

NBSIR 76-1029 (R)

# **Unitary Heat Pump Specification for Military Family Housing**

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Center for Building Technology  
Institute for Applied Technology  
National Bureau of Standards  
Washington, D. C. 20234

March 1, 1976

Final Report

Issued August 1976

Prepared for  
**Family Housing Division  
Directorate of Engineering  
Department of the Air Force  
Washington, D. C. 20330**



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**U.S. DEPARTMENT OF COMMERCE, Elliot L. Richardson, *Secretary***

**Edward O. Vetter, *Under Secretary***

**Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology***

**NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director***



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## ABSTRACT

The purpose of this report is to establish, for unitary heat pump equipment, the requirements for performance, testing, rating, design, safety, serviceability and reliability for system and components; and conformance conditions. This report is intended for guidance in military procurement and applies to hermetic electrically-driven vapor compression unitary heat pumps of the remote (split) and packaged (integral) types, the air-to-air and water-to-air classes, and sizes from 17,000 to 84,000 Btu/h for both heating and cooling functions.

Key Words: Heating and cooling; military family housing; specification; unitary heat pump

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# UNITARY HEAT PUMP SPECIFICATION FOR MILITARY FAMILY HOUSING

## 1. PURPOSE, SCOPE AND CLASSIFICATION

- 5 A. Purpose - The purpose of this specification is to establish, for unitary heat pump equipment, the requirements for performance, testing, rating, design, safety, serviceability, and reliability for system and components; and conformance conditions. This specification is intended for guidance in military procurement.
- B. Scope - This specification applies to hermetic electrically-driven vapor-compression unitary heat pumps of the types defined in Section 1-C having suitable heating and cooling capacities for military family housing.
- 10 C. Classification and Definition - The term heat pump, applied to a year-round air conditioning system, denotes a system in which refrigeration equipment is used in such a manner that heat is taken from a heat source and given up to the conditioned space when heating service is desired, and heat is removed from the conditioned space and discharged to a heat sink when cooling and dehumidification are desired. Unitary heat pumps shall be defined as consisting of one or more factory-made assemblies which normally include indoor conditioning coil(s), compressor(s), outdoor coil(s) or water-to-refrigerant heat exchanger and necessary controls to provide both heating and cooling functions. The heating function may be supplemented by electric resistance heaters. Unitary heat pumps within the scope of this specification shall be classified by:
- 15

### 1. Physical configuration (Type)

- a. Remote (split) type - The indoor and outdoor units are separated and remote one from the other.
- 20 b. Packaged (integral, single) type - The indoor and outdoor units are housed in a single cabinet assembly.

### 2. Heat source and sink (Class)

- a. Air-to-air heat pump - Air is the heat sink and source medium for the outdoor and indoor units.
- 25 b. Water-to-air heat pump - Water is the heat sink and source medium for the outdoor unit

or condenser and chiller. Air is the medium providing conditioned air to spaces.

3. Size (Capacity at ARI Standard Rating Conditions)

Cooling - 17,000 to 84,000 Btu/h  
(5,000 to 24,600 watts)  
Heating - 17,000 to 84,000 Btu/h

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2. REFERENCED SPECIFICATIONS AND STANDARDS

The specifications and standards of the issue listed below (including amendments, addenda, and errata), but referred to thereafter by designation only, form a part of this specification to the extent required by the reference thereto:

- 10           1. American National Standards Institute (ANSI)
- B9.1-1971     Safety Code for Mechanical Refrigeration
- B79.1-1968   Number Designation of Refrigerants
2. Air-Conditioning and Refrigeration Institute (ARI)
- 15            230-62     Application Engineering Standard for Year-Round Residential Air Conditioning
- 240-67     Standard for Unitary Heat Pump Equipment
- 260-67     Standard for Application, Installation and Servicing of Unitary Equipment
- 270-67     Standard for Sound Rating of Outdoor Unitary Equipment
- 20            275-69     Standard for Application of Sound-Rated Outdoor Equipment
- 520-68     Standard for Positive Displacement Refrigerant Compressors and Condensing Units
- 710-71     Standards for Liquid Line Driers
- 25            3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- 37-69     Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment

1972 Handbook of Fundamentals

4. Underwriters Laboratories, Inc. (UL)

559 Standard for Safety - Heat Pumps

984 Standard for Safety - Sealed (Hermetic type)  
Motor-Compressors

5

5. Department of Defense (DOD)

4270.21-1970 Guide Specifications for Military Family Housing - Air Conditioning, Mechanical Division 15.16a

AFM 88, Chapter 6 Engineering Weather Data, Air Force, Army and Navy Manual  
TM5-785  
NAVFAC P-89

10

6. National Environmental Systems Contractors Association (NESCA)

Manual G Selection of Distribution System

Manual J Load Calculation for Residential Winter and Summer Air Conditioning

Manual K Equipment Selection and System Design Procedures

15

7. American Society for Testing and Materials (ASTM)

B117-64 Standard Method of Salt Spray (Fog) Testing

D1654-61 Standard Method of Evaluation of Painted or Coated Specimens Subjected to Corrosion Environments

D2247-68 Standard Method for Testing Coated Metal Specimens at 100 Percent Relative Humidity

G33-72 Standard Recommended Practice for Recording Data From Atmospheric Corrosion Tests of Metallic-Coated Steel Specimens

20

### 3. PROCUREMENT GUIDELINES

5 A. Prerequisite - Prerequisite to the use of this specification for procurement it is necessary for the purchaser to determine weather data, design heating and cooling loads and the design for air distribution systems of the military residential housing to be equipped with the heat pump equipment obtained under this specification:

1. Weather data for outdoor design conditions should be in accordance with Engineering Weather Data Air Force, Army and Navy Manual.

