cutout to compensate for the higher discharge pressures of the Genetron® 407C system. This procedure should be done carefully to avoid exceeding the recommended operating limits of the compressor and other system components.

To avoid overcharging, it is best to charge the system by first measuring the operating conditions (including discharge and suction pressures, suction line temperature, compressor amps, super heat) before using the liquid-level sight glass as a guide.

17. Label Components and System

After retrofitting the system with Genetron® 407C, label the system components to identify the type of refrigerant (Genetron® 407C) and specify type of lubricant (by brand name) and viscosity grade in the system. This will help ensure that the proper refrigerant and lubricant will be used to service the equipment in the future.

Retrofit Checklist for Genetron® 407C

1. Record baseline data on original system performance _____
2. Recover HCFC-22 refrigerant charge using appropriate recovery equipment or pump down into receiver. _____
   *Record the amount of HCFC-22 removed. _____
3. Choose compressor lubricant. _____
4. Drain at least 90 percent of the lubricant from the compressor. _____
5. Measure amount of lubricant removed. _____
6. Recharge compressor with polyol ester lubricant. _____
   *Use the same amount that was removed from the existing system. _____
7. Reinstall compressor. _____
8. Recharge the original HCFC-22. _____
9. Run the System. _____
10. Repeat Flushing Procedure (steps 4-9). _____
11. Evaluate expansion device. _____
    Consult equipment manufacturers first. No change is necessary in most cases.
12. Replace filter drier with new drier approved for use with Genetron 407C. _____
13. Reconnect system and evacuate. _____
14. Check system for leaks. _____
    (Re-evaluate system following leak check).
15. Charge system with Genetron 407C. _____
    ALWAYS REMOVE LIQUID ONLY FROM CYLINDER
    Use correct charge size. _____
    *Initial charge 85 percent by weight of original HCFC-22 charge. _____
    *Record amount of refrigerant charged. _____
16. Check system operation. _____
    *Adjust charge to achieve desired operating conditions. _____
    *If low, remove liquid only from cylinder in increments of 5 percent of original HCFC-22 charge _____
17. Label components and system for type of refrigerant, i.e. Genetron 407C and lubricant. _____

Recycling and Reclamation

The Clean Air Act Amendments of 1990 require mandatory recycling and reclamation of Genetron® 407C during maintenance, service or repair of air-conditioning and refrigeration equipment. Your Genetron® Wholesaler offers a refrigeration reclamation program for Genetron® 407C.

For the name of your nearest Genetron® Wholesaler, call 1-800-631-8138.

Environmental Considerations

Genetron® 407C 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® 407C is not considered a "hazardous waste" by the Resource Conservation Recovery Act (RCRA). Because Genetron® 407C is considered to have minimum biodegradability, care should be taken to avoid releases to the environment.

The disposal of Genetron® 407C 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.

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 technical properties. Much of this information is available online at www.genetron®.com. In addition, Honeywell technical specialists are available to assist you in all phases of using Genetron® 407C – especially retrofitting, 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

