energy right® **Program**

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:

Type of Pump	**Certification Standard**
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 70ºF EWT		COP at 50ºF EWT	
January 1, 1992	10.5		2.70	
Earth Coupled Heat Pumps (ARI 330 or CAN/CSA-C446-M90):				
Effective Date	EER at 77ºF EWT		COP at 32ºF 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	**Cooling**
Indoor = 70ºF dry bulb	Indoor = 75ºF dry bulb, 50% relative humidity (62-63ºF wet bulb)
Outdoor = Varies with locale	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.

1. 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.

2. 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.
3. 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.
4. 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.

1. 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.
2. 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.
3. 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.
4. 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 (ECHP)
- 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.

energy right® **Program**

Heat Pump Inspection Procedures

Heat pump installations in the *energy right*® Heat Pump Plan may receive an inspection following installation. Inspectors shall complete the Heat Pump Installation Inspection Checklist (TVA 6254T) to verify key items involving the heat pump installation and the applicable section of the Work Completion (TVA 6254T-1).-

The inspection requirements listed apply to all types of heat pumps. For inspections performed for QCN members, the installing member may typically be requested to attend the inspection.

General Guidelines

NOTICE: For personal safety, be sure to turn the electric power off at the household service box or at the unit disconnect(s) prior to attempting an investigation of items internal to the heat pump section(s) and/or during placement or removal of test equipment at the time of an inspection. Exercise caution AT ALL TIMES when working with or around electrical components (a heat pump either energized or de-energized).

Inspectors inspect installations for compliance with selected Installation Standards. They will not represent themselves as safety or code inspectors and will not indicate to the Customer that an inspection under this program serves the purpose of any required electrical code, building code, fire safety, or other inspection.

If more than one heat pump installation is installed at a dwelling, every attempt should be made to inspect all installations during the initial visit.

Every feasible attempt will be made to identify any and all deficiencies during the initial visit (although equipment operational problems may be identified during a reinspection) to eliminate the need for multiple visits to correct items.

- The inspector, prior to any inspection, shall determine that the applicable paperwork related to the installation and any necessary weatherization work is available and appropriately completed.

General Inspection Requirements

The inspector will perform an inspection using the Installation Inspection Checklist and Work Completion Form, which have both been previously completed by the installing QCN member.

General Criteria

- Equipment sized and selected to meet the requirements of the Installation Standards.
- Insulation prerequisites installed or in the process of being installed prior to heat pump inspection.
- All equipment is checked for Air-Conditioning & Refrigeration Institute listing. If a window heat pump, the Inspector shall verify the heat pump has a Association of Home Appliance Manufacturers label attached indicating the unit is listed with AHAM. The inspector shall verify that SEER and HSPF ratings (EER and COP for water source) meet criteria.
- Calculated cooling load falls within 500-850 square feet (range may be changed at TVA Customer Service Center discretion) of conditioned space per ton of calculated cooling capacity. If the load calculation results are outside the accepted range, attempt to attribute variance to some special

characteristic(s) of the structure (high percentage of glass, etc.). Observe structure characteristics and consult with the QCN member.

- Equipment cooling capacities (sensible and latent) are at stated design conditions with the calculated cooling loads (sensible and latent) to ensure minimum of 100 percent of calculated loads (independently) is achieved, and that equipment's sensible capacity does not exceed the calculated sensible load of the structure by greater than 125 percent. Variations to this requirement apply to direct exchange ground source heat pumps and earth coupled heat pumps. See Installation Standards.
- Calculated heating load falls within 5-8 watts per square foot (range may be changed at TVA Customer Service Center discretion) of conditioned space. If calculation is outside the acceptance range, attempt to attribute variance to some characteristic(s) of the structure. (Observe structure characteristics and consult with QCN member.)
- Calculated system balance point temperature is no higher than 35°F (unless allowed greater than 35°F as described in the Installation Standards).
- If in the above review, obvious and significant errors are detected that would cause the installed heat pump's capacity to fall outside the heat pump standards' sizing criteria for cooling and/or heating capacities, the job may fail inspection.

Equipment Selection. Inspector shall verify following items relating to equipment selection:

- Load calculations for proper method (Air Conditioning Contractors of America (Manual J, or approved equal) and required indoor/outdoor design temperatures. Heat loss shall be determined at 70°F dry bulb indoor temperature at the prevailing local outdoor winter design temperature, and heat gain shall be determined at 75°F dry bulb, 50 percent relative humidity, indoor space conditions and at the prevailing local outdoor summer design temperature and humidity.
- Manufacturer's equipment capacities (provided by installing QCN member at time of inspection) compare to QCN member calculated heat loss and heat gain (both sensible and latent) to determine if the system(s) installed meets the sizing requirements in the Installation Standards.
- Ground water source heat pumps sized to maintain the indoor design conditions listed above and meet sensible/latent requirements for an entering water temperature within 10 percent of the ground water temperature of the local area.
- Direct exchange ground source heat pumps and earth coupled heat pumps sized to meet 100 percent of the total heating load at design, but shall not exceed 200 percent of the total (sensible and latent) cooling load at design.
- If a heat pump is installed in a manufactured home using existing manufactured housing ductwork, manufactured ductwork is capable of operating as required by the Installation Standards and installed heat pump is approved for that use by the heat pump manufacturer.
- Load calculations for Business shall also be performed by a proper method (Manual N or an approved method).

Indoor/Outdoor Equipment. Inspector shall verify the following items relating to indoor/outdoor equipment:

- One-piece concrete (or other accepted material) pad must be used as primary support.
- Outdoor air circuit has free air intake and discharge and no short circuiting of outdoor air.
- Installation of outdoor thermostat(s) (or approved equal) if required or present, and proper range and setting. Power distributor may not require outdoor thermostats. If outdoor thermostat is present, setting(s) shall be recorded on *energy right* Heat Pump Plan (Heat Pump Installation Inspection Checklist) TVA 6254T.
- Electrical inspection has been requested and if so a copy of the electrical permit is on site (if applicable).

- Mechanical inspection requested installation has passed, and if so, a copy of the permit is on site (if applicable).
- Proper type and size of overcurrent protection.
- Disconnect is within sight and within 50 feet of each piece of motorized equipment.
- Condensate drain (minimum size of 3/4 inch) is trapped and installed for proper drainage.
- Service space accessible for replacement of any part or entire unit.
- Refrigerant piping (split system) has acceptable length and lift.
- Refrigerant piping (split system) has proper insulation, contact, and support.
- Acceptable shroud, flashing, etc., to protect ductwork from weather (package unit).
- Emergency secondary drain pan installed (if necessary).
- Resistance heater(s) size (if applicable) is minimum for supplementary heating--design heat load minus compressor output at design outdoor conditions, as well as maximum for supplementary heating--less than or equal to 100 percent of design heat load or 10 kW, whichever is larger.

Operation and Controls. Inspector shall verify the following items related to operation and controls:

- Proper CFM (cubic feet/minute) of conditioned air per ton of cooling (12,000 Btuh), if applicable:

  Select method from the following and perform CFM test.

  - Air Flow Determination Funnel Method. While air flow measurement is not an exact science, this method appears to be the most reliable. This requires a square-to-round duct and a Bacharach "Flow- Rite" velocity meter or equivalent.

    Turn the indoor blower-only switch to "ON" or "Continuous" at the wall thermostat. Read each supply register air velocity by placing the funnel over each register. Attempt to center the funnel on the register for the most accurate readings.

    Sum all the register velocities obtained above and multiply the total by 0.267 to calculate the supply system air flow.

  - Air Flow Determination Heat Rise Method. This can be performed when a 10 kW or less resistance electric heater is energized. If possible, disconnect all but the first (W2) heat stage by turning off breakers.

    Energize the resistance heating elements and indoor blower motor only. Read and record the blower motor amps, heater amps, and voltage at the heat pump unit.

    Add the amps and multiply the sum by the volts and by 3.413 to obtain the heater system Btu input.

    Allow time for the temperatures to stabilize and read the average supply air temperature in the supply duct 6'-10' downstream of the electric heater assembly, or at a register close to the heat pump. Read the average return air temperature in the return duct(s) 6'-10' upstream of the unit, or at the return air grille(s).

    Divide the Btu input by the difference in average supply and return air temperatures and by 1.1 to obtain the system air flow volume (cubic feet/minute).

  - Air Flow Determination Return Air Grille Method. Measure velocity of air at return air grille(s) with a velometer. Take readings at 6 or more locations on the face of grille (symmetrically) and average.

    Total air (CFM) = velocity (Feet per minute average) x area of grille (nominal dimensions) (gross square feet) x .75 (effective area constant).

- Proper heating operation:
  - First Stage Heating.

    Energize first stage heating at the indoor thermostat and check by removing indoor thermostat cover, turning on first stage heating until first bulb is closed. If compressor only operates, check amperage to resistance heaters or observe heater relays for open position to determine that the resistance heat is off.
  - Second Stage Heating (Outdoor temperature above outdoor thermostat setting—above balance point).

    Energize first and second stage heating at the indoor thermostat, and check by removing indoor thermostat cover, turning on first and second stage heating until both bulbs are closed. If compressor only operates, check amperage to resistance heaters or observe heater relays for open position to determine resistance heat is off.
  - Second Stage Heating (Outdoor temperature is below outdoor thermostat setting—below balance point).

    Energize first, then second stage heating at the indoor thermostat, and check by removing indoor thermostat cover, turning on first stage heating until first heating bulb closes. If compressor only operates, check amperage to resistance heaters or observe heater relays for open position to determine resistance heat is off, closing first and second bulbs of indoor thermostat.

    Verify that only one bank (maximum of 10 kW) of resistance heat comes on to supplement the compressor. If more than one outdoor thermostat is used (if required by distributor), determine that the additional outdoor thermostat(s), or approved equivalent properly controls the additional bank(s) of the supplemental heat.
  - Emergency Heating.

    Set indoor thermostat to emergency heat position, then operate thermostat so both heating bulbs close. Verify that compressor does not operate and that all supplementary heat (controlled by outdoor thermostats) are energized. (This may be checked by the temperature rise method or ammeter reading at the equipment).
- Check for Proper Cooling Operation. Energize system in the cooling mode at the indoor thermostat. Check to see if compressor is energized and that outlet air temperature is approximately 50°F to 70°F dry bulb.
- Check System for Proper Capacity:
  - Check capacity by ONE of the following methods:

    Heating Capacity (compressor only) When the Outside Air Temperature is Below 75°F.

    Turn all auxiliary heating power switches to the off position, place unit in the heating mode (first bulb closed only) and allow the unit to run in the heating mode for at least 10 minutes. Allow time for the temperatures to stabilize and read the average supply air temperature in the supply duct or at a register close to the heat pump. Read the average return air temperature in the return duct(s) 6'-10' upstream of the unit, or at the return air grille(s). Estimate the compressor heat output using the following formula: Btuh = temperature difference x 1.1 x CFM (CFM will come from one of the three methods detailed earlier). Check outdoor temperature and refer to manufacturer's catalog data for rated output of unit at this outdoor air temperature. Verify that system capacity is within ± 10% of the equipment manufacturer's rating at the test conditions.

    Cooling Capacity When the Outside Air Temperature is Above 75°F.

    Place system in the cooling mode, record intake air temperature to outdoor unit. At supply air outlet and inlet indoors record wet bulb and dry bulb temperatures. From Enthalpy Table (Figure E-1), record heat content values that correspond to supply and return air wet bulb temperatures, h1 and h2, respectively. Estimate total heat removed from space by:

Btuh = (h2 - h1) x 4.5 x CFM (Note: h1 = heat content of air from Table A-1 corresponding to supply air wet bulb temperature)

h2 = heat content of air from Enthalpy Table, corresponding to return air wet bulb temperature

CFM = measured or calculated air flow of system.

Check outdoor temperature and refer to manufacturer's catalog data for rated output of unit at this outdoor air temperature. Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

Conditioned Area Components. Inspector shall verify the following relating to conditioned area components:

- Proper thermostat for the installation.
- Location of thermostat prevents external heat or cold influence.
- Thermostat is level.
- Mercury bulbs (if so equipped) have no cracks and discoloration.
- Thermostat wiring connections accurate and tight.
- Thermostat temperature indicator (if so equipped) compared against a reliable source.
- Thermostat securely attached to stud or other building component and free from drafts from stud space behind thermostat.
- Thermostat has emergency heat switch (unless waived by other sections of these guidelines).
- Return air (RA) grille(s) at proper location(s) and proper size(s).
- Measure velocity of air at RA grille(s) with a velometer. Take readings at 6 or more locations (symmetrically) on face of grille(s) and average. Maximum speed of returning air shall be less than 500 feet per minute (fpm).
- Filter location(s) are accessible so filter(s) can be replaced easily.
- Proper location of supply outlets.
- Supply outlets have acceptable supply capacity to distribute system air volume at acceptable speeds.
- Several supply outlets checked as necessary for maximum discharge velocity range of 400-700 FPM. Take readings at 3 or more locations on face of grille and average.
- Check the average temperature difference between any room or space within the conditioned structure (single level) for a maximum difference of not more than 4°F.

Air Distributor System. Inspection shall verify the following relating to air distributor system:

- Duct system has proper design and installation per ACCA, SMACNA, or ASHRAE criteria.
- Duct system has minimum of 400 CFM/12,000 Btuh air flow across the indoor coil based on the equipment's ARI cooling capacity (if applicable).
- Proper aspect ratio for rectangular duct work.
- All seams and joints airtight and properly sealed/taped.
- Proper vibration isolation connectors (if necessary).
- Verify that duct system does not contact ground.
- Acceptable duct material utilized.
- Proper support and hanging material.
- Proper sizing of branch ducts (minimum of 4", maximum of 8", round, or equivalent).
- Return duct work sized to return the design CFM capacity of the supply system.

- Proper duct work insulation levels (if applicable).

Additional Requirements for Specific Heat Pump Types

Following these general requirements are listings of additional requirements for specific heat pump types:

- Split-Type Dual-Fuel Heat Pump System
- Package-Type Dual-Fuel Heat Pump System
- Manufactured Home Heat Pump System
- Free-Delivery Split Heat Pump
- Packaged Terminal Heat Pump
- Self-Contained Through-the-Wall Heat Pump
- Window Heat Pump System
- Ground Water Source Heat Pump
- Earth Coupled Heat Pump
- Direct Exchange Ground Source Heat Pump

Split-Type Dual-Fuel Heat Pump Inspection Procedures

Inspection shall verify the dual-fuel heat pump (DFHP) equipment and duct system(s) adheres to installation standards (latest revision) with the following exceptions.

Air Flow Determination. Air flow determination shall be performed as follows. Blower speed shall be as used for heat pump operation by either of the following:

- Heat pump shall be operating in either cooling or heating mode (first stage heating only). Fan switch shall be in the "on" position and system switch in "off" position.
- CFM measurement shall be determined by the funnel method. If measurement cannot be made by the funnel method, use the return air grille velocity method.

Proper Control Setting. Proper control setting (including any temperature differential as may be required by the manufacturer)

Proper Heat Pump/Furnace Operation

- If outdoor temperature (ODT) is below 75°F, check the following:
  - Perform compressor heating capacity check
  - If ODT is above structure's theoretical balance point:

    First stage thermostat - heat pump only operates

    Second stage thermostat - furnace only operates until second stage is satisfied
  - If ODT is below structure's theoretical balance point and above the economic balance point:

    First stage thermostat - heat pump only operates

    Second stage thermostat - furnace only operates until second stage is satisfied (compressor is off during this time); after second stage is satisfied, compressor energizes
  - If ODT is below structure's theoretical balance point and below the economic balance point: First and/or second stage thermostat - furnace only operates
  - Emergency heat operation - There are no provisions for emergency heat mode for DFHP. In the event of the heat pump compressor or associated refrigeration equipment becoming inoperative, the furnace shall provide all required heating controlled from the second stage of the indoor thermostat in the heating mode.