10 2. Design sensible heating and sensible and latent cooling loads should be determined in accordance with procedures described in Chapters 21 and 22 (Residential Cooling Loads), ASHRAE Handbook of Fundamentals, or procedures given in ARI 230 or NESCA Manual J.

15 3. Air distribution systems should be suitable for both winter heating and summer cooling and should conform to practices established in NESCA Manual G, Manual K and ARI 260 for design, selection and installation of duct system and insulation, and registers and diffusers. Sections of DOD 4270.21 covering requirements for installation of heating and air conditioning equipment and air distribution systems, testing of heating and air conditioning systems, etc., should be used in preparation of project specifications for military family housing.

20 4. If water-to-air heat pumps are to be considered, an adequately proven year-round supply of water should be available. The quality (hardness, acidity, mineral content and bacterial count) of the water and its temperature for both winter and summer seasons should be determined and stated in the request for purchase.

B. Instructions to Purchaser - Items which must be specified by the purchaser of unitary heat pump equipment in the contract or purchase order with reference to the provisions referred to in this specification are as follows:

25 1. Required voltage and related electrical characteristics.



2. Winter and summer design indoor and outdoor conditions and the seasonal heating hours for 5 F (2.8 C) temperature increments below 65 F (18.3 C) as given in the Engineering Weather Data Manual.
3. Required heating and cooling capacities, in Btu/h (watts), at specified winter and summer design conditions, respectively.
4. Type and class of heat pump required. Also size and dimension limitations, or other special construction considerations.
5. Additional preproduction, postproduction capacity tests, conformance and/or reliability tests as required. Also if any or all tests are to be waived.
6. Specific performance data desired in addition to required test data.
7. Minimum external resistance of air distribution system when delivering the rated capacity and air quantity.
8. When water-to-air heat pumps are specified, data covering water quantity available in gallons per minute, summer and winter water temperature, water source and quality of water will be furnished by the military services.
9. For geographical regions of high corrosion potential, such as coastal regions with salt spray exposure, specify salt spray test (ASTM B117) with 720 hours of exposure for portions of heat pump units exposed to the outdoor environment. For all other regions specify salt spray test with 240 hours of exposure. Include special technical provisions required by the procuring military services.

#### 4. GENERAL REQUIREMENTS

- A. Description - Throughout this specification the term "heat pump" will be used interchangeably with the term "unitary heat pump" as defined in Sections 1-B and 1-C. Any heat pump furnished under this specification shall be the standard cataloged product of a manufacturer who has produced that model at least one year prior to the date of request for procurement. Heat pumps with only minor changes resulting in a model number change may be accepted by

the contracting officer (purchaser). Standard catalog product heat pumps with only changes specifically required to meet this specification may be accepted by the contracting officer. The burden of proof that the changes do not adversely effect the performance, reliability and safety compared to the model for which one year of service has been demonstrated shall rest with the heat pump manufacturer. All heat pumps of a given type, class and size to be delivered under a specific contract or purchase order shall be of the same manufacturer and model. Remote (split) type heat pumps shall consist of a complete packaged outdoor unit and a complete packaged indoor unit. Precharged factory supplied tubing shall be furnished with remote type heat pumps with capacities up to 44,000 Btu/h (12,900 watts). Packaged (integral) type heat pumps shall consist of a single factory-assembled sheet-metal casing complete with indoor and outdoor units piped and wired, ready for connection to duct system and electric circuits. The complete system heating and cooling capacity shall not be less than the design loads specified in the contract or purchase order. Unless otherwise specified, the maximum airflow and minimum external pressure shall be as required in ARI 240. Unit components shall be readily accessible for maintenance and service. High and low side service valves shall be provided. Self closing valves will be acceptable. Certain requirements in this specification, particularly current overload protection, crankcase heating, time delay mechanisms and liquid flood-back protection are included for system reliability needs. If a manufacturer has alternative means to accomplish these functions, the acceptance shall be dependent on proof submitted by the heat pump manufacturer, and acceptable to the contracting officer. This proof shall include written certification that the alternative means satisfy the functional requirements.

B. Standards - Heat pumps shall conform to the standards ARI 240, UL 559 and ANSI B9.1, and shall meet the requirements for listing in UL Electrical Appliance and Utilization Equipment List. Proof shall be submitted showing that the items furnished under this specification conform to such requirements. The labels of the ARI and the UL for the manufacturer's standard model will be acceptable as sufficient evidence that the items conform to the label-identified standards of these organizations. In lieu of such certification, label or listing, a written certificate from a testing laboratory or agency adequately equipped and competent to perform such services shall be submitted stating that the items have been tested and that the heat pump units and assembled components conform to requirements specified in ARI 240, UL 559 and ANSI B9.1. Description of test methods shall accompany certificate.