407C Thermodynamic Table - English Units

Temp. (°F)	Bubble Pressure (Liquid) (psia)	Dew Pressure (Vapor) (psia)	Vapor Volume (ft³/lb)	Liquid Density (lb/ft³)	Liquid Enthalpy (Btu/lb)	Enthalpy Δ H (Btu/lb)	Vapor Enthalpy (Btu/lb)	Liquid Entropy (Btu/lb-F)	Vapor Entropy (Btu/lb-F)
-40	17.4	12.4	4.0515	85.50	0.00	104.25	104.25	0.0000	0.2524
-38	18.4	13.1	3.8437	85.28	0.63	103.90	104.53	0.0015	0.2518
-36	19.3	13.9	3.6486	85.06	1.26	103.55	104.81	0.0030	0.2512
-34	20.3	14.7	3.4653	84.85	1.90	103.19	105.09	0.0045	0.2507
-32	21.3	15.5	3.2931	84.63	2.53	102.84	105.37	0.0060	0.2501
-30	22.4	16.3	3.1311	84.41	3.17	102.47	105.64	0.0074	0.2496
-28	23.5	17.2	2.9786	84.19	3.80	102.12	105.92	0.0089	0.2491
-26	24.7	18.1	2.835	83.97	4.44	101.76	106.20	0.0104	0.2485
-24	25.9	19.1	2.6997	83.75	5.08	101.39	106.47	0.0118	0.2480
-22	27.1	20.1	2.5722	83.53	5.72	101.02	106.74	0.0133	0.2475
-20	28.4	21.2	2.4519	83.31	6.36	100.65	107.01	0.0147	0.2471
-18	29.8	22.2	2.3383	83.09	7.00	100.28	107.28	0.0162	0.2466
-16	31.2	23.4	2.231	82.86	7.64	99.91	107.55	0.0176	0.2461
-14	32.6	24.6	2.1296	82.64	8.29	99.53	107.82	0.0191	0.2456
-12	34.1	25.8	2.0338	82.41	8.93	99.16	108.09	0.0205	0.2452
-10	35.6	27.0	1.9431	82.19	9.58	98.77	108.35	0.0219	0.2447
-8	37.2	28.4	1.8572	81.96	10.22	98.40	108.62	0.0234	0.2443
-6	38.9	29.7	1.7759	81.73	10.87	98.01	108.88	0.0248	0.2439
-4	40.6	31.1	1.6989	81.50	11.52	97.62	109.14	0.0262	0.2434
-2	42.4	32.6	1.6259	81.27	12.17	97.24	109.41	0.0276	0.2430
0	44.2	34.1	1.5566	81.04	12.83	96.83	109.66	0.0291	0.2426
2	46.1	35.7	1.4909	80.81	13.48	96.44	109.92	0.0305	0.2422
4	48.0	37.3	1.4284	80.57	14.14	96.04	110.18	0.0319	0.2418