- If outdoor temperature is above 75°F, check the following:
  - Perform compressor cooling capacity check
  - Check furnace only in heating operation
  - First and/or second stage thermostat - furnace only operates

    NOTE: A QCN member representative will have to temporarily field wire to "close" control setting.
  - Emergency heat operation - furnace only operates

Package-Type Dual-Fuel Heat Pump System Inspection Procedures

Inspector shall verify dual-fuel heat pump packaged system and duct system(s) adheres to Installation Standards with the following exceptions:

Air Flow Determination. Air flow determination shall be performed as follows: Blower speed shall be used for heat pump operation by either of the following:

- Heat pump shall be operating in either cooling or heating mode (first stage only) or
- Fan switch shall be in the "On" position and the system switch in the "Off" position.

CFM Measurement. CFM measurement shall be determined by the funnel method. If measurement cannot be made by the funnel method, use the return air grille velocity method.

Proper Control Setting. Proper control setting (including any temperature differentials as may be required by the manufacturer.

Proper Heat Pump/Furnace Operation.

- If outdoor temperature (ODT) is below 75°F, check the following:
  - Perform compressor heating capacity check
  - If an outdoor thermostat is utilized, check to ensure that the setting is at the structure balance point and:
  - If ODT is above the setting of the outdoor thermostat:

    First stage of indoor thermostat - heat pump only operates.

    Second stage of indoor thermostat - furnace only operates until second stage is satisfied (this could occur upon heat pump compressor failure)
  - If ODT is below the setting of the outdoor thermostat:

    First stage of indoor thermostat - furnace only operates (no second stage)
  - If an outdoor thermostat is not utilized:

    First stage of indoor thermostat - heat pump only operates.

    Second stage of indoor thermostat - furnace only operates until second stage is satisfied.
  - There are no provisions for emergency heat mode for DFHP packaged systems. In the event of the heat pump compressor or associated refrigeration equipment becoming inoperative, the furnace shall provide all required heating controlled from the second stage of the indoor thermostat in the heating mode.

Manufactured Home Heat Pump System Inspection Procedures

Inspector shall verify the manufactured home heat pump equipment and duct system(s) adheres to installation standards (latest revisions). (See Installation Standards for certain sections that do not apply.) In addition, inspector shall verify the following:

- Heat pumps installed in manufactured homes use field installed supply and/or return ductwork section, and it is installed in compliance with Installation Standards.
- The heat pump applied to manufactured housing ductwork is capable of operating within manufacturer's specifications and is approved for that use.
- The manufactured home was made after 1976.
- The heat pump/manufactured duct system provides the manufacturer's recommended air flow across the indoor coil.

Free-Delivery Split Heat Pump, Packaged Terminal Heat Pump, Self-Contained Through-the-Wall Heat Pump, Window Heat Pump System Inspection Procedures

Inspector shall verify the free-delivery split heat pump, packaged terminal heat pump, self-contained through-the-wall heat pump, and window heat pump adhere to installation standards. (See Installation Standards for certain sections that do not apply.) In addition, inspector shall verify the following:

- Air flow is as recommended by the manufacturer.
- Integral auxiliary electric heat is provided by the manufacturer within the unit cabinet or fan coil section as part of the heat pump.
- Integral auxiliary heaters are controlled by the heat pump indoor thermostat.
- Installing QCN member has met manufacturer's instructions for the complete installation of the system, including any recommended parts and accessories and any necessary wall/window case.
- The joint around the unit case (between the case and wall or window) to ensure weathertight seal with caulk, seals, or gaskets, as provided by the manufacturer.
- Cabinets are checked for proper alignment and any unnecessary holes. Holes allowed are for the manufacturer's approved internal condensate drain system (condensate drain lines shall be sized in accordance with the manufacturer's recommendations and all instances at least as large as the heat pump's drain connection).

Ground Water Source Heat Pump and Earth Coupled Heat Pump Inspection Procedures

Inspector shall verify the ground water source heat pump and earth couple heat pump adhere to installation standards. (See Installation Standards for certain sections that do not apply.) In addition, inspector shall do the following:

- Check ground water source heat pump and earth coupled heat pump for installation of pressure/temperature (P/T) test ports installed in the "water-in" and "water-out" piping runs at the unit. The P/T test ports shall be as close as possible to the heat pump.
- Check system heating capacity as follows:
  - Allow heat pump system to operate for at least 15 minutes.
  - Measure water pressure drop between water-in and water-out test plugs at heat pump. (Use same instrument to measure both to reduce error).
  - Measure entering water temperature at water-in test plug.

- Using manufacturer's performance data, determine the water flow rate (gallons per minute) and the heating capacity of the installation using the measured pressure drop and the measured entering water temperature.
- Determine heating capacity by using the following formula:

  Btuh = TD x 1.1 x CFM

  TD = temperature difference between supply air and return air

  1.1 = air properties constant

  CFM = Cubic feet per minute air calculated, from funnel, temperature rise, or return air method
- Verify that system capacity is + 10 percent of the equipment manufacturer's rating at the test conditions.

- Check system cooling capacity as follows:
  - Allow system to operate for at least 15 minutes
  - Measure water pressure drop between water-in and water-out test plugs at heat pump. (Use same instrument to measure both to reduce error).
  - Measure entering water temperature at water-in test plug.
  - Using manufacturer's performance data, determine the water flow rate (gallons per minute) and the cooling capacity of the installation using the measured pressure drop and the measured entering water temperature.
  - Determine cooling capacity by using the following formula:

    Btuh = (h2 - h1) x 4.5 x CFM

    h1 = heat content of air from Enthalpy Table corresponding to supply air wet bulb temperature.

    h2 = heat content of air from Enthalpy Table corresponding to return air wet bulb temperature.

    At supply air outlet and inlet indoors record wet bulb and dry bulb temperatures.

    4.5 = air properties constant

    CFM = Cubic feet per minute air calculated, from funnel, temperature rise, or return air method

    (From Enthalpy Table record heat content values that correspond to supply and return air wet bulb temperatures, h1 and h2, respectively)
  - Verify that system capacity is $\pm$ 10 percent of the equipment manufacturer's rating at the test conditions.

Direct Exchange Ground Source Heat Pump Inspection Procedures

Inspector shall verify the direct exchange ground source heat pump (DXGS) and duct system(s) adhere to installation standards. (See Installation Standards for certain sections that do not apply.) In addition, inspector shall do the following:

- Verify the distances between the compressor and the ground coil and compressor to air handling blower unit as required by DXGS manufacturer. Both vertical height and total line distance shall be within limits as specified by manufacturer. Insure all linesets, both vapor and liquid, are insulated with rubatex, or similar insulation non-corrosive to copper.
- Determine system heating capacity. System inspection should never be conducted within 48 hours of completion of soaker hose operation, and should not be conducted within one week of completion

of soaker hose operation if the DXGS system is installed during the heating season. Consult with the QCN member to determine appropriate inspection time during heating season. For heating capacity tests, the return air temperature should be between 65 degrees F. and 70 degrees F.

- Measure the compressor run current while in the heat mode. The expected current readings should fall within the ranges as specified by the manufacturer.
- The air flow shall be between 400 and 450 CFM per ton of capacity.
  - Determine heating capacity by using the following formula:

    Btuh = TD x 1.1 x CFM

    TD = temperature difference between supply air and return air

    1.1 = air properties constant

    CFM = cubic feet per minute air calculated, from funnel, temperature rise, or return air method
  - Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

    Note: If the heating capacity is low, this may be due to an unadjusted heating valve. The QCN member can adjust the heat valve before re-calculating the heating capacity.
- Determine system cooling capacity. For cooling capacity tests, the return air temperature should be between 75 degrees F. and 80 degrees F.
- Measure the compressor run current while in the heat mode. The expected current readings should fall within the ranges as specified by the manufacturer.
- The air flow shall be between 400 and 450 CFM per ton of capacity.
  - Determine cooling capacity by using the following formula:

    Btuh = (h2 - h1) x 4.5 x CFM

    h1 = heat content of air from Enthalpy Table corresponding to supply air wet bulb temperature.*

    h2 = heat content of air from Enthalpy Table corresponding to return air wet bulb temperature.*

    4.5 = air properties constant

    CFM = cubic feet per minute air calculated, from funnel, temperature rise, or return air method

    * At supply air outlet and inlet indoors record wet bulb and dry bulb temperatures.

    (From Enthalpy Table record heat content values that correspond to supply and return air wet bulb temperatures, h1 and h2, respectively)
  - Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

Procedures for Notifying Customer and QCN member of Failed Inspections

When a program required inspection of an installation is made and the installation is not in compliance with program standards, the Inspector will indicate on the Heat Pump Installation Inspection Checklist (TVA 6254T) and on the Work Completion/ Form (TVA 6254T-1) (where applicable) the reason(s) for the failure to pass the inspection. The QCN member may be allowed to correct minor deficiencies while the inspector is on-site. Customer and QCN members must receive a copy of Heat Pump Installation Inspection Checklist.

All deficiencies must be corrected and be in compliance within 10 business days. Following corrections by the QCN member, the inspector shall be notified, after which a reinspection shall be scheduled and performed. If, during this

reinspection, other items not previously identified are shown to be in violation of the installation standards, the QCN member shall have 10 additional business days to correct the deficiencies, after which the third and final reinspection shall occur.

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Heat Pump Plan Weatherization Standards for Existing Homes

Attic Insulation

Applicability. Attic and ceiling insulation shall be installed when the existing effective insulation value is less than R-19 or when vertical walls surrounding conditioned rooms in the attic area do not have effective existing insulation.

Material Specifications for Blocking Materials. The following materials shall be used to provide any required blocking around heat-dissipating objects, attic accesses, pull-down stairways, chimneys, vent pipes from gas- or oil-fired appliances, etc.:

- Mineral fiber batts
- Sheet metal
- Gypsum board (sheetrock)
- Wood
- Other materials approved by TVA prior to their installation

Material Specifications for Insulation Support. The following materials shall be used to support insulation, as required in the installation standards and procedures:

- Wire or nylon mesh
- Wire or nylon lacing materials
- Other materials approved by TVA prior to their installation

Installation Requirements. The QCN member shall be responsible for ensuring that all attic insulation materials installed comply with these Program Standards.

- *Existing Conditions*—The QCN member shall be responsible for determining if the installation of additional attic or ceiling insulation will cause structural damage to the residence, such as ensuring that the ceiling will support the additional weight of the insulation. If applicable, QCN members shall notify inspectors and customers prior to installing insulation if they determine that an R-value different from that recommended should be installed.
- *Amount of Insulation to be Installed*—If no attic insulation exists, R30 shall be installed. If there is R18 or existing insulation, R19 shall be installed.
- *QCN Member Responsibilities*—The QCN member shall be responsible for completing all preparation work involving insulation materials already existing in the residence, such as uncovering recessed light fixtures, doorbell transformers, and other heat-dissipating devices that were covered with existing insulation, providing blocking around such devices when necessary, etc.
- *Improperly Installed Vapor Barriers*—Vapor barriers on existing batt or blanket insulation that have been installed improperly shall be either turned over so they are placed toward the living area of the residence (warm side in winter), or made ineffective by slashing several times with a sharp knife.

- *Wet or Damp Existing Insulation*—Adequate attic ventilation shall be provided when the existing insulation is found to be wet or damp, and the insulation shall be allowed to dry prior to installing additional attic insulation. If the insulation fails to dry after a reasonable period of time, it shall be replaced.
- *Customer Responsibilities*—The customer shall be responsible for seeing that preparation work such as repairing the ceiling, roof leaks, pipe leaks, vent leaks, removing objects stored in the attic, etc., is completed if failure to do so would adversely affect the installation of additional insulation.
- *Blocking Materials*—Blocking materials shall be installed in accordance with the following requirements:
  - Mineral fiber batts shall not be placed on the narrow edge.
  - Sheet metal used as firestopping or blocking material shall be secured in place using nails, tacks, staples, or screws.
  - Gypsum board/sheetrock or wood shall be secured in place using nails or screws. When using these materials as blocking, the clearances to both the insulation and the blocking shall be maintained.
  - Blocking materials shall be installed so that their height is above that of any surrounding loose-fill insulation material.
- *Clothes Dryer Vents* —Clothes dryers shall be vented to the outside.
- *Plumbing and Other Pipes, etc.*—Cracks and gaps around ceiling penetrations, such as plumbing, exhaust fans, etc., should be sealed prior to installing ceiling insulation.
- *Recessed Light Fixtures*—Insulation shall not be installed within 3 inches of the sides of a recessed incandescent or fluorescent light fixture (including its wiring compartment and ballast), and insulation shall not be installed over the top of such fixtures. The 3-inch air space shall be provided by utilizing acceptable blocking materials.
- *Doorbell Transformers*—Insulation may contact the sides of but shall not cover doorbell transformers.
- *Masonry Chimneys*—All insulation and blocking materials shall be kept a minimum of 3 inches away from masonry chimneys. When loose-fill insulation material is used for ceiling insulation, acceptable blocking materials shall be used to ensure a minimum 3-inch clearance. Unfaced mineral fiber batts may provide the minimum clearance by serving as blocking for loose-fill insulation, or other types of blocking may be used to ensure the minimum clearance. The gap (crack) between the interior ceiling finish material and the masonry chimney should be firestopped and sealed in accordance with locally adopted codes and regulations.
- *Factory-Built (Metal) Chimneys*—All insulation and blocking materials shall be kept a minimum of 3 inches away from factory-built chimneys. The minimum 3-inch clearance shall be provided by utilizing acceptable blocking materials. In some installations where loose-fill insulation is installed as ceiling insulation, the sides of the chimney support box may serve as the blocking material if it provides the minimum 3-inch clearance. Insulation shall not be installed in or over the chimney support box.
- *Vent Pipes from Gas or Oil-fired Furnaces, Water Heaters, etc*—Insulation materials shall be installed no closer than 3 inches to a vent pipe, or the clearance specified on the vent pipe label, from a gas or oil-fired furnace, water heater, etc., where the vent pipe passes through the ceiling. When loose-fill materials are installed as ceiling insulation, acceptable blocking materials shall be used to provide the required clearance and to prevent the insulation material from falling into the cavity around the vent pipe.
- *Venting*—Range hoods and bathroom exhaust fans shall be vented to the outside in conjunction with adding attic insulation. The vent pipes shall not be vented through an existing attic ventilator unless the minimum required net free area for the attic would still exist without the use of that ventilator. If a bathroom or kitchen is not properly vented to the outside, one of the following venting methods must be used:

- The vent exhaust opening must be extended a minimum of 6 inches above the insulation level in the attic.
- Insulation or blocking materials shall not be installed within 3 inches of the side containing an exhaust opening that is not extended above the attic insulation level. This 3-inch air space shall be maintained by utilizing one of the acceptable blocking methods.
- If a bathroom or kitchen vent terminates in a dropped (suspended) ceiling cavity or soffit area and cannot, or will not, be properly vented to the outside, then the vent exhaust opening must be extended to a minimum of 6 inches above the insulation level in the attic.
- Kitchen range vents that extend through the roof shall be vented vertically with a maximum of two bends (45 degrees or less per bend) using continuous airtight metallic kitchen vent sections and connections.

- *Electrical Junction Boxes*—Improperly terminated wiring connections that are unprotected and will be covered with insulation shall be corrected by either of the following methods:
  - Installing a metal or approved plastic cover on the open electrical junction box
  - Installing a complete junction box where one does not exist at an electrical connection
- *Knob-and-Tube Wiring*—Insulation materials shall not conceal or cover knob-and-tube wiring.
  - Cellulose insulation shall not contact knob-and-tube wiring.
  - Mineral fiber insulation materials (fiber glass and rock wool) may contact knob-and-tube wiring, but shall not conceal or cover the wiring.
  - Blocking materials shall be used with loose-fill insulation materials when the level of the insulation will exceed the wiring height. If faced batts are used, the facing shall not contact the electrical conductors.
  - When batts or blankets with an attached vapor barrier (or other facing) are installed, the facing shall not contact the electrical conductors. Batts or blankets with double facings shall not be used for this application.
- *Whole-House Attic Fans*—Loose-fill insulation materials shall be prevented from falling into whole-house attic fans by installing acceptable blocking materials around the fan housing. If the fan motor is mounted outside of the fan housing and the insulation to be added could contact the motor, acceptable blocking materials shall also be installed to provide 3-inch clearance around the motor.
- *Unfinished Attics*—Only thermal insulation materials accepted by TVA shall be installed. Other insulation materials such as organic cellular (polystyrene, polyurethane, etc.) may be used in certain applications, such as for cathedral ceilings, if prior permission from TVA is obtained.
- *Loose-Fill Insulation*—When loose-fill insulation materials are installed, the installer shall leave one empty bag of each type of material used at the residence for identification by the inspector.
- *Areas To Be Insulated*—Insulation shall be installed above ceilings separating conditioned (heated or cooled) rooms from non-conditioned attic areas. The areas to be insulated shall be the gross area identified by using outside wall dimensions.
- *Verification of Material Installed*—Loose-fill insulation materials shall be installed in accordance with the manufacturer's coverage chart, at the specified weight per square foot and depth required to achieve the thermal resistance (R) value needed to meet the minimum requirements for a heat pump installation.

