ANSI/AHRI Standard 870
(formerly ARI Standard 870)

2005 Standard for
Performance Rating of Direct GeoExchange Heat Pumps

Approved American National Standard
ANSI

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AHRI STANDARD 870-2005 (formerly ARI Standard 870-2005) WITH ADDENDUM 1, *Performance Rating of Direct GeoExchange Heat Pumps*

June 2009

AHRI Standard 870-2005 with Addendum 1, *Performance Rating of Direct GeoExchange Heat Pumps,* is comprised of only the shaded portions shown. The June 2009 Addendum 1 has been incorporated into the already published 2005 version of AHRI Standard 870 to avoid confusion.

Particular additions (shown shaded in the standard), deletions ~~(shown with a strikethrough and shaded in the standard)~~, and corrections (shown shaded in the standard) are as follows:

1 In Appendix C, equation C2 was corrected.

$$\text{System Capacity} = q_{hx} - (3.412)\,(W_c \; \sout{+ W_{ah}}) = q_{cooling}$$

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IMPORTANT

SAFETY DISCLAIMER

ARI does not set safety standards and does not certify or guarantee the safety of any products, components or systems designed, tested, rated, installed or operated in accordance with this standard/guideline. It is strongly recommended that products be designed, constructed, assembled, installed and operated in accordance with nationally recognized safety standards and code requirements appropriate for products covered by this standard/guideline.

ARI uses its best efforts to develop standards/guidelines employing state-of-the-art and accepted industry practices. ARI does not certify or guarantee that any tests conducted under its standards/guidelines will be non-hazardous or free from risk.

ARI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

The certification program includes all factory made residential, commercial and industrial Direct Geoexchange Heat Pumps as defined in Section 3. It does not apply to the rating and testing of retrofit units.

Certified Ratings

The following certification program ratings are verified by test at the Standard Rating Conditions:

1. Cooling Capacity, Btu/h
2. Energy Efficiency Ratio, EER, Btu/W · h
3. Heating Capacity, Btu/h
4. Coefficient of Performance, COP

Note:

This standard supersedes ARI Standard 870-2001.

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SECTION 1. PURPOSE

1.1 *Purpose*. The purpose of this standard is to establish for Direct Geoexchange Heat Pumps: definitions; classification; test and rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data; and conformance conditions.

1.1.1 *Intent.* This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 *Review and Amendment*. This standard is subject to review and amendment as technology advances.

SECTION 2. SCOPE

2.1 *Scope.* This standard applies to factory made residential, commercial and industrial Direct Geoexchange Heat Pumps, as defined in Section 3.

2.1.1 *Energy Source*. This standard applies only to electrically-driven, mechanical compression type systems.

2.1.2 *Alternative Applications*. Equipment designed for rating under this standard may not be suitable for alternative applications covered in ISO 13256-1.

2.2 *Exclusions.* This standard applies to the rating and testing of complete refrigeration systems and does not apply to individual assemblies for separate use.

SECTION 3. DEFINITIONS

All terms in this document shall follow the standard industry definitions in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration* unless otherwise defined in this section.

3.1 *Coefficient of Performance (COP).* A ratio of the Cooling/Heating Capacity in watts [W] to the power input values in watts [W] at any given set of Rating Conditions expressed in watts/watt [W/W]. For heating COP, supplementary resistance heat shall be excluded.

3.1.1 *Standard Coefficient of Performance.* A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.2 *Cooling Capacity.* The capacity associated with the change in air enthalpy which includes both the Latent and Sensible Capacities expressed in Btu/h [W].

3.2.1 *Latent Capacity.* Capacity associated with a change in humidity ratio.

3.2.2 *Sensible Capacity*. Capacity associated with a change in dry-bulb temperature.

3.3 *Direct Geoexchange Heat Exchanger.* A continuous sealed underground closed loop heat exchanger with one refrigerant supply tube and one refrigerant return tube. More than one such Direct Geoexchange Heat Exchanger may be supplied with each heat pump and the Direct Geoexchange Heat Exchanger(s) may be factory or field assembled.

