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Committee for Special Project 53 for Pacific Northwest
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Recommendations for Energy Conservation Standards for New Residential Buildings

Volume 1: Text of the Standard

May 1989

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

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RECOMMENDATIONS FOR ENERGY CONSERVATION STANDARDS
FOR NEW RESIDENTIAL BUILDINGS

VOLUME 1: Text of the Standard

ASHRAE TEC SP-53

May 1989

Prepared for
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Pacific Northwest Laboratory
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PREFACE

The Energy Conservation for New Buildings Act of 1976, as amended, 42 U.S.C. Section 6831 et. seq. requires the U.S. Department of Energy to issue energy conservation standards for the design of new residential and commercial buildings. The standards will be mandatory only for the design of new federal buildings, and will serve as voluntary guidelines for the design of new non-federal buildings.

This report documents the development and testing of a set of recommendations, from the American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) Special Projects Committee No. 53, designed to provide the technical foundation for the Congressionally-mandated energy standard for new residential buildings. The recommendations have been developed over the past 25 months by a multidisciplinary project team, under the management of the U.S. Department of Energy and its prime contractor, Pacific Northwest Laboratory.

The report has been issued in four volumes that are briefly described below:

- VOLUME I - Text of the Standard contains the text of the recommendations for the residential energy conservation standard. The text contains a microcomputer program used in developing the Standard's requirements.
- VOLUME II - Automated Residential Energy Standard - User's Guide provides a description of how to use the program, suggests methods for obtaining and deriving input data, and provides the interpretation of the output.
- VOLUME III - Introduction and Background to the Standard Development Effort is a description of the Standard development process and contains the rationale for the general approach and specific criteria contained within the recommendations.
- VOLUME IV - Description of the Testing Process details how the Standard was tested and provides case studies of the possible impact of the Standard in select locations throughout the country. It is supported by a description of the assumptions and input data, and an analysis of the results.

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1.0 PURPOSE

The purpose of this Standard is to provide for the development of requirements for new residential buildings that promote the efficient use of energy within economic constraints and without compromising the comfort and safety of the occupants.

2.0 SCOPE

2.1 Building Types

This Standard covers the design and construction of new residential buildings of three stories, or fewer, including single-family detached housing, multifamily housing such as duplexes, townhouses, condominiums and garden apartments, and manufactured housing (mobile homes), all of which have complete kitchen facilities for each dwelling unit.

Hotels, motels, jails, barracks, nursing homes, convents, and monasteries, which are transient in nature and do not have complete kitchen facilities in each dwelling unit, are not included within the scope of this Standard.

2.2 Building Assemblies and Systems

The Standard covers the design and construction of the building envelope, and heating, cooling, and service water heating equipment and systems which are a permanent part of the building.

3.0 DEFINITIONS, ABBREVIATIONS, ACRONYMS

3.1 Purpose

The purpose of this section is to define terms, symbols, abbreviations, and acronyms applicable to this Standard.

3.2 Scope

Except for those definitions given in Section 3.3, the 1986 edition of "Terminology of Heating and Ventilation, Air Conditioning, and Refrigeration" as published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, herein after referred to as ASHRAE terminology, shall apply to this Standard.

3.3 Definitions

Annual Fuel Utilization Efficiency (AFUE). The ratio of the annual output of useful energy delivered by fossil fuel heating equipment to the total energy used by the equipment. The AFUE is expressed as a percentage.

Automatic. Self-acting, operating control actuated by an impersonal influence, as for example a change in electrical current, fluid pressure, temperature, or other functional variable.

Building thermal envelope. The elements of a building which enclose conditioned spaces and through which thermal energy may be transferred to or from the ambient atmosphere or to or from unconditioned spaces.

Building type. The classification of the building by usage or configuration.

Candidate design. A prospective building design to be tested for compliance.

Conditioned floor area. The floor area of the conditioned space measured from the interior wall surfaces.

Conditioned space. A space within a building that is intended to be either heated or cooled.

Default value. A predefined value to be used in a calculation procedure when an alternative value has not been provided.

Dwelling unit. A building or building space intended to house people, comprising one or more rooms designed for living, sleeping, and eating, and having complete cooking and sanitary facilities.

Energy Conservation Measure (ECM). A building material or component whose use will affect the energy consumed for space heating, space cooling, and/or service hot water.

Energy Factor (EF). A measure of the overall efficiency of a water heater based on its recovery efficiency, standby loss, and energy input.

Fenestration. Any non-opaque opening in a building envelope. Included are: glazing materials of glass or plastic, with the framing, mullions, muntins, dividers, external and internal shading devices, and integral (between the glass) shading system.

Heating, Ventilating and Air Conditioning (HVAC) system. A system that provides either collectively or individually the comfort heating, ventilating and/or air conditioning within a building.

Heating Seasonal Performance Factor (HSPF). The total heating output (Btu) of a heat pump during its normal annual usage period for heating divided by the total electric input (Wh) during the same period.

Manufactured housing (mobile home). A dwelling fabricated according to HUD Manufactured Housing Construction and Safety Standards as defined in 24 CFR 3280.2(16).

Multifamily housing. A building with more than one dwelling unit.

Opaque area. All exposed areas of a building envelope that enclose conditioned space and do not transmit solar radiation.

Orientation. The directional placement of a building surface with reference to its outward normal.

Reference design. A generic building design, of the same size and occupancy type as the candidate design, which complies with the prescriptive requirements of this Standard and has specified assumptions concerning shape, orientation, HVAC, and other system parameters.

Renewable energy sources. Energy sources that are not depleted (within many lifetimes) through use of the energy. This includes such sources as solar radiation, wind, wave and tide forces, geothermal, temperature differences established by natural factors (lake, pond, or ocean temperature differences), and nocturnal thermal exchanges.

Sash crack. The sum of all perimeters of all ventilators, sash, doors, and other envelope penetrations based on overall dimensions of such parts expressed in feet, counting two adjacent lengths of perimeter as one.

Seasonal Energy Efficiency Ratio (SEER). The total cooling of an air conditioner (Btu) during its normal annual usage period for cooling divided by the total electric input (Wh) during the same period.

Service water heating (domestic hot water). Supply of hot water for purposes other than space conditioning.

Single-family housing. Buildings containing one dwelling unit.

Thermal mass. Materials with significant heat capacity and surface area which affect building loads by storing and releasing thermal energy.

Unconditioned space. Space within a building that is not conditioned (see conditioned space).

Unitary cooling and heating equipment. One or more factory-made assemblies which normally include an evaporator or cooling coil, or compressor and condenser combination, and may include a heating function as well.

4.0 DEVELOPING THE CRITERIA AND DEMONSTRATING COMPLIANCE

4.1 General

This section outlines the procedure for developing the criteria of the Standard and demonstrating compliance with those criteria as shown in Figure 4.1. The criteria are developed using the procedures contained in Section 4.3 and applied in Sections 5 through 8 of the Standard. Compliance is demonstrated when all of the provisions of Section 5 have been met, and when the provisions of either Section 6 or Section 7 or Section 8 have been met.

Figure 4-1: Schematic of Standard Compliance Process

4.2 Compliance Paths

4.2.1 Packages

Section 6 provides a prescriptive, single design compliance method designed for ease of use.

4.2.2 Points

Section 7 provides an option oriented method designed for ease of use, but with greater flexibility than the package approach of Section 6.

4.2.3 Performance

Section 8 provides an analysis method allowing greater flexibility in building and system design.

4.3 Development of Criteria

The criteria for the Standard shall be generated using the computer program contained in Section 4.4 and as appropriate to those items outlined in Sections 4.3.1, 4.3.2, and 4.3.3.

Standards can be generated for those geographic locations, building types, and financial considerations required by the area of jurisdiction. Criteria for each possible combination of location, building type, and energy costs shall be generated and compared. A separate set of requirements shall be developed for each combination unless the resulting criteria are similar for two or more combinations. In this case, the requirements shall be combined (e.g. if in a specific location, the criteria generated for multifamily housing are similar to those for single family housing, the same set of requirements shall apply to both housing types).

4.3.1 Location

A reference location or locations shall be selected to represent the climate of the jurisdiction. If none of the locations provided in the computer program (Section 4.4) are within the jurisdiction, follow the directions in the User's Manual. If more than one location is required within the jurisdiction, separate sets of requirements shall be developed and compared. Where the results vary significantly, a separate standard shall be developed for each location. Where the results are similar, requirements for locations can be combined.

4.3.2 Building Type

For each location and each building type used within the location, a set of requirements shall be developed using the computer program (Section 4.4). The separate sets of requirements for each building type shall be compared. Where the results vary significantly, a separate standard shall be developed for each building type. Where the results are similar, requirements for building types within a location can be combined.

4.3.3 Energy Prices

For each building type in each location, the appropriate average fuel and electric prices shall be used in the computer program (Section 4.4) to generate requirements. Where more than one source of energy is available within a location and the prices vary, separate sets of requirements shall be developed and compared. Where the results vary significantly, a separate standard shall be developed for each type of energy. Where the results are similar, the requirements can be combined.

4.4 Automated Residential Energy Standard (ARES) Computer Program

The program for generating values for the Standard is contained in a pocket at the front of this document:

5.0 DESIGN CRITERIA

This section includes the minimum and mandatory design and construction requirements for the thermal envelope, infiltration and ventilation, heating, cooling, and service hot water systems and equipment. This section shall be used in conjunction with any one of the alternative compliance paths: Packages (Section 6), Points (Section 7), or Performance (Section 8).

5.1 Building Thermal Envelope

This section provides minimum requirements that apply to the building thermal envelope of the conditioned space including the ceilings, walls, slab floors, floors over unheated spaces, foundation walls, basement walls, crawl spaces, doors, windows, and other assemblies or components separating conditioned space from unconditioned space or outside air.

5.1.1 Thermal Insulation

All building thermal envelope assemblies shall meet the minimum insulation levels specified herein. All insulation thermal requirements in this Standard are specified in terms of the thermal resistance (R-value) for the insulating material(s) only.

5.1.1.1 Ceilings/Roof Insulation

Roofs and their associated parts (knee walls, gable ends, etc.), roofs with attics, built-up roofs, cathedral ceilings, wall surfaces considered as ceilings, wells for skylights and surfaces separating conditioned space from unconditioned attic space are defined as ceiling/roof assemblies. Wall areas that separate conditioned living space from unconditioned attic space (such as walls supporting cathedral ceilings, gambrel roofs, or dormers) shall be considered as ceiling/roof assemblies. These assemblies shall be insulated to the minimum level as determined by Section 4.3.

5.1.1.2 Wall Insulation

Walls are defined as building thermal envelope sections within 30° of vertical and which separate the conditioned space from the outside air or which separate conditioned space from unconditioned space. These sections include wall assemblies and surfaces treated as bearing or non-bearing walls such as mansard roofs, exterior walls, internal walls, basement and foundation walls, stairway enclosures,

interior shaft partitions, etc., which separate conditioned space from other spaces. All wall assemblies shall be insulated to the minimum level as determined by Section 4.3.