Loose-fill insulation materials shall be installed in accordance with the coverage chart data with no adjustments made for framing, such as joists, etc.

The QCN member shall specify the following applicable information on a receipt (attic card; also referred to as the builder's statement) removed from the insulation bag or container, or an equivalent card, and posted in an easily visible location near the attic access:

- For batts or blankets - the coverage area in square feet, thickness, and R-value of the insulation installed.
- For loose-fill insulation - the coverage area in square feet, thickness, R-value, and the number of bags installed.

The attic card shall be signed and dated by the QCN member. If attic insulation is installed in more than one area of the residence, the data for each area shall be entered on the attic card or a separate attic card shall be completed for each area.

- *Installation of Batts and Blankets*—Batts or blankets shall fit tightly against the sides of joists and fit tightly at the ends against adjoining batts, blankets, or framing materials.

  Batts and blankets shall be cut and split to fit between any cross-bracing if looping over the cross-bracing will require more than one-third of the batt to extend above the attic floor joists.

  Batts or blankets with an attached vapor barrier shall not be installed over existing attic insulation unless the vapor barrier facing is removed or rendered ineffective by slashing.

- *Insulation Contacting the Roof Sheathing*—A minimum 1-inch air space shall be maintained between insulation materials and the roof sheathing, including residences without a soffit area.

  If insulation materials contact the roof sheathing, the minimum 1-inch air space between the insulation and the roof sheathing shall be provided prior to installing additional insulation materials.

- *Suspended Ceilings and Dropped Cavities (Soffits)*—Suspended (dropped) ceilings with gypsum or plaster finish material shall be insulated in accordance with the installation requirements for unfinished attics.

  Insulation installed above removable or fixed suspended ceiling tiles (panels) shall be independently supported so that no additional weight is exerted on the ceiling panels. Batt or blanket insulation only shall be used. The batt or blanket insulation shall be either unfaced or have a flame spread rating of not more than 75 and a smoke-developed rating of not more than 450. (If faced batt or blanket insulation is used, a fact sheet for the material shall be left with the customer for verification of the flame spread and smoke-developed ratings.)

  Adequate ventilation shall be provided between the insulation material and the original ceiling. Ventilation openings (holes) shall be cut in the original ceiling when necessary to ventilate the space between the insulation and the original ceiling. The openings shall provide the minimum required ventilation net free area for the suspended ceiling area and shall be located in the original ceiling adjacent to opposite exterior walls of the suspended ceiling area to provide adequate cross-ventilation. A minimum of two holes shall be required for each room where partitions extend to the original ceiling.

- *Dropped Cavities (Soffit)*—Dropped cavities that are open in the attic (above built-in cabinets, showers, etc.) shall be insulated by either of the following methods:
  - Using an R-19 batt on the sides and the bottom of the cavity
  - Providing necessary blocking around any heat-dissipating objects and completely filling the cavity with loose-fill insulation

  WARNING: If the dropped cavity (soffit) is not open in the attic and contains a heat dissipating object (recessed light, etc.), then insulation shall not be installed above the cavity.

  - Installing boards or a piece of plywood across the top of the cavity in order to support the insulation to be added

  WARNING: This method shall not be used for cavity containing recessed light fixtures or other heat-dissipating devices.

- *Permanent Stairways*—Accessible wall and sloped ceiling areas of permanent stairways separating conditioned areas from non-conditioned areas shall be insulated with batt or blanket insulation using support material described in these standards.

- *Furnaces Mounted in the Attic*—When ceiling insulation is installed in a residence with an attic-mounted furnace, the insulation shall not block the combustion air to the furnace. This shall be accomplished by providing a 3-inch clearance between the insulation material and the furnace housing. When loose-fill insulation is installed, acceptable blocking materials shall be installed around the furnace.
- *Attic Accesses and Pull-Down Stairways*—Attic access coverings (panels) located in conditioned areas shall be insulated with batts or blankets and weather-stripped. The insulation batt or blanket shall be stapled or glued to the top of the access covering. When loose-fill insulation is used to insulate the ceiling, suitable blocking materials shall be placed around the perimeter of the access opening. Cracks between wood trim or molding and ceiling finish materials around the perimeter of the opening shall be caulked.

  Mineral fiber batts shall be placed around the perimeter of the opening of an attic pull-down stairway when the ceiling is insulated with loose-fill materials. The opening shall be weather-stripped and caulked similar to attic access panels.
- *Unfinished Floored Attics*—The installation requirements for unfinished attics shall also apply to unfinished attics that are floored with the following exception:
  - Beneath flooring - Insulation installed beneath the flooring material shall completely fill each joist cavity, either (1) beneath and above flooring (installing insulation above and beneath the flooring material) or (2) above flooring only (installing insulation above the flooring material only).
- *Finished Attics (Conditioned Areas Within an Attic)*
  - Vertical Walls - Batts or blankets shall be used to insulate the vertical walls of a conditioned room in an attic.
  - Sloped Ceilings - Batt or blanket insulation shall be installed above the sloped ceiling areas. A minimum 1-inch air space shall be provided in each cavity between the insulation and the roof sheathing for ventilation. The residence shall have a combination high and low ventilation system. Continuous ridge and eave/soffit vents may be required in some cases to adequately ventilate each joist or rafter cavity.
  - Horizontal Ceilings - Batt, blanket, or loose-fill insulation shall be installed above the horizontal ceiling area provided the installation requirements for unfinished attics are also met.
  - Adjacent Areas - Insulation installed in unfinished attic floors adjacent to conditioned areas within an attic shall extend a minimum of 1 foot beyond the vertical walls of the conditioned areas.
  - Vapor Barrier - If a vapor barrier does not exist in the conditioned area within the attic, one shall be added by either installing a vapor barrier separately or installing batts or blankets with an attached vapor barrier with the vapor barrier facing the conditioned area (warm side in winter). Insulation with the vapor barrier installed facing away from the conditioned area is acceptable, if it is made ineffective by slashing, or if the facing is completely removed.
  - Supporting - The insulation shall be supported by acceptable supporting materials as described in these standards.
  - Types of Insulation Support Materials - Wire staves shall not be used to support batt or blanket insulation when installed in vertical walls of a conditioned room in an attic. Acceptable methods for supporting the batt insulation shall be (1) stapling the vapor barrier through the thickness of the insulation, providing the insulation does not remain compressed; (2) nailing or stapling the flange to the studs (reverse flange batts only); (3) attaching approved netting directly to the side of studs using approved staples; or (4) lacing back and forth between nails or staples placed in the bottom of the studs to adequately support the insulation.
- *Cathedral Ceilings*—Cathedral ceilings shall be insulated by installing either a suspended (dropped) ceiling or by insulating the sloped ceiling.

  Insulating Beneath the Cathedral Ceiling.

- Approval - Prior approval for this installation must be obtained from the TVA Customer Service Center and the customer.
- Materials - Cathedral ceilings shall be insulated by installing new ceiling finish material on the bottom of the rafters and installing batt, blanket, or rigid board insulation between the roof sheathing (old ceiling) and the new ceiling, or by fastening rigid board insulation to the bottom of the rafters. When organic cellular rigid board insulation (polystyrene, polyurethane, etc.) is used, it shall be protected by an interior finish material having a finish rating of at least 15 minutes, such as 1/2-inch gypsum board.
- Ventilation - A minimum 1-inch air space shall be maintained in each cavity between the insulation and the roof sheathing for ventilation, and there shall be high and low ventilation for each joist cavity. Continuous ridge and eave/soffit vents may be required in some cases to adequately ventilate each cavity.
- Vapor Barrier - A vapor barrier, attached to either the insulation or the finish material, shall be used. If a vapor barrier is attached to the insulation and more than one layer of insulation is installed, all vapor barriers except the one adjacent to the finish material shall be removed (peeled off).

- *Installing Suspended (Dropped) Ceilings*—Cathedral ceilings may be insulated by installing a horizontal suspended (dropped) ceiling and insulating above it provided the requirements for suspended ceilings in unfinished attics are met. If removable panels are used in the dropped ceiling, batt or blanket insulation shall be used. Adequate ventilation shall be provided above the dropped ceiling.
- *Exterior Roof Insulation Systems*—An exterior roof insulation system may be installed above a cathedral ceiling. Ventilation between the insulating sheathing and the roof decking need not be provided when this type of insulation system is installed.
- *Vaulted Ceilings*—The installation requirements for unfinished attics shall also apply to vaulted ceilings. In some instances (to ensure adequate ventilation in steep sloped ceilings, etc.), batt or blanket insulation materials shall be required.
- *Flat Roofs*—A suspended ceiling may be installed and insulation added above it. The installation requirements addressed in the suspended ceiling section for unfinished attics shall apply to insulating the suspended ceiling.
- *Uninsulated Walls of Multilevel Dwellings Separating Conditioned Areas From Non-conditioned Attics*—Uninsulated walls shall be insulated using batts or blankets, if the wall is accessible. For installation requirements for this type wall, refer to the vertical wall sections for finished attics.

Attic Ventilation

The attic shall be properly ventilated to prevent the possible occurrence of condensation or moisture damage to the insulation materials or structure.

Ventilation Requirements. The amount of ventilation shall comply with Section 604-4.2 of the U.S. Department of Housing and Urban Development (HUD)/Federal Housing Administration (FHA) Minimum Property Standards for One- and Two-Family Dwellings. This section specifies that the ratio of total ventilation net free area (NFA) to ceiling area (the entire attic floor area over both conditioned and non-conditioned spaces) shall not be less than 1 square foot of ventilation net free area for each 150 square feet of attic floor area (1:150). This ratio may be reduced to one square foot of ventilation net free area for each 300 square feet of attic floor area (1:300) provided one of the following two requirements is met:

- *High and/or Low Ventilation With Vapor Barrier*—An effective vapor barrier having a moisture transmission rate of 1.0 perm or less is installed next to the living or conditioned area (the warm side in winter) of the ceiling in combination with ventilators located in the upper portion of the attic space to be ventilated (high ventilation) or in the lower portion of the attic space to be ventilated (low ventilation), or both.

- *High and Low Ventilation* —At least 50 percent of the required net free area can be provided by ventilators located in the upper portion of the attic space to be ventilated at least 3 feet vertically above eave or cornice vents. The remaining 50 percent of the required net free area can be provided by ventilators located in the lower portion of the attic space to be ventilated, usually in the eave or cornice areas of the attic. This ventilation system is described as a high-low combination system.

Material Specifications. A ventilator shall be constructed from a durable material (preferably metal), contain rain louvers designed to restrict the entrance of weather elements (rain, snow, etc.) into the attic area, and shall contain a screening material with openings not larger than 1/4 inch to restrict the entrance of insects, birds, and small animals into the attic area. The screening material may be omitted if louvered slit-type openings not larger than 1/4 inch serve as an insect barrier.

If there is evidence that more than the minimum ventilation requirements are needed, additional ventilation may be added to an area of the attic even though the total existing vent area meets the minimum standard/required NFA.

Ventilators (roof, ridge, gable, or eave) shall be positioned for maximum effectiveness without causing damage to the house structure or reducing the performance of the ventilator. The location of the vents shall be selected so that the natural air flow through the vents will not be restricted.

Ventilation Installation Requirements

- *General*—Static roof ventilators are recommended when additional attic ventilation is necessary but cannot be achieved by the addition of soffit, ridge, or gable vents.
- *Installation on Sloped Roofs*—-Roof vents shall be installed so that at least 50 percent of the upper half and sides of the flashing (flange) is positioned under the roofing material and is securely nailed to the roof. Caution: If a new roof has been installed over one or more old roofs, the flashing (flange) shall be installed under the outermost roof. All flashings for vents or rain deflectors shall extend beyond the rain grooves on the top side.

The lower part of the flashing shall be positioned over the roofing material and securely nailed to the roof deck at each corner and mid-span if required. The underside of the flashing shall be sealed along the top edge and two sides using a high-quality mastic or sealant (roofing cement or a caulking material with a minimum 10-year life expectancy) to prevent leaks; however, the bottom edge of the flashing shall not be sealed. Nails located on the top and sides of the flashing shall be positioned under the roofing material, not through the material. Nail heads shall have a neoprene washer or be covered with a waterproof mastic or sealant.

- *Roof Vents in Lieu of Soffit Vents*—-If low ventilation cannot be achieved by installing soffit vents, static roof vents shall be located as low as possible on the roof line to meet ventilation requirements.
- *Rain Deflectors*—When static roof vents are installed low in the roof or are installed on a high-pitched roof having a slope of 45 degrees or greater, a rain deflector device shall be installed from 4 to 10 inches above the vent cap if the vent does not contain a built-in provision on the upper side that prevents water from entering the vent (e.g., rectangular vents with no louvers or openings on the upper side). The rain deflector shall have a minimum height of 4 inches, a width equivalent to that of the vent flashing, and shall have a "curl" at the top to prevent water splash-over. The base of the rain deflector shall extend beyond the rain grooves in the outermost roofing shingles immediately on top of the deflector base.
- *Installation on Flat Roofs*—Flanges shall be installed over the top layer of roofing and sealed around the entire perimeter with a high quality sealant as described above. Vents shall not be installed on corrugated or graveled roofing systems.
- *Ridge Vents*—Ridge vents shall be installed whenever possible to achieve high ventilation. Manufacturer instructions concerning end-on-end connections, caps, sealants, etc., shall be carefully followed to prevent leaks.
- *Soffit Vents*—Soffit vents shall be installed with the sloped louvers pointing toward the house.

Caulking, Sealants, and Glazing Materials

Applicability. The installation of caulks, sealants, and glazing materials is applicable when no effective caulk, sealant, or glazing material exists where needed or where installed around the inside and outside perimeter of a prime window, storm window, door, or other non-movable cracks or opening separates conditioned areas from non-conditioned areas.

Material Specifications. Oil and resin base (clay base) caulking materials have a much shorter life expectancy and shall not be used. Also, rope caulk shall not be used.

Installation Requirements.

- *General (Caulks and Glazing Materials*—Any preparation work required to repair the window sash, repair of the lock at the meeting rail, replacement of window or door frame, painting or removal of paint prior to caulking or glazing, replacement of cracked or missing glass panes, etc.) shall be completed prior to installing caulking or glazing materials.

  When preparing for caulking or glazing, the surface must be completely free of moisture, since most caulks will not adhere to a damp surface. The ambient temperature at the time of application shall be between 40°F and 100°F or as otherwise specified by the manufacturer on the cartridge or can.

  All existing caulking or glazing materials around the window or glass pane shall be removed. All particles of dirt and debris shall be brushed out with a wire brush and the area rubbed with a clean cloth.

  When specified by the manufacturer of the caulking or glazing material to be used, porous surfaces shall be primed with the type of primer recommended by the manufacturer.

  When caulking and glazing has been completed, all caulks and sealants or other stains resulting from work performed under this section shall be removed from glass and adjoining areas.

- *Caulking*—Generally, the depth of caulks shall not be greater than the width of the joint. Joints or spaces deeper than one-half inch shall be built up to a depth of three-eighths inch below adjacent surfaces with approved filler and backup materials prior to caulking.

  Filler and backup materials shall be polyurethane foam, oakum, untreated jute, pointing mortar, or other oil-free materials.

  One-component polyurethane foam sealants used as filler materials or as caulks shall be protected from direct sunlight by a cover material or by painting exposed surfaces, and installed in accordance with the manufacturer's instructions and all applicable local building codes.