C. Heat Pump Cooling and Heating Capacity - The heat pump heating and cooling (sensible and latent) capacities shall not be less than that specified for the winter and summer outdoor design conditions of the contract or purchase order when tested in accordance with Section 5-B1. If the sensible cooling capacity of the heat pump at summer design conditions is more than twice the design sensible cooling load, the heat pump shall be equipped with means to modulate or otherwise limit the design capacity-to-design-load ratio to two or less. Heat pumps with supplemental electric resistance heat shall be sized to provide by compression (and indoor fan heating) at least 70 percent of the calculated annual heating requirement for the building served (see Section 7). A method for determining the heating by compression as a percent of the annual heating requirements is given in Section 7. The minimum capacity for the supplemental heaters shall be the difference between the design heating load and the heat output by compression at the winter design outdoor temperature.

The heat pump manufacturer shall state the rated voltage and capacity of supplemental heaters. The heaters shall provide this capacity when tested in accordance with Section 6-A4. Air-source heat pumps shall have seasonal performance factors (SPF), for the heating season, including supplemental heating and defrosting greater than:

Outdoor Design Temperature, F (C)	SPF (Minimum)
35 (1.7) to 45 (7.2)	2.25
20 (-6.7) to 34 (1.1)	2.0
1 (-17.2) to 19 (-7.2)	1.5
-20 (-28.9) to 0 (-17.8)	1.25

The definition of and the method for calculating seasonal performance factors (SPF) are given in Section 7. A sample problem is included. Forms corresponding to Table 7-1, with calculations of seasonal performance factor for air-source heat pumps as given in Section 7 shall be submitted with the bid.

D. Heat Pump Coefficient of Performance - The heat pumps shall have coefficients of performance when tested and rated in accordance with Sections 5 and 6 equal to or greater than the following:



Air	Water
Source	Source

	2.0	2.5
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	2.5	2.5
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5	ARI 17 F (-8.3 C) Application Rating Condition (Heating)	1.7	-
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10 E. Operational and Reliability Requirements - Unless otherwise specified in the contract or purchase order at least one heat pump of each type, class, model and size scheduled for delivery under this specification shall be subjected to and successfully pass the operational and reliability tests required in Section 5 of this specification and shall conform to the requirements contained in Section 6 of this specification.

15 F. Supplemental Electric Resistance Heat - If supplementary heat is needed to satisfy the heating requirements (see Section 4-C) of this specification, supplemental electric resistance heaters shall be provided and shall be located downstream of the indoor coil. The electric heaters shall be electrically wired in accordance with UL 559 and controlled in one or more steps so that they shall provide sufficient additional heating capacity for building heat demand loads in excess of the compression and indoor fan heating capacity. No single step of supplemental heating shall produce a temperature rise in the discharge air greater than 35 F (19.4 C). The heaters shall be controlled by means of outdoor and indoor thermostats interlocked one with the other. The outdoor thermostat, whose operation shall override that of the indoor thermostat, shall prevent the supplementary heaters from operating at outdoor temperatures above 35 F (1.7 C) except as required to offset cooling effect during defrost operation (Section 4-I). For the heating operation, the indoor thermostat shall operate in at least two steps. The first step shall initiate heat pump operation for heating by compression only. The second step (and additional step(s), if provided) shall control heating provided by the supplemental heaters. The cut-off temperature for the first set of supplemental heaters shall be between 0.5 (.3) and 1.5 F (.8 C) below the cut-off temperature for the compression heating. Additional steps of supplemental heating if required shall be activated for both cut-off and cut-on, respectively in 0.5 (.3) to 1.0 F (.6 C) steps below the first step of supplemental heating by the thermostat. The total operating temperature differential between thermostat cut-on and cut-off of the compression heating control shall not exceed 2 F (1.1 C).



G. Refrigerant - The refrigerant shall be of Group I Classification as described in ANSI B79.1. The type of refrigerant to be used in the system shall be as specified in the contract or purchase order. If not so specified, the refrigerant shall be one of the following types: R-12, R-22, R-500, R-502.

5 H. Indoor Temperature Control - Temperature controls for heat pump operation shall be capable of being set to control heating at any temperature at least from 55 F (12.8 C) to 75 F (23.9 C) and to control cooling at any temperature from 75 F (23.9 C) to at least 85 F (29.4 C). The thermostat shall be factory locked to prevent setting above 85 F or below 55 F. When the heat pump system is operating (except during defrost operation), the temperature control shall be capable of regulating the indoor temperature at the thermostat to within 1 F (.6 C) of the control setting when only compression heating is being provided and to within 2 F (1.1 C) of the control setting when compression and supplemental heating is required. For control of supplemental heat see Section 4-F. The thermostat shall contain or a sub-base shall be provided containing selector switches for COOL-OFF-HEAT and FAN-AUTO-ON.

10 I. Defrost - Air-source heat pumps designed to operate with a defrost cycle shall include positive actuation and termination means for defrosting the coils and fins of the outdoor unit automatically with suitable drain provisions to remove condensate and meltage without freeze-up or other malfunctions throughout the entire range of application temperatures.