3.4 *Direct Geoexchange Heat Pump.* A heat pump consisting of one or more factory made assemblies which normally include an indoor conditioning coil with air moving means, compressor(s) and refrigerant-to-earth heat exchanger(s), including means to provide a heating function or a cooling function or both. The separate assemblies shall be designed to be used together, and the requirements of rating outlined in the standard are based upon the use of matched assemblies.

3.4.1 *Functions.* Direct Geoexchange Heat Pumps shall provide the function of air-circulating, cooling and heating with controlled temperature, and may include the functions of water heating, air-cleaning, dehumidifying or humidifying.

Models designated as "cooling only" units need not include the heating function, and models designated as "heating only" units need not include the cooling function.

3.5 *Energy Efficiency Ratio (EER).* A ratio of the Cooling Capacity in Btu/h to the power input values in watts at any given set of Rating Conditions expressed in Btu/(W · h).

3.5.1 *Standard Energy Efficiency Ratio*. A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.6 *Heating Capacity.* The capacity associated with the change in dry-bulb temperature expressed in Btu/h [W].

3.7 *Part-Load Rating.* A rating based on tests performed at Part-Load Rating Conditions.

3.8 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. The term Published Rating includes the rating of all performance characteristics shown on the heat pump or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

3.8.1 *Application Rating*. A rating based on tests performed at application Rating Conditions (other than Standard Rating Conditions).

3.8.2 *Standard Rating*. A rating based on tests performed at Standard Rating Conditions.

3.9 *Rating Conditions*. Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.9.1 *Standard Rating Conditions*. Rating Conditions used as the basis of comparison of performance characteristics.

3.10 *"Shall" or "Should".* "Shall" or "should" shall be interpreted as follows:

3.10.1 *Shall*. Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.10.2 *Should.* "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.11 *Standard Air*. Air weighing 0.075 lb/ft^3 [1.2 kg/m^3] which approximates dry air at 70°F [21°C] and at a barometric pressure of 29.92 in Hg [101.3 kPa].

3.12 *Test Fluid.* The liquid filling the test water coil.

SECTION 4. CLASSIFICATION

4.1 *Classification.* Direct Geoexchange Heat Pumps within the scope of this standard shall be classified as shown in Table 1.

Table 1. Classification of Direct Geoexchange Heat Pumps

	ARI Type			Arrangement*	
Designation	Heating and Cooling	Heating Only	Cooling Only		
Split System				FAN	COMP
	HRCU-DGX-CB	HORCU-DGX-CB	HCRCU-DGX-CB	EVAP	COND
Split System w/ No Indoor Fan				COMP	
	HRCU-DGX-C	HORCU-DGX-C	HCRCU-DGX-C	EVAP	COND
*Denotes cooling mode function.					

SECTION 5. TEST AND RATING REQUIREMENTS

5.1 *Standard Rating.* Standard Ratings shall be established at the Standard Rating Conditions specified in 5.1.3. All Standard Ratings shall be verified by tests conducted in accordance with ASHRAE Standard 37, and with the test methods and procedures as described in this standard except that the total Cooling and Heating Capacity shall be the average of the air enthalpy method and the water coil method. Standard Ratings of units which do not have indoor air-circulating fans furnished as part of the model, i.e., split system with indoor coil alone (Table 1), shall be established by subtracting from the total Cooling Capacity 1,250 Btu/h/1,000 ft^3/min [0.776 kW per m^3/s], and by adding the same amount to the Heating Capacity. Total power input for both heating and cooling shall be increased by 365 W/1,000 ft^3/min [0.776 kW per m^3/s] of indoor air handled.

5.1.1 *Values of Standard Capacity Ratings.* These ratings shall be expressed only in terms of Btu/h [W] in multiples of 100 [30].

5.1.1.1 Standard Ratings relating to Cooling or Heating Capacities shall be net values, including the effects of circulating-fan heat, but not including supplementary heat.

5.1.2 *Values of Standard Energy Efficiency Ratio or Coefficients of Performance.* Standard Energy Efficiency Ratios for cooling, whenever published, shall be expressed in multiples of the nearest 0.1 Btu/(W · h) [the nearest cooling *COP* in multiples of 0.1]; Standard Coefficients of Performance for heating, whenever published, shall be expressed in multiples of the nearest 0.1.