  Thresholds shall be caulked on the inside edges when installed, and excess caulk shall be removed after the threshold is set.

  All caulking and sealing work shall follow the recommendations or printed instructions of the manufacturer.

  If the caulk being installed is a non-paintable type, it shall be color-coordinated with the existing caulking and exterior of the residence. Glazing Materials for Sealing Glass Panes.

  – Pliable Glazing Compounds. If the existing putty or glazing compound is ineffective on only one side of the window pane, it shall be replaced on that side of the window pane only with glazing compound.

    Glazing points shall be spaced no further than 12 inches apart with a glazing point inserted within 3 inches of each corner of the glass pane. A minimum of four glazing points (one on each side) shall be required for very small glass panes.

    Back-bedding compound or glazing tape used as a bed between the wood sash and the glass pane shall be optional.

    Painting of the glazing compound after its application shall be as recommended by the manufacturer but is not within the scope of the program and will be the customer's responsibility.

- Rigid and Flexible Vinyl Glazing Materials. When rigid or flexible vinyl glazing materials are used around the perimeter of a glass pane in a metal window sash or insert, a back-bedding compound or glazing tape shall also be installed in accordance with the manufacturer's instructions to seal around the perimeter of the glass pane.

  Back-bedding compound or glazing tape shall not be required when channel glazing is used. A glass adhesive or sealant shall be used when the wrap-around (metal) glass molding method is used to reglaze a window.

Weatherstripping and Thresholds

Applicability. The installation of weatherstripping materials is applicable when no effective weatherstripping exists in cracks around operable portions of windows, doors, attic accesses, and other operable openings separating conditioned areas from non-conditioned areas.

Material Specifications for Window and Door Frame Weatherstripping. Weatherstripping materials shall consist of narrow strips of material placed over or in the movable joints of windows, doors, or other areas of the residence to reduce the passage of air and moisture.

Weatherstripping materials shall be high-quality and durable, with a minimum installed life expectancy of 10 years. Products that will deteriorate within this time when subjected to sunlight, moisture, other weather conditions, or normal use shall not be used.

A weatherstripping material appropriate for the type of opening shall be used. Spring strips, V-strips, and replacement pile may be used in compression or friction (sliding) joints.

Material Specifications for Thresholds/Door Sweeps. Thresholds shall be of a permanent type that will effectively seal the bottom of an exterior door against air infiltration when the door is closed. Thresholds shall be of the following types:

- A metal body with a vinyl insert that contacts the bottom of the door for the entire length of the threshold or width of the door.
- A metal saddle with a door shoe on the bottom of the door.

Door sweeps may be used on interior doors that separate conditioned areas from non-conditioned areas where thresholds are deemed to be unsafe.

Installation Requirements

- Any required preparation work shall be completed prior to installing weatherstripping. The QCN member shall be responsible for completing preparation work of a minor nature, such as removing defective weatherstripping, dirt, and loose paint.
- The customer shall be responsible for ensuring that all major preparation work such as carpentry work required to repair or replace window and door frames, priming and painting surfaces prior to installing weatherstripping, and repair or replacement of hinges is completed before weatherstripping is installed.
- Weatherstripping materials shall be installed in accordance with the manufacturer’s instructions as printed on (or supplied with) the package.
- Surface-mounted weatherstripping materials shall be installed by closing the door, window, attic access, etc., and installing the weatherstripping material in or over the crack so that the weatherstripping is slightly compressed. The weather-strip shall sufficiently contact both surfaces and the crack shall be adequately sealed.
- Metal prime windows are often fitted with pile weatherstripping consisting of a short, bristle-like material on a backing. Cheaper piles often shrink after exposure to moisture and weather, and the

window sashes may become loose fitting and inadequately weather-stripped. It is sometimes possible to remove the defective pile weatherstripping and replace it with new pile. The new pile and its backing shall be made of a material, such as polypropylene, that will not shrink. If the new pile cannot be inserted into its slot (or track) in the window, a knife may sometimes be used to force it into place. For easier replacement and a proper seal, ensure pile of the correct size (width of backing and height of pile) is used for each specific window.

- The inside perimeter of casement and other hinged windows shall be weather stripped when an efficient seal does not already exist. Spring metal and vinyl strips, V-strips, and certain vinyl strips with a small flexible bulb may be used on these windows. They are attached to the jamb running alongside the window stops to ensure a proper seal when the window is shut.
- Door sweeps, thresholds, and replacement vinyl inserts shall be installed in accordance with the manufacturer's instructions.

When applicable, the vinyl insert shall be replaced rather than installing a complete threshold. If the existing threshold is damaged beyond repair or one does not exist, a complete threshold, either a vinyl bulb threshold or a door shoe, should be installed.

The following requirements should be observed when installing a vinyl bulb threshold:

- The door shall be removed and the door bottom trimmed to achieve a 1/8-inch bevel. The bevel shall be cut in the direction to allow opening and closing of the door.
- The threshold shall be cut to the required width so that the complete length of crack at the bottom of the door will be sealed.
- The threshold shall be shimmed to the height required to achieve a good seal and shall be secured in place using screws.
- The inside edge of the threshold shall be embedded in caulk when the threshold is installed.
- Screws, bolts, or other anchoring devices shall be used to secure the threshold.

After installation, the door shall open and close properly and the bulb shall achieve a proper seal.

The following requirements shall be observed along with the manufacturer's installation instructions when installing a door shoe:

⇒ The door panel shall be removed to allow full access to the sill.

⇒ The threshold shall be installed if one does not already exist or if the existing threshold will not seal properly with the new door shoe. The threshold shall be shimmed to achieve the proper height.

⇒ The threshold shall be embedded in caulk along the interior intersection with the flooring and along the two ends at the door jambs.

⇒ The door panel should be measured and the bottom edge shall be trimmed to provide a weathertight seal with the threshold.

⇒ The door shoe shall be cut the same length as the width of the door panel and secured to the bottom of the panel with screws.

⇒ The door shall be opened and closed to ensure its proper operation and to ensure that the vinyl insert achieves a good seal.

Storm Windows (SW) and Fixed Glass (FG)

Applicability. Storm windows or fixed glass may be installed when an existing home contains single-glazing (one layer of glass) primary windows without existing storm windows.

Material Specifications. Storm windows used in conjunction with a single glazed prime window, to achieve double glazing, shall be a storm window certified by the American Architectural Manufacturers Association (AAMA), the National Accreditation and Management Institute (NAMI), or an equivalent certification program. Evidence of certification by AAMA, NAMI or equivalent shall be a (1) certification label, (2) listing in the latest edition of their certified product directory, or (3) letter of certification from the certification authority.

The inserts of storm windows installed in the program must be removable from the main frame. For operating storm windows and internally-applied fixed storm windows, the inserts should be removable toward the inside. For externally-applied fixed storm windows, the inserts should be removable toward the outside.

On certain prime windows, the storm window insert may not be removable toward the inside due to the prime window design. For these windows the storm window insert may be removable toward the outside. Examples are Oriel windows and the fixed light of a 3-light horizontal slider. The meeting rails of the storm window should be checked for proper alignment with the meeting rails of the prime window.

Approved thermal break materials shall have a minimum life expectancy of 15 years.

Installation Requirements

- *Application*—Storm windows may be installed on the interior or exterior side of the prime window opening to achieve an isolated air space between the two glazing materials of ¾-inch minimum to 4 inches maximum. Storm windows designed for interior installation should be used in cases where (1) the prime window cannot be effectively sealed against excessive air leakage or where (2) mechanical operation of the prime window or access to the prime window would make external application impractical.
- *Preparation*—The prime window shall be made as weathertight as possible both inside and outside (excluding required weepage systems) before a storm window or fixed glass is installed. This includes weatherstripping, caulking, reglazing, replacing of broken glass, or other work required to make the prime window weathertight. If a prime window requires caulking, the caulk should be applied in such a manner as to avoid interfering with the mounting surface where the storm window, thermal break (spacer), or subframe, will be installed.
- *Building Codes*—It shall be the QCN member's responsibility to comply with local building codes regarding the installation of operating or fixed storm windows or fixed glass. The QCN member shall refer to the manufacturer's instructions concerning removal of retaining bands or shipping clips.
- *Weepage*—When the storm window is installed on the exterior side of the prime window, weep holes (approximately 1/8 inch round or equivalent) or an effective weepage system shall be provided for each insert track (glass and screen) and on the main frame, sill expander, and sill subframe near each corner of the window. Weep holes shall be located with a maximum of 4 feet on-center in between. A weepage system should be provided in prime windows for internally applied storm windows if not provided by the prime window manufacturer.
- *Piggyback*—The QCN member will be permitted to install piggyback or fixed glass over better grade wood prime windows that are designed especially to accept the manufacturer's storm window inserts and over any wood casement or wood-awning-type single glazed prime windows.
- *Mounting Devices*—All mounting hardware, screws, or other miscellaneous items in direct contact with aluminum storm windows shall be of aluminum, stainless steel, or other non-corrosive material compatible with aluminum. All mounting hardware in direct contact with steel storm windows shall be of non-reactive material that is compatible with steel.

  When subframing materials are used for mounting storm windows, the sub frames shall be anchored to the prime window frame or window opening mounting surface with adequate anchoring devices to provide a secure installation of the storm window.

  Screws used for installing storm windows shall be equally spaced approximately 12 inches apart beginning approximately 2 inches from the main frame corners with not less than two screws per jamb. Where the design of the prime window opening does not provide a mounting surface for the storm window at the head or sill, or access to the head, screws will not be required if the storm

window is adequately secured to the window opening and is weathertight except for the weep holes along the sill. If the storm window is not adequately secured, the installer will be required to add the necessary mounting brackets, subframing, and thermal break materials.

- *Metal Storm Windows Over Wood Prime Windows*—The storm window shall be effectively sealed to the prime window opening by one of the following methods:
  - Applying a continuous bead of approved caulk to the mounting surface (perimeter) of the prime window or to the perimeter of the storm window before setting the window in place and then pressing the storm window so as to embed the window frame into the caulk.
  - Installing a continuous, flexible, closed-cell vinyl material or an approved, closed-cell foam tape or extrusion weatherstrip material as a seal between the two surfaces.

    NOTE: The materials used must completely seal the window opening to provide a weathertight seal except for the sill weep hole openings. Rigid materials used as spacers will require caulking.

- *Metal Storm Windows Over Metal Prime Windows*—If caulking is required to seal the perimeter of a metal prime window frame and wall opening, it should be applied in such a manner as to avoid interfering with the storm window installation. Caulk will not be accepted as a thermal break material in any application. The storm window shall be effectively sealed to the prime window opening by one of the following methods:
  - Secure an approved rigid thermal break (spacer) material to the window opening with screws on approximate 12-inch centers to form a secured mounting surface for the storm window, or secure the rigid thermal break material to the perimeter of the storm window framing. Apply a continuous bead of approved caulk to the mounting surface or to the perimeter of the storm window before setting the window in place and then press the storm window to embed the window frame into the caulk. Secure storm window in place with screws equally spaced approximately 12 inches apart beginning approximately. 2 inches from the main frame corners.
  - Install a continuous, flexible, closed-cell vinyl material or an approved, closed-cell foam tape or extrusion thermal break material to the prime window opening mounting surface or to the perimeter of the storm window. Then press the storm window in place and secure with screws approximately 12-inch centers beginning approximately 2 inches from the main frame corners.

  NOTE: Caulk should be applied over the thermal break along the head of the storm window (exterior side) if the head is exposed to the weather as in an overlap installation where water could accumulate on the gasket material.

- *Fixed Storm Windows*—Fixed storm windows or hinged inserts will be allowed to cover metal casement, awning, or jalousie prime window openings subject to the approval of the TVA Customer Service Center on an individual design basis. In any of these three prime window types, the fixed or hinged storm window may be applied internally or externally. However, the installation should not prevent the normal operation of the prime window with the storm insert removed.

- *Coverage (Thermal Isolation)*—Metal storm windows applied over metal prime windows shall to completely and effectively isolate (thermally) the entire external or internal prime window opening, including any mullions. Fixed or operating storm windows installed on the interior of metal casement, awning, or jalousie prime windows will be exempt from this requirement; however, the storm window should cover as much of the interior metal prime window as possible without interfering with the operating hardware of the prime window. On any grouping of windows joined by a metal mullion bar, the storm windows must be installed either all on the inside or all on the outside.

NOTE: For metal prime windows, the storm window shall not be installed as an insert in the screen track.

- *Wood Subframes For Metal Window Applications*—Wood may be used as a thermal break or as a subframe between metal-to-metal application provided the wood meets the 1/4 inch or greater minimum thickness for hardwoods and 3/16 inch or greater minimum thickness for softwoods. Wood trim installed as a subframe for blindstop applications or as a thermal break must be water-repellent preservative-treated or the wood must be protected against moisture penetration and painted with a

finish coat. A priming coat of alkyd (oil-based) paint or latex (water-based) paint is acceptable in these applications as a preservative treatment (protectant).

- *Trim for Bug-Eye Windows*—When wood strips are used to thermally isolate the framing of a bug-eye prime window (a prime window that protrudes from the window opening), the wood must be water-repellent preservative-treated. Finish coats are required if the storm window is mounted to the wood trim.
- *Other Installation Techniques*—Other methods of installation will be subject to field review. They will be approved if determined by the TVA to be equal to any one of the methods described above.
- *Fixed Glass (FG) Over Wood Prime Windows*—A piece of glass without a sash mold (unframed sheet glass) defined as fixed glass may be installed over a fixed wooden prime window (picture window) in lieu of a framed insert (also defined as fixed glass) or a fixed storm window provided the glass is placed on neoprene shims at the base for support and is sealed around the perimeter with an approved caulk or other sealant. Wood molding or other suitable material shall be used to secure the glass to the opening. Framed fixed glass inserts over wood shall be installed as described in these standards.

QCN member's Post-Installation Verification. Each storm window installed shall be checked by the QCN member to ensure the following:

- The meeting rail or stile aligns with the meeting rail or stile of the prime window and that the window is installed with adequate clearance to permit operation of both the storm and prime windows and to permit removal of the storm window inserts.
- All movable parts of the storm window operate without binding and final adjustments are made where necessary to ensure proper fit and functioning.
- Weep holes (or an effective weepage system) are located in each glass and screen insert track and in the sill of externally applied storm windows to provide adequate ventilation and proper drainage.
- All main frame joints (lap, butt, miter, etc.) are either welded, brazed, or mechanically linked and sealed.

Interior Applied, Thermoplastic Storm Windows

Definition. An interior applied, thermoplastic storm window is defined by TVA to be a storm window assembly consisting of a removable plastic glazed panel and an approved master frame or subframe installed to the interior side of a primary window opening. The panel shall consist of non-glass glazing material (such as acrylic, polymethyl methacrylate, polycarbonate, or other approved transparent thermoplastic sheet material as approved by TVA) in place of silicate glass glazing and shall contain a thermoplastic (polymer) trim rail or sash mold around its perimeter that is compatible with the glazing material. The panel and the master framing or subframing shall attach the storm window panel to the primary window opening by a mounting system approved by TVA.

The storm window assembly shall provide an effective weather seal under normal wind conditions and pressures around the perimeter of the window opening and along any meeting rails/stiles contained within a multi-panel assembly that will provide an air tightness greater than that of the existing prime window over which it is applied

Cleaning and Repair. Each interior applied, thermoplastic storm window installed under the program shall have the instructions for cleaning the glazing material permanently affixed to the window in a location clearly visible from inside the room after the window has been installed. The instructions shall recommend a suitable cleaning solvent, detergent, wiping cloth, and cleaning procedure. They shall also contain information about where repair service and cleaning supplies may be obtained.

Installation Requirements

- *Application*—Interior applied, thermoplastic storm windows are to be installed only on the interior side of the prime window opening and in such a manner as to cover the entire window and provide

thermal isolation of the entire prime window opening. Subframes such as angles or blind stops shall be required if a suitable mounting surface of wood or metal is not available.

NOTE: If installed over an operable prime window, the prime window should be in the closed and locked position.