15 J. Protective Mechanisms, Controls and Auxiliary Equipment - The heat pump system shall contain the necessary components; protective mechanisms, controls and auxiliary equipment for it to meet the requirements and tests set forth in this specification. Safety devices and protective controls shall be used to limit or terminate abnormal operating conditions and shall not be used to control normal heat pump operations. Also refer to Section 4-B.

20 K. Sound Rating - All outdoor unitary heat pump equipment shall be sound rated and tested in accordance with ARI 270 and ARI 275 and shall not exceed a sound rating of 20 as defined in these standards. The ARI label will be acceptable as sufficient evidence of compliance. In lieu of such certification or label, a written certificate from a testing agency or laboratory adequately equipped and competent to perform such services shall be submitted stating that the equipment has been tested and conforms to requirements specified in ARI 270 and to the requirements of this specification.

L. Hermetic Motor-Compressor Units - Hermetic motor-compressor units shall conform to the standards of UL 984 and ARI 520 with regards to construction, performance and testing. The requirements for motor-compressor protection systems of these standards shall also apply in addition to the following:

5 1. Thermal Protection - An internal motor-winding temperature-sensing protection device of the automatic reset type for the compressor motor shall be provided to prevent motor operation under excessive motor winding temperatures. The heat pump manufacturer's recommended maximum motor winding temperature shall not be exceeded when the heat pump is operating under any of the tests prescribed in ARI 240, and in no case shall winding temperature under any of these test conditions exceed 300 F (149 C), when measured as described in paragraph 7.2 of ARI 520. The heat pump manufacturer's recommended maximum motor winding temperature shall be stated in the bid submission.

10 2. Current Overload Protection - Motor running-current overload protection of the manual or automatic reset type, conforming to the National Electric Code (refer to UL 984), shall be provided for the compressor motor. If manual reset is provided it shall be readily accessible and the reset means clearly marked.

15 3. Crankcase Heating - Means shall be provided for heating the compressor crankcase during "off" cycles to minimize liquid foaming and prevent consequent liquid slugging under compressor starting conditions caused by retention of refrigerant by oil in the compressor. Crankcase heaters either external or internal (except for motor windings used as heaters) shall be readily replaceable from the exterior without breaking the refrigerant seal.

20 4. Time Delay Mechanism - The motor protection system shall contain a device or means that delays operation of the compressor motor for a period of at least 3 but not more than 6 minutes after compressor operation is called for when shut-down for any reason, inadvertent or otherwise has occurred. (Note: This is needed to diversify startup loads in housing areas after power interruption and to guard against short cycling of individual units.)

5. Liquid Flood-Back - A means shall be provided for protecting the compressor from liquid flood-back, under all design conditions of operation, including defrost. Properly designed and sized accumulators will satisfy this requirement. Accumulators must provide for return of oil to the compressor.

5 M. Moisture in Refrigerant - The system shall contain a filter-drier in the liquid line to both the indoor and outdoor coils, conforming to ARI 720. Filter driers shall be so installed as to be easily removed for replacement. Refrigerant piping shall be circuited such that backwashing of the filter-drier by reversal of refrigerant flow does not occur. The moisture content in the refrigerant shall not exceed 30 ppm at time of heat pump installation and at conclusion of the Reliability Tests (see Section 6-C).

10 N. Strainer - If the heat pump system uses capillary tubes as a refrigerant expansion device, strainer(s) shall be installed in the line ahead of each capillary tube assembly capable of stopping passage of scale and other particulate matter of minor dimension greater than 20% of the bore size of the smallest tube.

15 O. Materials in Outdoor Unit - The materials of which the components in the outdoor unit are fabricated and the method of fabrication shall be such that when a heat pump system is subjected to the Reliability Tests (Section 6-C) of this specification, it shall pass the tests and retain its physical and structural integrity. The use of dissimilar metals in intimate contact with each other shall be avoided wherever these joints are exposed to moisture in normal operation in order to minimize galvanic corrosion between the metals. When the use of dissimilar metals cannot be avoided, construction methods shall be utilized which minimize or eliminate the galvanic effect. Coils and fins of the outdoor coil shall be corrosion resistant or treated to resist corrosion. All materials in both indoor and outdoor sections shall be of such type or construction that the unit can satisfactorily pass the applicable salt spray/humidity tests in Section 6-C. Coils, fins and fan shall be protected from physical damage by means of a suitable grill or other means which do not lower the airflow through the coil enough to prevent the specified performance of the system.

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25 P. Air Filters - Air filters mounted on the air return to the indoor unit shall be furnished. The air filter installation shall preferably be integral with the indoor unit and if mounted remotely in the house duct system, the duct must be leak tight to the unit. The air filter shall be readily accessible for removal from the indoor unit for cleaning or replacement after residential installation. The air filter installation shall have no unplugged holes or cracks allowing air to bypass the filter prior to reaching indoor coil.