5.1.1.3 Floor Insulation

This subsection provides minimum insulation levels for all floor assemblies, including floors over unheated basements and crawl spaces, floors over outside air, overhangs, and for heated and unheated slabs on grade.

5.1.1.3.1 Floors Over Unconditioned Spaces

Insulation in floors over unconditioned spaces shall have a minimum insulation level as determined by Section 4.3.

5.1.1.3.2 Floors Over Outside Air

Insulation in floors over outside air shall meet the minimum requirements specified for ceiling/roof assemblies in Section 5.1.1.1.

5.1.1.3.3 Slabs

Slabs not containing or poured over heating sources shall be insulated with perimeter insulation to the minimum level as determined by Section 4.3.

Slabs containing or poured over heating sources shall be insulated with perimeter insulation of at least 2 F-ft²-hr/Btu above that required for unheated slabs. If no insulation is required on unheated slabs, then none will be required on those with heating sources.

5.1.1.4 Door Thermal Requirements

The opaque portions of all doors separating conditioned space from unconditioned space or outside air shall have a maximum thermal conductance of 0.395 Btu/hr-ft²-F. Glazing area in doors which cover more than 10% of the surface area of the door shall be considered as fenestration and shall comply with those sections applicable to fenestration.

5.1.1.5 Thermal Requirements for Fenestration

Fenestration covered under this Standard includes windows, glass doors, and skylights. All areas of fenestration separating conditioned spaces from unconditioned spaces or outside air shall have the thermal characteristics allowed under Section 4.3. Fenestration in unconditioned spaces is not governed by this Standard.

5.1.2 Orientation of Fenestration

Reference is made in this Standard to the orientation or direction that the fenestration areas face. Eight directions are provided: north, northeast, east, southeast, south, southwest, west, and northwest. Fenestration facing within 22.5°

° of a direction is considered to face that direction.

5.1.3 Shading Coefficients for Fenestration

All fenestration shall have the shading characteristics allowed under Section 4.3.

5.1.4 Thermal Mass

This Standard contains separate requirements for structures using mass in the building thermal envelope walls. For wall assemblies to qualify for thermal mass consideration, the weight of the entire wall assembly shall be at least 40 pounds per square foot of wall surface area; and any required insulating material(s) as specified in Section 5.1.1.2 shall be placed on the exterior side of the mass material or shall be integral with the mass material.

5.1.5 Water Vapor Control

The design of buildings for energy conservation may increase the water vapor pressure differentials between the interior and exterior environments. Vapor retarders, ventilation, and mechanical humidity control shall be used as required to maintain the thermal and moisture integrity of the building envelope.

5.2 Infiltration/Ventilation Requirements

This section contains requirements for controlling air leakage into and out of conditioned spaces within the building thermal envelope. Special provisions for controlling radon gas entry into the structure in geographical locations where radon has been deemed to pose a health threat are described in Appendix B of the Standard.

Each residential structure shall provide for restricted air exchange with unconditioned spaces and outside air. No portion of this section is intended to compromise occupant health or comfort as provided for in ASHRAE Standard 62. Implementation of any of the measures in this section shall not reduce the air exchange rate below the 0.35 air changes per hour as specified in Standard 62 to maintain acceptable indoor air quality.

5.2.1 Certification of Doors and Windows

All doors and windows used in a residential structure shall be certified as to air leakage. Rates of air leakage shall be determined in accordance with ANSI/ASTM E 283-84 "Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors". The testing shall be done at a pressure differential of 1.57 lb/ft², which is equivalent to a 25 mile per hour wind speed. All air leakage requirements identified in this Standard are based upon tests at the above condition.

5.2.2 Window Leakage

All windows installed between conditioned and unconditioned spaces or outside air shall have a maximum air leakage rate of 0.37 ft³/min per foot of crack as determined under Section 5.2.1.

5.2.3 Door Leakage

All doors installed between conditioned and unconditioned spaces or outside air shall have a maximum air leakage rate of 0.37 ft³/min per ft² of surface area as determined under 5.2.1.

5.2.4 Thermal Envelope

5.2.4.1 Foundation and Below Grade Walls

Foundation walls and walls below grade enclosing conditioned space shall be treated, caulked, and sealed in a thorough manner to avoid the entry of unwanted moisture, chemicals, or radon gas.

5.2.4.2 Exterior Joints

All exterior joints (such as soleplate, wall frame corners, wall and ceiling joints, window and door frames) shall be properly sealed with a durable caulking material. Joints between dissimilar materials (wood and masonry or concrete and metal) shall allow for differential expansion and

contraction of such materials so as to provide a permanent seal for the joint.

5.2.4.3 Outside Penetrations

All outside penetrations in the envelope, between conditioned and unconditioned spaces or outside air, must be sealed with caulking or other suitable materials. Such penetrations include those for: faucets, electrical outlets and wiring, flues and vents, and all penetrations through the top plate of exterior walls.

5.2.4.4 Moveable Joints

All moveable joints between doors and door frames and windows and window frames shall be weatherstripped or gasketed with appropriate materials.

5.2.4.5 Interior Joints

All interior joints between the walls and interior ceilings shall be taped to reduce air exchange.

5.2.4.6 Exhaust Air

Exhaust air from bathrooms, kitchens, and utility areas shall be provided as required by other health and safety standards to assure acceptable indoor air quality. Such exhaust systems shall be fitted with approved back draft dampers to prevent air leakage into the conditioned space while fans are not operating.

5.2.4.7 Fireplaces

Fireplaces shall be enclosed with reasonably airtight door assemblies fitted across the openings of their combustion chambers. The perimeters of such assemblies shall be fitted with materials to make as leakproof a seal to the fireplace as possible. Makeup combustion air shall be provided from the outside air with an operable damper to avoid excess losses of warm interior air during winter use. The fireplace flue shall be provided with all building code required dampers and components, and the dampers shall be fitted with readily accessible controls.

5.2.5 Air Exchange Control Packages

The prescriptive and point-system compliance approaches (Sections 6 and 7) require either the minimum or the tight package of air exchange controls. These packages are defined in Table 5.1.

Table 5.1 - Air Exchange Control Packages

<u>Building Component</u>	<u>Minimum Package</u>	<u>Tight Package(a)</u>
Soleplate	Caulked	Caulked
Wall/Ceiling Joints	Taped	Taped
Window/Door Frames	Caulked	Caulked
Window Leakage, max.	0.37 cu.ft./min	0.28 cu.ft./min
Door Leakage, max.	0.37 cu.ft./min	0.37 cu.ft./min
Attic Access	No requirement	Weatherstripped
Electrical Outlets	No requirement	Gasketed
Duct, Flue Penetrations	Sealed	Sealed
Fireplace	Outside Air	Outside Air
Exhaust Fans	Dampers	Dampers
Ducts	Taped	Taped
Air Infiltration Barrier	No requirement	Walls & Ceiling

(a)For the tight package, all access areas to attics from conditioned spaces shall be weatherstripped or gasketed to seal the conditioned spaces from outside air leakage. All electrical outlets, receptacles, or switches on interior and exterior walls shall be equipped with gaskets installed under the cover plates. Continuous air Infiltration Barriers shall be provided on walls and ceilings of the building thermal envelope. All barrier materials shall have a perm rating of at least four. All joints and penetrations of the air barrier shall be sealed against air leakage.

5.3 Heating, Ventilating, and Air Conditioning (HVAC) Systems

This section applies to heating, ventilating, and air conditioning systems and equipment.

The equipment addressed in this section is limited to the following:

- 1) Equipment using single phase electric power.
- 2) Unitary air conditioners and heat pumps with capacities less than 65,000 Btu/h.
- 3) Warm air furnaces less than 225,000 Btu/h input.
- 4) Boilers less than 300,000 Btu/h input.

Mechanical equipment or systems not included above shall meet all applicable requirements found in ANSI/ASHRAE/IES Standard 90A-1980 Standard for ENERGY CONSERVATION IN NEW BUILDING DESIGN(9).

5.3.1 Performance Data for HVAC Equipment and System Components

5.3.1.1 Rated Combinations

Suppliers of HVAC system equipment and system components shall furnish, upon request by prospective purchasers, system designers, or contractors, the DOE, ARI, or GAMA rated seasonal performance efficiencies (AFUE, SEER, HSPF, and COP, as applicable) and the inputs and outputs of all such HVAC products. The manufacturer of electric resistance heating equipment shall make available to prospective purchasers, designers or contractors, upon request, full load energy input over the range of voltages the equipment is intended to operate.

5.3.1.2 Non-rated Combinations

Indoor coil and outdoor condensing unit combinations not rated by the manufacturer shall not be used as part of the heating and/or cooling system.

5.3.1.3 Cooling Equipment Selection Criteria

Cooling equipment selections shall be based on information that provides both the sensible and latent cooling capacity for the following conditions:

1. Air cooled condensing unit operating at the summer design conditions, or water cooled condensing unit operating at the expected average water temperature.
2. Indoor fan operating at an appropriate flow rate (approximately 300 cfm per ton of sensible coil capacity).
3. Indoor coil operating in a range of entering dry bulb and entering wet bulb temperatures that can be expected to occur at the summer design conditions.

5.3.2 Minimum Equipment Efficiency Levels

This section provides minimum requirements related to equipment performance levels (see Public Law 100-12).

Table 5.2 - Minimum Efficiencies for Furnaces and Boilers

<u>Equipment Type</u>	<u>AFUE Percent</u>
Furnaces	78
Boilers	80
Boilers, gas steam	75
Furnaces, mobile home	75

Table 5.3 - Central Air Conditioners and Heat Pumps

<u>Equipment Type</u>	<u>SEER Btu/Wh</u>	<u>HSPF Btu/Wh</u>
Split Systems	10.0	6.8
Single Packaged Systems	9.7	6.6

5.3.3 Heating System Characteristics

5.3.3.1 Wall Heaters

Wall heaters shall not be installed on outside walls.

5.3.3.2 Zoning of Electric Resistance Units

Structures, or portions thereof, using individual electric resistance heating units (including baseboard units and low density ceiling radiant systems) shall be zoned and controlled as specified in Section 5.3.8. Heaters shall be installed in each area in accordance with the calculated heat loss of that area. When two or more heaters are installed in any one zone, they shall be controlled by a single thermostat.

5.3.3.3 Electric Baseboard Heaters

The watt density shall not exceed 250 Watts per linear foot of heater.

5.3.3.4 Central Electric Furnace

Electric furnaces greater than 6kW shall be divided into at least two stages.