- *Preparation*—The prime window shall be made as weathertight as possible both inside and out (excluding required weepage systems) before a storm window is installed. This includes but is not limited to any weatherstripping, caulking, replacing of broken glass, or other work required to make the prime window weathertight. If a prime window requires caulking, the caulk should be applied in such a manner as to avoid interfering with the mounting surface where the storm window or subframe will be installed and shall comply with these standards. If the prime window requires weatherstripping, the weather strip material should be applied in accordance with these standards. Weepholes (approximately 1/8-inch diameter or equivalent) or an effective weepage system should be provided near the corners along the prime window sill when internally applied storm windows are installed.
- *Building Codes*—It shall be the QCN member's responsibility to comply with local building codes concerning any restrictions on the installation of interior applied, thermoplastic storm windows.
- *Pre-Installation Requirements*—The installer shall verify that the storm window assembly is not damaged before installation.

  The installer shall refer to the manufacturer's instructions concerning construction, assembly, and installation of the storm window assembly.

  Interior applied, thermoplastic storm windows shall be sized to cover the entire window opening over which they will be installed.

  Any operating or hinged glazed insert panels of a storm window assembly shall be in the same position as the operating sash of the prime window.

  Any meeting rails or meeting stiles of the storm window assembly shall be aligned with the respective meeting rails or meeting stiles of the prime window.
- *Storm Window Assembly*—Interior applied, thermoplastic window assemblies shall adhere to the following requirements:
  - Be custom-fitted to each prime window opening to match the size and shape of the existing window opening
  - Be installed in a vertical position only; sloped installations shall not be permitted
  - Be mounted on the interior side of the prime window opening to achieve an isolated air space between the two glazing materials of 3/4 inch minimum to 4 inches maximum
  - Be permanently attached to the prime window opening and provide a weather tight seal establishing an air tightness greater than that of the existing exterior prime window over which it is installed

  Clearance must be allowed for prime window light operation, removal, and cleaning. Where the design of the prime window precludes mounting the storm window to cover the entire window opening, the installation must be accepted in advance by TVA and the customer.

  When subframing materials are used for mounting interior applied, thermoplastic storm windows, subframes shall be permanently attached to the prime window opening or mounting surface with mechanical fasteners positioned on approximately 12-inch centers to provide a secure installation for the storm window assembly.

  Subframes shall be effectively sealed to the prime window opening by a continuous bead of approved caulk. The sealant shall provide a permanent seal between the storm window assembly and the surrounding prime window opening.

  Thermoplastic hook-and-loop mounting systems, such as Velcro, or equivalent, are not permitted.

A thermoplastic insert panel may be attached to its framing members by use of magnetic strips if the following conditions are met:

- The magnetic holding force of the magnetic strip shall be a minimum of 6-1/2 pounds per linear foot with a maximum of 10 percent variance at zero air gap around the window perimeter.
- Thermoplastic storm windows larger than 16 square feet shall have permanent retaining clips or other suitable fasteners compatible with the window materials installed to prevent inadvertent removal and/or lateral movement of the storm panel in any direction, parallel or perpendicular to the glazing surface, under normal conditions. The clips or fasteners shall be disengagable to enable window cleaning, maintenance, and exit through operable prime windows.

Stacking multi-poled, polymer-based magnets is not permitted.

Floor Insulation and Ventilation

Applicability. This improvement is applicable only if none of the following conditions exist:

- Presence of any effective floor insulation
- Underfloor area of insufficient height for installing floor insulation
- Floor is over an area that is being converted or will be converted to a conditioned space
- Underfloor area is subject to moisture problems (such as flooding or drainage problems)

Material Specifications. Materials installed as floor insulation must be an acceptable material suitable for floor insulation.

When physically possible, a continuous ground cover vapor barrier should be applied to cover approximately 80 percent of the crawl space ground surface to assist in keeping crawl space humidity at a low level. This will decrease the ventilation requirements as shown below. If a ground cover vapor barrier is not feasible, additional crawl space ventilation may be needed as described in these Standards.

Six mil polyethylene or 55 lb. roll roofing shall be used.

Ventilation. The frame and screening materials used for the foundation wall vents shall be constructed of durable materials (preferably metal) and be of sufficient size and number to provide the minimum required net free area of ventilation as shown below.

MCSV		
Ratio of Total Net		
Under Floor Area	**Ventilating Area to Floor Area**	**Minimum Number of Vents**
Without ground cover vapor barrier	1/150	4
With ground cover vapor barrier	1/1500	4

Support Materials for Floor Insulation. In general, support materials shall be rot-proof, rust-proof, stretch-free and strong enough not to break when affixed to the underfloor structure.

- When netting and staples are used as support, netting shall be knotted, looped, woven, or heat fused at all junctions; staples shall be the type commonly used to support insulation batts.
- Wire staves shall be made of a single piece of 13-gage (0.087 inch diameter) or larger “hard drawn” steel wire, pointed at both ends. Staves shall be manufactured especially for the purpose of supporting underfloor batt or blanket insulation.

- Staves shall be of good quality steel with sufficient spring to return to their original shape with little or no deformation when released.
- Wire staves shall have a length between 1/2 inch to 2 inches longer than the inside joist spacing on which the staves are used.
- When the wire staves are cut to a shorter length to fit smaller joist spacings, the cut shall be on a diagonal in such a way to produce a barb that will more easily secure the wire stave into the joist.
- Wire, nylon string, or other equivalent permanent materials of sufficient strength shall be used to support the insulation material.
- Nails with small heads, such as brads or casing and finishing nails shall not be used.

Installation Requirements. The QCN member for each weatherization item covered under Floor Insulation shall be responsible for ensuring that all materials used and work done comply with the installation procedures and criteria outlined in these standards.

- *Preparation Work*—Work identified as preparation work shall be completed prior to, or in conjunction with, installing floor insulation.
- *Existing Conditions*—The QCN member shall be responsible for determining if the installation of additional floor insulation will cause structural damage to the residence. If applicable, QCN members shall notify inspector and customers prior to installing insulation if they determine that an R-value different from that recommended should be installed.

The QCN member shall be responsible for completing all preparation work involving insulation materials already existing in the residence, such as blocking around heat-dissipating devices that were covered with existing insulation, etc.

The customer shall be responsible for seeing that preparation work such as repairing the floor, foundation wall leaks, pipe leaks, vent leaks, removing objects stored in the crawl space area, etc., is completed if failure to do so would adversely affect the installation of additional insulation.

- *General Requirements*
  - Cross Bracing. Batts and blankets shall fit snugly against the floor joists, cross-braces, headers, and adjacent batts or blankets. Gaps between floor joists and insulation caused by carpenter error or warped joists shall be stuffed with insulation to reduce energy loss. Batts or blankets shall be cut and split in such a way as to fit between any cross-bracing if looping under the cross-bracing will require more than one-third of the batt or blanket to extend below the floor joists. Any method other than cutting and splitting at the cross-bracing must be approved by TVA.
  - Heat Dissipating Devices. Insulation materials shall maintain a minimum 3-inch clearance from heat dissipating devices such as furnaces and electric motors; also the insulation material shall be prevented from blocking or restricting combustion air openings of gas or oil-fired furnaces.
  - Underfloor Protection. Insulation materials in open underfloor areas shall be protected from the weather and other hazards by fastening (stapling) a minimum 6-mil thickness polyethylene to the bottom of the floor joists perimeter inwards 2 to 3 feet. In addition, the floor insulation shall be supported by poultry netting or nylon mesh beneath the entire floor to protect it from destruction by animals.
  - Crawlspace Vents. Proper crawl space ventilation, as discussed in these standards, shall be installed if needed. The insulation shall not cover or block the ventilation system in any way.
  - Exhaust Vents. Clothes dryer and other exhaust vents shall be vented to the outside.
- *Vapor Barriers*—An acceptable floor vapor barrier shall be installed toward the winter-warm side of the insulation.
  - Approximately 80 percent ground coverage is recommended for existing homes (one year old or older). In placing the vapor barrier over the underfloor surface, the adjoining edges shall be

overlapped at least 4 inches, with 6 inches preferred. To achieve this approximate 80 percent coverage, areas adjacent to foundation walls and support piers should remain uncovered.

- After the vapor barrier is in place and all openings lapped or taped (small tears may be repaired by taping over them with a quality duct tape), bricks, other small masonry pieces, or an equivalent material shall be used to prevent movement of the barrier. Other methods used to prevent movement of the barrier shall be submitted to TVA for approval on a case-by-case basis. Ground cover shall be used in conjunction with ventilation, not in place of it.
- In extremely damp underfloor areas where there is concern over the possibility of drying out the residence too rapidly, the vapor barrier should be installed initially to cover approximately 50 percent of the ground surface, with enough material folded back for eventual 80-percent coverage.

- *Vents*—After determining the correct number of vents required for the particular underfloor area, vents shall be evenly distributed around the foundation to provide the best air flow over the greatest area. When only four vents are required or possible, two vents should be located on the prevailing wind side of the house and the other two on the opposite side. As with attic vents, foundation vents should remain open in winter as well as in summer to provide the necessary ventilation. However, during freezing conditions, it is advisable to temporarily close vents located next to water pipes in order to lessen the chances of water in the pipes freezing.
  - Vent openings shall be located as close to building corners as is practical and should provide cross-ventilation through at least two opposing foundation walls. Adequate cross-ventilation shall be provided whenever possible for all separate areas within a partitioned crawl space.
  - Vent locations for proper cross-ventilation of crawl space areas shall be defined according to the “polygon method.”
  - First, the crawl space is sketched with the location of all existing and/or proposed vent openings shown. The vent opening locations are then connected with straight lines (which do not cross each other) to form a polygon (i.e., a multi-sided figure, such as a triangle, rectangle, pentagon, hexagon, etc.). If the crawl space is partitioned, a polygon is drawn for each separate crawl space area.
  - If the area of the resulting polygon covers 70 percent, or more, of the crawl space area to be ventilated, then the distribution of the ventilators is adequate.
  - If the area of the resulting polygon does not cover 70 percent of the crawl space area, then additional vent openings or relocation of proposed vent openings shall be required to allow a similarly drawn polygon to indicate an adequate distribution of ventilators.
  - All other possible steps (such as making access doors into screened vents, enlarging existing foundation vents by removing wooden screen frames, etc.) should be taken to increase total existing net free area instead of adding more openings in foundation walls.

energy right® **Residential Program**

Heat Pump Plan Weatherization Inspection Procedures

Inspection Procedures

When inspection of weatherization is required for dwellings being equipped with heat pumps under the *energy right*® Heat Pump Plan, the following check lists will be used.

Attic Insulation - Preparation Work - Checklist

- Verify that all specified preparation work was completed.
- Verify that no insulation has been added that would cause damage to the structure.
- Verify that any needed preparation work, such as correcting roof leaks, to ensure the insulating ability of the insulation material has been completed.
- Ensure that proper insulating materials have been placed around knob-and-tube wiring in accordance with TVA standards.
- Ensure that all sources of infiltration (air leaks) from the conditioned area into the attic have been properly sealed.
- If the vapor barrier was improperly installed on the existing insulation, verify that it has been properly installed or made ineffective before additional insulation was added.
- Ensure that approved cover plates have been installed on electrical junction boxes and that all electrical connections are properly enclosed or the electrical junction boxes have been properly blocked around.
- Verify that proper clearances and blocking have been provided around all heat-dissipating devices and objects, such as recessed light fixtures, chimneys, flues, and exhaust fans.
- Verify that proper blocking has been provided when required around other devices, such as the attic access or stairway, doorbell transformers, whole-house attic fans, exhaust fans that are not vented to the outside, etc.
- Ensure that the proper ventilation air space exists above insulation materials that previously contacted the roof sheathing (1-inch minimum).
- Ensure that clothes dryer vents have been extended to the outside.

Attic Insulation - Unfinished Attics - Checklist

- Verify that all work specified on it has been completed by comparing it with the Heat Pump Installation Inspection Checklist TVA 6254T and the installed materials.
- Verify that approved materials have been installed. If loose-fill insulation was installed, verify that the installer left an empty insulation bag on the premises.
- Ensure that insulation has been installed only in the areas which should have been insulated.
- Ensure that the material installed meets the R-value which should have been installed.
- Check that the builder's statement (attic card) has been attached to a rafter, joist, etc., is clearly visible from the attic access entrance, and has been completed in accordance with TVA standards.
- Determine from the coverage chart on the attic card if the correct number of bags of loose-fill material (if installed) has been installed. If the density of the loose-fill insulation appears improper, proceed with the following:
- Ask customers if they counted the number of bags actually installed and obtain the number.

- If the customer did not count the number of bags installed, proceed with Measuring the Depth of Insulation Checklist.

Attic Insulation - Measuring The Depth Of Insulation - Checklist

- Measure the depth of insulation in each section using a nonmetallic ruler. Record the depth of each section.
- If batt or blanket insulation with a vapor barrier was used, ensure that the vapor barrier is turned toward the attic floor if there was no existing insulation or removed if there was existing insulation.
- Verify that batt or blanket insulation fits tightly against the sides of joists and against the ends of each batt or blanket.
- Ensure that insulation does not contact chimneys, flues, or other energy-dissipating objects and that such insulations are properly blocked.
- Ensure that cavities or voids which drop to a lower level have been insulated properly.
- Verify that there is at least 1 inch of air space between the insulation and roof sheathing.
- Ensure that permanent stairway ceilings and walls have been insulated properly.
- Verify that the insulation installed does not cover or block any attic ventilation. (Check the eave vents without light in the attic--light can be seen coming through the eave vents from the outside.)
- Ensure that the attic access door is insulated and weatherstripped if it is located in a conditioned area.

NOTE any deficiencies detected during the inspection on the Heat Pump Installation Inspection Checklist TVA 6254T.

- Ensure that the QCN member has removed any unused materials and debris from the premises.

NOTE: All attics insulated with loose-fill insulation should be measured in at least three different points in the attic (preferably in the middle and at both ends) in order to verify that the insulation has been installed with a consistent depth throughout the attic area and at the minimum depth specified on the coverage chart.

Attic Insulation - Floored Attics - Checklist

Inspect insulation installed in floored attics using the same procedures outlined for inspecting attic insulation in unfinished attics, with the following exceptions:

- If insulation has been installed beneath the flooring material, verify that each joist cavity has been completely filled with insulation by looking through the cracks between the boards or under the area where the flooring material ends. Do not remove any flooring material secured to ceiling joists to inspect the installation.
- If insulation has been installed above the flooring material, ensure that the proper R-value has been installed by checking the density (number of bags installed) and the minimum thickness of the installed material.

Attic Insulation - Finished Attics - Checklist

Inspect insulation installed in finished attics using the same procedures outlined for attic insulation in unfinished attics, with the following exceptions:

- If batt or blanket insulation has been installed in the vertical walls, ensure the following:
  - The insulation has been installed with any vapor barriers facing the living area.
  - The insulation is supported in an approved manner.
- Verify that batt or blanket insulation has been installed, when possible, above the sloped ceiling areas with a minimum 1-inch air space provided for ventilation between the insulation and the roof sheathing.
- Ensure that the proper amount of insulation has been installed above the horizontal ceiling area as well as in the unfinished attic areas adjacent to the finished attic area.

Insulation in Cathedral Ceilings Checklist

- Verify that the amount of insulation has been approved by the TVA Customer Service Center prior to the installation.
- If a new ceiling finish material has been installed, ensure that proper ventilation has been provided between the insulation and the roof sheathing.
- If polyurethane or polystyrene rigid board insulation has been installed, ensure that an interior finish material having a minimum 15-minute finish rating (1/2-inch gypsum board) has been installed between the insulation and the living area.

Insulation in Vertical Interior Walls of Multi-Level Dwellings Separating Conditioned Areas From Attics - Checklist

- Verify that insulation has been installed and supported in uninsulated vertical interior walls of multi-level dwellings separating conditioned areas from attics in accordance with TVA standards.