Q. Water-to-Air Heat Pumps - Water-to-air heat pumps shall be designed to meet the following performance requirements:

1. The water temperature leaving the condenser during cooling operation shall not exceed 100 F (37.8 C).
2. The water temperature leaving the water-to-refrigerant heat exchanger during heating operation shall not be less than 45 F (7.2 C).
3. A low pressure cut-out device with a manually reset lockout relay shall be installed near the inlet to the compressor to prevent freezing during the heating operation.
4. The water-to-refrigerant heat exchanger, internal piping and connections shall be composed of cupronickel alloy or the equivalent corrosion resistance.
5. Construction and/or piping for water-to-refrigerant heat exchangers shall include provision for isolation and access valving for the purposes of chemical cleaning or physical access for mechanical cleaning of the water side of heat exchange surfaces.

5. QUALITY ASSURANCE PROVISIONS

A. Responsibility for Inspection and Examination - The contractor (supplier) shall be responsible for the fulfillment of all inspection requirements as specified herein. The contractor shall be responsible for insuring that the components of the system, even though manufactured by a secondary supplier, are tested, and examined, and are satisfactory for inclusion in the heat pump system. The supplier shall also be responsible for the fulfillment of requirements of the referenced applicable documents for any components of the heat pump system. Unless otherwise specified in the contract or purchase order, the Government (purchaser) reserves the right to perform any of the inspections to determine if the requirements set forth in Section 4 are fulfilled. If the Government so desires it may contract this responsibility to any qualified commercial or Government laboratory.

B. Tests for Quality Conformance - Three types of tests required by this specification shall be performed, or shall have been performed for each type, class, model and size of heat pump to be supplied in the contract or purchase order; namely, 1) Capacity, 2) Operational, and 3) Reliability Tests. The data required shall be obtained from tests described in Section 6, with regard

to all inspections and capacity, operational and reliability tests. The Government reserves the right to make any or all inspections and tests necessary in addition to those required in the contract or purchase order to assure conformance with specification requirements at any time prior to final acceptance. If such additional testing indicates failure to conform, the cost of the unit or component tested and the cost of testing will be borne by the supplier. If such additional testing indicates conformance, the cost of the unit or component tested and the cost of testing will be borne by the Government.

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1a. Capacity Tests - Heating - For air-source heat pumps, the supplier shall provide manufacturer's performance data sufficient to establish curves of heating capacity and power input (including defrost effects, but not including supplemental heat) versus outdoor air temperature, with return indoor air temperature between 70 and 75 F (21.1 and 23.9 C). The outdoor temperature range should be from 62 F (16.7 C) to the winter outdoor design temperature specified in the contract or purchase order or to the lowest temperature at which the heat pump will operate to satisfy the seasonal performance factor calculation required in Section 4-C. Certified performance data shall be provided for the heating capacity and power input at the standard rating condition and the application rating condition as described in ARI 240.

20  
For water-source heat pumps manufacturer's performance data shall be provided showing heating capacity and power input versus (1) entering winter design water temperature, if the entering winter design water temperature specified in the contract or purchase order is lower than 60 F (15.6 C). Return indoor air temperature shall be between 70 and 75 F (21.1 and 23.9 C). Certified performance data showing heat capacity and power input shall be provided for the standard rating conditions described in ARI 240.

25  
1b. Capacity Tests - Cooling - Air air-source heat pumps, manufacturer's performance data showing the cooling capacity and power input shall be provided for the design summer outdoor temperature, and certified performance data shall be provided for the standard rating condition described in ARI 240. For water-source heat pumps, manufacturer's performance data shall be provided showing cooling capacity versus entering water

temperature and minimum water flow rate (or leaving water temperature) if the entering summer design water temperature specified in the contract or purchase order is warmer than 75 F (23.9 C). Certified performance data shall be provided showing cooling capacity at standard rating conditions described in ARI 240. For all cooling tests return indoor air conditions shall be as described in ARI 240.

For the heating and cooling capacity tests above, if, in the contract or purchase order an air system distribution resistance or airflow different from the values listed in Section 4.1.9 of ARI 240, is specified, the performance data required shall be adjusted accordingly.

Manufacturer's performance data is data based on tests of which the accuracy is attested to by the unit manufacturer. Certified performance data is data of which the accuracy is attested to either by an independent testing laboratory or by a certification program such as that of ARI.

2. Operational Tests - The heat pump system shall operate satisfactorily under standard and maximum operating conditions (refer to Section 4-E). Heat pumps scheduled for delivery under this specification shall meet all requirements of ARI 240, Section 6, Performance Requirements. The ARI label will be accepted as evidence of meeting this requirement. In lieu of such certification or label, a written certificate from a testing agency or laboratory adequately equipped and competent to perform such services shall be submitted stating that the equipment conforms to requirements specified in ARI 240.

3. Reliability Tests - The heat pump shall be subjected to the reliability tests listed in Section 6-C of this specification and shall conform to the listed requirements, and shall perform without damage to any part.

C. Sampling for Capacity and Operational Tests - Unless otherwise required in the contract or purchase order, one heat pump of each type, model and size scheduled for delivery and picked at random shall have been or shall be subjected to all listed capacity tests and operational tests and shall satisfactorily conform to all test requirements. The tests on each heat pump shall



be made sequentially with the capacity tests being performed first. The heat pump tested as representative of each type, model and size shall pass all tests described in Section 5-B, and as specified under Sections 6-A and 6-B.