5.3.3.5 Bath Ceiling Units

Bath ceiling units providing any combination of heat, light, and/or exhaust shall be provided with

controls permitting separate operation of each function.

5.3.4 Equipment Sizing Procedures

Heating and cooling loads for the purpose of sizing shall be determined in accordance with one of the procedures described in the ASHRAE HANDBOOK, Fundamentals Volume (1), or other acceptable procedures as found in References 2, 3, 4, 5, and 7. The design parameters in Sections 5.3.4.1 through 5.3.4.3 shall apply for all load calculation methods.

5.3.4.1 Outdoor design conditions

Winter and summer design conditions required by the selected computational procedure shall be selected for listed locations from the ASHRAE HANDBOOK, Fundamentals Volume (1), from the columns for 97.5% values for winter and 2.5% values for summer. Where documentation exists, adjustments may be made to reflect local climates or local weather experience.

5.3.4.2 Indoor design conditions

The winter heating design temperature shall be 70 °F dry bulb. If humidification is provided, it shall be designed to a maximum relative humidity of 30%.

For cooling calculations the design temperature shall be 75 °F dry bulb. The design relative humidity within the conditioned space shall be 50%.

5.3.4.3 Infiltration/Ventilation

Heat gain (loss) from air infiltration and outdoor ventilation shall be calculated in accordance with Section 5.3.4. The sum of the infiltration and outdoor ventilation air shall not be less than 0.35 ACH.

5.3.5 Heating-Cooling Equipment Sizing

5.3.5.1 Heating Equipment

All design load requirements shall be calculated in accordance with Section 5.3.4.

5.3.5.1.1 Fossil Fuel Heating Equipment

The capacity of the heating equipment shall not be more than 125 percent of the design heating load. Where the next available size exceeds this limitation or a larger size is required to provide the air flow rate for cooling, the next larger size may be used.

5.2.5.1.2 Electric Resistance

Total installed wattage of baseboard units shall not exceed 125% of the design heating load.

Electric furnaces, fan-coil units, and duct heaters shall be sized within 3kW of the design heating load.

5.3.5.2 Cooling Equipment

5.3.5.2.1 Cooling Equipment

Cooling equipment shall be selected so that its sensible capacity is not more than 125% of the design sensible cooling load, or the closest available size provided by the manufacturer. In addition, the corresponding latent capacity of the equipment shall not be less than the calculated latent cooling load.

5.3.5.2.2 Zoned Cooling Equipment

Zoned cooling equipment sizing shall require an appropriate cooling load calculation for each zone(1,7). When separate units are used in each zone, equipment selection shall be the same as above. When two or more zones are served by one central unit, the capacity of the central unit shall not be more than 125% of the peak block load.

5.3.5.3 Heat Pump

Heat pump sizing shall be based on the design cooling load unless the refrigeration cycle heating capacity is less than the design heating load of the conditioned space at the design condition. In this case the refrigeration cycle heating capacity shall be sized to provide the lowest possible balance

point on heating without exceeding 125% of the cooling design load. The supplementary plus refrigeration cycle heating capacity shall not exceed 125% of the calculated design heating load. The total of the installed emergency and supplementary heat shall not exceed 100% of the design heating load.

5.3.6 Distribution Systems

5.3.6.1 Air Distribution Systems

System sizing and design shall use accepted engineering standards such as ASHRAE HANDBOOK HVAC SYSTEMS AND APPLICATIONS Volume (10) or other equivalent procedures governed by the following:

5.3.6.1.1 System Design

Duct layout and design shall be based on the following:

1. Calculation of each room CFM shall be based on the greater of the heating or sensible cooling load.
2. Duct size shall be determined by the CFM requirements of each room, the available static pressure and the total equivalent length of the various duct runs.
3. Friction loss data shall correspond to the type of material used in duct construction.

5.3.6.1.2 Installation

All ductwork shall be constructed, erected and sealed in accordance with one of the following:

1. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Heating and Air Conditioning Installation Standards.
2. SMACNA Fibrous Glass Duct Construction Standards, 5th Edition, 1979.
3. SMACNA/TIMA/ADC Standard on Flexible Duct, 1980.

5.3.6.1.3 Balancing

The system design shall provide means for balancing the air distribution system. Adjustable dampers as a part of the supply air diffusers are acceptable as a minimum.

5.3.6.1.4 Diffusers and Grilles

Only diffusers and grilles rated for throw and pressure loss over an appropriate range of flow rate by the manufacturer shall be used. They shall be selected according to ASHRAE procedures in Reference 1.

5.3.6.1.5 Insulation

All air ducts located outside the conditioned space shall be insulated to a minimum thermal resistance level of 6 hr-F-ft²/Btu exclusive of inside and outside air film resistances. A vapor retardant shall be installed or exist as an integral outside layer of the insulation. All joints in the ducts and vapor retardant shall be sealed with foil backed, acrylic adhesive tape.

5.3.6.1.6 Ducts in Exterior Envelope Assembly

Ducts located in exterior envelope assemblies shall be placed inside the thermal insulation and shall not reduce the insulation value of the insulation. Where building assemblies act as plenums, such as floor systems, they shall be insulated as provided above for ducts.

5.3.6.2 Hydronic Distribution Systems

5.3.6.2.1 Sizing and Design

All piping shall be sized and designed in accordance with recognized engineering standards such as the Hydronic Institute's publications I-B-R Installation Guide for Residential Hydronic Heating Systems No., 250, or ASHRAE HANDBOOK, Fundamentals Volume, Chapter 34, (1).

5.3.6.2.2 Installation

All piping for space heating purposes shall be installed using guidelines of recognized engineering standards such as I-B-R Installation Guide for Residential Hydronic Heating Systems No. 200 and I-B-R Advanced Installation Guide for Hydronic Heating Systems No. 250.

5.3.6.2.3 Insulation

Hydronic heating pipes located outside the conditioned space or within thermal envelope assemblies shall be insulated with pipe covering having equivalent unit thermal resistance (R_{eq}) of 4 hr-ft²-F/Btu (R-4). Required thicknesses shall be determined as follows:

$$t = r_1 \left[\exp\left(\frac{R_{eq}}{R_{per} * r_1} \right) - 1 \right]$$

where:

- t = required thickness of insulation in inches
- r_1 = pipe outside radius in inches
- R_{eq} = required equivalent R-value of insulation = 4 hr-ft²-F/Btu
- R_{per} = R-value per inch of insulating material (flat)

HVAC chilled water piping, regardless of location shall be insulated with R-4 material having a permeability of not greater than 0.2 grain/h-ft²-in.Hg per inch. Material not meeting this requirement shall be protected with a vapor retarding covering having a permeance of at least 0.01 grain/h-ft²-in.Hg.

5.3.7 Ventilation

5.3.7.1 Requirements for Ventilation

5.3.7.1.1 Outside Air Requirements

If the design infiltration calculations (see Section 5.3.4) indicate that the summer infiltration rate is less than 0.35 ACH, additional outside air shall be provided by an energy recovery device to increase the total outside air to 0.35 ACH and with a flow rate not less than 50 CFM.

5.3.7.1.2 Combustion Air

Fossil fueled, central type heating equipment shall not take combustion air from the conditioned space.

5.3.7.1.3 Exhaust CFM

Kitchens and baths shall be provided with intermittent mechanical exhaust to the outdoors at the following minimum rates:

Kitchens - 100 CFM
Baths - 50 CFM

5.3.7.2 Ventilation Equipment

Exhaust fans, heat recovery ventilators and other ventilating equipment used to meet the requirements in 5.3.7.1, shall be rated by the manufacturer for airflow performance and installed accordingly.

5.3.7.2.1 Heat Recovery Ventilators

Consideration shall be given to use of heat recovery in ventilation systems.

5.3.7.2.2 Dampers

Outside air intakes and exhausts shall be provided with automatic or gravity dampers that close when the system is not operating.

5.3.8 Controls

5.3.8.1 Temperature Control

Each system or zone shall be provided with a single thermostat for the regulation of temperature. As a

minimum, each floor of a dwelling shall have a thermostat. Each thermostat shall be capable of being set by adjustment or selection of sensors.

5.3.8.1.1 Set Points

Where used to control heating, cooling or both heating and cooling, the thermostat shall be capable of being set from 55

°F to 85 °F and shall be incapable of operating the system heating and cooling at the same time.

5.3.8.1.2 Location of Controls

Temperature controls shall be mounted on an inside wall sealed at the bottom and top and thermally insulated from the effects of the outside environment.

5.3.8.1.3 Electric Furnaces

A furnace, greater than 6kW in capacity shall have at least two stages, the second stage shall be controlled by an outdoor thermostat having a range selection of -22

°F to 55 °F or by the second stage of a two stage indoor thermostat.

5.3.8.1.4 Heat Pump Controls

Thermostats for heat pump heating systems shall be specifically designed for heat pump setback control, (i.e., independently control the resistance elements).

5.3.8.2 Zoned System Control

Where zoned cooling units are used in conjunction with zoned heating, controls must be provided to prevent simultaneous heating and cooling.

5.3.8.3 Ventilation Control

Each mechanical ventilator (supply and/or exhaust) shall be provided with a readily accessible, dedicated adjustable device for shut-off or volume reduction.

5.3.8.4 Humidity Control

If a structure is equipped with a means of adding moisture to maintain specific selected relative humidities in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to provide space relative humidity levels above 30%.

5.3.8.5 Heat Pump Supplementary Heater

5.3.8.5.1 Electric Resistance

The heat pump shall be installed with a control to prevent electric supplementary heater operation when the outdoor temperature is above the heat pump balance point. However, electric supplementary heater operation is permitted during defrost.

5.3.8.5.2 Fossil Fuel

Supplementary heat derived from any combustion heating or stored-energy heating equipment shall be activated if the outdoor temperature is below the heat pump balance point.

5.4 Service Water Heating (Domestic Hot Water - DHW)

5.4.1 Scope

This section applies to residential-type service water heating equipment only. Such equipment shall be clearly identified on the basis of physical and/or performance parameters (i.e., upper limits on storage capacity, input rating, etc.).

Service water heating equipment that does not fall under the criteria of residential-type service water heating equipment as defined in this section (e.g. central systems) shall meet all applicable requirements for service water heating equipment found in ANSI/ASHRAE/IES Standard 90A-1980 for ENERGY CONSERVATION IN NEW BUILDING DESIGN(9).

5.4.2 Performance Data of Domestic Hot Water Equipment

Suppliers of domestic hot water equipment shall, upon request the of prospective purchasers, system designers or contractors, provide the GAMA rated Energy Factor (EF) and the rated input and output of all such DHW products.

5.4.3 Minimum Equipment Efficiency Levels

All domestic water heaters shall meet the requirements of Table 5.4.