5.1.2.1 In the determination of values of Standard Energy Efficiency Ratio or Coefficient of Performance, the power inputs to the compressor(s) and fan(s), plus controls and other items included as part of the model number(s) shall be used.

5.1.3 *Standard Rating Conditions.* The test conditions for Standard Ratings shall include the following:

5.1.3.1 *Test Fluid.* The liquid used in the test water coil shall be water which has been freeze-protected with the addition of 15% methanol, by weight..

5.1.3.2 *Standard Rating Conditions.*

a. *Cooling (not required for heating only models).*

Air temperature entering indoor portion of unit: 80.0°F [26.7°C] dry-bulb, 67.0°F [19.4°C] wet-bulb

Air temperature surrounding unit: 80.0°F [26.7°C] dry-bulb

Refrigerant temperature from test water coil (liquid line): 77.0°F [25.0°C]

b. Heating (not required for cooling only models).

Air temperature entering indoor portion of unit: 70.0°F [21.1°C] dry-bulb, 60.0°F [15.6°C] wet-bulb.

Air temperature surrounding unit: 70.0°F [21.1°C] dry-bulb

Refrigerant temperature from test water coil (vapor line) 32.0°F [0°C]

5.1.3.3 *Electrical Conditions.* Standard Rating tests shall be performed at the nameplate rated voltage(s) and frequency.

For heat pumps with dual nameplate voltage ratings, Standard Rating tests shall be performed at both voltages, or at the lower of the two voltages, if only a single Standard Rating is to be published.

5.1.3.4 *Indoor-Side Air Quantity.* All Standard Ratings shall be determined at an indoor-side air quantity, delivered against at least the minimum external resistance required by 5.1.3.6. All air quantities shall be expressed as ft^3/min [m^3/s] of Standard Air.

a. Direct Geoexchange Heat Pumps shall be rated at the indoor-side air quantity delivered when operating against the minimum external resistance specified in 5.1.3.6 or at a lower indoor-side air quantity, if so specified by the manufacturer.

b. Heat pumps which do not incorporate an indoor fan, but are rated in combination with a device employing a fan shall be rated as described under a. above. For heat pumps of this class which are rated for general use to be applied to a variety of heating plants, the indoor-side air quantity shall be as specified by the manufacturer in his Standard Ratings, or the air quantity obtained through the indoor coil assembly when the pressure drop across the indoor coil assembly and the recommended enclosures and attachment means is not greater than 0.30 in H_2O [75 Pa], whichever is less.

Indoor-side air quantities as referred to herein apply to the air quantity experienced when the unit is cooling and dehumidifying under the Standard Rating Cooling Conditions specified in this section. Heating-only units shall use the air quantity experienced when the unit is operating under the Standard Rating Conditions. This air quantity shall be employed in all other tests prescribed herein without regard to resulting external static pressure, or if so specified by the manufacturer, the air quantity employed in all of the tests shall be that achieved at the external resistance employed in the Standard Rating cooling test.

5.1.3.5 *Requirements for Separated Assemblies.* All Standard Ratings for heat pumps in which the compressor section is separated from the indoor section, as in Type HRCU (Table 1), shall be determined with at least 25.0 ft [7.62 m] of interconnecting tubing on each line, of the size recommended by the manufacturer. Heat pumps in which the interconnecting tubing to the Direct Geoexchange Heat Exchanger is furnished as an integral part and a recommended length is furnished, shall be tested with the complete length of tubing furnished, or with 25.0 ft [7.62 m] of tubing, whichever is greater. The line sizes, insulation and details of installation shall be in accordance with the manufacturer's published recommendations.

5.1.3.6 *Minimum External Resistances.* Indoor air-moving equipment intended for use with field installed duct systems shall be designed to operate against, and tested at not less than, the minimum external resistance shown in Table 2 when delivering the rated capacity and air quantity specified in 5.1.3.4. Indoor air-moving equipment not intended for use with field installed duct systems shall be tested at 0 in H_2O [0 Pa] external pressure. In interpreting this requirement, it is required that the most restrictive filters, supplementary heating coils and other equipment recommended as optional parts of the heat pump be in place and that the net external resistances specified above are available for the external duct system.

