

TVA Recommended Heat Pump Installation Standards

Encouraging the Purchase of Energy Efficient Heat Pumps

The *energy right*[®] Heat Pump Plan is designed to encourage the installation of electric heat pumps meeting program standards and requirements at residential dwellings and small commercial businesses.

Under the plan, distributors of TVA power may be eligible to receive an MVP for installation of a heat pump meeting TVA's installation standards.

Qualifying Homes and Business'

The following requirements must be met to qualify:

- Weatherization levels of the home must meet or exceed the following requirements:
 - Attic insulation of R-19 minimum (where physical construction of the attic allows installation of insulation by conventional methods)
 - Adequate weather-stripping
 - Adequate caulking

Note: Additional weatherization such as floor insulation and storm windows may be required to meet minimum thermal balance point.

- In a dwelling application, if requirements are not met, additional weatherization must be in the process of being installed to meet or exceed (up to the maximum allowed) those required levels. Weatherization standards and weatherization inspection procedures are found in the Reference Materials Manual. Distributors may select requirements for business applications.
- Equipment shall be sized and selected to meet the requirements of the Installation Standards section of this section.

These minimum weatherization measures shall be installed before the final inspection of the heat pump system. Installation of customer optional storm windows and floor insulation, installed in conjunction with the heat pump, must also be completed prior to the system inspection. All new weatherization measures installed must be in accordance with Reference Materials.

Market Value Payments (MVP)

Description. A distributor may receive an MVP which is described in the TVA Schedule Heat Pump (Section 7.7-Schedule HP). The MVP may be passed along to third parties—or may be used in another manner at the distributors' discretion as noted in the Program Implementation Plan.

The distributor may receive one MVP per dwelling/business per year. The Distributor receives the MVP based on the efficiency of the heat pump installed by a customer, provided the following conditions are met:

- The distributor has selected to participate in the Heat Pump Plan as described in Article III, Program Plans
- The heat pump is installed in a dwelling or qualifying business.
- The installation has been shown by an inspection to meet program standards.

Payments. TVA will pay MVP by Electronic Funds Transfer (EFT) or a mutually agreed upon alternative arrangement. Payments will be based on heat pump installations successfully entered in the *energy right* Program data base, which have not been previously paid.

- Amount of MVP—The distributor will be paid for heat pumps meeting all requirements in the *energy right* Program agreement according to the current payment plan (Schedule HP). MVP is based on efficiency.
- Adjustment of Payment Rates—When the payment rate is adjusted, the distributor will be informed of the adjustment and its effective date. After the effective date of any adjustment in the payment rate, the distributor will have three months to inspect and qualify any installations committed to prior to the effective date of the adjustment as evidenced by documentation confirming the date of that commitment.

Payment Procedures. Distributors apply for payment by submitting a Work Completion Form to TVA’s database.

Documentation. The distributor shall maintain files containing information for each participant in the *energy right* Heat Pump Plan. At a minimum, distributor records shall include the following:

- A completed Work Completion/ Form indicating the size, type, etc., of each heat pump.
- A Quality Contractor Network (QCN) member invoice providing the brand, type unit, rated capacity, and serial and model numbers of the equipment installed.

Financing

If a distributor has selected financing for the Heat Pump Plan, see Article X for requirements and procedures. Financing is limited to heat pump equipment and accessories and associated weatherization as listed in the Financing Section of the Reference Materials for existing dwellings only. At this time, there is no financing for the business application.

Responsibilities

Distributor Responsibilities. Distributors participating in the *energy right* Heat Pump Plan are responsible for the following:

- Arranging for all program-required inspections
- Coordinating QCN member participation with TVA Customer Service Center personnel. If the distributor believes a QCN member participating in the program in their area has violated program criteria, the distributor may collect any evidence to support the claim, and may present such evidence to the appropriate Customer Service Center TVA personnel
- Notifying all QCN members participating in the program in their service area of how the heat pump program will operate in their area, if any incentives or rebates are available and what percentage of inspections will be performed

Contractor (QCN) Responsibilities. TVA will maintain a list of heat pump contractors who apply and qualify for membership in the Quality Contractor Network (a group of contractors listed by TVA). Only QCN members shall participate in the *energy right* Heat Pump Plan.

If a QCN member, or representative, has any questions about weatherization measure(s), installation criteria, inspection procedures, or forms, the inspector should be notified prior to installation.

QCN members are responsible for:

- Determining if the dwelling or business is a good application for the installation of a heat pump, which may include the condition of the structure as well as living habits of the residents; for example, a home in obvious need of extensive structural repair would not be a good application
- Determining the legal owner of the dwelling prior to applying for program financing
- Ensuring that the installation of the heat pump does not alter the structural integrity of the dwelling
- Informing customer, preferably in writing, of details about the heat pump installation prior to beginning work, including:
 - type of equipment and accessories
 - weatherization work required
 - location of heat pump units
 - location of registers, return air grilles, thermostats, ductwork, etc.
 - alterations to home
 - time frame for installation
- Program compliance of all subcontractors and making customers aware when work will be subcontracted
- Customer approval of any changes from original estimate or installation design
- Installing improvements to meet minimum program requirements for the installation of a heat pump; also, the QCN member is responsible for installing weatherization improvements in conjunction with the heat pump installed under the program to meet minimum requirements. If an inspector determines that more than the minimum requirements were pre-existing, additional installed improvements will not be financed.
- Providing quality workmanship performed in a workman-like manner in compliance with all specifications listed in the program guidelines
- Submitting a detailed invoice of the heat pump installation, which separates costs for the heat pump, ductwork, weatherization, extended warranty, programmable thermostat(s), electrical upgrades, and/or other applicable and acceptable costs
- Practicing good business ethics and ensuring customer satisfaction to best of their ability, including leaving the premises in a “broom clean” condition after the installation
- Honoring all service and warranty commitments made to customers

Customer Responsibilities. Customers participating in the *energy right* Heat Pump Plan are responsible for:

- Providing a copy of a deed or other evidence of ownership of the dwelling to meet a condition of financing eligibility under the program
- Entering into an agreement with a member of the QCN for the installation of a heat pump
- Notifying the distributor to arrange for the loan closing or inspection
- Ensuring that the heat pump is installed to the customer’s satisfaction
- Signing the Work Completion Form after the work is completed to the customer’s satisfaction

Installation Standards

Standards for installation of heat pumps are divided into groupings to make finding specific information easier. Below is a list of paragraphs applicable to all heat pump installations, unless stated otherwise for specific heat pumps:

- General Information
- Heat Pump Equipment and Installation Standards
- Quality Contractor Network Member
- Equipment Requirements
- Equipment Installation
- Duct System Design, Modification, and Installation
- Duct System Insulation
- Refrigerant Piping Installation
- Refrigerant Piping Insulation
- Condensate Piping
- Air Filters
- Noise Abatement and Vibration Elimination
- Electrical Requirements
- Indoor Thermostat
- Auxiliary Electric Heaters
- Outdoor Thermostat (Power Distributor Option)
- Extended Warranty Programs
- Performance Guarantee

Following these paragraphs are additional standards applicable to specific heat pump types.

Throughout the Installation Standards, references are made to industry standards. References to these standards are listed in Figure 4-5, References for Technical Standards.

General Information.

- References to Specific Items—Reference in these specifications to any article, device, product, material, fixture, form or type construction by name, make, or catalog number shall not be construed as limiting competition or an endorsement of a manufacturer. These references are only intended to establish minimum standards of quality.
- Codes—The QCN member is responsible for compliance with locally adopted public codes or regulations affecting work under these specifications. Where local codes or regulations require greater standards than those required in this section, local codes govern. Where local codes or regulations permit lower standards than those required by these specifications, the standards contained herein govern. TVA does not assume any responsibility for determining, interpreting, or enforcing compliance with local codes and regulations. In addition, TVA does not interpret or determine local codes and regulations.
- Materials and Appliances—Unless otherwise stipulated, the QCN member must furnish all labor, equipment, tools, materials, and services necessary for the execution and completion of all work. All equipment and materials shall be new and of the quality specified in these standards.