Table 5.4 - Efficiency Levels of DHW Equipment

<u>TYPE</u>	<u>Energy Factor (EF) Minimum</u>
Gas	0.62-0.0019V
Electric	0.95-0.000132V
Oil	0.59-0.0019V

EF = Energy Factor, overall heater efficiency as determined by the DOE Test Procedure. (Tested in accordance with Appendix E to Subpart B of Title 10 Code of Federal Regulations Part 430-Uniform Test Method for Measuring the Energy Consumption of water heaters, January 1, 1981.)

V = Storage tank volume in gallons.

5.4.4 Water Heaters, Storage Tanks, and Piping

5.4.4.1 Tank Insulation

DHW storage tanks, other than combination residential domestic water heating equipment shall be insulated to a minimum level of 12 hr-F-ft²/Btu.

5.4.4.2 Pipe Insulation

Above ground piping for non-circulating systems shall be insulated to a minimum of 2 hr-ft²-F/Btu when the length of pipe is greater than 15 feet from heater to service point. Continuously circulating hot water piping shall be insulated to a minimum of 4 hr-F-ft²/Btu.

5.4.4.3 Combustion Air

Fossil fueled units shall be installed so that combustion air is taken from outside the conditioned space.

6.0 PRESCRIPTIVE COMPLIANCE PATH

This section provides procedures for demonstrating compliance using the Prescriptive Compliance Path. These procedures shall be used in conjunction with, and shall not supersede, the minimum requirements and design guidelines provided in Section 5.0.

Section 7.0 (Points Compliance Path) and Section 8.0 (Performance Compliance Path) are alternative compliance paths, and shall not be used in conjunction with this section.

6.1 Procedure to Develop the Prescriptive Compliance Packages

The requirements of the prescriptive compliance packages shall be developed using the procedures described in Section 4.3 of this Standard. The procedures in Section 4.3 provide the capability for developing alternative compliance packages to meet the specific needs of users.

Separate prescriptive packages shall be developed for all applicable combinations of location, housing type, and heating and cooling systems, as discussed in Section 4.3 and Sections 6.1.1 through 6.1.3.

6.1.1 Jurisdiction and Reference Weather Location

A set of compliance packages may be provided for individual locations or groups of locations within a jurisdiction. If the list of locations provided in Section 4.3 does not include a location within the jurisdiction, use an available location closest to the jurisdiction with weather conditions similar to those of the jurisdiction.

6.1.2 Housing Type

Separate compliance packages may be provided for three types of housing as defined below:

Single-family detached housing. This category includes one story, two story, bi-level, split level, and other housing constructed on a single dwelling unit per building lot basis.

Multifamily attached housing. This category includes garden apartments, townhouses, rowhouses, multi-plexes, and other forms of housing with one or more common surfaces.

Manufactured or mobile housing. Manufactured housing or structures, transportable in one or more sections, built on a permanent chassis and designed to be used with or without a permanent foundation.

6.1.3 HVAC Equipment Types

The Prescriptive Compliance Path can be used only with limited combinations of heating and cooling equipment. Only the equipment combinations listed in Table 6.1 are allowed in the package path. For other combinations, either the Points Compliance Path (see Section 7.0) or the Performance Compliance Path (see Section 8.0) must be used.

Table 6.1 - Allowable Equipment Type Combinations

<u>Heating Equipment</u>	<u>Cooling Equipment</u>
Gas-fired furnace.	Direct expansion
Oil-fired furnace.	Direct expansion
LPG-fired furnace.	Direct expansion
Electric resistance.	Direct expansion
Electric heat pump	Electric heat pump

6.1.4 Domestic Hot Water Equipment Types

The Prescriptive Compliance Path can be used with any of the domestic hot water (DHW) equipment types listed in Table 6.2.

Table 6.2 - DHW Equipment

Gas-fired Heater
Oil-fired Heater
LPG-fired Heater
Electric Resistance Heater
Electric Heat Pump

6.2 Compliance Procedure

The Prescriptive Compliance Path packages developed through the procedures in Section 4.3 will be provided in the format shown in Table 6.3. A package consists of a unique combination of building envelope energy conservation measures, HVAC equipment types and Domestic Hot Water Equipment. Every energy feature of the home shall meet or exceed the values contained in the selected package.

6.3 Alternative Packages

The materials in Section 4.3 provide the capability to develop one or more alternative packages to the basic prescriptive package generated for each location/house type combination. These alternative packages will result in the same or less annual energy use as the "basic" prescriptive package in Table 6.3.

Table 6.3 Prescriptive Compliance Package

Housing Type: []			
Heating Type: []			
	PACKAGES		
Energy Conservation Measure Category	Basic	Alternate 1	Alternate 2
INSULATION (R-Value)			
Ceiling	[R-]	[R-]	[R-]
Wall			
Frame	[R-]	[R-]	[R-]
High Mass	[R-]	[R-]	[R-]
Foundation/Floor			
Slab	[R-]	[R-]	[R-]
Crawlspace	[R-]	[R-]	[R-]
Heated Basement	[R-]	[R-]	[R-]
Unheated Basement	[R-]	[R-]	[R-]
INFILTRATION PACKAGE	[]	[]	[]
FENESTRATION			
Fenestration Type	[]	[]	[]
Fenestration Area			
Max. Total	[%]	[%]	[%]
Min. South	[%]	[%]	[%]
MECHANICAL EQUIPMENT EFFICIENCY			
Heating (AFUE)	[%]	[%]	[%]
Cooling (SEER)	[]	[]	[]
DOMESTIC HOT WATER			
Oil (EF)	[]	[]	[]
Gas (EF)	[]	[]	[]
LPG (EF)	[]	[]	[]
Electric (EF)	[]	[]	[]
Solar Option	---	[]	[]

7.0 POINTS

This section provides procedures for demonstrating compliance using the Points Compliance Path. The points shall be used in conjunction with, and shall not supersede, the minimum requirements and design guidelines provided in Section 5.0.

Section 6.0 (Prescriptive Compliance Path) and Section 8.0 (Performance Compliance Path) are alternative compliance paths, and shall not be used in conjunction with this section.

7.1 Procedure to Develop the Points Compliance Path

Equations are provided to be used in demonstrating compliance using the Points path. The equations make use of point values that shall be developed using the procedures described in Section 4.3 of this Standard and the Automated Residential Energy Standard (ARES) computer program contained in Section 4.4. Appendix B provides a detailed description of how the equations are used.

The calculation of points for compliance is a two step process: 1) determine the total points ("Target Points") that the proposed home design would receive if built with the "Basic" package of energy measures (see Basic Package, Table 6.3), and 2) determine the total points ("Design Points") that the proposed home design would receive if built with the proposed energy measures. The number of Design Points shall not exceed the number of Target Points to comply with the Standard. In demonstrating compliance Target Point and Design Point totals are computed using the methods, procedures, and materials in accordance with Sections 7.2 through 7.12.

7.1.1 Jurisdiction and Reference Weather Location

Points values may be provided for individual locations or groups of locations within a jurisdiction. If the list of locations provided in Section 4.3 does not include a location within the jurisdiction, use an available location closest to the jurisdiction with weather conditions similar to those of the jurisdiction.

7.1.2 Housing Type

Separate compliance points may be provided for three types of housing as defined below:

Single family detached housing. This category includes one story, two story, bi-level, split level and other housing constructed as a single unit per building lot.

Multifamily attached housing. This category includes garden apartments, townhouses, rowhouses, multi-plexes, and other forms of housing with one or more common surfaces.

Manufactured or mobile housing. Manufactured housing includes structures transportable in one or more sections, built on a permanent chassis and designed to be used with or without a permanent foundation.

7.1.3 Points Tables

Tables of point values to be used with the equations in this section are generated by the ARES computer program contained in Section 4.4. Sample point tables are provided in Appendix B.

7.2 Point Computation Summary Form

Table 7.1 is provided for computing the Target and Design Points. Separate heating and cooling points are determined, for both the Target and Design homes, in accordance with the procedures of this section. Target and Design cooling point estimates are required only if the unit is to be mechanically cooled using either a heat pump or direct expansion (DX) cooling system with central distribution.

Points are determined for both the space conditioning and the service hot water systems. Points for these two end uses are combined, yielding Total Target Points and Total Design Points. Compliance is demonstrated if the Total Design Points do not exceed the Total Target Points.

Table 7.1. Point Computation Summary Form

Component	Source Equation	TARGET		DESIGN	
		Heating	Cooling	Heating	Cooling
Ceiling Insulation	7-1,7-2	_____	_____	_____	_____
Wall Insulation	7-3,7-4	_____	_____	_____	_____
Floor Insulation	7-5,7-6	_____	_____	_____	_____
Air Infiltration	7-7,7-8	_____	_____	_____	_____
Glazing Layers	7-9,7-10	+ _____	+ _____	+ _____	+ _____
SUBTOTAL 1	Note (a)	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
Glazing Orientation	7-11,7-12	- _____	+ _____	- _____	+ _____
SUBTOTAL 2	Note (b)	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
Base Points	7-13	± _____	± _____	± _____	± _____
SUBTOTAL 3	Note (c)	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
HVAC Efficiency Heating Cooling	7-14,7-15	x _____	x _____	x _____	x _____
TOTAL HEATING AND COOLING POINTS	Note (d)	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
TOTAL SPACE CONDITIONING POINTS	Note (e)	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
Domestic Hot Water Points	7-16,7-17	+ _____		+ _____	
TOTAL POINTS	Note (f)	<div style="border: 3px double black; width: 60px; height: 20px;"></div>		<div style="border: 3px double black; width: 60px; height: 20px;"></div>	

Notes for Table 7.1:

- a) Sum the points in each column to obtain entries for the four SUBTOTAL 1 boxes.
- b) Subtract the Glazing Layers Heating points and add Glazing Layers Cooling points to obtain entries for the four SUBTOTAL 2 boxes.

- c) Sum the Base Points and SUBTOTAL 2 to obtain SUBTOTAL 3 entries. Note: Some Base Points may be negative. In this case, subtract them from SUBTOTAL 2.
- d) Multiply Heating SUBTOTAL 3 by HVAC Heating Points to obtain TOTAL HEATING POINTS. Multiply Cooling SUBTOTAL 3 by HVAC Cooling Points to obtain TOTAL COOLING POINTS.
- e) Sum TOTAL HEATING and TOTAL COOLING POINTS to obtain TOTAL SPACE CONDITIONING POINTS.
- f) Sum TOTAL SPACE CONDITIONING POINTS and Domestic Hot Water Points to obtain TOTAL POINTS.