6	50.0	39.0	1.3691	80.34	14.79	95.64	110.43	0.0333	0.2414
8	52.1	40.8	1.3128	80.10	15.45	95.24	110.69	0.0347	0.2410
10	54.2	42.6	1.2592	79.87	16.11	94.83	110.94	0.0361	0.2406
12	56.4	44.4	1.2082	79.63	16.77	94.42	111.19	0.0375	0.2403
14	58.7	46.4	1.1597	79.39	17.43	94.01	111.44	0.0389	0.2399
16	61.0	48.4	1.1135	79.15	18.10	93.59	111.69	0.0402	0.2395
18	63.4	50.4	1.0695	78.91	18.76	93.17	111.93	0.0416	0.2392
20	65.9	52.6	1.0276	78.66	19.43	92.75	112.18	0.0430	0.2388
22	68.5	54.8	0.9876	78.42	20.10	92.32	112.42	0.0444	0.2385
24	71.1	57.0	0.9495	78.17	20.77	91.89	112.66	0.0458	0.2381
26	73.8	59.4	0.9131	77.93	21.44	91.46	112.90	0.0471	0.2378
28	76.6	61.8	0.8784	77.68	22.11	91.02	113.13	0.0485	0.2375
30	79.4	64.3	0.8453	77.43	22.79	90.58	113.37	0.0499	0.2371
32	82.4	66.8	0.8136	77.17	23.47	90.13	113.60	0.0512	0.2368
34	85.4	69.5	0.7833	76.92	24.15	89.68	113.83	0.0526	0.2365
36	88.5	72.2	0.7544	76.67	24.83	89.23	114.06	0.0540	0.2362
38	91.7	75.0	0.7267	76.41	25.51	88.77	114.28	0.0553	0.2358
40	94.9	77.9	0.7002	76.15	26.20	88.31	114.51	0.0567	0.2355
42	98.3	80.8	0.6748	75.89	26.88	87.85	114.73	0.0580	0.2352
44	101.7	83.9	0.6505	75.63	27.57	87.38	114.95	0.0594	0.2349
46	105.3	87.0	0.6273	75.37	28.26	86.91	115.17	0.0607	0.2346
48	108.9	90.2	0.605	75.10	28.96	86.42	115.38	0.0621	0.2343
50	112.6	93.5	0.5836	74.83	29.65	85.94	115.59	0.0634	0.2340
52	116.4	96.9	0.5631	74.57	30.35	85.45	115.80	0.0648	0.2337
54	120.3	100.4	0.5435	74.29	31.05	84.96	116.01	0.0661	0.2334
56	124.3	104.0	0.5246	74.02	31.75	84.46	116.21	0.0675	0.2331
58	128.4	107.7	0.5065	73.75	32.45	83.96	116.41	0.0688	0.2328
60	132.6	111.5	0.4891	73.47	33.16	83.45	116.61	0.0702	0.2325

