



CERTIFICATE

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By the Authority Vested By Part 5 of the United States Code § 552(a) and Part 1 of the Code of Regulations § 51 the attached document has been duly INCORPORATED BY REFERENCE and shall be considered legally binding upon all citizens and residents of the United States of America. *HEED THIS NOTICE:* Criminal penalties may apply for noncompliance.



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WASHINGTON, D.C.

AHRI Standard 330
(Formerly ARI Standard 330)

1998 Standard for
**Ground Source
Closed-Loop
Heat Pumps**



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IMPORTANT

SAFETY RECOMMENDATIONS

It is strongly recommended that the product be designed, constructed, assembled and installed in accordance with nationally recognized safety requirements appropriate for products covered by this standard.

AHRI, as a manufacturers' trade association, uses its best efforts to develop standards employing state-of-the-art and accepted industry practices. However, AHRI does not certify or guarantee safety of any products, components or systems designed, tested, rated, installed or operated in accordance with these standards or that any tests conducted under its standards will be non-hazardous or free from risk.

ARI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

The certification program includes ground source closed-loop heat pumps that are electrically driven, mechanical compression type systems as defined in the standard and included in this program.

Equipment Covered: This program applies only to ground source closed-loop heat pumps, rated below 135,000 Btu/h [40 kW] at AHRI Standard Rating Conditions (Cooling).

Exclusion: This certification program does not apply to the rating and testing of individual assemblies, such as condensing units or coils, for separate use.

Certified Ratings

The following certification program ratings are verified by test:

1. Cooling Capacity, Btu/h [W]
2. EER, Btu/W·h [W/W]
3. Heating Capacity, Btu/h [W]
4. COP, W/W
5. Fluid Flow, gpm [L/s]

Note:

This standard supersedes ARI Standard 330-93.

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GROUND SOURCE CLOSED-LOOP HEAT PUMPS

Section 1. Purpose

1.1 Purpose. The purpose of this standard is to establish for ground source closed-loop heat pumps: definitions and classification; requirements for testing and rating; performance requirements; marking and nameplate data; and conformance conditions.

1.1.1 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 ground source closed-loop 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 related ARI Standards 320 and 325.

2.2 Exclusions. This standard does not apply to individual assemblies for separate use.

Section 3. Definitions

3.1 Definitions. All terms in this document will 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.

3.2 Coefficient of Performance (COP). A ratio of the heating capacity in watts [W], excluding supplementary resistance heat, to the power input in watts [W] at any given set of rating conditions expressed in watts/watt [W/W]. (The international community uses the term EER as equivalent to cooling COP.)

3.2.1 Standard Coefficient of Performance. A ratio of the capacity to power input obtained at Standard Rating Heating Conditions.

3.3 Energy Efficiency Ratio (EER). A ratio of the cooling capacity in Btu/h [W] to the power input in watts [W] at any given set of rating conditions, expressed in Btu/W·h [W/W].

3.3.1 Standard Energy Efficiency Ratio. A ratio of the capacity to power input values obtained at Standard Rating Conditions.

3.4 Ground Source Closed-Loop Heat Pump. A ground source closed-loop heat pump typically uses fluid circulated through a subsurface piping loop as a heat source/heat sink. The heat exchange loop may be placed in horizontal trenches or vertical bores, or submerged in a body of surface water. The temperature of the fluid is related to climatic and operating history conditions and usually varies from 25°F to 100°F [-3.9°C to 37.7°C]. Rated efficiencies include an allowance for power to circulate the fluid. A ground source closed-loop heat pump consists of one or more factory-made assemblies which normally include an indoor conditioning coil with air moving means, compressor(s) and refrigerant-to-fluid heat exchanger(s), including means to provide both cooling and heating, cooling only or heating only functions. When such equipment is provided in more than one assembly, 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. Ground source closed-loop 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 provided the following are met on the corresponding model:

1. The components of the air-conditioning refrigerant system (cooling system) are substantially the same on the heat pump system.
2. Switches, thermostats and/or other controls of electrical components required for the reverse cycle can be altered or deleted as required to provide heating or cooling only.

- 3. All other chassis components, fans, motors, pumps, housings, etc., must be substantially the same between both versions.

3.5 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. As used herein, 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.