7.3 Ceiling Insulation Points Computation

The equations below are provided to determine the number of Ceiling Insulation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Ceiling Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{TARGET Htg. Mult. (Table 7.2)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad (7-1a)$$

$$\text{Cooling: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{TARGET Clg. Mult. (Table 7.2)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad (7-1b)$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{DESIGN Htg. Mult. (Table 7.3)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad (7-2a)$$

$$\text{Cooling: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{DESIGN Clg. Mult. (Table 7.3)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad (7-2b)$$

7.4 Wall Insulation Point Computation

The equations below are provided to determine the number of Wall Insulation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Wall Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Wall Area}}{\text{TARGET Htg. Mult. (Table 7.4)}} \times \frac{\text{TARGET Htg. Mult. (Table 7.4)}}{\text{TARGET Htg. Mult. (Table 7.4)}} = \frac{\text{TARGET Htg. Mult. (Table 7.4)}}{\text{TARGET Htg. Mult. (Table 7.4)}} = \text{_____} \quad (7-3a)$$

$$\text{Cooling: } \frac{\text{Wall Area}}{\text{TARGET Clg. Mult. (Table 7.4)}} \times \frac{\text{TARGET Clg. Mult. (Table 7.4)}}{\text{TARGET Clg. Mult. (Table 7.4)}} = \frac{\text{TARGET Clg. Mult. (Table 7.4)}}{\text{TARGET Clg. Mult. (Table 7.4)}} = \text{_____} \quad (7-3b)$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Wall Area}}{\text{DESIGN Htg. Mult. (Table 7.5)}} \times \frac{\text{DESIGN Htg. Mult. (Table 7.5)}}{\text{DESIGN Htg. Mult. (Table 7.5)}} = \frac{\text{DESIGN Htg. Mult. (Table 7.5)}}{\text{DESIGN Htg. Mult. (Table 7.5)}} = \text{_____} \quad (7-4a)$$

$$\text{Cooling: } \frac{\text{Wall Area}}{\text{DESIGN Clg. Mult. (Table 7.5)}} \times \frac{\text{DESIGN Clg. Mult. (Table 7.5)}}{\text{DESIGN Clg. Mult. (Table 7.5)}} = \frac{\text{DESIGN Clg. Mult. (Table 7.5)}}{\text{DESIGN Clg. Mult. (Table 7.5)}} = \text{_____} \quad (7-4b)$$

7.5 Floor/Foundation Insulation Point Computation

The equations below are provided to determine the number of Floor/Foundation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Floor/Foundation Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Component Size}^*}{\text{Component Size}^*} \times \frac{\text{TARGET Htg. Mult. (Table 7.6)}}{\text{Component Size}^*} = \frac{\quad}{1000} = \quad (7-5a)$$

$$\text{Cooling: } \frac{\text{Component Size}^*}{\text{Component Size}^*} \times \frac{\text{TARGET Clg. Mult. (Table 7.6)}}{\text{Component Size}^*} = \frac{\quad}{1000} = \quad (7-5b)$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Component Size}^*}{\text{Component Size}^*} \times \frac{\text{DESIGN Htg. Mult. (Table 7.7)}}{\text{Component Size}^*} = \frac{\quad}{1000} = \quad (7-6a)$$

$$\text{Cooling: } \frac{\text{Component Size}^*}{\text{Component Size}^*} \times \frac{\text{DESIGN Clg. Mult. (Table 7.7)}}{\text{Component Size}^*} = \frac{\quad}{1000} = \quad (7-6b)$$

- * Enter the area (sqft) for a floor over a crawlspace or unheated basement.
Enter the perimeter length (ft) for slabs and heated basements.

7.6 Air Infiltration Points Computation

The equations below are provided to determine the number of Air Infiltration, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Air Infiltration

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{TARGET Htg. Mult. (Table 7.8)}}{\text{TARGET Htg. Mult. (Table 7.8)}} = \frac{\quad}{1000} = \quad (7-7a)$$

$$\text{Cooling: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{TARGET Clg. Mult. (Table 7.8)}}{\text{TARGET Clg. Mult. (Table 7.8)}} = \frac{\quad}{1000} = \quad (7-7b)$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{DESIGN Htg. Mult. (Table 7.9)}}{\text{DESIGN Htg. Mult. (Table 7.9)}} = \frac{\quad}{1000} = \quad (7-8a)$$

$$\text{Cooling: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{DESIGN Clg. Mult. (Table 7.9)}}{\text{DESIGN Clg. Mult. (Table 7.9)}} = \frac{\quad}{1000} = \quad (7-8b)$$

7.7 Fenestration Layers and Sash Material Points Computation

The equations below are provided to determine the number of Fenestration Layers and Sash Material, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Window Layers and Sash Material

$$\text{Heating: } \frac{\text{Floor Area}}{\text{TARGET Htg. Mult. (Table 7.10)}} \times \frac{\text{TARGET HOME}}{\text{TARGET POINTS}} = \frac{\quad}{1000} = \quad (7-9a)$$

$$\text{Cooling: } \frac{\text{Floor Area}}{\text{TARGET Clg. Mult. (Table 7.10)}} \times \frac{\text{ } }{\text{ } } = \frac{\text{ } }{\text{ } / 1000} = \text{ } \quad (7-9b)$$

$$\text{Heating: } \frac{\text{Window Area}}{\text{DESIGN Htg. Mult. (Table 7.11)}} = \frac{\quad}{\quad} / 1000 = \quad (7-10a)$$

$$\text{Cooling: } \frac{\text{Window Area}}{\text{DESIGN Clg. Mult. (Table 7.11)}} \times \frac{\text{ } }{\text{ } / 1000} = \text{ } \quad (7-10b)$$

7.8 Glazing Area and Orientation Point Computation

The equations below are provided to determine the number of Glazing Area and Orientation Design Heating and Cooling Points. Values for the Target Heating and Cooling Points, and the Design Multipliers (Option and Overhang) are provided by the ARES Computer Program.

TARGET Point Calculation - Fenestration Area and Orientation

<u>TARGET HOME:</u>	<u>TARGET POINTS</u>
Heating: <u>Floor Area</u>	<u>(Table 7.12)</u> (7-11a)

Cooling: $\frac{\text{Floor Area}}{(\text{Table 7.12})}$ (7-11b)

DESIGN Point Calculation - Fenestration Area and Orientation

DESIGN HOME: HEATING CALCULATION

Orientation	Glazing Area	Energy Option Multiplier (Table 7.13)	Overhang Multiplier (Table 7.14)	Fenestration Factor (F)
North	_____ x _____	_____	x _____ / 100 = _____	_____
Northwest	_____ x _____	_____	x _____ / 100 = _____	_____
East	_____ x _____	_____	x _____ / 100 = _____	_____
Southeast	_____ x _____	_____	x _____ / 100 = _____	_____
South	_____ x _____	_____	x _____ / 100 = _____	_____
Southwest	_____ x _____	_____	x _____ / 100 = _____	_____
West	_____ x _____	_____	x _____ / 100 = _____	_____
Northwest	_____ x _____	_____	x _____ / 100 = _____	_____
				+
Total HEATING Fenestration Factor (F)				_____
DESIGN Points:				_____ (7-12a)
				(Table 7.15)

DESIGN HOME: COOLING CALCULATION

Orientation	Glazing Area	Energy Option Multiplier (Table 7.13)	Overhang Multiplier (Table 7.14)	Fenestration Factor (F)
North	_____ x _____	_____	x _____ / 100 = _____	_____
Northwest	_____ x _____	_____	x _____ / 100 = _____	_____
East	_____ x _____	_____	x _____ / 100 = _____	_____
Southeast	_____ x _____	_____	x _____ / 100 = _____	_____
South	_____ x _____	_____	x _____ / 100 = _____	_____
Southwest	_____ x _____	_____	x _____ / 100 = _____	_____
West	_____ x _____	_____	x _____ / 100 = _____	_____
Northwest	_____ x _____	_____	x _____ / 100 = _____	_____
				+
Total COOLING Fenestration Factor (F)				_____
DESIGN Points:				_____ (7-12b)
				(Table 7.15)

7.9 Base Load Computation

The equations below are provided to determine the number of Base Load Heating and Cooling Points. Values for the Heating and Cooling Multipliers are provided by the ARES Computer Program.

Point Calculation - Base Load

$$\begin{array}{l} \text{Heating: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{Heating Multiplier (Table 7.16)}}{\text{Heating Multiplier (Table 7.16)}} = \frac{\quad}{1000} = \frac{\quad}{\text{TOTAL POINTS}} \quad (7-13a) \end{array}$$

$$\begin{array}{l} \text{Cooling: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{Cooling Multiplier (Table 7.16)}}{\text{Cooling Multiplier (Table 7.16)}} = \frac{\quad}{1000} = \frac{\quad}{\text{TOTAL POINTS}} \quad (7-13b) \end{array}$$

7.10 HVAC Equipment and System Efficiency Point Computation

The equations below are provided to determine the number of HVAC Systems, Target and Design, Heating and Cooling Points. Values for Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Mechanical Equipment

$$\begin{array}{l} \text{TARGET HOME:} \quad \text{TARGET POINTS} \\ \text{Heating: } \frac{\quad}{\text{(Table 7.17)}} = \frac{\quad}{\quad} \quad (7-14a) \end{array}$$

$$\begin{array}{l} \text{Cooling: } \frac{\quad}{\text{(Table 7.17)}} = \frac{\quad}{\quad} \quad (7-14a) \end{array}$$

$$\begin{array}{l} \text{DESIGN HOME:} \quad \text{DESIGN POINTS} \\ \text{Heating: } \frac{\text{Equipment Multiplier (Table 7.18)}}{\text{Equipment Multiplier (Table 7.18)}} \div \frac{\text{Efficiency Indicator}}{\text{Efficiency Indicator}} = \frac{\quad}{\quad} \quad (7-15a) \\ \text{Cooling: } \frac{\text{Equipment Multiplier (Table 7.18)}}{\text{Equipment Multiplier (Table 7.18)}} \div \frac{\text{Efficiency Indicator}}{\text{Efficiency Indicator}} = \frac{\quad}{\quad} \quad (7-15b) \end{array}$$

7.11 Domestic Hot Water Point Calculation

Values for the Target DHW Points and Design and Target Points for demonstrating compliance using Solar DHW System, are provided by the ARES Computer Program. The ARES Computer Program is also used to determine the DHW Multiplier in calculating the Design DHW Points.