- Testing and Samples—The QCN member, or material manufacturer, shall, if required, furnish satisfactory evidence as to the kind, quality, and performance of materials used. Upon TVA request, test data from an independent laboratory and material samples shall be provided.
- General Requirements—TVA reserves the right to waive portions of these standards if, after review of individual circumstances, a heat pump installation can otherwise meet the standards and intent of the program.
 - The requirements listed under “Qualifying Homes” at the beginning of this section must be met as part of an approved heat pump installation. General standards apply unless a heat pump type is specifically exempted. Additional standards for specific types are also listed.
 - The term "heat pump" shall mean any heat pump consisting of one or more factory assemblies that normally include an indoor coil, compressor(s), outdoor coil (or a refrigerant-to-water heat exchanger if water source or refrigerant-to-ground if direct exchange), and air moving means, including means to provide heating and cooling. An assembly, or matched assemblies designed for use together, shall be matched and certified per the following standards:

| <u>Type of Pump</u> | <u>Certification Standard</u> |
|--|---|
| Air-source heat pumps | ARI Standard 240 |
| Packaged terminal heat pumps | ARI Standard 380 |
| Dual Fuel heat pumps | ARI 240, ARI 325, ARI 330, or must be listed in the latest version of the Canadian Standards Association directory: CAN/CSAA-C446-M90. American Gas Association, Gas Appliance Laboratory, or Gas Appliance Manufacturer’s Association, |
| Self-contained through-the-wall heat pumps | ARI Standard 240, HSP-A and HRCU-A-CB-O |
| Free-delivery split heat pumps | ARI Standard 240, HSP-A and HRCU-A-CB-O |
| Window/wall-mounted heat pumps | ANSI/AHAM RAC-1 |
| Ground-water source heat pumps | ARI Standard 325 |
| Direct-exchange ground source heat pumps | ARI Standard 870 |
| Earth-coupled heat pumps | ARI Standard 330 or CSA Performance of Ground and Water Source Heat Pumps CAN/CSA-C446-M90 |

Notes:

| | |
|------|---|
| ARI | Air-Conditioning & Refrigeration Institute |
| ANSI | American National Standards Institute |
| AHAM | Association of Home Appliance Manufacturers |
| CSA | Canadian Standards Association |

Maximum cooling capacity shall be 60,000 Btuh (5 tons) at ARI conditions.

Heat Pump Equipment and Installation Standards. These standards cover residential installations of heat pumps that are designed to use outdoor air or water as a heat source. All equipment must be safety tested and listed by either Applied Research Laboratories, ETL Testing Laboratories, Inc., or Underwriters' Laboratories. Additional laboratories may be accepted upon review by TVA. Performance shall be certified under the latest revision of Air-Conditioning & Refrigeration Institute or Association of Home Appliance Manufacturers Guidelines. These standards are intended to apply to heat pumps installed in a single zone with independent controls.

The latest Air-Conditioning & Refrigeration Institute directory listing will be used for capacity and efficiency ratings. The effective date for each publication of the directory will be no later than the first day of the month following the date of the directory.

All equipment and materials shall be new (not previously used or installed) and of a quality specified in these standards.

Quality Contractor Network Member Selection. Before installing a system, each contractor must be a current member of the QCN. Heat pump contractors interested in joining the QCN may inquire through the TVA Customer Service Center in their business area. Upon such request, the contractor will be furnished applicable information and will be notified of meetings/training/procedures required for participation purposes. Each applicant will be notified as to the decision rendered pertaining to their participation after TVA's review. QCN membership is subject to participation and performance requirements furnished to each QCN member. For business applications the QCN contractor must have completed Manual N Certification.

Equipment Requirements.

1. All heat pumps installed must meet or exceed the minimum efficiency rating shown below. (Note: All efficiency ratings must meet future minimum efficiency ratings as required by the Department of Energy.)

Table 4-1. Minimum Efficiency Requirements

| Air-Source Heat Pumps (ARI Standard 240): | | | | |
|--|-------------------|------|-----------------|------|
| | Package Heat Pump | | Split Heat Pump | |
| Effective Date | SEER | HSPF | SEER | HSPF |
| January 1, 1993 | 9.70 | 6.60 | 10.00 | 6.80 |
| January 23, 2006 | 13.0 | 7.70 | 13.00 | 7.70 |
| Water Source Heat Pumps (ARI Standard 325 or CAN/CSA-C446-M90): | | | | |
| Effective Date | EER at 70°F EWT | | COP at 50°F EWT | |
| January 1, 1992 | 10.5 | | 2.70 | |
| Earth Coupled Heat Pumps (ARI 330 or CAN/CSA-C446-M90): | | | | |
| Effective Date | EER at 77°F EWT | | COP at 32°F EWT | |
| No minimum efficiency requirement | Not applicable | | Not applicable | |

2. QCN member will perform an equipment sizing and thermal balance point calculation which includes final insulation and weatherization levels (upon completion of the installation), including required weatherization improvements. Heat loss and heat gain calculation methods shall be based on the procedures contained in the Air Conditioning Contractors of America (ACCA) Manual J or Manual N (latest TVA-adopted revision) or the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals (latest revision). The heat loss/heat gain calculation shall state (may be written in by dealer/contractor) the construction numbers and corresponding surface area (square feet), or linear feet if applicable, and the structure sensible and latent loads at design conditions. Design conditions shall be as follows:

Heating

Indoor = 70°F dry bulb

Outdoor = Varies with locale

Cooling

Indoor = 75°F dry bulb, 50% relative humidity (62-63°F wet bulb)

Outdoor = Varies with locale

All cooling calculations shall allow for a 3°F maximum temperature swing.

3. The total cooling capacity of heat pumps consists of the sum of the sensible and latent capacities at a given set of design conditions. All heat pump systems installed must be sized to provide at least 100 percent and not more than 125 percent of the sensible load requirements (Btuh) of the structure, and at least 100 percent of the latent load requirements (Btuh) of the structure (no maximum limit) to

meet the summer design conditions listed under Equipment Requirements, item 2 (above). However, the above maximum sizing criteria (125 percent of sensible) shall not apply when: (1) the total capacity of the unit installed, at TVA design conditions, is 23,000 Btuh or less or (2) no unit with 23,000 Btuh is available and the manufacturer's unit nearest to 23,000 Btuh is installed. The heat pump selected must meet or exceed the structure loads (within the above-mentioned limits), yet be as close to the structure loads as possible.

4. The heat pump refrigeration system heating capacity, exclusive of resistance heaters, shall be sized to meet the heating requirements of the structure with a balance point not to exceed 35°F dry bulb outdoor temperature. However, the 35°F balance point may be exceeded upon prior approval by TVA when: (1) the seasonal performance factor (SPF) is 2.0 or greater (TVA will calculate SPF from load calculations and equipment information) or (2) floor insulation is installed when the balance point is 38°F or less and storm windows and floor insulation are both installed when the balance point exceeds 38°F. The adjustment factor (C_d) for solar and internal gains have a value of 1 when calculating the balance point for setting the outdoor thermostat(s).
5. Heat pumps with multi-speed or variable speed compressors and indoor blower motors shall be sized within the cooling capacity range stated by equipment manufacturer. The duct system for multi-speed equipment shall be sized based on the cubic feet per minute volume recommended by the manufacturer.

Equipment Installation. The following requirements for installation apply, unless otherwise stated.