Attic Ventilation Checklist

- The access door is adequately weatherstripped if it is located in a heated (conditioned) area.
- The insulation does not contact the roof sheathing near eave vents.
- The insulation does not cover or block any attic ventilation. (Check the eave vents without light in the attic. Light can be seen coming through the eave vents if the airway is clear.)
- There is at least 1 inch of air space between the insulation and roof sheathing.
- The ventilation that was installed meets TVA standards, and the amount added fulfills TVA minimum requirements.
- The correct number of ventilators required for the attic area have been installed, are distributed to provide proper air flow and are not blocked by the insulation.
- A ceiling vapor barrier has been installed where required, in accordance with TVA standards.
- Exhaust vents from the living area (includes clothes dryers) are not vented into the attic space.
- Any corrective actions required in the attic prior to ventilation installation have been completed.
- The QCN member has removed unused materials and debris from the premises and has left the job site "broom clean" or its equivalent.
- All materials and installations thereof not mentioned in these procedures are in compliance with TVA standards.
- Any deficiencies detected during the inspection are noted on the Heat Pump Installation Inspection Checklist TVA 6254T.

Caulking Checklist

- If possible, ensure that all needed preparation work has been completed by the QCN member.
- Verify that the proper number of windows and doors have been caulked or glazed.
- Verify that caulking and glazing materials have been applied in a neat and uniform manner and adhere properly to adjacent building materials.
- Ensure that the tint of each material installed coordinates with the existing structure.
- Ensure that all caulks and sealants or other stains have been removed from glass and adjoining areas.
- Verify that any broken glass in existing prime or storm windows has been replaced.
- Ensure that any other sources of air infiltration have been corrected.
- Ensure that all surplus materials and debris are removed from the premises.
- Note any deficiencies detected during the inspection on the Heat Pump Installation Inspection Checklist TVA 6254T.

Weatherstripping Checklist

- Verify that all needed preparation work has been completed.
- Verify that the proper number of windows and doors have been weatherstripped.
- Verify that the surface to which the weatherstripping was applied was smooth and that old weatherstripping, dirt particles, loose paint, etc., were removed.
- Ensure that materials were installed in a functional position that assures their effectiveness while retaining proper operation of the window, door, etc.
- Ensure that thresholds are of a permanent type that effectively seal the bottom of the door against air infiltration when the door is in the closed position.
- Ensure that all surplus materials and debris are removed from the premises.
- Ensure that any deficiencies detected during the inspection are noted on the Heat Pump Installation Inspection Checklist TVA 6254T.

Storms Windows and Fixed Glass Checklist

- Verify that the number of storm windows to be installed agrees with the number of storm windows billed on the invoice.
- Verify storm windows have not been installed on any prime window with multiple glazing.
- Verify the storm window is not damaged and is set square and level within the opening.
- Verify the storm window is effectively sealed to the prime window opening by an acceptable method specified in the TVA standards.
- Ensure an effective weepage system is provided where the storm window is installed on the exterior side of the prime window.
- Ensure all mounting hardware, screws, and other items in direct contact with aluminum storm windows are of aluminum, stainless steel, or other non-corrosive material compatible with aluminum.
- Ensure screws used for installing the storm windows are spaced according to TVA standards.
- Ensure storm windows are installed in such a manner to completely and effectively cover the entire prime window opening unless exempt by TVA standards.
- Ensure the operating glass insert of the storm window is in the same position as the operating glass insert of the prime window.
- Verify screens that would interfere with the operating of the storm window have been removed.
- Verify main frame members that are not welded or brazed have been sealed with an acceptable seam sealer.
- Verify any caulk applied to the prime window does not adversely interfere with the storm window's mounting or operation.
- Verify any prime window weatherstripping has been installed according to TVA standards and does not interfere with the operation or removal of storm window operating inserts.
- Ensure mounting devices are used in accordance with TVA standards.
- Ensure subframing materials are properly anchored to the prime window or window opening.
- Ensure trim has been installed around all bug-eye prime windows unless the customer signs a disclaimer statement.
- Ensure any piggyback or insert type storm windows are installed on better grade wood prime windows that are designed especially to accept storm inserts.
- Verify all glazing compounds, adhesives, and stains are removed from glass and adjoining areas.
- Verify frames are constructed to permit vertical movement of the operating inserts without binding.
- Verify meeting rails interlock with one another or contact tightly with weatherstripping.

- Verify all operating inserts are operable from the inside and all inserts are removable. Inserts shall be removable from the inside, unless insert removal to the inside is impossible due to the prime window design. Example: the large Oriel window insert may be removable to the outside.
- Ensure main frames and subframes provide necessary clearances for operating prime windows.
- Ensure the inserts are removable. Non-removable inserts, when allowed, are classified as fixed glass.
- Ensure that all inserts tightly contact the main frame and/or weatherstripping when used.
- Verify an acceptable thermal break material is provided between the storm and prime window frame with a minimum of 1/8-inch perpendicular distance between them.
- Verify permission for the installation was obtained from the customer and the TVA Customer Service Center.
- Verify a fixed glass installed over a fixed wooden prime window is placed on neoprene shims at the base and sealed with an approved caulk or sealant.
- Verify that for fixed glass installed over a fixed wooden prime window, wood molding or other suitable material secures the glass to the opening.
- Verify fixed glass over a metal prime window is framed and glazed, and then installed in the same manner as any applicable storm window in accordance with TVA standards.
- Verify all surplus materials and debris are removed from the premises.
- Verify any deficiencies detected during the inspection are noted on the Heat Pump Installation Inspection Checklist TVA 6254T.

Floor Insulation Checklist

- Verify that all specified preparation work was completed.
- Verify that no insulation has been added that would cause damage to the structure.
- Verify that any needed preparation work, such as correcting pipe leaks to ensure the effectiveness of the insulation material, has been completed.
- Verify that proper clearances have been provided around all heat-dissipating devices and objects, such as furnaces and electric motors.
- Ensure that clothes dryer vents have been extended to the outside.
- Verify that approved materials have been installed.
- Ensure that insulation has been installed only in those areas which should have been insulated.
- Ensure that the material installed meets the R-value which should have been installed.
- If batt or blanket insulation with a vapor barrier was used, ensure that the vapor barrier is turned toward the floor.
- Verify that insulation fits tightly against the sides of joists and against the ends of each batt or blanket.
- Ensure that the insulation installed does not have an objectionable odor in the living area of the residence.
- Verify that the insulation installed does not cover or block any floor ventilation.
- Note any deficiencies detected during the inspection on the Heat Pump Installation Inspection Checklist TVA 6254T.
- Ensure that the QCN member has removed any unused materials and debris from the premises.

Floor Ventilation Checklist

Proceed to the underfloor area and begin the inspection ensuring the items listed below:

- Verify the insulation does not cover or block any floor ventilation.
- Verify that the ventilation in place meets TVA standards and the amount added, if any, fulfills TVA minimum requirements.

- Verify the correct number of ventilators required for the floor area have been installed and distributed to provide proper air flow and are not blocked by the insulation.
- Ensure any ground cover vapor barrier meets the appropriate TVA standards.
- Ensure exhaust vents from the living area (includes clothes dryers) are not vented into the underfloor space.
- Ensure any corrective actions required in the underfloor area prior to ventilation installation have been completed.
- Ensure the QCN member has removed all unused materials and debris from the premises and has left the job site "broom clean" or its equivalent.
- Verify all materials and installations thereof not mentioned in these procedures are in compliance with TVA standards.
- Verify any deficiencies detected during the Inspection are noted on the Heat Pump Installation Inspection Checklist TVA 6254T.

energy right® **Program**

Heat Pump Major Minor Inspection Criteria

Heat Pump Inspection Procedures

a. General Inspection Requirements

Utilizing Heat Pump Plan Heat Pump Installation Inspection Checklist and Work Completion Form, which have both been previously completed by the installing **Quality Heat Pump Contractor**, the **Inspector** will perform a **Inspection** using the following criteria as a general guide.

1) Equipment shall be sized and selected to meet the requirements of the **Standards.** ***(Major)***

2) The Inspector shall verify insulation prerequisites are installed or in the process of being installed prior to heat pump inspection. ***(Major)***

3) All equipment shall be checked for Air-Conditioning and Refrigeration Institute (ARI) listing. If a window heat pump, the Inspector shall verify the heat pump has a AHAM label attached indicating the unit is listed with AHAM. The Inspector shall verify that SEER and HSPF ratings (EER and COP for water source) meet criteria. ***(Major)***

4) Check that the calculated cooling load falls within 500-800* square feet of conditioned space per ton of calculated cooling capacity. If the load calculation results are outside the accepted range, attempt to attribute variance to some special characteristic(s) of the structure (high percentage of glass, etc.). Observe structure characteristics and consult with the **Quality Heat Pump Contractor.** ***(Major)***

   * This range may be changed at TVA Customer Service Center discretion.

5) Compare selected equipment cooling capacities (sensible and latent) at stated design conditions with the calculated cooling loads (sensible and latent) to assure minimum of 100 percent of calculated loads (independently) is achieved, and that equipment's sensible capacity does not exceed the calculated sensible load of the structure by greater than 125%. Variations to this requirement apply to Direct Exchange Ground Source Heat Pumps (DXGS). See **Standards**. ***(Major)***

6) Check that the calculated heating load falls within 5-8 watts* per square foot of conditioned space. If calculation is outside the acceptance range, attempt to attribute variance to some characteristic(s) of the structure. Observe structure characteristics and consult with **Quality Heat Pump Contractor**. ***(Major)***

   * This range may be changed at TVA Customer Service Center discretion.

7) Check that the **Quality Heat Pump Contractor** calculated system balance point temperature is no higher than 35°F (unless allowed greater than 35°F as described in the **Standards**). ***(Major)***

8) If in the above review, obvious and significant errors are detected which would cause the installed heat pump's capacity to fall outside the heat pump standards' sizing criteria for cooling and/or heating capacities, the job may fail inspection. ***(Major)***

b. Equipment Selection

1) Check load calculations for proper method (ACCA Manual J or approved equal) and required indoor/outdoor design temperatures. Heat loss shall be determined at 70°F DB indoor temperature at the prevailing local outdoor winter design temperature, and heat gain shall be determined at 75°F DB, 50% RH, indoor space conditions and at the prevailing local outdoor (95 degrees) summer design temperature and humidity. ***(Major)***

2) Compare the manufacturer's equipment capacities (provided by installing **Quality Heat Pump Contractor** at time of inspection) to **Quality Heat Pump Contractor** calculated heat loss and heat gain (both sensible and latent) to determine if the system(s) installed meets the sizing requirements in the **Standards**. ***(Major)***

3) Ground Water Source Heat Pumps (GWSHP) shall be sized to maintain the indoor design conditions listed above and meet sensible/latent requirements for an entering water temperature (EWT) within 10% of the ground water temperature of the local area. ***(Major)***

4) Earth Coupled Heat Pumps (ECHP) shall be sized to maintain the indoor design conditions listed above. System shall be sized to meet sensible/latent requirements for an EWT of 90°F. ***(Major)***

5) Direct Exchange Ground Source Heat Pumps (DXGS) shall be sized to meet 100 percent of the total heating load at design, but shall not exceed 200 percent of the total (sensible and latent) cooling load at design. ***(Major)***

6) If a heat pump is installed in a Manufactured Home using existing manufactured housing ductwork, check to determine if the manufactured ductwork is capable of operating as required by the **Standards** and if the installed heat pump is approved for that use by the heat pump manufacturer.

c. Equipment (outdoor/indoor)

1) Check for a one piece concrete (or accepted) pad (must be used as primary support). ***(Major)***

2) Check the outdoor air circuit for free air intake and discharge and no short circuiting of outdoor air shall occur. ***(Major)***

3) Check for the installation of outdoor thermostat(s) (or approved equal) if required or present, and for proper range and setting. ***(Major)*** Power distributor may not require outdoor thermostat on first 10 kW of auxiliary heat. Outdoor thermostat (or approved equal) shall be used to control auxiliary heat over 10 kW. Setting(s) should be recorded on Energy Efficient Heat Pump Plan (Heat Pump Installation Inspection Checklist) TVA 6254T.

4) Verify if an electrical inspection has been requested and the installation has passed, and if so, that a copy of the permit is on site (if applicable). ***(Major)***

5) Verify if a mechanical inspection has been requested and the installation has passed, and if so, that a copy of the permit is on site (if applicable). ***(Major)***

6) Check for proper type and size of overcurrent protection. ***(Major)***

7) Check that disconnect is within sight and within 50 feet of each piece of motorized equipment. ***(Major)***

8) Check for approved grounding of equipment. ***(Major)***

9) Check for condensate drain (minimum size of 3/4 inch) which is trapped and installed for proper drainage (if applicable).

10) Check service space for accessibility for replacement of any part or entire unit. ***(Major)***

11) Check refrigerant piping (split system) for acceptable length and lift. ***(Major)***

12) Check refrigerant piping (split system) for proper insulation, contact, and support.

13) Verify the existence of acceptable shroud, flashing, etc., to protect duct work from weather (package unit).

14) Check to see if an emergency, secondary drain pan is installed, (if necessary). ***(Major)***

15) Check resistance heater(s) size (if applicable):

a) Minimum for supplementary heating - design heat load minus compressor output at design outdoor conditions.

b) Maximum for supplementary heating - less than or equal to 100% of design heat load or 10 kW, whichever is larger.

d. Operation and Controls

1) Check for proper CFM (cubic feet/minute) of conditioned air per ton of cooling (12,000 Btuh), if applicable: ***(Major)***

Select method from the following and perform CFM test. Where possible, use the procedure which was performed by the **Quality Heat Pump Contractor** during the **Quality Heat Pump Contractor** Inspection.

a) Air Flow Determination Funnel Method

While air flow measurement is not an exact science, this method appears to be the most reliable. This method, however, should be compared to the following two methods to confirm results (within ± 10%). This requires a square-to-round duct and a Bacharach "Flow- Rite" velocity meter or equivalent.

Turn the indoor blower **only** switch to "ON" or "Continuous" at the wall thermostat. Read each supply register air velocity by placing the funnel over each register. Attempt to center the funnel on the register for the most accurate readings.

Sum all the register velocities obtained above and multiply the total by 0.267 to calculate the supply system air flow.

b) Air Flow Determination Heat Rise Method

This can be performed when a 10 kW or less resistance electric heater is energized. If possible, disconnect all but the first (W2) heat stage by turning off breakers.

Energize the resistance heating elements and indoor blower motor only. Read and record the blower motor amps, heater amps, and voltage at the heat pump unit.

Add the amps and multiply the sum by the volts and by 3.413 to obtain the heater system Btu input.

Allow time for the temperatures to stabilize and read the average supply air temperature in the supply duct 6'-10' downstream of the electric heater assembly, or at a register close to the heat pump. Read the average return air temperature in the return duct(s) 6'-10' upstream of the unit, or at the return air grille(s).

Divide the Btu input by the difference in average supply and return air temperatures and by 1.1 to obtain the system air flow volume (cubic feet/minute).

c) Air Flow Determination Return Air Grille Method

Measure velocity of air at return air grille(s) with a velometer. Take readings at 6 or more locations on the face of grille (symmetrically) and average.

Total air (CFM) = velocity (Feet per minute average) x area of grille (nominal dimensions) (gross square feet) x .75 (effective area constant).

2) Check for proper heating operation: *(Major)*

a) First Stage Heating

Energize first stage heating at the indoor thermostat and check by the following:

(i) Remove indoor thermostat cover

(ii) Turn on first stage heating until first bulb is closed - compressor only operates

(iii) Check amperage to resistance heaters or observe heater relays for open position to determine that the resistance heat is off.

b) Second Stage Heating-outdoor temperature is above outdoor thermostat setting (above balance point)

Energize first and second stage heating at the indoor thermostat, and check by the following:

(i) Remove indoor thermostat cover

(ii) Turn on first and second stage heating until both bulbs are closed - compressor only operates

(iii) Check amperage to resistance heaters or observe heater relays for open position to determine resistance heat is off.

c) Second Stage Heating - outdoor temperature is below outdoor thermostat setting (below balance point)

Energize first, then second stage heating at the indoor thermostat, and check by the following:

(i) Remove indoor thermostat cover

(ii) Turn on first stage heating until first heating bulb closes - compressor only operates

(iii) Check amperage to resistance heaters or observe heater relays for open position to determine resistance heat is off.