407C Thermodynamic Table - English Units

Temp. (°F)	Bubble Pressure (Liquid) (psia)	Dew Pressure (Vapor) (psia)	Vapor Volume (ft³/lb)	Liquid Density (lb/ft³)	Liquid Enthalpy (Btu/lb)	Enthalpy Δ H (Btu/lb)	Vapor Enthalpy (Btu/lb)	Liquid Entropy (Btu/lb-F)	Vapor Entropy (Btu/lb-F)
62	136.9	115.4	0.4724	73.19	33.87	82.94	116.81	0.0715	0.2322
64	141.4	119.4	0.4564	72.91	34.58	82.42	117.00	0.0728	0.2320
66	145.9	123.5	0.4409	72.62	35.30	81.89	117.19	0.0742	0.2317
68	150.5	127.7	0.4261	72.33	36.01	81.37	117.38	0.0755	0.2314
70	155.2	132.0	0.4118	72.05	36.73	80.83	117.56	0.0769	0.2311
72	160.1	136.4	0.3981	71.75	37.46	80.28	117.74	0.0782	0.2308
74	165.0	140.9	0.3849	71.46	38.18	79.73	117.91	0.0795	0.2305
76	170.1	145.6	0.3722	71.16	38.91	79.18	118.09	0.0809	0.2302
78	175.2	150.3	0.3599	70.86	39.64	78.61	118.25	0.0822	0.2299
80	180.5	155.2	0.3481	70.56	40.37	78.05	118.42	0.0835	0.2297
82	185.9	160.2	0.3367	70.25	41.11	77.47	118.58	0.0849	0.2294
84	191.5	165.3	0.3257	69.94	41.85	76.89	118.74	0.0862	0.2291
86	197.1	170.6	0.3152	69.63	42.60	76.29	118.89	0.0876	0.2288
88	202.9	175.9	0.305	69.31	43.34	75.70	119.04	0.0889	0.2285
90	208.8	181.4	0.2951	68.99	44.09	75.09	119.18	0.0902	0.2282
92	214.8	187.0	0.2856	68.67	44.85	74.47	119.32	0.0916	0.2279
94	221.0	192.8	0.2765	68.35	45.60	73.85	119.45	0.0929	0.2276
96	227.2	198.6	0.2676	68.01	46.37	73.21	119.58	0.0943	0.2273
98	233.6	204.7	0.259	67.68	47.13	72.58	119.71	0.0956	0.2270
100	240.2	210.8	0.2508	67.34	47.90	71.93	119.83	0.0970	0.2267
102	246.9	217.1	0.2428	67.00	48.68	71.26	119.94	0.0983	0.2264
104	253.7	223.6	0.2351	66.65	49.45	70.60	120.05	0.0996	0.2261
106	260.6	230.1	0.2276	66.30	50.24	69.91	120.15	0.1010	0.2258
108	267.7	236.9	0.2203	65.94	51.02	69.23	120.25	0.1024	0.2254
110	274.9	243.7	0.2133	65.58	51.81	68.53	120.34	0.1037	0.2251
112	282.3	250.8	0.2066	65.22	52.61	67.81	120.42	0.1051	0.2248
114	289.8	258.0	0.2	64.84	53.41	67.09	120.50	0.1064	0.2244
116	297.5	265.3	0.1936	64.47	54.22	66.35	120.57	0.1078	0.2241
118	305.3	272.8	0.1875	64.08	55.03	65.60	120.63	0.1092	0.2237
120	313.3	280.5	0.1815	63.69	55.85	64.83	120.68	0.1105	0.2234
122	321.4	288.3	0.1757	63.30	56.67	64.06	120.73	0.1119	0.2230
124	329.7	296.3	0.1701	62.89	57.50	63.26	120.76	0.1133	0.2226
126	338.1	304.5	0.1646	62.48	58.34	62.45	120.79	0.1147	0.2223
128	346.7	312.8	0.1593	62.07	59.18	61.63	120.81	0.1161	0.2219
130	355.4	321.3	0.1542	61.64	60.03	60.79	120.82	0.1175	0.2215
132	364.3	330.1	0.1492	61.21	60.89	59.93	120.82	0.1189	0.2210
134	373.4	338.9	0.1443	60.76	61.76	59.05	120.81	0.1203	0.2206
136	382.7	348.0	0.1396	60.31	62.63	58.15	120.78	0.1217	0.2202
138	392.1	357.3	0.135	59.85	63.52	57.23	120.75	0.1232	0.2197
140	401.6	366.8	0.1305	59.37	64.41	56.29	120.70	0.1246	0.2192
142	411.4	376.4	0.1262	58.89	65.31	55.32	120.63	0.1261	0.2188
144	421.3	386.3	0.1219	58.39	66.22	54.34	120.56	0.1275	0.2182
146	431.4	396.4	0.1178	57.88	67.15	53.31	120.46	0.1290	0.2177
148	441.7	406.7	0.1137	57.35	68.08	52.27	120.35	0.1305	0.2172