1. The QCN member is responsible for the installation meeting all applicable codes (local, state, and national) pertaining to the installation and operation of heat pumps and electric heating equipment. All applicable codes supersede manufacturer's specifications or TVA specifications. When an electrical and/or mechanical permit is required by code authorities or officials, a copy of each appropriate permit will be made available to TVA and/or distributor personnel prior to or during final inspection. Where the manufacturer's specifications require a greater standard than that required by TVA, the manufacturer's specification governs. Unless otherwise required by these standards, the equipment shall be installed in accordance with the equipment manufacturer's recommendations.
2. The air flow from two or more units shall not be connected in parallel to a common supply or return air duct system. Outdoor units shall not be installed where ductwork is necessary to connect to outdoor air through remote wall or roof openings.
3. Outdoor units shall meet or exceed all clearances specified by the manufacturer's published specifications. Unless the manufacturer's specifications state a greater clearance allowance and are available at the time of inspection, a minimum of 4 feet of unobstructed air discharge flow from the unit and a minimum of 18 inches of air intake clearance shall be required.
4. Outdoor units shall be located so that roof or other drainage will not interfere with proper equipment operation. Outdoor units located on grades in or near parking areas, alleys, or driveways shall be protected from damage by vehicles and shall be arranged so that vehicles or objects will not block or obstruct air intake or discharge. Outdoor units shall not be located within 4 feet of kitchen, laundry, or other exhausts that could cause coil contamination.
5. All units shall be located to allow service access for removal of any unit component without removing any piping, ductwork, or other permanently installed fixtures or components.
6. All package units and the outdoor sections of split units shall be mounted on a level, one-piece concrete pad. (Other pads which accomplish the same desired results may be acceptable after satisfactory performance has been proven to TVA.) Newly installed pads shall be isolated from the building structure. Pads shall rest on well settled ground with adequate provision for drainage away from the building. The minimum mounting height of the outdoor unit from grade or pad level shall be as recommended by the manufacturer. The distance between the coil and grade level shall be 6 inches minimum, or the manufacturer's requirement if different. Indoor sections shall have suitable and permanent support to prevent transmission of objectionable noise or vibration generated by the equipment to the structure.
7. Heat pump sections containing the outdoor coil and/or compressor shall not be located in the attic.

Duct System Design, Modification, and Installation. The following standards apply unless otherwise stated:

1. Duct design and installation shall be as recommended by Air Conditioning Contractors of America Manuals D, E, G, and L, Sheet Metal & Air-Conditioning Contractors National Association, Inc. (SMACNA) manuals, and/or the American Society of Heating, Refrigeration, & Air-Conditioning Engineers (ASHRAE) Handbook, unless otherwise stated in these standards. Air distribution system design and installation shall provide air flow across the indoor heat pump refrigerant coil at a minimum of 400 cubic feet per minute per 12,000 Btuh of the equipment's Air-Conditioning & Refrigeration Institute (ARI) certified cooling capacity. An air flow less than 400 cfm per 12,000 Btuh will be accepted only when the manufacturer's product performance data shows the equipment was certified with an air flow less than 400 cfm per 12,000 Btuh of cooling capacity (or if unit is variable speed type which modulates refrigeration processes and fan(s) cubic feet per minute) and clearly reveals the rated air flow in the product performance data. Airflow for water-source heat pump systems shall be within the airflow parameters as specified by the heat pump manufacturer.
2. The long cross-section dimension on rectangular duct shall not exceed three times the shorter dimension unless prior approval is given by TVA.
3. All duct joints, seams and fittings, and return air pans in *newly installed* duct shall be sealed as described in the Fasteners and Sealants for Ductwork Table (Table 4-2). A list of acceptable mastic sealants will be made available from TVA. All supply boots shall be sealed with reinforced mastic sealant or caulked (if needed) where they penetrate floors, side walls, or ceilings. When starting collars are used with ductwork, only adhesive gasket metal starting collars shall be used in transitions from trunk duct to branch duct.
4. Flexible vibration isolation connectors, or approved equal, shall be installed (as necessary) in sheet metal ductwork at the unit in both the supply and return. Ductwork shall be properly aligned at these connectors with no offset.
5. Ductwork shall not contact the ground.
6. Metal ductwork shall be installed in a workman-like manner in accordance with the acceptable practices given in the ASHRAE Handbook or the SMACNA "Low Pressure Duct Construction Standards" (latest revision) manual. Rectangular sheet metal ducts shall be a minimum of 28-gauge thickness and all seams and joints shall be mechanically fastened. All metal ducts shall be securely supported, hung, or suspended by metal hangers, straps, or brackets and the support material in contact with the duct, or external insulation, shall not be less than 3/4 inches wide. Duct hangers shall not be more than 10 feet apart for rectangular metal duct, or 12 feet for round duct. Supporting straps shall be installed within 2 feet of supply boots. All rectangular metal ducts 24 inches wide and wider shall be cross broken or beaded to provide additional support. The joints of round sheet metal duct shall be secured with screws.
7. Rigid fibrous glass ductwork (duct board) may be installed instead of insulated sheet metal ductwork. (Exception: Rigid fibrous glass ductwork shall not be installed in crawlspace areas without prior approval from a TVA or power distributor representative.) This ductwork shall be a minimum 1-inch thick, 3-1/4 pound per cubic foot density and bear Underwriters' Laboratories' 181 approval as a Class 1 air duct. Fabrication and assembly shall be in strict accordance with details listed in the fiberglass manufacturer's applications manual or the SMACNA "Fibrous Glass Duct Construction Standards" (latest revision). Hanger spacing shall not be more than 8 feet between hangers with the support material in contact with the duct not less than 3/4 inch wide. Tapes utilized shall be only those specifically recommended by the ductwork manufacturer in their installation instructions.
8. Flexible ductwork (minimum R-4) may be installed instead of insulated sheet metal ductwork and rigid fibrous glass ductwork. (Exception: Flexible ductwork shall not be installed in crawlspace areas without prior approval from a TVA or power distributor representative.) Flexible air duct shall be tested to and comply with Underwriters' Laboratories Standard 181 (Factory Made Air Ducts and Connectors) by a laboratory with facilities, equipment, and expertise to perform testing of electrical and gas-burning appliances, heating, ventilation, and air-conditioning equipment, air ducts, and fire extinguisher as they relate to the BOCA National Codes, the Uniform Codes, and the Standard Codes. Acceptable laboratories are Applied Research Laboratories, ETL Testing Laboratories, Inc., or Underwriters' Laboratories.

All flexible duct shall be listed as Class 1 air duct with a moisture impervious sleeve. Assembly shall be in strict accordance with details listed in the flexible ductwork manufacturer's and/or equipment supplier's applications manual or the SMACNA "Flexible Duct Performance Standards" and "Flexible Duct Installation Standards" (latest revisions).

Flexible air duct shall be sized to include allowances for the surface roughness of the flexible duct material. The methods outlined by the Air Conditioning Contractors of America (ACCA) Manual Q, the use of friction charts specifically for sizing flexible, vinyl-coated helix core ducts (provided by ACCA Manual D, ASHRAE guidebooks, etc.), and the use of duct sizing slide rules that provide the same information found on friction charts and are specifically for flexible, vinyl coated helix core ducts, are recommended.

Since air velocities in low velocity duct systems are dictated by noise and friction considerations, particular attention should be given to maintaining velocities in flexible ducts that do not exceed industry recommendations. Flexible air duct shall be supported at the manufacturer's recommended intervals, but not to exceed a maximum distance of 10 feet. Supporting straps shall be installed within 2 feet of supply boots. Hanger material shall be not less than 1 inch wide and shall be suitable for use with flexible ductwork (without cutting ductwork). The maximum permissible sag shall be 1/2-inch per foot between the hangers. Collars shall be used to connect flexible duct and shall be a minimum of 2 inches in length. Collars shall be inserted into the flexible duct a minimum of 1 inch before fastening and sealed with a mastic sealant.