(iv) Close first and second bulbs of indoor thermostat. Verify that only one bank (maximum of 10 kW) of resistance heat comes on to supplement the compressor.

(v) If more than one outdoor thermostat is used (if required by Distributor), determine that the additional outdoor thermostat(s), or approved equivalent properly controls the additional bank(s) of the supplemental heat.

(vi) d) Emergency Heating

Set indoor thermostat to emergency heat position. Operate thermostat so both heating bulbs close. Verify that compressor does not operate and that all supplementary heat (controlled by outdoor thermostats) are energized. (This may be checked by the temperature rise method or ammeter reading at the equipment).

3) Check for Proper Cooling Operation: *(Major)*

Energize system in the cooling mode at the indoor thermostat. Check to see if compressor is energized and that outlet air temperature is approximately 50°F to 70°F dry bulb.

4) Check System for Proper Capacity: *(Major)*

a) Check capacity by <u>ONE</u> of the following methods:

i) Heating Capacity (compressor only) When the Outside Air Temperature is Below 75°F

Turn all auxiliary heating power switches to the off position.

Place unit in the heating mode (first bulb closed only) and allow the unit to run in the heating mode for at least 10 minutes.

Allow time for the temperatures to stabilize and read the average supply air temperature in the supply duct or at a register close to the heat pump. Read the average return air temperature in the return duct(s) 6'-10' upstream of the unit, or at the return air grille(s).

Estimate the compressor heat output using the following formula:

Btuh = temperature difference x 1.1 x CFM (CFM will come from one of the three methods detailed earlier).

Check outdoor temperature and refer to manufacturer's catalog data for rated output of unit at this outdoor air temperature.

Verify that system capacity is <u>+</u> 10% of the equipment manufacturer's rating at the test conditions.

ii) Cooling Capacity When the Outside Air Temperature is Above 75°F

Place system in the cooling mode.

Record intake air temperature to outdoor unit

At supply air outlet and inlet indoors record wet bulb and dry bulb temperatures.

From Table A-1, record heat content values that correspond to supply and return air wet bulb temperatures, h1 and h2, respectively.

Estimate total heat removed from space by:

Btuh = (h2 - h1) x 4.5 x CFM

Note: h1 = heat content of air from Table A-1 corresponding to supply air wet bulb temperature.

h2 = heat content of air from Table A-1 corresponding to return air wet bulb temperature.

CFM = measured or calculated air flow of system.

Check outdoor temperature and refer to manufacturer's catalog data for rated output of unit at this outdoor air temperature.

Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

iii) Capacity verification by Quality Heat Pump Contractor representative utilizing pressure/temperature gauges.

Have **Quality Heat Pump Contractor** representative attached refrigerant gauges to the heat pump refrigeration circuit and record suction and discharge pressures.

Compare findings to equipment specification at the observed ambient and air flow (cfm).

Have representative make any necessary additions or evacuations (utilizing proper refrigerant recover equipment) to the refrigerant circuit.

Record capacity before and after modifications.

e. Conditioned Area Components

1) Check for proper thermostat for the installation. ***(Major)***

2) Check location of thermostat for external heat or cold influence. ***(Major)***

3) Check thermostat to assure that it is level. ***(Major)***

4) Visually inspect mercury bulbs (if so equipped) for cracks and discoloration.

5) Check thermostat wiring connections for accuracy and tightness.

6) Check the thermostat temperature indicator (if so equipped) against a reliable source.

7) Check for security of thermostat to stud or other building component and for drafts from stud space behind thermostat.

8) Check thermostat for emergency heat switch (unless waived by other sections of these guidelines). ***(Major)***

9) 9) Check return air (RA) grille(s) for proper location(s) and proper size(s).

10) Measure velocity of air at RA grille(s) with a velometer. Take readings at 6 or more locations (symmetrically) on face of grille(s) and average. Maximum speed of returning air shall be less than 500 feet per minute (fpm).

11) Check filter location(s) for accessibility so that filter(s) can be replaced easily.

12) Check supply outlets for proper location.

13) Check supply outlets for acceptable supply capacity to distribute system air volume at acceptable speeds.

14) Check SEVERAL supply outlets as necessary for maximum discharge velocity range of 400-700 FPM. Take readings at 3 or more locations on face of grille and average.

15) Check the average temperature difference between any room or space within the conditioned structure (single level) for a maximum difference of not more than 4°F. ***(Major)***

f. Air Distribution System

1) Check duct system for proper design and installation per ACCA, SMACNA, or ASHRAE criteria.

2) Check duct system design to assure a minimum of 400 cfm/12,000 Btuh air flow across the indoor coil based on the equipment's ARI cooling capacity (if applicable). ***(Major)***

3) Check rectangular duct work for proper aspect ratio.

4) Check all seams and joints for airtight integrity and proper sealing/taping.

5) Check for proper vibration isolation connectors (if necessary).

6) Verify that duct system does not contact ground. ***(Major)***

7) Verify that acceptable duct material is utilized.

8) Check for proper support and hanging material.

9) Check branch ducts for proper sizing (minimum of 4", maximum of 8", round, or equivalent). ***(Major)***

10) 10) Verify that return duct work is sized to return the design cfm capacity of the supply system. ***(Major)***

11) Check duct work for proper insulation levels (if applicable).

g. Dual-Fuel Heat Pump (DFHP) Split System Inspection Procedures

Inspect DFHP equipment and duct system(s) for adherence to Standards (latest revision)

The preceding inspection procedures shall apply to all DFHP split systems:

1) See **Standards** for sections that do not apply to DFHPs.

2) Air flow determination shall be performed as follows: ***(Major)***

a) Blower speed shall be as used for heat pump operation by either of the following:

i) Heat pump shall be operating in either cooling or heating mode (first stage heating only)

OR

ii) Fan switch shall be in the "on" position and system switch in "off" position.

b) CFM measurement shall be determined by the funnel method. If measurement cannot be made by the funnel method, use the return air grille velocity method.

3) Inspect for proper control setting (including any temperature differential as may be required by the manufacturer). ***(Major)***

4) Inspect for proper heat pump/furnace operation. ***(Major)***

a) Outdoor temperature (ODT) is below 75°F, check the following:

i) Perform compressor heating capacity check

ii) If ODT is above structure's theoretical balance point:

- First stage thermostat - heat pump only operates
- Second stage thermostat - furnace only operates until second stage is satisfied iii) If ODT is below structure's theoretical balance point and above the economic balance point:
- First stage thermostat - heat pump only operates
- Second stage thermostat - furnace only operates until second stage is satisfied (compressor is off during this time); after second stage is satisfied, compressor energizes

iv) If ODT is below structure's theoretical balance point and below the economic balance point:

- First and/or second stage thermostat - furnace only operates

v) Emergency heat operation - There are no provisions for emergency heat mode for DFHP. In the event of the heat pump compressor or associated refrigeration equipment becoming inoperative, the furnace shall provide all required heating controlled from the second stage of the indoor thermostat in the heating mode.

b) Outdoor temperature is above 75°F, check the following:

i) Perform compressor cooling capacity check

ii) Check furnace only in heating operation

First and/or second stage thermostat - furnace only operates

NOTE: A **Quality Heat Pump Contractor** representative will have to temporarily field wire to "close" control setting.

iii) Emergency heat operation - furnace only operates

h. Dual-Fuel Heat Pump (DFHP) Packaged System Inspection Procedures

Inspect DFHP packaged system and duct system(s) for adherence to Standards.

The preceding inspection procedures shall apply to all DFHP packaged systems with the following exceptions:

1) See **Standards** for sections that do not apply to DFHPs.

2) Air flow determination shall be performed as follows: ***(Major)***

a) Blower speed shall be used for heat pump operation by either of the following:

i) Heat pump shall be operating in either cooling or heating mode (first stage only)

OR

ii) Fan switch shall be in the "On" position and the system switch in the "Off" position.

b) CFM measurement shall be determined by the funnel method. If measurement cannot be made by the funnel method, use the return air grille velocity method.

3) Inspect for proper control setting (including any temperature differentials as may be required by the manufacturer. ***(Major)***

4) Inspect for proper heat pump/furnace operation. ***(Major)***

a) Outdoor temperature (ODT) is below 75°F, check the following:

i) Perform compressor heating capacity check

ii) If an outdoor thermostat is utilized, check to assure that the setting is at the structure balance point and:

If ODT is **above** the setting of the outdoor thermostat:

First stage of indoor thermostat - heat pump only operates.

Second stage of indoor thermostat - furnace only operates until second stage is satisfied (this could occur upon heat pump compressor failure)

If ODT is **below** the setting of the outdoor thermostat:

First stage of indoor thermostat - furnace only operates (no second stage)

iii) If an outdoor thermostat is not utilized:

First stage of indoor thermostat - heat pump only operates.

Second stage of indoor thermostat - furnace only operates until second stage is satisfied.

iv) There are no provisions for emergency heat mode for DFHP packaged systems. In the event of the heat pump compressor or associated refrigeration equipment becoming inoperative, the furnace shall provide all required heating controlled from the second stage of the indoor thermostat in the heating mode.

i. Manufactured Home Heat Pump Inspection Procedures

Inspect Manufactured Home heat pump equipment and duct system(s) for adherence to **Standards**

The preceding inspection procedures shall apply to all Manufactured Home heat pump systems except as follows:

1) See **Standards** for certain sections that do not apply to Manufactured Home heat pump equipment.

2) Verify that when heat pumps installed in manufactured homes use field installed supply and/or return ductwork section, and it is installed in compliance with **Standards**. ***(Major)***

3) Check to see that the heat pump applied to manufactured housing ductwork is capable of operating within manufacturer's specifications and is approved for that use. ***(Major)***

4) Verify that the manufactured home was made in 1976. ***(Major)***

5) Verify that the heat pump/manufactured duct system provides the manufacturer's recommended air flow across the indoor coil. ***(Major)***

j. Free-Delivery Split Heat Pump (FDSHP), Packaged Terminal Heat Pump (PTHP), Self Contained Through-The-Wall Heat Pump (SCTTWHP), and Window Heat Pump (WHP) Inspection Procedures

Inspect FDSHP, PTHP, SCTTWHP, and WHP equipment and duct system(s) for adherence to Standards.

The preceding inspection procedures shall apply to all FDSHP, PTHP, SCTTWHP, and WHP systems except as follows:

1) See **Standards** for certain sections that do not apply.

2) Air flow shall be as recommended by the manufacturer. ***(Major)***

3) Check to see if integral auxiliary electric heat is provided by the manufacturer within the unit cabinet or fan coil section as part of the heat pump. ***(Major)***

4) Verify that any integral auxiliary heaters are controlled by the heat pump's indoor thermostat. ***(Major)***

5) Verify that installing **Quality Heat Pump Contractor** has met manufacturer's instructions for the complete installation of the system, including any recommended parts and accessories and any necessary wall/window case. ***(Major)***

6) Inspect the joint around the unit's case (between the case and wall or window) to assure weathertight seal with caulk, seals, or gaskets, as provided by the manufacturer. ***(Major)***

7) Check cabinets for proper alignment and any unnecessary holes. Holes allowed are for the manufacturer's approved internal condensate drain system (condensate drain lines shall be sized in accordance with the manufacturer's recommendations and all instances at least as large as the heat pump's drain connection**).** ***(Major)***

k. Ground Water Source Heat Pump (GWSHP) and Earth Coupled Heat Pump (ECHP) Inspection Procedures

Inspect GWSHPs and ECHPs and duct system(s) for adherence to **Standards**

The preceding inspection procedures shall apply to both GWSHPs and ECHPs except as follows:

1) Check GWSHP and ECHP for installation of pressure/temperature (P/T) test ports installed in the "water-in" and "water-out" piping runs at the unit. The P/T test ports shall be as close as possible to the heat pump. ***(Major)***

2) Check system heating capacity as follows: ***(Major)***

a) Allow heat pump system to operate for at least 15 minutes.

b) Measure water pressure drop (PD) between water-in and water-out test plugs at heat pump. (Use same instrument to measure both to reduce error).

c) Measure entering water temperature at water-in test plug.

d) Using manufacturer's performance data, determine the water flow rate (GPM) and the heating capacity of the installation using the measured PD and the measured EWT.

e) Determine heating capacity by using the following formula:

Btuh = TD x 1.1 x CFM

TD = temperature difference between supply air and return air

1.1 = air properties constant

CFM = Cubic feet per minute air calculated, from funnel, temperature rise, or return air method

f) Verify that system capacity is $\pm$ 10% of the equipment manufacturer's rating at the test conditions.

3) Check system cooling capacity as follows: ***(Major)***

a) Allow system to operate for at least 15 minutes

b) Measure water pressure drop (PD) between water-in and water-out test plugs at heat pump. (Use same instrument to measure both to reduce error).

c) Measure entering water temperature at water-in test plug.

d) Using manufacturer's performance data, determine the water flow rate (GPM) and the cooling capacity of the installation using the measured PD and the measured EWT.

e) Determine cooling capacity by using the following formula:

Btuh = (h2 - h1) x 4.5 x CFM

h1 = heat content of air from Table A-1 corresponding to supply air wet bulb temperature.*

h2 = heat content of air from Table A-1 corresponding to return air wet bulb temperature.*

4.5 = air properties constant

CFM = Cubic feet per minute air calculated, from funnel, temperature rise, or return air method

* At supply air outlet and inlet indoors record wet bulb and dry bulb temperatures.

(From Table A-1, record heat content values that correspond to supply and return air wet bulb temperatures, h1 and h2, respectively)

f) Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

I. Direct Exchange Ground Source Heat Pump (DXGS) Inspection Procedures

Inspect DXGS and duct system(s) for adherence to **Standards**.

The preceding inspection procedures shall apply to DXGS:

1) Verify the distances between the compressor and the ground coil and compressor to air handling blower unit as required by DXGS manufacturer. Both vertical height and total line distance shall be within limits as specified by manufacturer. Insure all linesets, both vapor and liquid, are insulated with rubatex, or similar insulation non-corrosive to copper. ***(Major)***

2) Determine system heating capacity. System inspection should never be conducted within 48 hours of completion of soaker hose operation, and should not be conducted within one week of completion of soaker hose operation if the DXGS system is installed during the heating season. Consult with the Quality Heat Pump Contractor to determine appropriate inspection time during heating season. For heating capacity tests, the return air temperature should be between 65 degrees F. and 70 degrees F. ***(Major)***

3) 3) Measure the compressor run current while in the heat mode. The expected current readings should fall within the ranges as specified by the manufacturer. ***(Major)***

4) The air flow shall be between 400 and 450 CFM per ton of capacity. ***(Major)***

a) Determine heating capacity by using the following formula:

Btuh = TD x 1.1 x CFM

TD = temperature difference between supply air and return air

1.1 = air properties constant

CFM = Cubic feet per minute air calculated, from funnel, temperature rise, or return air method

b) Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

Note: If the heating capacity is low, this may be due to an unadjusted heating valve. The **Quality Heat Pump Contractor** can adjust the heat valve before re-calculating the heating capacity.

5) Determine system cooling capacity. For cooling capacity tests, the return air temperature should be between 75 degrees F. and 80 degrees F. ***(Major)***

6) Measure the compressor run current while in the heat mode. The expected current readings should fall within the ranges as specified by the manufacturer. ***(Major)***

7) The air flow shall be between 400 and 450 CFM per ton of capacity. ***(Major)***

a) Determine cooling capacity by using the following formula:

Btuh = (h2 - h1) x 4.5 x CFM

h1 = heat content of air from Table A-1 corresponding to supply air wet bulb temperature.*

h2 = heat content of air from Table A-1 corresponding to return air wet bulb temperature.*

4.5 = air properties constant

CFM = Cubic feet per minute air calculated, from funnel, temperature rise, or return air method

* At supply air outlet and inlet indoors record wet bulb and dry bulb temperatures.

(From Enthalpy Table, record heat content values that correspond to supply and return air wet bulb temperatures, h1 and h2, respectively)

b) Verify that system capacity is ± 10% of the equipment manufacturer's rating at the test conditions.