407C Thermodynamic Table - SI Units

Temp. (°C)	Bubble Pressure (Liquid) (kPa)	Dew Pressure (Vapor) (kPa)	Vapor Volume (m^3/kg)	Liquid Density (kg/m^3)	Liquid Enthalpy (kJ/kg)	Enthalpy Δ H (kJ/kg)	Vapor Enthalpy (kJ/kg)	Liquid Entropy (kJ/kg-C)	Vapor Entropy (kJ/kg-C)
-40	120	86	0.2529	1370	145.45	242.33	387.78	0.7856	1.8415
-39	126	90	0.2412	1366	146.77	241.60	388.37	0.7913	1.8393
-38	132	95	0.2302	1363	148.09	240.86	388.95	0.7969	1.8372
-37	138	99	0.2197	1360	149.42	240.11	389.53	0.8025	1.8351
-36	144	104	0.2098	1357	150.74	239.38	390.12	0.8081	1.8330
-35	151	110	0.2004	1354	152.07	238.62	390.69	0.8136	1.8310
-34	158	115	0.1916	1351	153.40	237.87	391.27	0.8192	1.8290
-33	165	121	0.1832	1348	154.73	237.12	391.85	0.8247	1.8270
-32	172	126	0.1753	1344	156.07	236.35	392.42	0.8302	1.8251
-31	179	132	0.1677	1341	157.40	235.60	393.00	0.8357	1.8232
-30	187	139	0.1606	1338	158.74	234.83	393.57	0.8412	1.8213
-29	195	145	0.1538	1335	160.08	234.05	394.13	0.8467	1.8195
-28	203	152	0.1474	1332	161.42	233.28	394.70	0.8522	1.8177
-27	212	159	0.1413	1328	162.77	232.49	395.26	0.8576	1.8159
-26	221	166	0.1354	1325	164.11	231.72	395.83	0.8630	1.8142
-25	230	173	0.1299	1322	165.46	230.93	396.39	0.8684	1.8124
-24	239	181	0.1247	1319	166.81	230.13	396.94	0.8739	1.8107
-23	249	189	0.1197	1315	168.16	229.34	397.50	0.8792	1.8091
-22	259	197	0.1149	1312	169.52	228.53	398.05	0.8846	1.8074
-21	269	206	0.1104	1309	170.88	227.72	398.60	0.8900	1.8058
-20	280	215	0.1061	1306	172.24	226.91	399.15	0.8953	1.8042
-19	291	224	0.1019	1302	173.60	226.10	399.70	0.9007	1.8026
-18	302	233	0.0980	1299	174.96	225.28	400.24	0.9060	1.8011
-17	314	243	0.0943	1296	176.33	224.45	400.78	0.9113	1.7995
-16	326	253	0.0907	1292	177.70	223.62	401.32	0.9166	1.7980
-15	338	263	0.0873	1289	179.07	222.78	401.85	0.9219	1.7965
-14	351	274	0.0840	1285	180.45	221.94	402.39	0.9272	1.7951
-13	364	285	0.0809	1282	181.82	221.10	402.92	0.9324	1.7936
-12	377	296	0.0780	1279	183.20	220.24	403.44	0.9377	1.7922
-11	391	308	0.0751	1275	184.59	219.37	403.96	0.9429	1.7908
-10	405	320	0.0724	1272	185.97	218.52	404.49	0.9482	1.7894
-9	419	332	0.0698	1268	187.36	217.64	405.00	0.9534	1.7880
-8	434	345	0.0673	1265	188.75	216.77	405.52	0.9586	1.7867
-7	449	358	0.0649	1261	190.15	215.88	406.03	0.9638	1.7853
-6	465	371	0.0626	1258	191.55	214.98	406.53	0.9690	1.7840
-5	481	385	0.0605	1254	192.95	214.09	407.04	0.9742	1.7827
-4	498	400	0.0584	1251	194.35	213.19	407.54	0.9794	1.7814
-3	514	414	0.0563	1247	195.76	212.28	408.04	0.9845	1.7801
-2	532	429	0.0544	1243	197.17	211.36	408.53	0.9897	1.7789
-1	550	445	0.0526	1240	198.58	210.44	409.02	0.9949	1.7776
0	568	461	0.0508	1236	200.00	209.51	409.51	1.0000	1.7764
1	587	477	0.0491	1233	201.42	208.57	409.99	1.0051	1.7752
2	606	494	0.0475	1229	202.84	207.63	410.47	1.0103	1.7740
3	625	511	0.0459	1225	204.27	206.67	410.94	1.0154	1.7728
4	645	529	0.0444	1221	205.70	205.71	411.41	1.0205	1.7716
5	666	547	0.0429	1218	207.14	204.74	411.88	1.0256	1.7704
6	687	566	0.0415	1214	208.58	203.76	412.34	1.0307	1.7692
7	709	585	0.0402	1210	210.02	202.77	412.79	1.0358	1.7681
8	731	604	0.0389	1206	211.47	201.78	413.25	1.0409	1.7669
9	753	624	0.0376	1203	212.92	200.77	413.69	1.0460	1.7658
10	776	645	0.0364	1199	214.37	199.77	414.14	1.0511	1.7647
11	800	666	0.0353	1195	215.83	198.75	414.58	1.0561	1.7636
12	824	688	0.0342	1191	217.29	197.72	415.01	1.0612	1.7624