3.5.1 Standard Rating. A rating based on tests performed at Standard Rating Conditions.

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

3.6 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.

3.6.1 Standard Rating Conditions. Rating conditions used as the basis of comparison of performance characteristics.

3.7 "Shall," "Should," "Recommended" or "It Is Recommended." "Shall," "should," "recommended" or "it is recommended" shall be interpreted as follows:

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

3.7.2 Should, Recommended or It Is Recommended. "Should," "recommended" or "it is recommended" is used to indicate provisions which are not mandatory but which are desirable as good practice.

Section 4. Classification

4.1 Classification. Normally, ground source closed-loop heat pumps within the scope of this standard may be classified as shown in Table 1.

Section 5. Testing 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.

Table 1. Classification of Ground Source Closed-Loop Heat Pumps

Types of Ground Source Closed-Loop Heat Pumps				
Designation	ARI Type ⁺			Arrangement [*]
	Heating and Cooling	Cooling Only	Heating Only	
Single Package	HSP-GS	HCSP-GS	HOSP-GS	FAN COMP EVAP COND
Split System	HRCU-GS-CB	HCRCU-GS-CB	HORCU-GS-CB	FAN COMP EVAP COND
Split System with No Indoor Fan	HRCU-GS-C	HCRCU-GS-C	HORCU-GS-C	COMP EVAP COND

⁺ A suffix of "O" following any of the above classifications indicates equipment not intended for use with field-installed duct systems (see 5.1.3.6).

^{*} Denotes cooling mode function.

Standard Ratings relating to cooling or heating capacities shall be net values, including the effects of circulating-fan heat, but not including supplementary heat. Standard Input Ratings shall be the total power input to the compressor(s) and fan(s), plus controls and other items included as part of the model number(s).

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 (see table 1), shall be established by subtracting from the total cooling capacity 1250 Btu/h per 1000 scfm [775 watts per m³/s], and by adding the same amount to the heating capacity. Total power input for both heating and cooling shall be increased by 365 watts/1000 scfm [775 watts per m³/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 Btu/h [10 W].

5.1.2 Values of Standard Energy Efficiency Ratio or Coefficients of Performance. Standard ratios of energy efficiency for cooling, whenever published, shall be expressed in multiples of the nearest 0.1 Btu/W·h [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.

In calculating EER's or COP's, a penalty for water (fluid) pump effect of 0.8 watts per gpm per ft of H₂O [4.2 watts per L/s per kPa] (approximately 25% pump efficiency total) shall be added to the measured power input. Furthermore, a pressure drop of 17 ft. of H₂O [51 kPa] shall be added for the loop to determine the total pressure drop of the system for the pumping penalty.

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

5.1.3.1 Fluid. The fluid for all tests shall be based on the use of a 15% solution by weight of sodium chloride and water.

- a. Heat pumps shall be rated at the indoor-side air quantity delivered when operating

5.1.3.2 Standard Rating Conditions.

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

Air temperature entering indoor portion of unit..... 80°F [26.7°C] dry bulb
 67°F [19.4°C] wet bulb
 Air temperature surrounding unit..... 80°F [26.7°C] dry bulb
 Fluid temperature entering refrigerant-to-fluid heat exchanger..... 77°F [25.0°C]
 Fluid flow rate..... As specified by manufacturer

(Note: This flow rate shall be used for all tests.)

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

Air temperature entering indoor portion of unit.....70°F [21.1°C] dry bulb
 60°F [15.6°C] wet bulb, max.
 Air temperature surrounding unit..... 70°F [21.1°C] dry bulb
 Fluid temperature entering refrigerant-to-fluid heat exchanger..... 32°F [0°C]
 Fluid flow rate..... As specified in Standard Rating Cooling Test

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 as outlined below. All air quantities shall be expressed as cfm [m³/s] of Standard Air (density 0.075 lb per cu ft [1.2 kg/m³]).

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, 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. of H₂O [0.075 kPa], 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 High Temperature Rating Cooling Conditions specified in this section. Heating-only units shall use the air quantity experienced when the unit is operating under the Standard High Temperature Heating Rating Conditions. This air quantity, except as noted in 6.3, 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 Standard Rating Cooling test.