Flexible Class 1 air duct may be used for both supply and return applications. Flexible Class 1 air duct connectors may be used only on the return duct.

1. Any ductwork opening through a foundation wall or manufactured home bottom board material or skirting shall be sealed with sheet metal to prevent the loss of conditioned air and the entrance of animals, etc. This opening and external ductwork shall also be protected from the weather.

Where animals could travel beneath an external duct covering (shroud) and into a crawlspace through the foundation wall opening, the shroud shall extend beneath the external duct to prevent intrusion. This covering shall be sheet metal and continuous from unit to structure, encompassing the ductwork to and from the unit. The installing contractor in cooperation with the installation inspector shall determine on a case-by-case basis the need for this continuous shroud.

2. The minimum size of any branch supply duct or return shall be 4 inches in diameter, or equivalent. The maximum size of a branch duct to a supply outlet shall be 8 inches in diameter, or equivalent.
3. Supply air registers and grilles shall be of sufficient number, size, and location to prevent objectionable drafts and noise and to provide balanced air circulation and temperature. Where possible, supply air outlets shall be located at the outside perimeter of the space to be conditioned. Supply registers shall have adjustable dampers so the user can easily make minor regulations of air flow. Each supply register shall be designed for the specific application and shall permit proper diffusion of air along the outside perimeter without interference from drapes, curtains, etc. Average face velocity of each supply register shall not exceed 700 feet per minute or be less than 400 feet per minute.
4. Return air inlet registers and grilles shall be of sufficient number and size, and located to prevent objectionable drafts and noise and provide balanced air circulation. The cubic feet per minute capacity of return air registers, grilles, and ductwork at acceptable air speeds, shall not be less than the design cubic feet per minute capacity of the supply system. In two-story, or multi-level residences, there shall be a minimum of one return air grille on each level, sufficiently sized and equal to the supply cubic feet per minute. Return air registers and grilles shall, where possible, be located at low levels and sized for a maximum average face velocity of 500 feet per minute.
5. Branch duct takeoffs shall be more than 4 feet from the indoor supply side of the unit or the supplemental electric heater assembly. Readily accessible balancing or volume control dampers with outside locking devices shall be provided, as needed, in the supply branch ducts to regulate the air flow to each register. The balancing dampers should be located as close as possible to the supply trunk. Provisions (i.e., main trunk line volume control damper in the largest trunk, etc.) shall

be provided, if needed, to regulate air flow where the main supply trunk divides. Supply branch ducts shall not originate from the end of the main supply trunk line.

6. The average temperature difference between any room or space within the conditioned structure (same level) shall not be more than 4°F.
7. Multi-zone duct systems utilizing dampening devices to control the flow of air and multiple thermostats (one per zone) shall be installed in accordance with manufacturer's installation manuals.
8. Ductwork shall not be installed where it will be exposed in a living space without prior written approval from customers.

Table 4-2. Fasteners and Sealants for Ductwork
energy right[®] New Homes Plan (*All Duct*) and Heat Pump Plan (*Only New Duct*)

| Duct Joint or Connection | Inside Conditioned Space | Outside Conditioned Space |
|---|---------------------------------|---|
| Flex duct to collars, sleeves, or fittings | Band plus UL tape or mastic | Band plus UL tape or mastic |
| Adhesive gasket (flanged) metal starting collar to metal plenum, metal duct, or metal junction box | Screws | Screws (Mastic optional) |
| Spin-in or flanged metal collar to duct-board duct or duct-board plenum | Mastic | Mastic |
| Metal round pipe with dovetailed fitting to metal plenum, metal duct, or metal junction box | Screws and mastic | Screws and mastic |
| Metal round pipe with transverse lap joints | Screws and mastic or UL tape | Screws and mastic or UL tape |
| Metal plenums and metal square/rectangular duct with transverse drive and S joints | None | Mastic |
| Metal plenums and metal square/rectangular duct with longitudinal snap-lock (shop bent) joints | None | None |
| End caps and corners of supply and return plenums | Mastic | Mastic |
| Metal elbow swivel joints | None | None (Mastic optional) |
| Plenums to air handler | Mastic | Mastic |
| Air handler cabinet doors (excluding filter doors) | None | None (unless leakage is apparent due to poorly fitting doors) |
| Duct boot to sheetrock wall/ceiling and flooring | None | Secure tight and caulk |
| Metal return panning to joist | Mastic | Mastic |
| All ductboard joints and seams | Manufacturer approved UL tape | UL tape and mastic |

Duct System Insulation. The following requirements apply unless otherwise stated.

- Both supply and return sheet metal ducts shall be insulated as follows:

Table 4-3. Insulation for Supply and Return Ducts

| Duct Insulation (New or Existing) | Duct Location | Minimum Insulation Thickness* |
|-----------------------------------|---------------------|---------------------------------------|
| New | Unconditioned space | 2" wrap or 1" liner |
| Existing | Unconditioned space | 1" wrap or ½" liner (except attic) |
| Existing | Attic | 2" wrap or 1" liner |

Notes:

*Equivalent combinations may be used to achieve the required thickness. All material, new or existing, shall be vapor sealed and meet the following specifications: wrap- 0.75-pound per cubic foot density, liner- 1.5-pound per cubic foot density.

If upgrading the existing duct system in the attic is not cost effective, at the homeowner's request, additional duct insulation may be waived.

Ductwork exposed to outdoor ambient temperatures and weather conditions shall be lined with 1.5 inch, 1.5-pound per cubic foot density insulation or wrapped with 3 inch, .75-pound per cubic foot density insulation and vapor sealed and shall be weatherproofed. Internal duct insulation shall consist of flexible, resilient glass fiber board or sheets specially faced on the air stream side to ensure a smooth surface and unrestricted air flow. Welded tabs or adhesive pins shall be used in addition to adhesive to secure insulation. Internal duct insulation shall be carefully applied so that there are no voids or gaps in the finished work. Where both external insulation and internal insulation are used, they shall overlap at least 6 inches.

- All insulating materials used shall meet the appropriate specifications required by American Society for Testing & Materials E-84, C-553; National Fire Protection Association 90A, NFPA 90B; and Underwriters' Laboratories 181.
- All vapor barrier seams shall lap a minimum of 2 inches, be mechanically fastened, and be sealed with a foil or high grade tape to maintain vapor barrier integrity. Where necessary, provisions shall be made to prevent support devices from cutting through or damaging the vapor barrier.
- Insulation shall fit snugly but not be pulled tight enough to cause more than 25 percent compression.

Refrigerant Piping Installation. The following requirements apply unless otherwise stated.

- Split systems shall use only new, appropriately insulated refrigerant line sets specified by the manufacturer. Excess tubing length shall not exceed 10 feet and shall be coiled to provide oil drainage toward the compressor. Refrigerant piping in excess of 50 feet shall be approved and sized according to manufacturer specifications.
- Refrigerant piping shall be supported properly to prevent excessive sagging, movement, or vibration. Supports shall limit lateral movement, but permit normal thermal expansion and contraction. Isolation type hangers, or equivalent, shall be used at a minimum of 10 feet intervals to support refrigerant lines from floor joists and other parts of the structure.
- Refrigerant pipe passing through openings in the unit cabinet shall be installed to prevent wear or vibration through contact with the cabinet or components within the unit. Refrigerant piping passing through the building wall shall be protected to prevent contacting each other or the structure. Kinks or restrictions in the refrigerant line shall not exceed 25 percent of the cross sectional area.
- Refrigerant piping installed in the earth below a concrete slab shall be encased in conduit or a minimum of Schedule 40 polyvinyl chloride. The encasement diameter shall be at least 3/4 inches greater than that of the tubing and its insulation. The casing shall be laid in a straight line to permit removal or insertion of the piping and shall terminate above the grade level.