5.2 *Part-Load Rating.* Heat pumps which are capable of capacity control shall be rated at each step of capacity reduction provided by the heat pump and allowed by the controls.

5.2.1 *Part-Load Rating Conditions.* The conditions of test for Part-Load Ratings are the same as for the Standard Ratings (5.1) except for the following:

5.2.1.1 *Part-Load Rating Temperatures Cooling (Not required for heating only models).*

Air temperature entering indoor portion of unit: 80.0°F [26.7°C] dry-bulb, 67.0°F [19.4°C] wet-bulb

Refrigerant temperature from test water coil (liquid line): 70.0°F [21.1°C]

Table 2. Minimum External Resistance

Standard Capacity Ratings		Minimum External Resistance	
Bth/h x 1000	W x 1000	In H_20	kPa
Up thru 28	Up thru 8.2	0.10	0.025
29 thru 41	8.2 thru 12.3	0.15	0.037
42 thru 64	12.3 thru 19.0	0.20	0.05
65 thru 70	19 thru 21	0.20	0.05
71 thru 105	21 thru 30.8	0.25	0.06
106 thru 134	31.1 thru 39.3	0.30	0.07
135 thru 210	39.6 thru 61.6	0.35	0.09
211 thru 280	62.1 thru 82.1	0.40	0.10
281 thru 350	82.6 thru 103	0.45	0.11
351 thru 400	103.1 thru 117	0.55	0.14
401 thru 500	118.6 thru 146	0.65	0.16
501 and over	147.9 and over	0.75	0.19

5.2.1.2 *Part-Load Rating Temperatures Heating (not required for cooling only models).*

Air temperature entering indoor portion of unit: 70.0°F [21.1°C] dry-bulb, 60.0°F [15.6°C] wet-bulb.

Air temperature surrounding unit: 70.0°F [21.1°C] dry-bulb

Refrigerant temperature from test water coil (vapor line): 41.0°F [5.0°C]

5.2.1.3 *Capacity Reduction Means May Be Adjusted To Obtain The Specified Step Of Unloading.* No manual adjustment of indoor air quantities from those of Standard Rating conditions shall be made. Automatic adjustment of the quantities by system function is permissible.

5.3 *Application Ratings.* Ratings other than those specified in 5.1.3 and 5.2.1 can be published as Application Ratings, and shall be based on data determined by the methods prescribed in 5.1.

5.4 *Tolerances.* To comply with this standard, measured test results shall not be less than 95% of Published Rating for performance ratios (EER and COP) and capacity.

5.5 *Refrigerant Charge.* The amount of refrigerant charge in the heat pump system under test shall remain the same in both the heating and cooling modes.

SECTION 6. MINIMUM DATA REQUIREMENTS FOR PUBLISHED RATINGS

6.1 *Minimum Data Requirements for Published Ratings*. As a minimum, Published Ratings shall include Standard Ratings and Part-Load Ratings (where applicable). All claims to ratings within the scope of this standard shall include the verbiage "Rated in accordance with ARI Standard 870". All claims to ratings outside the scope of this standard shall include the verbiage "Outside the scope of ARI Standard 870". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

6.1.1 Published Ratings shall consist of the following information:

a. Cooling Capacity, Btu/h [W]
b. Energy Efficiency Ratio (EER), Btu/(W · h)
c. Heating Capacity, Btu/h [W]
d. Coefficient of Performance (COP), watts/watt [W/W]

SECTION 7. OPERATING REQUIREMENTS

7.1 Operating *Requirements*. To comply with this standard, Direct Geoexchange Heat Pumps shall be designed and produced in accordance with the provisions of this section in such a manner that any production unit shall meet the requirements detailed herein.

7.2 *Maximum Operating Conditions Test.* Direct Geoexchange Heat Pumps shall be designed and produced to pass the following maximum operating conditions test with an indoor-side coil air quantity as determined under 5.1.3.4.