5.1.3.5 Requirements for Separated Assemblies. All Standard Ratings for heat pumps in which the outdoor section is separated from the indoor section, as in Type HRCU (shown in Section 4), shall be determined with at least 25 ft. [7.6 m] of interconnecting tubing on each line, of the size recommended by the manufacturer. Heat pumps in which the interconnecting tubing is furnished as an integral part and a recommended length is not furnished shall be tested with the complete length of tubing furnished, or with 25 ft. [7.6 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. of H₂O [0 kPa] external pressure.

Table 2. Minimum External Resistance			
Standard Cooling Capacity Ratings		Minimum External Resistance	
Btu/h x 1000	[kw]	In. of H ₂ O	[kPa]
Up thru 28.9	Up thru 8.4	0.10	0.025
29 thru 42.9	8.5 thru 12.5	0.15	0.037
43 thru 70.9	12.6 thru 20.7	0.20	0.050
71 thru 105.9	20.8 thru 31.0	0.25	0.062
106 thru 134.9	31.1 thru 39.5	0.30	0.075
135 thru 210.9	39.6 thru 61.7	0.35	0.087
211 thru 280.9	61.8 thru 82.2	0.40	0.100
281 thru 350.9	82.3 thru 102.8	0.45	0.112
351 thru 400.9	102.9 thru 117.4	0.55	0.137
401 thru 500.9	117.5 thru 146.7	0.65	0.162
501 and over	146.8 and over	0.75	0.187

In interpreting this requirement, it is understood 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 (see 5.1) except for the following:

5.2.1.1 Part-Load Rating Temperatures (Cooling).

- Air temperature entering indoor portion of unit.....80°F [26.7°C] dry bulb
67°F [19.4°C] wet bulb
- Fluid temperature entering refrigerant-to-fluid heat exchanger.....70°F [21.1°C]

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

Air temperature entering indoor portion
of unit.....70°F [21.1°C] dry bulb
60°F [15.6°C] wet bulb max.
Air temperature surrounding
unit.....70°F [21.1°C] dry bulb
Fluid temperature entering refrigerant-
to-fluid heat exchanger.....41°F [5°C]

5.2.1.3 Capacity reduction means may be adjusted to obtain the specified step of unloading.

No manual adjustment of indoor air or water flow quantities from those of standard rating conditions shall be made. Automatic adjustment of the quantities by system function, however, is permissible. For water flow, a separate control signal output for each step of pump capacity will be considered automatic adjustment.

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

5.4 Publication of Ratings. Wherever application ratings are published or printed, they shall include, or be accompanied by, the Standard Capacity Ratings plus the Part-Load Rating (where applicable), and their corresponding power inputs, clearly designated as such, including a statement of the conditions at which the ratings apply.

5.4.1 Capacity Designation. The capacity designation used in published specifications, literature or advertising, controlled by the manufacturer, for heat pumps rated under this standard, are to be expressed only in Btu/h [W] at the Standard Rating Conditions specified in 5.1.3 plus Part-Load Rating Conditions specified in 5.2.1 and in the terms described in 5.1.1 through 5.1.2.

5.5 Tolerances. To comply with this standard, Standard Ratings for any production unit shall have an allowance for testing and manufacturing variations. The amount of this allowance of heating and cooling capacity, ratios of energy efficiency for cooling and coefficients of performance for heating should not be lower than minus 5 percent.

Section 6. Performance Requirements

6.1 Performance Requirements. To comply with this standard, ground source closed-loop heat pumps shall be designed and produced in accordance with the provisions of

this section in such a manner that any production unit will meet the requirements detailed herein.

6.2 Maximum Operating Conditions Test. Ground source closed-loop 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:

6.2.1 Temperature Conditions.

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

Air temperature surrounding
unit.....95°F [35.0°C] dry bulb
Air temperature entering
indoor portion
of unit.....95°F [35.0°C] dry bulb
71°F [21.7°C] wet bulb
Fluid temperature entering
refrigerant-to-fluid
heat exchanger.....100°F [37.8°C]
Fluid flow rate.....maintained same
as in 5.1.3.2

6.2.1.2 Heating *(not required for cooling only models).*

Air temperature entering
indoor portion
of unit.....80°F [26.7°C] dry bulb
Air temperature surrounding
unit.....80°F [26.7°C] dry bulb
Fluid temperature entering
refrigerant-to-fluid
heat exchanger.....75°F [23.9°C]
Fluid flow rate.....maintained same
as in 5.1.3.2

6.2.2 Voltages.

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

6.2.2.2 The power supplied to the heat pump shall be adjusted just prior to the shut down period (see 6.2.3.2) so that the resulting voltage at the unit's service connection is 86 percent of nameplate rated voltage when the compressor is on locked rotor. (For those dual voltage units so specified on their specification sheets for a minimum voltage 5 percent below the lower rated voltage, this

locked-rotor voltage setting shall be 91 percent of the lower rated voltage.)