- 5 D. Sampling for Reliability Tests - Unless otherwise required in the contract or purchase order, at least one heat pump of each type, class, model and size scheduled for delivery and picked at random shall be subjected to and successfully pass the reliability tests (Section 6-C) conducted in accordance with the following plan. If there are no failures in the first specimen, the type, class, model and size will be considered satisfactory with respect to the reliability tests and the unit tested can be included in the lot for delivery. If there are not more than two failures, a second trial, using three additional specimens of the same type, class, model and size, picked at random by a Government inspector shall undergo a test for conformance to all listed reliability requirements. If there is not more than one failure of the same kind, or not more than three failures altogether from that total of four specimens tested, the lot will be considered satisfactory with respect to the reliability tests. Any unit failing shall not be included in the lot for delivery. If there are two or more failures of the same kind, or four or more failures altogether from the total of four specimens tested, all heat pumps of that type, class, model and size shall be rejected.

15 6. TESTS

- 20 A. Capacity Tests - This section describes tests of heat pumps for determination of capacity and coefficient of performance. Test data required in Section 5 are derived from the tests described in Section 6. All of these tests shall be performed without the indoor thermostat in the system or with the thermostat set to call for continuous operation of the compression system. The resistance heaters shall be turned off during these tests. Both cooling and heating tests shall be performed as described in the following paragraphs. Testing procedures shall be as described in ASHRAE 37. Unless otherwise specified, test conditions shall be as set forth in ARI 240.

- 25 1. Heating Tests - A heating test at the standard rating and testing conditions specified by ARI 240 shall be performed. In addition, heating tests at the application rating conditions specified by ARI 240 and in Section 5-B of this specification shall be performed in accordance with ASHRAE 37.

2. Cooling Tests - Cooling tests at the standard rating conditions specified in ARI 240 and at application rating conditions in Section 5-B shall be performed on the heat pump in conformance with ASHRAE 37.

5

3. Coefficient of Performance - At rating and application conditions, the coefficient of performance of the heat pump for heating and cooling (see Section 4-D) shall be calculated from the test data. The definition of coefficient of performance given in ARI 240 shall apply. The test shall be performed without the supplemental heaters in operation.

10

4. Heating Capacity of Supplemental Heater - The heating capacity of the supplemental heaters shall be determined by the measurement of the electrical power usage of the supplemental heater(s). The electrical power usage shall be measured at specified voltage and at room temperature of 70 F (21.1 C) with suitable instrumentation accurate to within 2 percent of the measured value. The test data shall be used to determine compliance with Section 4-F.

15

B. Operational Tests - As stated in Section 5-B.2, required operational tests are the following tests described in the Performance Requirements of ARI 240:

1. Maximum Operating Condition Test
2. Low Temperature Operation Test for Cooling
3. Insulation Efficiency Test
4. Condensate Disposal Test

20

C. Reliability Tests - Temperature tolerances for the reliability test shall be as specified in performance requirements of ARI 240. Voltage tolerances shall be  $\pm 3$  volts. The tests will be conducted sequentially in the order given in Table 6-1. All of these tests shall be performed without the indoor thermostat in the system or with the thermostat shunted to call for continuous operation. All manual-reset operating, protective, and limit controls/devices shall be reactivated within 30 minutes following trip-out or similar operation throughout each test. Supplemental heaters shall not be operated in any of the reliability tests. Indoor unit air inlet temperature shall be held in the range from 70 (21.1) to 80 F (26.7 C) for tests (except for test

25



8). For all tests, the portion of the tests that call for unit operation implies continuous compressor operation except as controlled by protective/limit devices.

The portions of the heat pump that are normally exposed to the outdoor environment shall be tested in a corrosive environment (see 7 of Table 6-1) as described in ASTM B117 (salt spray test). Unless otherwise specified in the contract or purchase order, the duration of this test shall be 240 hours. The portions of the heat pump that are normally exposed to the indoor environment shall be tested as described in ASTM D2247 (100 percent relative humidity test). The time duration of this test shall be 240 hours. The extent of area of indoor and outdoor exposure to salt spray/humidity environment for corrosion testing of packaged (integral) type heat pumps shall be determined from size, dimension and construction considerations. Data to be taken before and after corrosion tests shall be recorded and results photographed as given in Section 3.3 of ASTM G33. For painted and all coated surfaces refer to ASTM D1654 for testing procedure where marks shall be scribed on vertical, horizontal, external and internal painted or coated surfaces. Rating Schedule No. 2 of ASTM D1654 shall be reported. The rating number shall not be less than 6 and there shall be no rust creep greater than 1/8" (3.18 mm) normal to the scribe marks for acceptance. Blistering or flaking of paint or coating and rust creep at screw holes shall be reported and rated as above. Oxidation and corrosion of bare metal parts and at joints of dissimilar metals shall be reported and photographed.