Point Calculation - Nonsolar Domestic Water Heating

$$\begin{array}{l} \text{TARGET HOME:} \\ \hline \end{array} \qquad \begin{array}{l} \text{TARGET POINTS} \\ \hline \end{array} \qquad \begin{array}{l} (7-16a) \\ \text{(Table 7.19)} \end{array}$$

$$\begin{array}{l} \text{DESIGN HOME:} \\ \hline \end{array} \div \begin{array}{l} \text{Energy} \\ \text{Factor} \end{array} = \begin{array}{l} \text{DESIGN POINTS} \\ \hline \end{array} \qquad \begin{array}{l} (7-16b) \\ \text{(Table 7.20)} \end{array}$$

Point Calculation - Solar Domestic Water Heating

$$\begin{array}{l} \text{TARGET HOME:} \\ \hline \end{array} \qquad \begin{array}{l} \text{TARGET POINTS} \\ \hline \end{array} \qquad \begin{array}{l} (7-17a) \\ \text{(Table 7.21)} \end{array}$$

$$\begin{array}{l} \text{DESIGN HOME:} \\ \hline \end{array} \qquad \begin{array}{l} \text{DESIGN POINTS} \\ \hline \end{array} \qquad \begin{array}{l} (7-17b) \\ \text{(Table 7.21)} \end{array}$$

8.0 PERFORMANCE COMPLIANCE PATH

This section provides procedures for demonstrating energy performance equivalent to that of the "Basic" prescriptive packages. The procedures here shall be used in conjunction with, and shall not supersede, the minimum requirements and design guidelines presented in Section 5.0.

Section 6.0 (Prescriptive Compliance Path) and Section 7.0 (Points Compliance Path) are alternatives and shall not be used in conjunction with this section.

8.1 Background

The provisions of this Standard are not intended to prevent the use of any material, system, or method of construction not specifically allowed herein provided such alternative designs use the same energy types and are equivalent on an annual energy cost basis.

The performance compliance path is designed to be used for designs that are atypical and that cannot readily be shown to comply under the package or points compliance paths. As such, it provides an opportunity to use innovative materials, equipment, regional practices, and new technologies within the framework of the Standard.

Compliance through the performance path uses a reference approach. The procedure consists of calculating energy costs for the proposed or candidate design and comparing those with energy costs for a reference design with characteristics defined in this section. These costs are then converted to points and combined with those for service hot water to develop design points and target points. If the TOTAL POINTS: DESIGN HOME for the proposed structure do not exceed TOTAL POINTS: TARGET HOME for the reference, the candidate design complies with the Standard.

The Design Points value for the candidate building, as developed through this section, is intended for comparing different designs on the basis of relative, annual energy costs. It is not to be used to project actual building energy costs, since it cannot account for construction and materials quality, building occupancy and operation, building maintenance, and weather variations.

8.2 Scope

Performance analysis of energy costs is NOT required for designs that comply under the prescriptive or point options of this Standard. This compliance option **IS ONLY REQUIRED** for those designs that fall outside the requirements of either of the other two options.

Performance analysis of energy costs is applicable to energy use for space conditioning only. Domestic water heating points are calculated separately (see Section 7.11) and then combined with the space conditioning points determined in this section. In this

process, compliance trade-offs between the two are allowed within the limits on any feature prescribed in Minimum and Mandatory Requirements (Section 5.0).

Estimates of energy used in other areas such as cooking or appliances is provided to allow calculation of energy costs under rate schedules that depend on total energy use. However, these uses will not vary between the candidate and the reference and can not be used as a variable in the compliance process.

8.3 Design Assumptions

8.3.1 General

All conditioned floor space in all dwelling units is assumed to be fully conditioned to maintain the specified thermostat set points during the entire year. If equipment to supply full heating, cooling, or domestic hot water is not specified for the candidate design, equipment meeting the minimum prescriptive requirements of this Standard shall be assumed to be installed in the dwelling unit.

8.3.2 The Candidate Design

The analysis of the candidate design shall take into account all qualities, details, and characteristics of the design that significantly affect energy use and energy cost. These may include construction, geometry, orientation, materials, equipment, and use of renewable energy sources. All items for which mandatory requirements are specified in Section 5.0 of this Standard shall be included in the candidate design. These characteristics and all significant energy conservation features shall be documented in the construction documents for the candidate design.

The Design Points (DP) for the candidate unit shall be calculated for one of the following conditions:

- 1) The DP of each specific dwelling unit, calculated based on its unique combination of design, orientation, site, and climate.
- 2) The highest DP for the Dwelling Unit Type for each orientation or closest cardinal orientation and site situation in which it is proposed to be built.
- 3) The highest DP for the Dwelling Unit Type simulated in each of the four cardinal directions. Compliance by this method provides acceptance for the candidate design, regardless of orientation.

For single family dwelling units, the DP shall be considered separately for each unit. For multi-family buildings, the DP may be considered separately for each dwelling unit or may be calculated for the entire building.

8.3.3 Reference Dwelling Unit

The reference shall be chosen from the "Basic" prescriptive package that represents the same generic dwelling type as the candidate design. The three dwelling types are single family dwelling, multi-family dwelling, and manufactured (mobile home) dwelling. For each dwelling type, up to five "Basic" prescriptive packages may be provided covering the range of equipment types used in heating and cooling (see Section 6). Envelope requirements for the reference are determined by the package with the same heating equipment type and same cooling equipment type as the candidate.

All of the envelope requirements for the reference (insulation levels, glazing type and conductance, and infiltration) will be as specified in the corresponding prescriptive package. Heating, Ventilating, and Air Conditioning equipment (HVAC) shall have the efficiencies, COPs, and SEERs as specified in the corresponding prescriptive package. The reference must use the same energy and equipment types for heating and cooling as specified in the candidate design.

The form and orientation of the reference dwelling unit shall be fixed. The reference unit shall be configured in the following manner:

8.3.3.1 Floor Area

The floor area of the reference unit shall be equal to that of the candidate unit.

8.3.3.2 Ceiling Area

The exposed ceiling area of the reference unit shall be the exposed area of the candidate unit. Exposed roof area of the reference unit shall be assumed to be horizontal, unventilated, of lightweight construction, and insulated to meet the roof conductance requirements as specified in the prescriptive section for the appropriate conditioning energy type.

8.3.3.3 Wall Area

The gross exterior wall area is equal to the gross exterior wall area of the candidate with one-fourth of the area located on each cardinal

orientation. The number, orientation, and area of non-glass doors in the reference shall be identical to that of the candidate design.

8.3.3.4 Glazing Area

The total vertical glazed area of the reference shall be equal to the total glazed area of the candidate design (including skylights) or 12% of the conditioned floor area, whichever is less. One-fourth of the reference glazed area shall be assumed to be located vertically on each cardinal orientation.

8.3.3.5 Construction

The analysis of the reference unit shall assume light weight, standard frame construction.

8.3.3.6 Floor Type

The reference shall have the same fraction of floor area over conditioned space, unconditioned space, unconditioned basements, crawl spaces, and floor slabs as the candidate design. All floor conditions in the reference shall be constructed and modeled in a manner consistent with that of the candidate design except that the reference shall meet the prescriptive package requirements for insulation of floor and foundations.

8.3.3.7 Shading

The walls and windows of the reference unit shall be considered unshaded.

8.3.3.8 Volume

The volume of the reference shall be calculated as eight feet times the floor area.

8.4 Standard Calculation Procedure for Space Conditioning Energy Use

The standard calculation procedure consists of methods and assumptions for calculating the annual energy use of the candidate and reference units and the Design Points and Target Points. The following assumptions shall be used:

8.4.1 Internal Heat Gains

Internal heat gains from lights, people, and equipment shall be considered in calculating space conditioning loads. The daily total, sensible, and latent internal loads (Btu/day) shall be determined by these equations:

$$\begin{aligned}\text{Total heat gain} &= \text{sensible heat gains} + \text{latent heat gains} \\ \text{Sensible heat gains (Btu/day)} &= (\text{floor area} \times 8.3) + 43,660 \\ \text{Latent heat gains (Btu/day)} &= 12160\end{aligned}$$

Internal gains shall be distributed over the day according to the fractions in the following table:

Internal Load (fraction of daily total)

Time of Day	Multiple Zones Zone 1	Multiple Zones Zone 2	Single Zone
Mid - 1 AM	0.0140	0.0063	0.0203
1 - 2 AM	0.0140	0.0063	0.0203
2 - 3 AM	0.0140	0.0063	0.0203
3 - 4 AM	0.0140	0.0063	0.0203
4 - 5 AM	0.0140	0.0063	0.0203
5 - 6 AM	0.0140	0.0199	0.0339
6 - 7 AM	0.0351	0.0075	0.0426
7 - 8 AM	0.0315	0.0537	0.0852
8 - 9 AM	0.0119	0.0379	0.0498
9 - 10 AM	0.0138	0.0166	0.0304
10 - 11 AM	0.0138	0.0166	0.0304
11 - Noon	0.0138	0.0268	0.0406
Noon - 1 PM	0.0138	0.0166	0.0304
1 - 2 PM	0.0138	0.0116	0.0254
2 - 3 PM	0.0138	0.0126	0.0264
3 - 4 PM	0.0138	0.0126	0.0264
4 - 5 PM	0.0138	0.0248	0.0386
5 - 6 PM	0.0100	0.0316	0.0416
6 - 7 PM	0.0100	0.0346	0.0446
7 - 8 PM	0.0260	0.0440	0.0700
8 - 9 PM	0.0260	0.0440	0.0700
9 - 10 PM	0.0260	0.0471	0.0731
10 - 11 PM	0.0245	0.0486	0.0731
11 - Midnight	0.0300	0.0360	0.0660
TOTAL	0.4254	0.5746	1.0000

Where multiple zone space conditioning is modeled for the candidate unit only, the hourly distribution shown for Zone 1 shall be used for bedrooms and bathrooms; the hourly distribution shown for Zone 2 shall be used for all other

conditioned rooms. Where single zone space conditioning is modeled, use the hourly distribution for Single Zone.

8.4.2 Internal Thermal Mass

For calculation purposes, the reference and candidate buildings are assumed to have an occupancy thermal mass (furniture and contents) of 4.5 pounds per square foot of floor area. The reference unit is also assumed to have 1.5 pounds per square foot of floor area in structural mass consisting of 0.5 inch thick gypsum board on walls and ceilings.

8.4.3 Envelope

8.4.3.1 Insulation and Glazing

The envelope insulation of the reference shall be determined using the prescriptive package appropriate to the candidate design's dwelling type and heating and cooling equipment types. The specified envelope characteristics of the candidate design shall be used in calculating its energy consumption for space conditioning.

8.4.3.2 Window Management

Glazing shall be assumed to be internally shaded by medium weight draperies in both the reference and candidate design even if no draperies are shown on the plan. The default drapery shall reduce the shading coefficient of the glazing 30% during the cooling season and 15% during the heating season, but shall have no effect on window conductance. Higher performance shading and insulation systems may be modeled if specified on the plans for the candidate design. To account for variations in occupant behavior, operable shading or insulation systems shall be assumed to achieve only 50% of their nominal decrease in shading coefficient or increase in insulation R-value when closed. If automatic motorized controls are installed, shading/insulation shall achieve 100% of their nominal performance.