6.2.2.3 Within one minute after the heat pump has resumed continuous operation (see 6.2.4.3), the voltage shall be restored to the values specified in 6.2.2.1.

6.2.2.4 Single phase dual voltage units whose lower voltage is 208V, which 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 this minimum voltage or 198V in accordance with 6.2.2.1, 6.2.2.2 and 6.2.2.3.

6.2.3 Procedure.

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

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

6.2.4 Requirements.

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

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

6.2.4.3 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.

6.3 Low-Temperature Start and Operate Test. Ground source closed-loop 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.

6.3.1 Temperature Conditions (Cooling). (not required for heating only)

Air temperature entering indoor portion of unit.....80°F [26.7°C] dry bulb
67°F [19.4°C] wet bulb
Fluid temperature entering refrigerant-

to-fluid heat exchanger.....32°F [0°C]
Fluid flow rate.....maintained same as in 5.1.3.2

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

6.3.2 Temperature Conditions (Heating). (not required for cooling only)

Air temperature entering indoor portion of unit.....60°F [15.6°C] dry bulb
Fluid temperature entering refrigerant-to-fluid heat exchanger.....25°F [-3.9°C]
Fluid flow rate..... maintained 90% of that specified in 5.1.3.2

6.3.2.1 Procedure. The unit shall soak for 10 minutes with 25°F [-3.9°C] fluid circulating through the coil. The unit shall start and run for a minimum of 30 min. without being interrupted by any type of safety control or limit control.

6.3.3 Requirements.

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

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

6.4 Insulation Efficiency Test (Cooling). Ground source closed-loop heat pumps shall be designed and produced to pass the following insulation efficiency 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 to the user.

6.4.1 Temperature Conditions.

Air temperature entering and surrounding indoor portion of unit.....80°F [26.7°C] dry bulb
75°F [23.9°C] wet bulb
Fluid temperature entering refrigerant-to-fluid heat exchanger.....50°F [10.0°C]
Fluid flow rate.....maintained same as in 5.1.3.2

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

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

6.5 Tolerances. The conditions for the tests outlined in 6.2, 6.3 and 6.4 are average values subject to tolerances of $\pm 1.0^{\circ}\text{F}$ [$\pm 0.6^{\circ}\text{C}$] for air wet bulb and dry bulb temperatures, $\pm 0.5^{\circ}\text{F}$ [$\pm 0.3^{\circ}\text{C}$] for fluid temperatures and ± 1.0 percent of the reading for voltages.

Section 7. Marking and Nameplate Data

7.1 Nameplate Data. The nameplate shall display the manufacturer's name, model designation, and electrical characteristics.

Recommended nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of ARI Standard 110. Recommended nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard Publicaton 38.

Section 8. Voluntary Conformance

8.1 Conformance. While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within its *Purpose* (Section 1) or *Scope* (Section 2) unless such claims meet all of the requirements of the standard.

APPENDIX A. REFERENCES - NORMATIVE

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

A1.1 AHRI Standard 110-97 (formerly ARI Standard 110-97), *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 1997, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, U.S.A.

A1.2 ASHRAE Standard 37-1988, *Methods of Testing 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.

A1.3 *ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigerating*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.4 IEC Standard Publication 38, *IEC Standard Voltages*, 1983, 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 AHRI Standard 320-98 (formerly ARI Standard 320-98), *Water-Source Heat Pumps*, 1998, Air-Conditioning Heating and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, U.S.A.

B1.2 AHRI Standard 325-98 (formerly ARI Standard 325-98), *Ground Water-Source Heat Pumps*, 1998, Air-Conditioning Heating and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, U.S.A.