5. The linear, one way length of refrigerant piping between the two sections of split units shall not exceed the maximum distance specified in the manufacturer's published literature. The compressor section shall not be more than 20 feet above or below the indoor unit. Oil traps or double suction risers, as required by the heat pump manufacturer, shall be provided for oil return.

Refrigerant Piping Insulation. Refrigerant vapor (suction) lines shall be continuously insulated and vapor sealed with a minimum thickness of 3/8 inch of foam rubber equivalent to 3/8 inch of AP Armaflex insulation, or equivalent. All refrigerant line insulation joints and seams shall be sealed with an appropriate glue to prevent moisture penetration.

Condensate Piping. The following requirements apply unless otherwise stated.

1. Condensate drain water piping shall comply with local codes, ordinances, and the manufacturer's recommendations.
2. Suitable means shall be provided for the collection and disposal of condensate from the equipment. Gravity type condensate drains shall be at least 3/4 inch nominal pipe size, or larger if recommended by the heat pump manufacturer, and may be copper or plastic.
3. An auxiliary drain pan with a separate 3/4 inch drain line shall be installed beneath the indoor unit where water damage may result if the main drain becomes restricted or plugged. The drain line from the auxiliary drain pan shall be run to a conspicuous point to serve as an alarm that the primary drain is restricted. When an auxiliary drain line is not installed, a unit cut-off switch shall be provided to indicate a potential condensate overflow. In dual-fuel heat pump installations where the indoor coil will be mounted above an existing furnace (vertical flow), an auxiliary drain pan shall not be required under the furnace.
4. Condensate shall not be permitted to drain into a crawlspace area. Drain lines shall be trapped at the unit, and lines shall be pitched in the direction of flow based on manufacturer's recommendations. Where a condensate lift pump is required, a check valve may be installed in the discharge line of the pump to prevent condensate back flow. In areas where damage may occur, an automatic compressor cut-off switch shall be provided to turn the heat pump off when a condensate pump fails to operate. If deemed necessary by TVA, a suitable drain clean-out shall be installed.
5. Primary condensate drain lines shall be insulated in all cases where sweating or dripping may cause property damage.
6. Any condensate drain line penetration through the structure of the residence shall be sealed and weatherproofed.

Air Filters. The following requirements apply unless otherwise stated.

1. All air filters shall be installed in the return air system in a location that is easily accessible for the homeowner to change. All return air must pass through the return air system. Filters shall not be installed in a package outdoor unit, attics, or crawlspaces without prior approval from TVA or the power distributor representative. When filter grilles are used, only one single filter shall be used per filter grille.
2. If used, electronic air cleaners should be the return air grille type and have efficiency ratings based on National Bureau of Standards Dust Spot Method Using Atmospheric Dust and the ASHRAE Standard 52-76, for Air Cleaning Devices. All air circulated by the system must pass through the electronic air cleaner. An interlock switch shall be provided to interrupt operation of the electronic air cleaner if the grille is opened. A switch permitting the cleaner to be manually turned on and off shall be provided. Non-electronic air cleaners shall also be tested to ASHRAE Standard 52-76 by an independent laboratory such as Applied Research Laboratories, ETL Testing Laboratories, Inc., or Underwriters' Laboratories and the results made available. If unique air filters are used, proper air volume and total duct system external static pressure must be considered.

Noise Abatement and Vibration Elimination. Suitable, permanent means shall be provided to prevent the transmission of objectionable noise or vibration from the equipment. Outdoor units shall be located to avoid transmission of objectionable noise to adjacent properties. Units should be located, if possible, away from sleeping areas or other areas where noise would be objectionable.

Electrical Requirements. The following requirements apply unless otherwise stated.

1. The installing QCN member shall comply with the manufacturer's recommendations, the National Electrical Code, and all local codes and ordinances. The residence shall have an electric service capable of supplying the existing lights, appliances, and proposed heat pump and auxiliary electric loads. Where codes prohibit, electrical wiring shall not be located in the ductwork.
2. An electrical disconnect shall be provided within sight and within 50 feet of each piece of motor-driven equipment.
3. The equipment nameplate data shall determine the type (fuse or breaker) and size of the overcurrent protection to be used, as well as specify the size of the auxiliary heater installed.
4. The use of aluminum wire is permitted only if: (a) local code allows, (b) the use is approved by the equipment manufacturer, (c) it is properly sized, (d) it is connected with lugs UL-approved for aluminum, and (e) it is coated with an approved material to eliminate corrosion.
5. Low voltage (24 volt) field-installed wiring shall be a minimum of 18 AWG and shall be color coded so the identity of each conductor can be easily established. Splicing of conductors is not acceptable. All low voltage wiring must be properly supported and protected from damage.

Indoor Thermostat. The following requirements apply unless otherwise stated.

1. The indoor thermostat shall be equipment compatible, installed level, and calibrated as specified by the equipment manufacturer. Indoor thermostats shall be located on an interior partition, column, etc., in an area that will be at approximately the return air temperature. The thermostat shall be mounted 4-1/2 to 5 feet above the floor and be free from undue influence of vibration or heat from lighting, sun, appliances, fireplaces, air-supply outlets, or outside air from entrance ways, etc. Thermostats shall not be installed in kitchens, bathrooms, alcoves, or bedrooms without prior approval from a TVA or power distributor representative.
2. Either a manual emergency heat switch on the subbase, or automatic controls (factory installed) within the heat pump shall be supplied to allow all of the auxiliary electric heaters to be electrically turned on during the heating season (under control of the indoor thermostat but with the compressor and outdoor thermostats bypassed) for use when the heat pump compressor or associated refrigeration equipment are inoperative.
3. Energy saving set-back thermostats, if used, shall be compatible with the installed equipment and be the incremental stage(s) recovery type (identifiable by product literature supplied by the QCN member) which reduces auxiliary heat operation to the minimum necessary during the recovery period, and is compatible with the installed equipment.

Auxiliary Electric Heaters. The following requirements apply unless otherwise stated.

1. Auxiliary electric heater assemblies shall be safety tested and listed for use with the manufacturer's equipment.
2. Auxiliary electric heater capacity shall be sized as follows:
 - Minimum - At 70°F indoor temperature and outdoor design conditions, the capacity shall be no less than the difference between the total calculated heat loss and the compressor output.
 - Maximum - At 70°F indoor temperature and outdoor design conditions, the capacity shall be no more than 100 percent of the total calculated heat loss. However, if 100 percent of the total calculated heat loss is less than 10 kW, the maximum allowable auxiliary heater bank capacity shall be either 10 kW or the manufacturer's nearest nominal element size.
3. Emergency heat for water source heat pumps shall be sized in accordance with the maximum sizing requirements stated above.
4. The wattage of auxiliary heater stages shall not exceed 10 kW (nominal) per stage.
5. Auxiliary electric heaters, wood heaters, or any other type heating device shall not be used to directly preheat the return air of an operating heat pump.

6. In no case (for normal heat pump operation) shall the auxiliary heater(s) be wired to energize during the first heating stage of the indoor thermostat.

Outdoor Thermostat (Power Distributor Option). The first stage of the electric auxiliary heaters shall be automatically controlled by the second heating stage of the indoor thermostat and subject to an outdoor thermostat set at the calculated heat pump/structure balance point. In normal heating operation, this shall eliminate the operation of the auxiliary heaters when the outdoor temperature is above the balance point setting. The outdoor thermostat, however, shall not prohibit the operation of any auxiliary heaters that provide air tempering during the defrost cycle. Additional heater stages shall also be controlled by additional outdoor thermostats set at their appropriate calculated balance points. Where outdoor thermostats are used, the adjustment factor (C_d) for solar and internal gains shall have a value of 1 when calculating the balance point for setting the outdoor thermostat. Other methods providing the same operating economy and accomplishing the same desired results will be acceptable after satisfactory performance has been proven to TVA.