As applicable, the following requirements must be met for acceptance:

- a. No impairing damage shall occur to any component during these tests.
- b. The temperature of the oil sump remote from the suction line inlet to the compressor shall at no time during operation of the compressor motor be less than 25 F (13.9 C) warmer than that of the suction line within 6 inches (.152 m) of the compressor shell.
- c. The temperature of the discharge line within 6 inches (.152 m) of the compressor shall at no time during operation of the compressor motor be less than 20 F (11.1 C) warmer than the saturation temperature corresponding to the discharge pressure for more than 5 minutes. Thermocouples shall be used for these measurements, shall be physically bonded to the respective surfaces (including at least 1 inch (.0254 m) of the leads) and shall be insulated from ambient conditions.

- 5
- d. No audible knocking or hammering of mechanical parts shall occur in excess of that occurring in normal continuous operation at standard rating conditions in ARI 240.
  - e. Average motor winding temperatures measured as described in paragraph 7.2 of ARI 520 shall not exceed 300 F (149 C) at any time during any of the reliability tests.
  - f. Discharge refrigerant line temperature within 6 inches (.152 m) of the compressor shall not exceed 300 F (149 C) during the reliability tests.
  - g. Upon completion of the reliability tests, the moisture content of the refrigerant shall be determined and the moisture content shall not exceed 30 ppm.
- 10

Table 6-1 Reliability Test Specifications

1. Heating and cooling test

Voltage as specified in the contract or purchase order

15 Outdoor air dry-bulb temperature 70 F (21.1 C) to 80 F (26.7 C)

Indoor air dry-bulb temperature 70 F (21.1 C) to 80 F (26.7 C)

100% operation - 50% cooling and 50% heating

20 Cycle reversal every hour

48 hours total test duration

2. High temperature test (cooling)

Voltage 90% of specified

25 Outdoor air dry-bulb temperature 130 F (54.4 C) to 140 F (60 C)

Indoor air dry-bulb temperature 70 F (21.1 C) to 80 F (26.7 C)

100% unit operation

24 hours total test duration

3. Low temperature test (heating)

Voltage 110% of specified

Outdoor air dry-bulb temperature 5 F (-15 C) (or lowest recommended manufacturer's operating temperature if higher than 5 F)

Indoor dry-bulb temperature 70 (21.1) to 80 F (26.7 C)

Operation: Off 24 hours, On 8 hours, Off 24 hours, On 8 hours

64 hours total test duration

4. Fan motor failure blocked air filter test (cooling)

Voltage as specified

Outdoor air dry-bulb temperature 95 F (35 C) to 105 F (40.6 C)

Indoor dry-bulb temperature 70 F (21.1 C) to 80 F (26.7 C)

100% unit operation: 12 hours at 50% of normal airflow across indoor coil, 12 hours with no airflow across indoor coil (indoor fan inoperative and filter face blocked for this test)

24 hours total test duration

5. Low refrigerant charge test (cooling)

Voltage as specified

Outdoor air dry-bulb temperature 95 F (35 C)

Indoor air dry-bulb temperature 70 F (21.1 C) to 80 F (26.7 C)

50% of manufacturer's recommended refrigerant charge

100% unit operation

24 hours total test duration

5

6. Low refrigerant charge test (heating)

Conditions same as 5 above, except outdoor air temperature 20 F (-6.7 C) to 35 F (1.7 C)

7. Salt-spray test - ASTM B117 (cooling operation one hour at conclusion)

10

Outdoor air dry-bulb temperature  $97 \pm 2$  F ( $36.1 \pm 1.1$  C) (atmospheric pressure in salt-spray chamber)

Indoor air dry-bulb temperature 70 F (21.1 C) to 80 F (26.7 C) (for one hour operation at conclusion of salt-spray test)

15

Compressor motor shall not be operated except for one hour at conclusion of salt-spray test

Voltage as specified

Outdoor unit fan 100% operation except as noted below

20

At the 24th and 96th hour of salt spray exposure, the heat pump fan and salt spray are turned off and the chamber door is left open for a period of 8 hours

At the end of the 8 hour period the test is resumed

25

At the conclusion of the final hour of actual salt-spray exposure, the spray shall be discontinued, the chamber door opened and the compressor turned on and operated in the cooling mode for one hour

Total duration of actual salt spray exposure shall be 240 hours (or 720 hours if specified in the contract or purchase order)

8. 100 percent relative humidity test - ASTM D2247

5 Indoor air temperature 85 F (29.4 C)

Indoor fan operation 100% (no heating or cooling coil operation)

Voltage as specified

Interruption conditions at the 24th and 96th hour as specified in test 7 above

10 240 hours total 100 percent relative humidity exposure

7. SEASONAL PERFORMANCE FACTOR

15 The seasonal performance factor (SPF) of air-source heat pumps, for the heating season, shall take into account all system energy requirements, including defrost operation, all fan motors, supplemental heat, etc., and shall be calculated from the relationship

$$SPF = \frac{X}{Y + Z}$$

where X = heat delivered to building during heating season, kWh

Y = energy input to all motors during heating season, kWh

20 Z = supplemental heat during heating season, kWh

Values for X, Y and Z are calculated in tabular form from the following information (see Table 7-1)

A - Outdoor temperature range, F; outdoor air temperature increments of 5 F (2.8 C) below 65 F (18.3 C)

25 B - Seasonal heating hours for A, hrs; found in the Engineering Weather Data Manual or is available from the U. S. Weather Bureau