8.4.3.3 Natural Ventilation

Both candidate and reference shall be assumed to utilize natural ventilation for cooling whenever the outdoor air conditions allows the indoor conditions to be maintained at a relative humidity of 70% or less. Ventilation control strategy shall be identical in both reference and candidate design. Natural ventilation may be used to reduce indoor air temperature below the cooling set point. The free vent area for the reference shall be

20% of the glazing area with vents uniformly distributed on each orientation. To account for screens and other obstructions, the maximum free vent area in the candidate design shall be 50% of the operable sash area.

8.4.3.4 Infiltration

One of two methods of calculating infiltration measures shall be used. For method 1, a constant air change rate of 0.52 air changes per hour shall be used for both the candidate design and the reference, and the minimum prescriptive infiltration requirements of Section 5.0 shall be met.

In method 2, the calculation of infiltration shall be done using the Effective Leakage Area (ELA) approach described in the ASHRAE Handbook, Fundamentals Volume(1). The ELA for the candidate design shall be determined using methods described in the ASHRAE Handbook or from standard test methods such as ANSI/ASTM E283-73 (Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors), or ASTM E779-86 (Determining Air Leakage Rate by Fan Pressurization). In no instance shall the ratio of ELA in square feet to the floor area in square feet of the candidate be less than 0.00023. For the reference, the ratio of ELA in square feet to the floor area in square feet of the candidate shall be 0.00035. The determination of the energy loss from infiltration in both the reference and candidate design shall be based on the hourly calculation of the specific infiltration as described in the 1985 ASHRAE Handbook, Fundamentals Volume(1), or an equivalent method.

8.4.4 HVAC Systems and Equipment

8.4.4.1 HVAC Design

The design energy use of the candidate design shall be calculated using the HVAC equipment specified. If equipment is not specified, for the candidate, its presence shall be assumed for the purposes of the performance analysis. If the system specified in the candidate design is not directly categorized in Section 5.0, the system from Section 5.0 which uses the same type of energy and which is most similar to the design shall be selected. Part load and outdoor temperature effects shall be considered, and the mechanical systems in the reference shall meet the minimum efficiencies specified in Section 5.0. If the candidate design uses more than one energy type for a single purpose, such as a combination of electricity and gas for space heating,

then the reference shall be assumed to use the predominant energy source for that purpose. In this instance, the prescriptive envelope requirements for the reference shall be derived from the equipment type that represents the majority of that use. In no case shall the equipment types used for heating or for cooling differ between the candidate design and the reference, except that the candidate may use site solar with electric backup for space conditioning regardless of the heating equipment type used in the reference.

The reference unit shall be assumed to be one thermal zone. Multiple thermal zones may be simulated in calculating the design energy cost of the candidate design if multi-zone automatic controls are specified in the construction documents.

8.4.4.2 Equipment Sizing and Redundant Equipment

For calculational methods where equipment size affect energy consumption, actual equipment sizes and types shall be used in the calculations. The reference shall have equipment sized in a consistent manner with, but not necessarily the same size as in the candidate design (Section 5.3.4). Redundant and/or emergency equipment need not be simulated if it is controlled such that it will not be in use during normal operations of the dwelling.

8.4.4.3 Thermostat Set Points and Control

In calculating the annual energy requirements for both the reference and candidate design, all conditioned spaces shall be maintained at the specified thermostat set points (see Table 8.1) at all times except for minor deviations consistent with good sizing practice at thermostat setup/setback and peak load conditions. If the specified equipment in the candidate design is too small to meet the increased load from such a thermostat control strategy, its size shall be increased in the calculations. If equipment to meet a load is not included in the candidate design, such equipment shall be assumed in the calculations and its energy use included. In no case shall the annual energy use of the candidate design be reduced by not fully conditioning its spaces. The number of hours that equipment does not meet the load in the candidate design must not exceed that of the reference.

For central conditioning systems without zonal control, the entire living space shall be assumed to consist of one thermostatically controlled zone. For houses with unconditioned basements, the basement shall be a separate,

unconditioned zone. The thermostat setting for the living space shall be as given in the following table:

Table 8.1 - Thermostat Setting in Degrees F

Time of Day	Multiple Zones				Single Zone	
	Zone 1		Zone 2		Heat	Cool
	Heat	Cool	Heat	Cool	Heat	Cool
Mid - 6 AM	60	78	60	85	60	78
6 - 9 AM	70	78	70	78	70	78
9 - 5 PM	60	85	70	78	70	78
5 - 11 PM	70	78	70	78	70	78
11 - Midnight	60	78	60	85	60	78

Setbacks for heat pump heating shall not be considered unless the thermostat specified in the construction documents is specifically designed for heat pump setback control (i.e., control the resistance elements independently of the refrigeration system), and uses a control strategy that reduces or eliminates the use of auxiliary heat for set up. For multiple zone candidate designs, Zone 1 in the table represents bedrooms and bathrooms while Zone 2 represents all other conditioned spaces.

8.5 The Calculation Tool

The calculation tool must be appropriate for the construction and configuration variables that are being analyzed. The calculation tool must be able to estimate the energy use of each specific construction parameter that deviates from the minimum prescribed values. Simplified calculation tools may be used to calculate the impact of certain construction variables. The following classes of calculation methods may be used for the conditions as specified:

8.5.1 Bin Calculation Method

Calculation techniques for this method are specified in ASHRAE Simplified Energy Calculation Procedure, TC 4.7. It is suggested that the ASHRAE WYEC bin weather data be used with this method as appropriate to the building location. Any Bin method which is comparable to the TC 4.7 Method may be used to analyze any of the following:

- envelope areas and thermal conductance
- furnace, heat pumps, and cooling equipment efficiency

8.5.2 Correlation Methods

Heating and cooling loads for representative configurations are generated using a detailed hourly transient computer analysis model. The results are then translated into simplified algorithms that can be presented as tables, nomograms, or microcomputer programs. Correlation methods may be used if it is shown that the construction variables to be analyzed are adequately quantified by the simulation program used to generate the data base and that the results are reliably re-created by the simplified algorithms. Correlation methods shall not be used for analysis of weather or construction variables not covered by or outside the range of the data base. The methodology used to generate the data base, the correlation techniques, and their comparison to the basic data shall be well documented.

8.5.3 Transient Analysis Using Weather Sample

This method uses calculation techniques as specified in the ASHRAE Handbook, Fundamentals Volume. The method shall use transfer function, finite difference, or other suitable techniques to calculate the transient responses of the dwelling. The method shall also use explicit equipment models to calculate equipment responses to varying weather conditions as recorded for consecutive intervals of one hour or less. If transcribed weather data for an entire year is not used, a minimum sample of at least 168 consecutive hours for each of the four seasons of the year must be used. The weather data must statistically represent the distribution of temperature and solar radiation in the long term weather records for the closest weather station having hourly records. ASHRAE WYEC weather data is recommended for use with transient analysis programs. Weather data may be adjusted to compensate for microclimate differences between the building site and the weather station. Programs based upon this methodology and including algorithms for computing shading and other solar effects as well as algorithms for computing the psychrometric properties of air systems may be used to evaluate any or all building variables.

8.5.4 General

While the Bin methods are often performed by hand, correlation and transient analysis usually require a computer. Hand calculation analyses shall include a written documentation of the assumptions made as well as the calculations for each variable examined. Computer analyses shall be performed using programs that utilize scientifically justifiable procedures for modeling building loads, systems, and equipment.

Computer program documentation must document the methods used and that the conservation measures are accurately modeled by the program.

Energy consumption for occupant energy uses shall be calculated according to Section 8.6. The energy consumption for these end uses shall be used only in determining rates for those schedules where rate is based on amount of energy used in a given period. The occupant energy consumption for all uses shall be equivalent for both the candidate design and the reference.

8.6 Calculating Design Energy Cost and Target Energy Cost

The Design Energy Cost (DEC) for the candidate design shall be calculated from the space conditioning energy consumption of the candidate design and the appropriate rate schedules for the energy types utilized. This value shall be added to the DHW Energy Cost, as determined in Section 7.11, to arrive at the Total Points for the candidate design. In a similar manner, the Target Energy Cost (TEC) for the Reference shall be calculated from the space conditioning energy consumption of the reference and the appropriate rate schedules for the energy types utilized. This value shall be added to the DHW Energy Cost for the reference DHW equipment, as determined in Section 7.11, to arrive at the Total Points for the reference. If the Design Points of the candidate do not exceed the Target Points of the reference, then the candidate design complies with the Standard.

For candidate:

$$\text{DEC} = [\text{Annual Energy Use for Heating (in MBtu)} \\ \times \text{Cost of Heating Energy (in \$/MBtu)}] + \\ [\text{Annual Energy Use for Cooling (in MBtu)} \\ \times \text{Cost of Cooling Energy (in \$/MBtu)}]$$

$$\text{Design Points} = 100 \times \text{DEC} + \text{DHW Points}$$

For reference:

$$\text{TEC} = [\text{Annual Energy Use for Heating (in MBtu)} \\ \times \text{Cost of Heating Energy (in \$/MBtu)}] + \\ [\text{Annual Energy Use for Cooling (in MBtu)} \\ \times \text{Cost of Cooling Energy (in \$/MBtu)}]$$

$$\text{Target Points} = 100 \times \text{TEC} + \text{DHW Points}$$

The unit cost of any energy type shall be the current rate or price quoted by the usual supplier and available at the building site for the type and size of the candidate. The same rate schedules shall be used for both the candidate design and the reference unless a different rate schedule is applicable to the candidate design due

APPENDIX A - RADON CONTROL MEASURES

The purpose of this section is to provide criteria for the control of the entry of radon into houses by incorporation of construction techniques that are inherently more resistant to radon entry. The criteria apply to basement, slab-on-grade, and crawl space construction. The control strategies presented should not be viewed as independent, unrelated techniques, but rather should be used in combinations, particularly where it is necessary to achieve large reductions in radon concentrations.

A.1 Background

Radon is a naturally occurring gas resulting from the radioactive decay of radium, a common element in many soils. Radon gas decays into radioactive progeny that can build up to unacceptable concentrations in houses. Exposure to radon and its progeny has been linked to lung cancer in uranium miners. The potential health impact (if any) of exposures to radon at typical indoor levels (less than eight picocuries per liter) is unknown.

The principal sources of radon in houses are: 1) soil and rock surrounding the house, 2) potable water, and 3) natural building materials used in the house. Soil is generally believed to be the most significant contributor to indoor radon, although radon contaminated private well water can be a significant, but usually secondary source.

The control methods presented in this section address only the mitigation of radon entry from soil. The major entry paths for radon are cracks in the concrete slab, cracks between poured concrete and blocks, pores and cracks in concrete blocks, slab-footing joints, exposed soil (as in sumps), and seams around plumbing and electrical penetrations of the slab and below-grade walls.

A.2 Determination of Need for Radon Control Measures

The susceptibility of a building site to radon gas should be determined by one or more of the following methods:

- a) Check with state and/or regional EPA offices for other radon problems in the area.
- b) Check local soil characteristics for conditions favorable for radon gas formation/transport.
- c) Conduct on-site soil testing for radon.