Extended Warranty Programs. Heat pump manufacturers should offer, for optional purchase by the customer, an extended service warranty program. Warranties backed by heat pump manufacturers and administered by a third party may be acceptable. All warranties shall meet the following criteria:

1. Term of Contract - Minimum of the second through the fifth years of equipment operation
2. Cost of Contract - Specified dollar amount for the term of the contract
3. Expense Limitations - No per occurrence or life of contract expense limitations on labor or material (other than limits on the installer's markup) imposed on the customer or the heat pump servicing agency
4. Service Mileage Limitations - Service mileage travel charges (if job site is beyond the servicing agency's normal service area) clearly stated and included in the cost of the contract at the time of the original contract execution
5. Cancellation Limitation - Cancellations made only upon a 30-day written notice to the customer and are limited to costs in which there has been substantial damage as a result of:
 - Act of God
 - Abuse of equipment by customer or an unapproved QCN member
 - Customer failing to follow instructions contained in the owner's manual
6. Availability of Parts and Labor - QCN member, equipment distributor and manufacturer shall maintain a reasonable stock of replacement parts so that defect(s) will be corrected within a reasonable period of time. Any necessary part(s) shall be secured and the unit repaired during a maximum period of 15 working days.
7. Manufacturers - The warranty must clearly state that the manufacturer has ultimate responsibility for honoring claims. A clear process for submission of claims directly to the manufacturer must exist if a third party administrator is needed.

Performance Guarantee. The following requirements apply.

1. The QCN member shall guarantee to the purchaser that the heat pump system will provide adequate and dependable comfort conditions during heating and cooling operations at the stated design temperatures and loads. This guarantee shall also include assurance of readily available and adequate service, service facilities, and replacement components and parts. For a 1-year period, running concurrently with the heat pump manufacturer's 1-year product warranty, the QCN member shall provide, without charge, replacement parts and service. The QCN member shall in all cases ensure that the manufacturer's warranty is fully maintained during the entire period of any warranty coverage.
2. It is recommended that on each installation the participating QCN member secure, in an easily visible location, a sticker showing their name, regular phone number, emergency service phone number (if applicable), and date of system startup. There shall be, either in the owner's possession or affixed near the unit, all installation and operating manuals and warranties, and the QCN member

or his/her representative shall instruct the owner on the complete operation of the heat pump system at the time of system startup.

Specific Guidelines. The following guidelines are additional standards for specific heat pump types.

- Dual-fuel heat pump (DFHP) systems
- Split-type dual-fuel heat pumps
- Package-type dual-fuel heat pumps
- Manufactured home heat pump systems
- Packaged terminal heat pumps (PTHP), self-contained through-the-wall heat pumps (SCTTWHP), free delivery split heat pumps (FDSHP), and window heat pump systems (WHPS)
- Water source heat pumps: ground water source heat pumps (GWSHP) and earth coupled heat pumps (EHP)
- Variable speed heat pumps (VSHP)
- Direct exchange ground source heat pumps (DXGS)

Dual-Fuel Heat Pump (DFHP) Systems. This section covers both the split-type and package dual-fuel heat pump systems. No parts of the Auxiliary Electric Heaters section shall apply to dual-fuel heat pumps. All other sections are applicable unless otherwise noted.

1. Indoor Thermostat section, item 2 shall not apply to a dual-fuel heat pump installation. At the power distributor's option, no emergency heat function shall exist on the indoor thermostat of a dual-fuel heat pump installed under the program. Thermostats and/or controls shall be designed to:
 - Allow the heat pump to operate above the thermal balance point of the structure. Above the thermal balance point, the heat pump should be controlled off the first bulb of the indoor thermostat.
 - Allow only the fossil-fuel furnace to operate below the thermal balance point of the structure. Below the thermal balance point, the furnace should be controlled off the first bulb of the indoor thermostat.
 - Not allow the fossil-fuel furnace and the heat pump to operate at the same time except in the defrost mode. The fossil-fuel furnace shall operate during the defrost cycle. (If the heat pump coil is positioned in the duct system upstream from the fossil-fuel furnace, the simultaneous operation of the fossil-fuel furnace and the heat pump is permissible).
2. The heat pump refrigeration system heating capacity shall be sized to meet the heating requirements of the structure down to a minimum of 40°F dry bulb outdoor temperature. If the heat pump compressor or associated refrigeration equipment is inoperative, the furnace shall provide all required heating controlled from the indoor thermostat in the heat mode. The system controls shall allow simultaneous operation of the heat pump's refrigeration cycle and the furnace only during the defrost cycle. The fossil-fuel furnace output capacity shall meet or exceed the total heat loss of the structure at the outdoor design temperature.
3. Unless otherwise required by the Installation Standards, the equipment (including the fossil-fuel furnace) shall be installed in accordance with the equipment manufacturer's specifications. The fossil-fuel furnace of a split-type dual-fuel heat pump and the package dual-fuel heat pump shall have a label attached identifying it as safety tested and listed by the American Gas Association, Gas Appliance Laboratory, ETL Testing Laboratories, Inc., Gas Appliance Manufacturer's Association, or Underwriters' Laboratories. The installing QCN member shall inspect any existing fossil-fuel furnace to determine if it is suitable for use with a split-type system.

Split-Type Dual-Fuel Heat Pumps. This section is related to the installation of all split-type dual-fuel heat pump systems to an existing central furnace, such as a fossil-fuel central furnace system in good working condition. The dual-fuel heat pump shall meet or exceed the minimum HSPF and SEER requirements of split-type heat pumps stated in Equipment Requirements section, item 1. The blower used in the dual-fuel heat pump installation (either the existing

one or a replacement) shall be capable of providing the proper air flow, based on final duct design, for the fossil-fuel furnace and the heat pump. If the existing blower must be replaced, the installing QCN member is responsible for selecting a blower that will satisfy the manufacturer's requirements of both the furnace and the heat pump.

The system shall include the control unit specified by the heat pump manufacturer. The control shall be located and mounted as specified by the heat pump manufacturer.

Package-Type Dual-Fuel Heat Pumps. This section is related to the installation of all package-type dual-fuel heat pump systems (single-package units that incorporate both a standard electric heat pump and a fossil-fuel furnace). The package-type dual-fuel heat pump shall meet or exceed the minimum HSPF and SEER requirements of package heat pumps as stated under Equipment Requirements subsection, item 1.

Manufactured Home Heat Pump Systems. This section is related to the installation of heat pump systems installed in manufactured homes built to the Department of Housing and Urban Development's Federal Manufactured Home Construction and Safety Standards, 1976. (Manufactured homes built prior to 1976 are not eligible to participate in the *energy right* Heat Pump Plan except when evidence through analysis indicates the manufactured home can achieve acceptable comfort levels following a heat pump installation with newly installed program ductwork.)

1. Heat pumps installed in manufactured homes may use the existing ductwork or new, field-installed ductwork. For existing manufactured homes manufactured ductwork, only items 9, 10, 14, and 15 of the Duct System Design, Modification, and Installation section shall apply. However, the average face velocity of each supply register shall not exceed 700 feet per minute or be less than 400 feet per minute. All field-installed supply and/or return ductwork shall be in accordance with the equivalent Installation and Duct System Design, Modification, and Installation sections. All other sections in these Installation Standards are applicable unless otherwise noted.
2. All heat pumps installed in manufactured homes shall operate within manufacturer's specifications and be approved for that use by the heat pump equipment manufacturer. The duct system shall provide the amount of air flow across the indoor coil as listed in the heat pump manufacturer's specifications. The installing QCN member is responsible for obtaining the required air flow.