7.2.1 *Temperature Conditions.*

7.2.1.1 *Cooling (Not required for heating only models).*

Air temperature surrounding unit: 95.0°F [35.0°C] dry-bulb

Air temperature entering indoor portion of unit: 95.0°F [35.0°C] dry-bulb, 71.0°F [21.7°C] wet-bulb

Refrigerant temperature from test water coil (liquid line): 100.0°F [37.8°C]

7.2.1.2 Heating (Not required for cooling only models).

Air temperature entering indoor portion of unit: 80.0°F [26.7°C] dry-bulb

Air temperature surrounding unit: 80.0°F [26.7°C] dry-bulb

Refrigerant temperature from test water coil (vapor line): 66.0°F [18.9°C]

7.2.2 *Voltages.*

7.2.2.1 Tests shall be run at 90% and 110% of the unit's nameplate rated voltage at the unit's service connection and at rated frequency, or at a lower than 90% minimum or a higher than 110% maximum voltage if so listed on the nameplate.

7.2.2.2 The power supplied to a single phase heat pump shall be adjusted just prior to the shut-down period (see 7.2.3.2) so that the resulting voltage at the unit's service connection is 86% of nameplate rated voltage when the compressor motor is at locked rotor (for 200V or 208V nameplate rated equipment, the restart voltage shall be set at 180V when the compressor motor is at locked rotor). Open circuit voltage for three-phase heat pumps shall not be greater than 90% of nameplate rated voltage.

7.2.2.3 Within one minute after the heat pump has resumed continuous operation (7.2.4.3), the voltage shall be restored to the values specified in 7.2.2.1.

7.2.2.4 Single phase dual voltage units whose lower voltage is 208V, and that specify on their specification sheets a minimum voltage to be applied at the unit service connection for the maximum operating conditions test, shall be tested at the lower of the unit's minimum voltage or 198V in accordance with 7.2.2.1, 7.2.2.2 and 7.2.2.3.

7.2.3 *Procedure.*

7.2.3.1 The heat pump shall be operated for two hours at the temperature conditions and voltage(s) specified.

7.2.3.2 All power to the heat pump shall be interrupted for a period sufficient to cause the compressor to stop (not to exceed five seconds) and then restored.

7.2.4 *Requirements.*

7.2.4.1 During both tests, the heat pump shall operate without failure to any of its parts.

7.2.4.2 The heat pump shall operate continuously without interruption for any reason for the two-hour period preceding the power interruption.

7.2.4.3 The unit shall resume continuous operation within two hours of restoration of power and shall then operate continuously for one hour. Operation and resetting of safety devices prior to establishment of continuous operation is permitted.

7.3 *Low-Temperature Start and Operating Test.* Direct Geoexchange Heat Pumps shall be designed and produced to pass the following low-temperature start and operating test when operating with air quantities as determined in 5.1.3.4.

7.3.1 *Temperature Conditions (Cooling).*

Air temperature entering and surrounding indoor portion of unit: 80.0°F [26.7°C] dry-bulb, 67.0°F [19.4°C] wet-bulb.

Refrigerant temperature from the test water coil (liquid line): 32.0°F [0.0°C].

7.3.1.1 *Procedure.* The low temperature operating test shall be continuous for a period of not less than 30 minutes after the specified temperature conditions have been established. A limit device shall not operate during these tests.

7.3.2 *Temperature Conditions (Heating).*

Air temperature entering and surrounding indoor portion of unit: 60.0°F [15.6°C] dry-bulb.

Refrigerant temperature from the test water coil (vapor line): 25.0°F [-3.9°C].

7.3.2.1 *Procedure.* The unit shall start and run for a minimum of 30 minutes without being interrupted by any type of safety control or limit control.

7.3.3 *Requirements.*

7.3.3.1 During the entire test, the heat pump shall operate continuously without damage to the equipment.

7.3.3.2 For a dual voltage unit, the unit shall operate continuously at the lower voltage.

7.4 *Insulation Effectiveness Test (Cooling).* Direct Geoexchange Heat Pumps shall be designed and produced to pass the following insulation effectiveness test when operating with air quantities as determined in 5.1.3.4 with controls, fans, dampers and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's instructions.

7.4.1 *Temperature Conditions.*

Air temperature entering and surrounding indoor portion of unit: 80.0°F [26.7°C] dry-bulb, 75.0°F [23.9°C] wet-bulb

Refrigerant temperature from test water coil: 50.0°F [10.0°C]

7.4.2 *Procedure.* After establishment of the specified temperature conditions, the unit shall be operated continuously for a period of four hours.