- C - Average building heat loss for A,  $10^3$  Btu/h
- D - Average heat pump capacity for A,  $10^3$  Btu/h; compressor and indoor fan heating, no supplemental heating
- E - Percent running time for heat pump, %; if  $C > D$ ,  $E = 100$ , otherwise  $E = 100 \times C/D$

5

- F - Rate of energy input to heat pump for A, kW
- G - Energy input to heat pump, kWh;  $G = B \times E \times F/100$
- H - Energy input from electric resistance heaters, kWh; if  $C < D$ ,  $H = 0$ ; otherwise  $H = B \times (C-D)/3.412$
- J - Energy input to building from heat pump, kWh;  $J = B \times E \times D/341.2$

10

Summing over the outdoor air temperature increments gives

$$X = \sum J + \sum H$$

$$Y = \sum G$$

$$Z = \sum H$$

15

for substitution in the definition for SPF.

A sample calculation for SPF is shown in Table 7-1. For a location at Forbes AFB, Kansas, the seasonal heating hours of column B are found in the Engineering Weather Data Manual, and the winter design temperature is 3 F (-16.1 C). The heating load is assumed to be 90,000 Btu/h (26,377 watts) with an indoor temperature of 70 F (21.1 C) and a design temperature difference of 67 F (37.2 C). The average heating loads (column C) are computed from the relationship:

20

$$Q = \frac{90,000}{70-3} (65-T) \text{ where } T \text{ is the average temperature for the temper-}$$

ature range in column A. Columns D and F are assumed values for heat pump performance for the temperature range in column A. Performing the indicated calculations given above, a SPF equal to 2.09 is found. The heating by compression as a percent of the total heat supplied is 81.4 percent. The percent of heating by compression shall be calculated for the water-source heat pump where columns D and F of Table 7-1 are assumed as constants when operating at the winter design temperature and design flow rates of the water source.

8. GUARANTY AND WARRANTY

5 A. Guaranty - The heat pump(s) to be furnished under this specification shall be guaranteed for a period of one (1) year from the date of acceptance thereof, either for beneficial occupancy or for final acceptance, whichever is earlier, against defective materials, design or workmanship. Upon receipt of notice from the Government of failure of any part of guaranteed equipment during the guaranty period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the contractor (supplier).

10 B. Warranty - If the hermetic motor compressor becomes inoperative as a result of defects in material or workmanship within four (4) years next following the expiration of one (1) year after the date of installation for use, the manufacturer shall furnish a new motor compressor. Labor, for replacement, and cost of refrigerant are not included as a part of this additional four-year warranty.

Table 7-1

## Sample Calculation for Seasonal Performance Factor

A	B	C	D	E	F	G	H	J
60/64	675	4.0	75.2	5.3	6.57	235.9		791.3
55/59	585	10.7	71.6	14.9	6.30	550.8		1,834.6
50/54	568	17.5	67.5	25.9	6.02	886.5		2,913.2
45/49	542	24.2	63.4	38.2	5.75	1,189.6		3,844.2
40/44	572	30.9	59.0	52.4	5.43	1,626.7		5,180.2
35/39	600	37.6	49.5	76.0	5.15	2,347.2		6,612.0
30/34	612	44.3	45.2	98.0	4.86	2,915.1		7,946.0
25/29	417	51.0	41.5	100.0	4.60	1,918.2	1,161.0	5,071.9
20/24	326	57.8	37.2	100.0	4.40	1,434.4	1,968.2	3,554.3
15/19	222	64.5	34.0	100.0	4.23	939.1	1,984.5	2,212.2
10/14	155	71.2	30.5	100.0	4.10	635.5	1,848.9	1,385.6
5/9	96	77.9	27.6	100.0	3.90	374.4	1,415.2	776.6
0/4	47	84.6	24.0	100.0	3.77	177.2	834.8	330.6
-5/-1	20	91.3	21.0	100.0	3.62	72.4	412.1	123.1
-10/-6	3	98.1	18.0	100.0	3.51	<u>10.5</u>	<u>70.4</u>	<u>15.8</u>
						$\Sigma = 15,313.5$	9,695.1	42,591.6

$$X = \Sigma J + \Sigma H = 42,591.6 + 9,695.1 = 52,286.7$$

$$Y = \Sigma G = 15,313.5$$

$$Z = \Sigma H = 9,695.1$$

$$SPF = \frac{X}{Y + Z} = \frac{52,286.7}{15,313.5 + 9,695.1} = 2.09$$

$$\text{Heat by compression as percent of total heat supplied} = \frac{42,591.6 \times 100}{42,591.6 + 9,695.1} = 81.4\%$$



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<p>16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)</p> <p>The purpose of this report is to establish, for unitary heat pump equipment, the requirements for performance, testing, rating, design, safety, serviceability and reliability for system and components; and conformance conditions. This report is intended for guidance in military procurement and applies to hermetic electrically-driven vapor-compression unitary heat pumps of the remote (split) and packaged (integral) types, the air-to-air and water-to-air classes, and sizes from 17,000 to 84,000 Btu/hr for both heating and cooling functions.</p>			
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