Procedures for notifying Customer and QCN member of Failed Inspections

When a program-required inspection of an installation is made and the installation is not in compliance with program standards, the inspector will indicate on the Heat Pump Installation Inspection Checklist (TVA 6254T) and on the Work Completion Form (where applicable) the reasons(s) for the failure to pass the inspection. The QCN member may be allowed to correct minor deficiencies while the inspector is on-site. Customer and QCN members must receive a copy of Heat Pump Installation Inspection Checklist.

All deficiencies must be corrected and be in compliance within 10 business days. Following corrections by the QCN member, the inspector shall be notified, after which a reinspection shall be scheduled and performed. If, during the reinspection, other items not previously identified are shown to be in violation of the installation standards, the QCN member shall have 10 additional business days to correct the deficiencies, after which the third and final reinspection shall occur.

energy right® Program

Heat Pump Installation Inspection Checklist (Sheet 1 of 2)

Legal Customer Name:

_____Date: _____/_____/_____

To operate at maximum efficiency, it is important that the system be installed correctly. The following checklist provides a simple means to check and verify key items involving the heat pump installation to assure efficient system operation and compliance with Program Standards. These items do not relieve the contractor from compliance with the standards in their entirety.

Place a check next to the number after assurance that heat pump system item(s) listed meets stated criteria.

NOTE: 5 point deduction from Quality Performance Index for each item not in compliance with Program Standards.

Contractor Checks Below:		Inspector Checks Below:
	Equipment	
_____	1. Heat pump meets minimum energy efficiency ratings.	_____
_____	2. Equipment properly sized to match required load calculation (provided by installing contractor).	_____
_____	3. Installation complies with all codes and ordinances; permit number(s): _____ _____	_____
_____	4. Outdoor equipment placed on level, one-piece concrete pad, or approved equal.	_____
_____	5. Equipment meets manufacturer's specified minimum clearances.	_____
	6. System operation: a. cooling ____ b. heating (2nd) _____ c. heating (1st) _____ d. emergency heat_____ e. fan _____ f. off _____	
_____	7. System capacity acceptable at outdoor ambient conditions observed during inspection.	_____
	Installation	
_____	8. Outdoor thermostats (as required) properly installed. (o) Setting(s): _____ F _____ F _____ Maximum 10 kW (nominal) per stage	
_____	9. Condensate line(s) properly installed, trapped, insulated (as required), and condensate drain pan installed (as necessary).	_____
_____	10. Refrigerant piping properly sized, sealed, and supported.	_____
_____	11. Minimum air flow of 400 cfm per 12,000 Btuh of the equipment's ARI certified cooling capacity. Air flow less than 400 cfm per 12,000 Btuh only accepted when ARI certified at lower rate.	_____
	Air Distribution	
_____	12. Duct design and installation as recommended by ACCA, etc., including proper sizing.	_____
_____	13. Ductwork properly supported.	_____
_____	14. Ductwork installed to avoid ground contact.	_____
_____	15. Return and supply air ducts, supply boots, return air pans sealed as required.	_____
_____	16. Opening(s) sealed where ductwork traverses foundation walls.	_____
_____	17. Duct system properly insulated and sealed with vapor barrier.	_____
_____	18. Adequate number of return air grilles, sufficiently sized, and equal to supply CFM.	_____
	Weatherization / Other	

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Heat Pump Installation Inspection Checklist (Sheet 2 of 2)

Heat Pump Brand _____ **Heat Pump Model(s)** _____

Total Cooling Capacity _____ **Total Sensible Capacity** _____
At ACCA/TVA Design Conditions **At ACCA/TVA Design Conditions**

Air Distribution Information

CFM Calculation - Sheet Metal Hood Method (Method #1)

Outlet Room I.D.												Total
Outlet Size												
Cone CFM (Note 1)												
Velometer FPM (Note 2)												
Manuf. Ak Factor												
Ak CFM (Note 3)												

Note 1: (Avg. FPM) x (0.267) (using 7-inch dia. cone) Note 2: Measured on grille face (symmetrically) Note 3: Ak CFM equals (Ak factor) x (Avg. FPM)

CFM Calculation - Temperature Rise Method (Method #2)

Place heat pump in *Emergency Heat Mode.*

Supply Air Temperature (SA) = _____ Return Air Temperature (RA) = _____

(SA) - (RA) = Temperature Difference (TD) = _____ (TD) x (1.1) = Temperature Range (TR) (TR) = _____

Volts = _____ Amps = _____ (Volts) x (Amps) = Watts = _____ (Watts) x (3.413) = (BTUH) = _____

(BTUH) / (TR) = CFM: _____ BTUH / _____ TR = CFM **CFM =** _____

CFM Calculation - Return Air Grille Method (Method #3)

Readings (FPM measured 1-inch off grille face symmetrically, take a minimum of 16 readings.)

Return Air Grille No. 1				Return Air Grille No. 2 (if applicable)			
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

Length (inches) = _____ Width (inches) = _____ Length (inches) = _____ Width (inches) = _____

Average FPM = _____ ***Note: Average FPM must be less than or equal to 500 FPM with filter in place.*** Average FPM = _____

Return Air Grille No. 1: (Average FPM) x (0.75) x (Length x Width) / 144 = CFM **CFM =** _____

Return Air Grille No. 2: (Average FPM) x (0.75) x (Length x Width) / 144 = CFM **CFM =**

Capacity

Heating

Heating (First Stage) ODT = _____

Supply Air Temp. (SA) = _____

Return Air Temp. (RA) = _____

(SA) - (RA) = (TD) = _____

BTUH = (CFM) x (1.1) x (TD) **BTUH =** _____

Cooling

Cooling ODT = _____

Return Air Wet Bulb Temp. = _____

Supply Air Wet Bulb Temp. = _____

Return Air Enthalpy (RAE) = _____

Supply Air Enthalpy (SAE) = _____

(RAE) - (SAE) = H = _____

BTUH = (H) x (CFM) x (4.5) = _____

energy right® Heat Pump Plan

Work Completion Form

1. Distributor ID#: _____ Distributor Name: _____

2. Work ID Number: _____ *(Work ID Number is assigned by energy right Web-entry Database)*

3. Inspection Date: _____ / _____ / 200____

4. QCN Contractor: _____ Contractor ID: _____

5. Legal 911 Address of New Home: _____ _____ _____
   Town/City *State* *Zip Code*

6. Structure: ❺ Single Family ❺ Multi-Family ❺ Business

7. Number of Dwellings/Businesses at this Address: _____

8. Type System Replaced: ❺ Electric Resistance ❺ Fossil-Fuel ❺ New Load ❺ Other

9. Type Heat Pump Installed: ❺ ASHP-Package ❺ ASHP-Split ❺ DFHP ❺ Advanced Geothermal
   ❺ Advanced Compressor Speed ❺ Advanced Triple Function

10. Number of Installed Units, 10 to 10.99 SEER: _____
11. Number of Installed Units, 11 to 11.99 SEER: _____
12. Number of Installed Units, 12 to 12.99 SEER: _____
13. Number of Installed Units, 13 to 13.99 SEER: _____
14. Number of Installed Units, Greater than 14 SEER: _____
15. Number of Installed Advanced Units: _____
16. Total Cooling Capacity: _____
17. Date Financed by TVA Lender (if applicable): _____ / _____ / 200____
18. Inspector Name: _____ Inspector Number: _____
19. Date Passed TVA Requirements: _____ / _____ / 200____

Invoice Created: _____ (Completed *by energy right Web-entry Database)*

For Distributor Records:

20. Account Name: _____ Account Number: _____
21. TVA Grace Period Installation: ❺ Yes ❺ No
22. Heat Pump Brand 1: _____ Heat Pump Brand 2: _____
23. Average HSPF or COP: _____
24. Quality Validation Contract: ❺ Yes ❺ No
25. Amount Financed: $_____ Finance Rate: _____
26. Water Heater Brand: _____
27. Security Filing Date: ____ / ____/ 200__
28. Other Measures: _____, _____, _____, _____
29. Date Passed Local Standards: ____ / ____/ 200__
30. Incentive Paid: $_____
31. Retained MVP: $_____
32. Comments: _____

Signatures: Customer: _____ Inspector: _____Date Completed: ____ / ____/ 200__

Contractor - Customer Affidavit

energy right® Program Privacy Act Information

The *energy right*® Program is being conducted by TVA and your electric power distributor as part of an effort to assist TVA in carrying out its electric power supply responsibilities under the Tennessee Valley Authority Act of 1933.

Your participation in this Program, and in any related financing for which you are eligible, is voluntary, and you may decline to participate without affecting your relationship with TVA or your power distributor. The personal information collected will not be used in making any decisions affecting you other than those directly related to your participation in the Program itself.

All information you furnish will be confidential and will not be disclosed in any form that would identify you except to employees of your power distributor or of TVA or to others involved in conducting the Program or as required by law. The information will be subject to the provisions of the Privacy Act of 1974.

This information is provided in accordance with section 3(e) (3) of the Privacy Act of 1974. You should retain a copy.

IMPORTANT NOTICE TO CONTRACTOR:

Contractor certifies that each heat pump identified below complies with applicable Program Standards and provides TVA permission to perform quality assurance audits at each address. These audits and any Program inspections are solely for the benefit of the power distributor and TVA to help assure Program purposes are being achieved and create or imply no duty or obligations to Contractor. Contractor is responsible for making any inspections to protect Contractor's interests. There is no GUARANTEE or WARRANTY, express or implied, from the power distributor or TVA as to the heat pump.

Contractor's Signature: _____ Date: ___/___/___

Shaded area to be completed by Inspector or Distributor

_____	_____	___	_____	_____
911 Street Address	*City*	*State*	*Number of Heat Pumps Installed*	*Inspected (Yes/No)*

nspections were performed on the Heat Pump(s) installed at the address above, as indicated.

Inspector Signature: _____ Date: ___/___/___

To Be Completed by Customer

Note: Customer is responsible for notifying Power Distributor when work is completed

Important Notices to Customer: Before signing, read the Privacy Act Information at the top of this form. There is no Guarantee or Warranty, express or implied, from your power distributor or TVA as to the work performed, any of the improvements installed, or their adequacy or effectiveness. Customer is responsible for making any inspections to assure Customer's interests are protected. For split-type Dual Fuel Heat Pumps, Customer is responsible for having a qualified gas or oil heating specialist check the gas or oil-fired forced-air furnace system to which the heat pump is added. Customer is advised to have this done.

By signing, Customer agrees that the work has been satisfactorily completed and certifies that any weatherization improvements have been satisfactorily installed. Customer further provides TVA permission to conduct quality assurance audits of the work and improvements and acknowledges that these audits and any Program inspections are solely for the benefit of the power distributor and TVA to help assure Program purposes are being achieved and create or imply no duty or obligations to Customer.

Customer Signature: _____ **Date:** _____/_____/_____

Contractor Homeowner Affidavit: February 1, 2002

Enthalpy in BTU per Pound of Dry Air

Wet Bulb Temperature F	Tenths of a Degree F									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
35	13.01	13.05	13.10	13.14	13.18	13.23	13.27	13.31	13.35	13.40
36	13.44	13.48	13.53	13.57	13.61	13.66	13.70	13.75	13.79	13.83
37	13.87	13.91	13.96	14.00	14.05	14.09	14.14	14.18	14.23	14.27
38	14.32	14.37	14.41	14.46	14.50	14.55	14.59	14.64	14.68	14.73
39	14.77	14.82	14.86	14.91	14.95	15.00	15.05	15.09	15.14	15.18
40	15.23	15.28	15.32	15.37	15.42	15.46	15.51	15.56	15.60	15.65
41	15.70	15.75	15.80	15.84	15.89	15.94	15.99	16.03	16.08	16.13
42	16.17	16.22	16.27	16.32	16.36	16.41	16.46	16.51	16.56	16.61
43	16.66	16.71	16.76	16.81	16.86	16.91	16.96	17.00	17.05	17.10
44	17.15	17.20	17.25	17.30	17.35	17.40	17.45	17.50	17.55	17.60
45	17.65	17.70	17.75	17.80	17.85	17.91	17.96	18.01	18.06	18.11
46	18.16	18.21	18.26	18.32	18.37	18.42	18.47	18.52	18.58	18.63
47	18.68	18.73	18.79	18.84	18.89	18.95	19.00	19.05	19.10	19.16
48	19.21	19.26	19.32	19.37	19.43	19.48	19.53	16.59	19.64	19.70
49	19.75	19.81	19.86	19.92	19.97	20.03	20.08	20.14	20.19	20.25
50	20.30	20.36	20.41	20.47	20.52	20.58	20.64	20.69	20.75	20.80
51	20.86	20.92	20.97	21.03	21.09	21.15	21.20	21.26	21.32	21.38
52	21.44	21.50	21.56	21.62	21.67	21.73	21.79	21.85	21.91	21.97
53	22.02	22.08	22.14	22.20	22.26	22.32	22.38	22.44	22.50	22.56
54	22.62	22.68	22.74	22.80	22.86	22.92	22.98	23.04	23.10	23.16
55	23.22	23.28	23.34	23.41	23.47	23.53	23.59	23.65	23.72	23.78
56	23.84	23.90	23.97	24.03	24.10	24.16	24.22	24.29	24.35	24.42
57	24.48	24.54	24.61	24.67	24.74	24.80	24.86	24.93	24.99	25.06
58	25.12	25.19	25.25	25.32	25.38	25.45	25.52	25.58	25.65	25.71
59	25.78	25.85	25.92	25.98	26.05	26.12	26.19	26.26	26.32	26.39
60	26.46	26.53	26.60	26.67	26.74	26.81	26.87	26.94	27.01	27.08
61	27.15	27.22	27.29	27.36	27.43	27.50	27.57	27.64	27.71	27.78
62	27.85	27.92	27.99	28.07	28.14	28.21	28.28	28.35	28.43	28.50
63	28.57	28.64	28.72	28.79	28.87	28.94	29.01	29.09	29.16	29.24
64	29.31	29.39	29.46	29.54	29.61	29.69	29.76	29.84	29.91	29.99
65	30.06	30.14	30.21	30.29	30.37	30.45	30.52	30.60	30.68	30.75
66	30.83	30.91	30.99	31.07	31.15	31.23	31.30	31.38	31.46	31.54
67	31.62	31.70	31.78	31.86	31.94	32.02	32.10	32.18	32.26	32.34
68	32.42	32.50	32.59	32.67	32.75	32.84	32.92	33.00	33.08	33.17
69	33.25	33.33	33.42	33.50	33.59	33.67	33.75	33.84	33.92	34.01
70	34.09	34.18	34.26	34.35	34.43	34.52	34.61	34.69	34.78	34.86
71	34.95	35.04	35.13	35.21	35.30	35.39	35.48	35.57	35.65	35.74
72	35.83	35.92	36.01	36.10	36.19	36.29	36.38	36.47	36.56	36.65
73	36.74	36.83	36.92	37.02	37.11	37.20	37.29	37.38	37.48	37.57
74	37.66	37.76	37.85	37.95	38.04	38.14	38.23	38.33	38.42	38.52
75	38.61	38.71	38.80	38.90	38.99	39.09	39.19	39.28	39.38	39.47
76	39.57	39.67	39.77	39.87	39.97	40.07	40.17	40.27	40.37	40.47
77	40.57	40.67	40.77	40.87	40.97	41.08	41.18	41.28	41.38	41.48
78	41.58	41.68	41.79	41.89	42.00	42.10	42.20	42.31	42.41	42.52
79	42.62	42.73	42.83	42.94	43.05	43.16	43.26	43.37	43.48	43.58
80	43.69	43.80	43.91	44.02	44.13	44.24	44.34	44.45	44.56	44.67
81	44.78	44.89	45.00	45.12	45.23	45.34	45.45	45.56	45.68	45.79
82	45.90	46.01	46.13	46.24	46.36	46.47	46.58	46.70	46.81	46.93
83	47.04	47.16	47.28	47.39	47.51	47.63	47.75	47.87	47.98	48.10
84	48.22	48.34	48.46	48.58	48.70	48.83	48.95	49.07	49.19	49.31
85	49.43	49.55	49.68	49.80	49.92	50.05	50.17	50.29	50.41	50.54

Interpolated to tenths of degrees from 1963 edition ASHRAE Guide and Data Book. Published by the American Heating, Refrigerating and Air Conditioning Engineers, Inc. Society of