7.4.3 *Requirements.* During the test, no condensed water shall drop, run or blow off from the unit casing.

7.5 *Tolerances.* The conditions for the tests outlined in 7.2, 7.3 and 7.4 are average values subject to tolerances of ±1.0°F [±0.6°C] for air wet-bulb and dry-bulb temperatures, ±0.5°F [±0.3°C] for refrigerant temperatures and ±1.0% of the reading for voltages.

SECTION 8. MARKING AND NAMEPLATE DATA

8.1 *Nameplate Data.* As a minimum, the nameplate shall display the manufacturer's name, model designation, and electrical characteristics.

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltages shown in Table 1 of ARI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard 60038.

SECTION 9. CONFORMANCE CONDITIONS

9.1 *Conformance.* While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's *Purpose* (Section 1) and *Scope* (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard cannot reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES - NORMATIVE

A1 Listed here are all standards, handbooks and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of the standard.

A1.1 ANSI/ARI/ASHRAE ISO Standard 13256-1:1998, *Water-source heat pumps-testing and rating for performance-Part I: Water-to-air and brine-to-air heat pumps*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tillie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.2 AHRI Standard 110-2002 (formerly ARI Standard 110-2002), *Air-Conditioning, Heating, and Refrigerating Equipment Nameplate Voltages,* 2002, Air-Conditioning and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 222013, U.S.A.

A1.3 ASHRAE Standard 37-1988, *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 1988, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.4 *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

A1.5 IEC Standard 60038, *IEC Standard Voltages*, 2002, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

B1 Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

B1.1 ANSI/ASHRAE Standard 34-2001 with addenda, *Number Designation and Safety Classification of Refrigerants*, 2001, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

B1.2 CSA Standard C748-94, *Performance of Direct-Expansion (DX) Ground-Source Heat Pumps*, 1994, Canadian Standards Association, 178 Rexdale Blvd., Etobicoke, Ontario, Canada M9W1RW3

APPENDIX C. OUTDOOR WATER COIL METHOD OF TESTING DIRECT GEOEXCHANGE HEAT PUMPS FOR CAPACITY - INFORMATIVE

C1 *Outdoor Water Coil Heat Exchanger Apparatus.*

C1.1 *General.* This Appendix summarizes some of the requirements obtained in ANSI/ASHRAE Standard 37. In this method, the total Cooling or Heating Capacity shall be determined from measurements of liquid temperature change and flow rate through the outdoor water coil heat exchanger which shall be used to condition the refrigerant in the Direct Geoexchange Heat Pump under test.

Note: This method shall be used only for the testing of equipment where the compressor shall be ventilated in the indoor air stream, is in an indoor closed compartment which is not ventilated, or is insulated with the equivalent of not less than 1.0 in [25.4mm] of glass fibers.

The outdoor water coil apparatus is shown schematically in Figure C1. The Test Fluid in the test fluid conditioning loop shall be maintained at a temperature and flow rate as necessary to control and maintain the temperature of the refrigerant leaving the outdoor water coil at the specified temperature for each required test.