Packaged Terminal Heat Pumps (PTHP), Self-Contained Through-The-Wall Heat Pumps (SCTTWHP), Free Delivery Split Heat Pumps (FDSHP), and Window Heat Pump Systems (WHP). The following subsections do not apply to the above-named systems: Equipment Requirements, item 1; Condensate Piping, item 3; Indoor Thermostat, and Auxiliary Electric Heaters. The minimum air flow requirement of 400 cubic feet per minute per 12,000 Btuh in Duct System Design, Modification, and Installation section, item 1, shall not apply. All other sections of these standards remain applicable unless otherwise noted.

1. Free-delivery split heat pumps, self-contained through-the-wall heat pumps, packaged terminal heat pumps, and window heat pump systems are designed to deliver conditioned air to the space without the use of ductwork. Self-contained through-the-wall heat pumps and packaged terminal heat pumps are designed to be installed through an exterior wall. Window heat pump systems are designed primarily for use in window installations. Free-delivery split heat pumps are split-type, free delivery heat pumps that may consist of one or more indoor units. The indoor units are designed to be attached to an indoor wall or ceiling.
2. The auxiliary electric heater for these types of heat pumps shall be provided by the heat pump manufacturer within the unit cabinet or fan coil section as part of the heat pump and shall be controlled by the unit's indoor thermostat.
3. These types of heat pumps shall be installed and supported in accordance with the manufacturer's instructions, subject to local building codes and standards. The installing QCN member shall be responsible for the complete installation of these systems, including the wall/window case.
4. Where ductwork is used, the duct design and installation shall be as recommended under Duct System Design, Modification, and Installation section. The only exception is where the heat pump manufacturer provides specific duct application and installation criteria for their equipment. In all cases, the duct design and installation shall be such that the system provides the amount of air flow across the indoor coil recommended in the manufacturer's specifications.

5. Only the manufacturer's recommended outdoor grilles, wall/window cases, support systems, wiring kits, and other accessories shall be used in the unit's installation.
6. The joint around the unit's case and the wall or window shall be sealed weathertight with caulk, seals, or gaskets as provided by the manufacturer.
7. No holes shall be permitted in the bottom of the heat pump's case except to accommodate, when applicable, the manufacturer's approved internal condensate drain system. If utilized, condensate drain pipes shall be sized in accordance with manufacturer's recommendations; in all instances, individual runouts shall be at least as large as the heat pump drain connection.
8. All cabinets, cases, and components shall be properly aligned to avoid extraneous noise during operation.

Water Source Heat Pumps: Ground Water Source Heat Pumps (GWSHP) and Earth Coupled Heat Pumps (ECHP). All other sections of these standards are applicable unless otherwise noted.

If the refrigeration system heating capacity is less than 100 percent of the structure's heat load at design, auxiliary electric heaters shall be used and sized in accordance with the Auxiliary Electric Heaters section. Emergency heat shall be installed and sized in accordance with the maximum sizing requirements for auxiliary heaters in the Auxiliary Electric Heaters section.

1. Ground Water Source Heat Pumps (GWSHP)
 - All ground water source heat pump water-to-refrigerant heat exchangers shall be made of cupro-nickel metal.
 - To ensure constant water temperature and quality, ground water shall be the only water source allowed for ground water source heat pumps (except when other sources of water can be proven to have a temperature and quality that can remain as constant as ground water). The installing QCN member shall be responsible for meeting all state and local drilling code requirements. Also, the QCN member is responsible for ensuring the well provides an adequate water flow for the ground water source heat pump based on the installation requirements.
 - A suitable, unobjectionable means of disposal of the ground water source heat pump discharge water shall be utilized. This may include a natural stream bed, dry well, body of water, or a recharge system. The discharge cannot enter a septic tank, drainage field, sewer system, or flow onto the property of others.
 - The ground water source heat pump refrigeration system heating capacity, exclusive of resistance heaters, may be sized to meet not more than 100 percent of the heating requirements of the structure at the heating indoor design conditions stated in Equipment Requirements subsection, item 2, utilizing the manufacturer's published capacities for an entering water temperature (EWT) within 10 percent of the ground water temperature of the local area. The ground water source heat pump shall also be sized to provide a minimum of 100 percent of the sensible and latent load requirements at the cooling indoor design conditions stated in Equipment Requirements section, item 2; however, the total cooling capacity shall not be more than two times the total cooling load. The gallon per minute flow rate shall be within the range as specified by the manufacturer. A suitable means shall be provided by the contractor to determine the flow rate of the installed heat pump (i.e., flow meter or pressure/temperature test ports at the heat pump).
2. Earth Coupled Heat Pumps (ECHP)
 - The earth coupled heat pump refrigeration system heating capacity, exclusive of resistance heaters, may be sized to meet not more than 100 percent of the heating requirements of the structure at the heating indoor design conditions stated in Equipment Requirements section, item 2, utilizing the manufacturer's published capacities for an entering water temperature of 40°F (heating).
 - The earth coupled heat pump shall also be sized to provide at least 100 percent of the sensible and latent load requirements at the cooling indoor design conditions stated in Equipment

Requirements section, item 2, utilizing the manufacturer's published capacities for an entering water temperature of 90°F (cooling); however, the total cooling capacity shall not be more than two times the total cooling load. The gallon per minute flow rate shall be within the range specified by the manufacturer.

– Earth Coil Design

- ⇒ The earth coil shall be sized and installed as recommended by the "Closed Loop/Ground-Source Heat Pump Installation Guide" and the "Ground Source Systems: Design and Installation Standard" by the International Ground Source Heat Pump Association. The earth coil design length shall satisfy the heat gain or heat loss, whichever is greater, for the structure.
- ⇒ The final earth coil design shall be determined by the QCN member, equipment distributor, and/or heat pump manufacturer. A computer printout (or equal) and sketch of the earth coil layout shall be available for review at the request of the inspector.

– Earth Coil Installations

- ⇒ Earth coils may be installed in either parallel or series. When parallel coils are used with a reduced header design or a reverse return header design, the total effective length of the individual loops shall be within 5 percent of each other to ensure balanced fluid flow through the loops.
- ⇒ Pipes entering the building through a foundation wall or floor shall be sealed and/or protected. The pipes shall be contained in a sleeve to protect them from chafing on the floor or wall as they expand and contract. If the possibility of ground water seepage through the opening exists, the area around the piping shall be protected and sealed.
- ⇒ The QCN member is responsible for meeting all applicable codes pertaining to the location of boreholes and trenches.
- ⇒ Pipes for headers and manifolds pipes shall be at least 2 feet below the ground surface.
- ⇒ Pond loop installations that meet the requirements of the heat pump manufacturer are acceptable.

– Horizontal Earth Coils (Excluding Header and Slinky Framework)

- ⇒ The average depth of any horizontal coil circuit shall be a minimum of 4 feet below the ground surface.
- ⇒ The average separation between earth coil trenches shall be at least 5 feet.
- ⇒ All entrenched piping shall be thoroughly backfilled to ensure complete soil contact with the pipe. Trenching residue consisting of a fine, granular material is suitable for backfilling. However, if large clumps of soil or rock are present, the piping must be surrounded with 4 inches of fine soil or equal. The unsuitable trench residue can then be used to fill the remainder of the trench.

– Vertical Earth Coils (Excluding Headers)

- ⇒ Vertical boreholes shall be drilled and backfilled with grout as specified in the "Grouting Procedures for Ground Source Heat Pump Systems" by Oklahoma State University.
- ⇒ Vertical boreholes shall be separated at least 10 feet if bores are in a single row. For boreholes in a grid pattern, a minimum center spacing of 20 feet is required.

– Piping Material and Fusing

- ⇒ Only polybutylene or high-density polyethylene pipe, as specified by the heat pump manufacturer, shall be used for earth coupled heat pump earth coils.