407C Thermodynamic Table - SI Units

Temp. (°C)	Bubble Pressure (Liquid) (kPa)	Dew Pressure (Vapor) (kPa)	Vapor Volume (m³/kg)	Liquid Density (kg/m³)	Liquid Enthalpy (kJ/kg)	Enthalpy Δ H (kJ/kg)	Vapor Enthalpy (kJ/kg)	Liquid Entropy (kJ/kg-C)	Vapor Entropy (kJ/kg-C)
13	849	710	0.0331	1187	218.76	196.68	415.44	1.0663	1.7613
14	874	732	0.0321	1183	220.23	195.63	415.86	1.0713	1.7602
15	900	756	0.0311	1179	221.71	194.57	416.28	1.0764	1.7591
16	926	779	0.0301	1175	223.19	193.50	416.69	1.0814	1.7580
17	953	804	0.0292	1171	224.68	192.42	417.10	1.0865	1.7570
18	981	829	0.0283	1167	226.17	191.33	417.50	1.0915	1.7559
19	1009	854	0.0274	1163	227.66	190.23	417.89	1.0966	1.7548
20	1038	880	0.0266	1159	229.16	189.12	418.28	1.1016	1.7537
21	1067	907	0.0258	1155	230.67	187.99	418.66	1.1067	1.7526
22	1097	934	0.0250	1150	232.18	186.86	419.04	1.1117	1.7516
23	1127	962	0.0243	1146	233.69	185.72	419.41	1.1167	1.7505
24	1159	991	0.0236	1142	235.21	184.56	419.77	1.1218	1.7494
25	1190	1020	0.0229	1137	236.74	183.39	420.13	1.1268	1.7483
26	1223	1050	0.0222	1133	238.27	182.21	420.48	1.1318	1.7472
27	1256	1080	0.0215	1129	239.81	181.01	420.82	1.1369	1.7462
28	1290	1112	0.0209	1124	241.35	179.81	421.16	1.1419	1.7451
29	1324	1143	0.0203	1120	242.90	178.58	421.48	1.1469	1.7440
30	1359	1176	0.0197	1115	244.46	177.34	421.80	1.1520	1.7429
31	1395	1209	0.0191	1111	246.02	176.09	422.11	1.1570	1.7418
32	1431	1243	0.0186	1106	247.59	174.82	422.41	1.1621	1.7407
33	1469	1278	0.0180	1102	249.17	173.54	422.71	1.1671	1.7396
34	1506	1313	0.0175	1097	250.75	172.24	422.99	1.1722	1.7385
35	1545	1349	0.0170	1092	252.34	170.93	423.27	1.1772	1.7373
36	1584	1386	0.0165	1087	253.94	169.59	423.53	1.1823	1.7362
37	1624	1424	0.0160	1083	255.54	168.25	423.79	1.1873	1.7350
38	1665	1462	0.0156	1078	257.15	166.89	424.04	1.1924	1.7339
39	1707	1501	0.0151	1073	258.77	165.50	424.27	1.1975	1.7327
40	1749	1541	0.0147	1068	260.40	164.10	424.50	1.2025	1.7315
41	1792	1582	0.0143	1063	262.04	162.67	424.71	1.2076	1.7303
42	1836	1624	0.0138	1057	263.68	161.24	424.92	1.2127	1.7291
43	1881	1666	0.0135	1052	265.34	159.77	425.11	1.2178	1.7279
44	1926	1709	0.0131	1047	267.00	158.29	425.29	1.2230	1.7266
45	1972	1754	0.0127	1042	268.67	156.78	425.45	1.2281	1.7254
46	2019	1799	0.0123	1036	270.35	155.25	425.60	1.2332	1.7241
47	2067	1845	0.0120	1031	272.04	153.70	425.74	1.2384	1.7228
48	2116	1891	0.0116	1025	273.75	152.12	425.87	1.2435	1.7215
49	2166	1939	0.0113	1020	275.46	150.52	425.98	1.2487	1.7201
50	2216	1988	0.0110	1014	277.18	148.89	426.07	1.2539	1.7187
51	2267	2037	0.0107	1008	278.92	147.23	426.15	1.2591	1.7173
52	2319	2088	0.0103	1002	280.67	145.55	426.22	1.2643	1.7159
53	2372	2139	0.0100	996	282.43	143.83	426.26	1.2696	1.7144
54	2426	2192	0.0098	990	284.20	142.09	426.29	1.2748	1.7129
55	2481	2245	0.0095	984	285.99	140.30	426.29	1.2801	1.7113
56	2537	2300	0.0092	978	287.79	138.49	426.28	1.2854	1.7097
57	2594	2356	0.0089	971	289.61	136.64	426.25	1.2908	1.7081
58	2651	2412	0.0087	965	291.44	134.75	426.19	1.2961	1.7064
59	2710	2470	0.0084	958	293.29	132.82	426.11	1.3015	1.7047
60	2769	2529	0.0082	951	295.16	130.85	426.01	1.3069	1.7029
61	2830	2589	0.0079	944	297.05	128.82	425.87	1.3124	1.7011
62	2891	2650	0.0077	937	298.96	126.76	425.72	1.3179	1.6992
63	2954	2712	0.0074	930	300.88	124.65	425.53	1.3235	1.6972
64	3017	2775	0.0072	922	302.83	122.48	425.31	1.3290	1.6952
65	3081	2840	0.0070	914	304.81	120.24	425.05	1.3347	1.6931
66	3147	2906	0.0068	906	306.81	117.95	424.76	1.3404	1.6909
67	3213	2973	0.0065	898	308.84	115.59	424.43	1.3461	1.6886

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