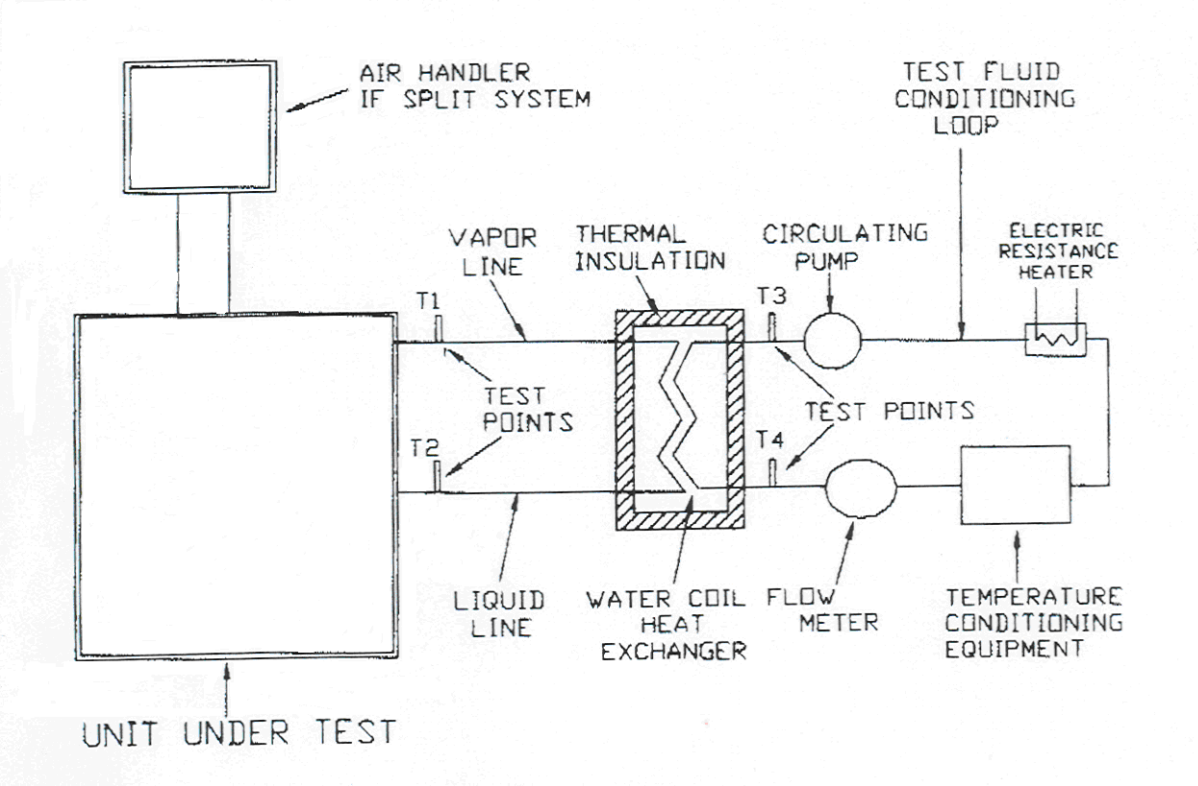

FIGURE C1

OUTDOOR WATER COIL TEST SET-UP FOR DIRECT GEOEXCHANGE HEAT PUMPS

NOTE: The vapor line at test point T1 is the vapor line connected to the earth loops in a normal field installation, and the liquid line at T2 is the liquid line connected to the earth loops.

C1.2 The Test Fluid in the test fluid conditioning loop shall be water which is freeze protected by the addition of the antifreeze solution.

C2 *Outdoor Water Coil Method.*

Calculation Method. The energy delivered to the unit under test, in the heating mode, or extracted from the unit under test in the cooling mode, by way of the test heat exchanger shall be calculated using Equation 1:

$$q_{hx} = (Q_w)\,(\rho)\,(\Delta t)\,(60)\,(C_p) \qquad C1$$

where q_{hx} = heat transfer rate in heating or cooling mode; Btu/h
Q_w = fluid flow rate measured by flow meter; gpm
ρ = density of Test Fluid; lb/gal
Δt = T4 – T3 ; °F
C_p = specific heat of Test Fluid; Btu/lb ·°F
T3 = temperature at test point 3
T4 = temperature at test point 4

For SI,

q_{hx} = $(Q_w)\,(\rho)\,(\Delta t)\,(60)\,(C_p)$ = watthours/hour
= $(Q_w)\,(\rho)\,(\Delta t)\,(K)\,(C_p)$ = watts

where Q_w = liters/min. of test fluid through Hx
ρ = density of test fluid in kg/liter
Δt = (T4 – T3) in °C
K = $^{60}/_{3.6}$= Constant to convert to $^{KWH}/_{H}$= 16.667
C_p = kilojoules/kilogram/°C = kj/kg/°C
= specific heat of test fluid

C3 *Calculation of Capacity and COP of system under test.*

C3.1 *Cooling Mode:*

$$\text{System Capacity} = q_{hx} - (3.412)\,(W_c + \sout{W_{ah}}) = q_{cooling} \qquad C2$$
$$\text{EER} = (q_{cooling})/(W_c + W_{ah}) = \text{Btu/Watt} \qquad C3$$