- ⇒ Polyethylene pipes shall be joined only by socket or butt heat fusion methods. Polybutylene pipe shall be joined only by the socket heat fusion method. Metal barbed fittings or clamps shall not be allowed below ground surface.
- ⇒ Only proper fusion equipment as specified by the heat pump and/or pipe manufacturer shall be used. Proper heater plate temperatures, heating times, and curing times for various grades, thickness, and sizes of pipe shall be maintained.
- ⇒ Equipment room piping may be plastic, copper, or other material as allowed by the heat pump manufacturer.
- Heat Pump & Circulation System Equipment and Installation
 - ⇒ Pressure/temperature (P/T) test ports, such as "Pete's Plugs" or equal, shall be installed at the "water-in" and "water-out" pipe connections on the heat pump.
 - ⇒ All equipment room piping shall be insulated with 1/2-inch Armaflex (or equal) insulation to prevent condensation.
 - ⇒ System components (such as circulating pumps) shall be installed as specified by the component and/or heat pump manufacturer. Only bronze or stainless steel pumps shall be allowed.
 - ⇒ The system circulating pump(s) shall have sufficient capacity to provide the design gallon-per-minute flow rate of the fluid being used in the system.
 - ⇒ The system circulating pump(s) shall provide sufficient fluid velocity in the earth coil to result in turbulent flow (Reynolds Number, $R > 2500$). The calculation shall be made with viscosity and density of the fluid taken at the system's designed lowest entering water temperature.
 - ⇒ The QCN member shall determine if antifreeze is required for the earth coil design. Calcium chloride or potassium acetate (GS4) shall not be used as anti-freeze because of their corrosive nature.
- Pressure Testing and Start-Up
 - ⇒ The earth coil shall be pressure tested before connecting it to the heat pump and prior to complete backfilling. The piping shall be filled with water and/or air and pressure tested to 80-100 psi for at least 30 minutes. A visual inspection shall be made for leaks. Vertical U-bend assemblies shall be pressure-tested before insertion into the borehole.
 - ⇒ When pressure testing is complete and a leak-free system is ensured, the system shall be thoroughly purged to remove air and debris. The preferred purging method is to use a flush cart consisting of a 1-1/2 to 2 HP water pump, tank, filter, flow meter, and flexible hose with connections. A minimum fluid velocity of 2 feet per second is required to purge the system of trapped air. The system circulating pump(s) cannot provide enough flow to remove pockets of trapped air out of the system.
 - ⇒ After the system has been filled and purged, it shall be pressurized as recommended by the heat pump manufacturer. Suggested pressures are 60 psi if installed during the heating season and 40 psi if installed during the cooling season.

Variable Speed Heat Pumps (VSHP). This section pertains to the installation of variable speed (compressor and fans) heat pump systems. All other sections of these standards are applicable unless otherwise noted.

1. The variable speed heat pump at high speed shall meet the required sensible and latent load of the structure as stated in the Equipment Requirements section. However, when the high speed sensible capacity exceeds the sensible load by 125 percent, the unit having a high speed sensible capacity closest to the sensible load shall be installed.

2. The capacity and air flow shall be determined with the variable speed heat pump operating at high speed. The QCN member may be required to be at the inspection site to assist the inspector in placing the variable speed heat pump in the service (or test) mode of operation to allow the unit to operate at high speed.
3. Air flow at high speed shall be equal to or greater than that specified by the manufacturer of the variable speed heat pump. See the Duct System Design, Modification, and Installation section for additional air flow and ductwork requirements.
4. An outdoor thermostat is not required when the installed auxiliary electric heat is less than 10 kW.
5. The air velocities at the supply registers shall have an average face velocity between 400 and 700 feet per minute and the return grille(s) shall be sized for a maximum average face velocity of 500 feet per minute when the variable speed heat pump fan is in the high speed mode of operation.

Some variable speed heat pump systems do not permit an interruption of the compressor when the system is operating. Such an interruption of these units shuts the system down and requires the variable speed heat pump to be reset. Therefore, some manufacturers of variable speed heat pumps may not allow any external load management device.

Direct Exchange Ground Source Heat Pumps (DXGS). This section pertains to the installation of DXGS heat pump systems. DXGS heat pumps utilize a copper ground coil heat exchanger, installed in the ground, for the refrigerant to circulate. The following sections are not applicable: Equipment Requirement section, items 1 and 3. All other sections are applicable unless otherwise noted.

1. The DXGS heat pump refrigeration system heating capacity, exclusive of resistance heaters, may be sized to meet not more than 100 percent of the heating requirements of the structure at the heating design conditions (which would eliminate the need for auxiliary electric heat). However, the DXGS heat pump total cooling capacity shall not be more than two (2) times the total cooling load in any application.
2. If the DXGS heat pump refrigeration system heating capacity is less than 100 percent of the structure's heat load at design, then auxiliary electric heaters shall be used, sized, and installed in accordance with Auxiliary Electric Heaters section, item 2.
3. Emergency heat for DXGS heat pumps shall be sized in accordance with the maximum sizing requirements for auxiliary electric heaters in Auxiliary Electric Heaters section, item 3.
4. The compressor section of DXGS heat pumps may be installed in the attic. However, an auxiliary condensate pan shall be installed beneath the section. A drain line for this auxiliary condensate pan is not be required.
5. Both the vapor and liquid lines shall be continuously insulated and vapor sealed with a minimum thickness of 3/8 inch of foam rubber equivalent to 3/8 inch of AP Armaflex, or equivalent. All refrigerant line insulation joints and seams shall be sealed with glue to prevent moisture penetration.

References for Installation Standards

1. ASHRAE Handbook of Fundamentals (Latest Revision); American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
2. National Electrical Code (Latest Revision); National Fire Protection Association (NFPA)
3. Standards for Safety, UL-303, 465, 559, and 1096 (Latest Revision); Underwriters' Laboratories, Inc. (UL)
4. Manuals D, E, G, H, J, and L; Air-Conditioning Contractors' of America (ACCA)
5. ASHRAE Standard 90-75; ASHRAE
6. Standard for Air-Source Unitary Heat Pump Equipment, Standard 240 (Latest Revision); Air-Conditioning and Refrigeration Institute (ARI)
7. Standard for Sound Rating of Outdoor Unitary Equipment, Standard 270 (Latest Revision); ARI
8. Low Pressure Duct Construction Standards; Sheet Metal and Air-Conditioning Contractors National Association, Inc. (SMACNA)
9. Fibrous Glass Duct Construction Standards; SMACNA
10. Flexible Duct Performance Standards and Flexible Duct Installation Standards; SMACNA
11. Standard Mechanical Code (Latest Revision); Southern Building Code Congress International, Inc.
12. Standard for Ground Water-Source Heat Pumps, Standard 325 (Latest Revision); ARI
13. Standard for Packaged Terminal Heat Pumps, Standard 380 (Latest Revision); ARI
14. Standard for Desuperheater/Water Heaters Standard 470 (Latest Revision); ARI
15. Earth-Coupled Heat Pump (ECHP) Installation Manual; TVA
16. Directory of Certified Unitary Air-Source Heat Pumps (Latest Directory); ARI
17. Directory of Certified Applied Air-Conditioning Products (Latest Directory); ARI
18. Directory of Certified Room Air Conditioners; Association of Home Appliance Manufacturers (AHAM)
19. American National Standard ANSI/AHAM RAC-1 (Latest Revision); AHAM.
20. American Society for Testing and Materials (ASTM) standard E-84, and C-553.
21. Standards 90A and 90B (Latest Revision); NFPA
22. National Bureau of Standards Dust Spot Method using Atmospheric Dust (Latest Revision) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers Standard 52-76, for Air Cleaning Devices (Latest Revision).
23. "Closed Loop/Ground Source Heat Pump Manual," by Electric Power Research Institute and the National Rural Electric Cooperative Association.
24. Standard for Ground Source Closed-Loop Heat Pumps, Standard 330 (Latest Revision), ARI.