Example, Cooling Mode:
Q_w = 11.13 gal/min
ρ = 8.345 lb/gal (water)
Δt = (65 – 55) = 10°F
C_p = 1.0 btu/lb/°F (water)
$Watts_{input}$ = 2,703 (9223 Btu/h)
q_{hx} = (11.13) (8.345) (65-55) (60) (1.0) = 55,728 Btu/h
$Btuh_{cool}$ = $Btu_{hx} – Btu_{input}$ = 55,728 – 9,223 = 46,505
EER = $Btu_{out}/watts_{in}$ = 46,505/2,703 = 17.2

For SI,
Q_w = 11.13 gpm = 42.13 liters/minute
ρ = 8.345 lb/gal = 1.0 kg/liter
Δt = (65 – 55) °F = (18.333 - 12.777) = 5.555 °C
$Watts_{input}$= 2,703 = 2,703
Q_{hx} = $(Q_w)\,(\rho)\,(\Delta t)\,(16.667)\,(C_p)$ = $Watts_{hx}$
= (42.13) (1.0) (7.222-1.666) (16.667) (4.185) = 16,324 Watts
$watts_{cool}$ = $W_{hx} – W_{input}$ = 16,324 – 2,703 = 13,621 watts
EER_{cool} = $watts_{cool}/watts_{input}$ = 13,621/2,703 = 5.04

C3.2 *Heating Mode:*

$$\text{System Capacity} = q_{hx} + (3.412)(W_c + W_{ah}) = q_{heating} \quad \text{C4}$$

$$\text{COP} = (q_{heating})/[(3.412)(W_c + W_{ah})] = \text{BTU}_{output}/\text{BTU}_{input} \quad \text{C5}$$

where:

W_c = Electric power to compressor; watts (W)
W_{ah} = Electric power to air handler; watts (W)

Q_w = 6.72 gal/min
ρ = 8.345 lb/gal (water)
Δt = (45 – 35) = 10°F
$Watts_{input}$ = 3.518 = 12,003 Btu/h
C_p = 1.0 Btu/lb/°F (water)
q_{hx} = (6.72) (8.345) (65 – 55) (60) (1.0) = 33647 Btu/h
Btu_{heat} = Btu_{hx} + Btu_{input} = 33,647 + 12,003 = 45,650 Btu/h
EER = Btu_{out}/Btu_{in} = 45,650 / 12,003 = 3.8

For SI,

q_{hx} = (Q_w) (ρ) (Δt) (1.667) (C_p)
= (25.435) (1.0) (7.222 – 1.666) (16.667) (4.185)
= 9.856 watts
$watts_{heat}$ = $watts_{hx}$ + $watts_{input}$ = 9,856 + 3,518 = 13,374
COP = $watts_{heat}$ / $watts_{input}$
= 13,374 / 3,518 = 3.80

C4 *Measurements*

C4.1 *Liquid Flow Rate Measurement.* The liquid flow rate through the test field conditioning loop shall be measured with a liquid quantity or flow meter in accordance with ASHRAE Standard 37.

C4.2 *Temperature Measurement.* Test fluid temperatures and refrigerant temperatures shall be measured with instruments in accordance with ASHRAE Standard 37.

C5 *Data to be Recorded.* All measured data shall be recorded as specified in ASHRAE Standard 37.

C6 *Test Results.* Capacity test results shall include the following quantities:

a. Total Cooling Capacity, Btu/h [W]
b. Sensible Cooling Capacity, Btu/h [W]
c. Latent Cooling Capacity, Btu/h [W]
d. Heating Capacity, Btu/h [W]
e. Indoor-side airflow rate, cfm [m^3/s]
f. External resistance to indoor airflow, in H_2O [kPa]
g. Total power input(s) to equipment or all equipment components, W [W]

C7 *Additional requirements for Outdoor Water Coil Tests.*

Test Fluid circulation shall be established so that the Test Fluid temperatures at test points T1 and T2 achieve stability at the test temperatures specified in Sections 5,6, and 7.

The heat exchanger in the outdoor water coil shall have a minimum test fluid temperature change of 5.0°F [3.0°C] between test points T3 and T4.