A.3 Construction to Reduce Radon Concentration

If the region in which the site is located is determined to have a potential radon problem, the design of the structure should incorporate radon resistant construction techniques such as described in "Radon

Reduction Techniques for Detached Houses - Technical Guidance" (EPA/625/5-86/019).

Construction techniques applicable to the different foundation types are described below.

A.3.1 Crawl Space Houses

Ventilation. Ventilation of the crawl space to transport the radon-borne soil gas that enters the crawl space from the soil to the outside should be provided through the use of standard foundation ventilation louvers. Uniform ventilation rates can be provided by the installation of fans.

Sub-floor sealing. In addition to the insulation, the underside of the house should be sealed with a polyethylene sheet to further reduce radon entry.

A.3.2 Basement and Slab-on-Grade Houses.

Sealing of Major Radon Sources. All exposed earth within the house, such as drainage sump areas, should be capped with an impermeable covering and exhaust-ventilated through the roof to the outdoors. All cover seams/joints should be sealed.

Sealing of Radon Entry Paths. All cracks in the concrete slab and below-grade walls, slab-footing joints, wall and slab penetrations of plumbing, and electrical service should be sealed with a gas-proof, non-shrinking sealant.

Foundation/Slab Construction. The sub-slab area should be filled with a uniform layer of loose aggregate to a minimum depth of eight inches and covered with a thick, reservoir-grade plastic vapor barrier. Any joints or other penetrations of the barrier should be sealed. The vapor barrier should be covered with a layer of sand.

The foundation and slab should be poured as a single (monolithic) unit wherever possible. Specially designed plastic strips should be used to separate any slab junctions.

The recommended water content of the concrete should be used to minimize shrinkage and cracks. Steel reinforcing mesh is to be imbedded in the slab for more effective resistance to shrinkage and cracking.

Below-Grade Wall Construction. Solid (poured) concrete walls should be used in below-grade wall construction whenever possible.

If block wall construction is necessary, concrete blocks should be used in preference to the more porous cinder blocks. Footings and block walls should also be adequately reinforced with steel to minimize cracking.

Hollow block walls should be capped, or otherwise, sealed at the wall top.

Interior and exterior block wall surfaces should be parged with appropriate vapor/water sealants.

Sub-slab De-pressurization. A method of sub-slab de-pressurization should be provided for transport of the radon-borne soil gas that originates in the soil beneath the house to the exterior before it enters the habitable portions of the house. This is accomplished by installing a network of perforated PVC drain pipe in the aggregate beneath the basement floor. The tile is connected to a vertical ventilation stack that extends from the floor slab through the roof. Passive mechanical ventilation is provided by a turbine ventilator. If additional, constant ventilation rates are required, a fan should be installed in the exhaust duct.

Drain Tile Soil Ventilation. Considerable amount of radon-borne soil gas enters a house through openings in the vicinity of the footings. If the house is designed with a perimeter drain system that surrounds the house, it can be used to draw radon away from these potential entry paths.

The drain tile ventilation system should consist of a water trap and riser(s) installed in the line to the soakaway, and an exhaust fan to provide the necessary suction on the tile system.

This approach is an alternative to the sub-floor de-pressurization technique described above.

A.4 Post-Construction Requirements

A.4.1 Indoor Radon Monitoring

Monitoring for radon should be done during the first heating season, within 12 months of completion of the house. The monitoring period should follow standard indoor radon and radon decay product measurement protocols described in the EPA publication "Interim Indoor Radon and Radon Decay Product Measurement Protocols" (EPA 520/1-84-04, April 1986).

A.4.2 Mitigation

If the monitoring results exceed minimum levels (yet to be established), further specific mitigation measures should be implemented. The exact measures depend upon the actual radon results, the design of the house, and the radon mitigation measures already in effect.

APPENDIX B

INSTRUCTIONS FOR DEMONSTRATING COMPLIANCE USING THE POINTS PATH

APPENDIX B - INSTRUCTIONS FOR DEMONSTRATING COMPLIANCE USING THE POINTS PATH

Section 7.0 of the Standard provides the procedures for demonstrating compliance using the Points Compliance Path. In that section, equations are provided to be used in the compliance process. This appendix provides a detailed description of how those equations are used.

The procedures for identifying the required energy conservation measures in each location and for selected housing types are described in Section 4.3. The point tables are developed using the ARES computer program described in Section 4.4. In demonstrating compliance, Target Point and Design Point totals are computed using the tables and equations in accordance with Sections B.1 through B.10.

B.1 Point Computation Summary Form

Table B.1 is provided as a worksheet for computing the Target and Design Points. Separate heating and cooling points are determined, for both the Target and Design homes, in accordance with the procedures of this section. Target and Design cooling point estimates are required only if the unit is to be mechanically cooled using either a heat pump or DX cooling system with central distribution.

Points are determined for both the space conditioning and the service hot water systems. Points for these two end uses are combined, yielding Total Target Points and Total Design Points. Compliance is demonstrated if the Total Design Points do not exceed the Total Target Points. For structures where two or more zones are served by separate central systems (heating or cooling), a separate Point Computation Summary Form (Table B.1) shall be completed to determine the Design Points for each zone. The Design Points from the individual Point Forms are then summed to yield the Total House Design Points. The Target Point computation shall assume only one thermal zone.

To complete the Point Computation Summary Form follow steps 1 through 6. Steps 1 through 4 are performed for the Target and then repeated for the Design.

- 1) Determine points entries for Ceiling Insulation, Wall Insulation, Floor/Foundation Insulation, Air Infiltration and Glazing Layers following the procedures in Sections B.2 through B.6. Enter these values in the appropriate boxes in Table B.1.
- 2) Sum the values in each column and enter the totals on the line labeled SUBTOTAL 1.
- 3) Determine the Glazing Orientation points from the procedures in Section B.7. Subtract the heating values from SUBTOTAL 1 and insert the difference in the box marked SUBTOTAL 2, HEATING. Add the cooling values to SUBTOTAL 1 and insert the sum in the box marked SUBTOTAL 2, COOLING.

- 4) Determine the entries for Base Points (heating and cooling) following the procedures in Section B.8. Note that the base points may be negative in some cases.
- 5) If the heating Base Points are positive, add them to the TARGET and DESIGN points in SUBTOTAL 2, and insert the sum in the box labeled SUBTOTAL 3, Heating. If the Base Points are negative, subtract them from SUBTOTAL 2 to get SUBTOTAL 3. Follow the same procedure for the Cooling columns.
- 6) Identify the Heating and Cooling Equipment Efficiency Multipliers following the procedures in Section B.9. Multiply each Subtotal 3 by the appropriate Equipment Multiplier and insert the products in the boxes on the row marked "TOTAL HEATING AND COOLING POINTS."
- 7) Add together the HEATING and COOLING POINTS for the TARGET HOME and enter the sum in the box marked "SPACE CONDITIONING POINTS". Add together the HEATING and COOLING POINTS for the DESIGN HOME and enter the sum in the box marked "SPACE CONDITIONING POINTS" for the DESIGN HOME.
- 8) Determine the TARGET and DESIGN Service Hot Water Points following the procedures in Section B.10. Enter these values in the appropriate boxes and add to the TARGET and DESIGN Space Conditioning Points. Enter the sum in the boxes indicated "TOTAL POINTS". Compliance is demonstrated if the "TOTAL POINTS" for the DESIGN does not exceed the "TOTAL POINTS" for the TARGET.

Table B.1. Point Computation Summary Form

Component	Source Equation	TARGET		DESIGN	
		Heating	Cooling	Heating	Cooling
Ceiling Insulation	B-1,B-2	_____	_____	_____	_____
Wall Insulation	B-3,B-4	_____	_____	_____	_____
Floor Insulation	B-5,B-6	_____	_____	_____	_____
Air Infiltration	B-7,B-8	_____	_____	_____	_____
Glazing Layers	B-9,B-10	+ _____	+ _____	+ _____	+ _____
SUBTOTAL 1		<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
Glazing Orientation	B-11,B-12	- _____	+ _____	- _____	+ _____
SUBTOTAL 2		<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
Base Points	B-13	± _____	± _____	± _____	± _____
SUBTOTAL 3		<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
HVAC Efficiency Heating Cooling	B-14,B-15	x _____	x _____	x _____	x _____
TOTAL HEATING AND COOLING POINTS		<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
TOTAL SPACE CONDITIONING POINTS		<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>	<div style="border: 1px solid black; width: 60px; height: 20px;"></div>
Domestic Hot Water Points	B-16,B-17	+ _____		+ _____	
TOTAL POINTS		<div style="border: 3px double black; width: 60px; height: 20px;"></div>		<div style="border: 3px double black; width: 60px; height: 20px;"></div>	

B.2 Ceiling Insulation Points Computation

To estimate the ceiling insulation points follow the steps described below:

- 1) Enter the area of that part of the ceiling to be insulated under the four "Ceiling Area" entries. All four entries shall be equal.
- 2) Based on the primary heating equipment type selected, obtain the heating multiplier for the target home from Table B.2. Place this value in the "Target Heating Multiplier" entry and multiply by the component area. To determine the "Target Points: Heating" divide by 1000.
- 3) Obtain the cooling multiplier for the target home from Table B.2. Place this value in the "Target Cooling Multiplier" entry and multiply by the component area. To determine the "Target Points: Cooling" divide by 1000.
- 4) Enter the heating multiplier (as determined from Table B.3 for the insulation level of the design) in the "Design Heating Multiplier" entry and multiply by the component area. To determine the "Design Points: Heating" divide by 1000.
- 5) Enter the cooling multiplier (as determined from Table B.3 for the insulation level of the design) in the "Design Cooling Multiplier" entry and multiply by the component area. To determine the "Design Points: Cooling" divide 1000.
- 6) Insert these values in the appropriate boxes in Table B.1 (see Note 1).

Note 1: If the ceiling of the Design home has different levels of insulation proposed in different areas, then equation B-2 should be repeated for each area of ceiling using the appropriate values from Table B.3. The Design Points for each ceiling area are summed to obtain the Design Heating Points and Design Cooling Points for ceiling insulation. These total points values are entered in the appropriate boxes on Table B.1. (For example, if part of the ceiling area is cathedral with R-38 insulation and the other part is a flat ceiling with R-30 insulation, the Heating and Cooling points are calculated by multiplying the cathedral ceiling area by the Multiplier for R-38, and adding that value to the product of the flat ceiling area and the Multiplier for R-30.)

Point Calculation - Ceiling Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{TARGET Htg. Mult. (Table B.2)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad \quad (\text{B-1a})$$

$$\text{Cooling: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{TARGET Clg. Mult. (Table B.2)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad \quad (\text{B-1b})$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{DESIGN Htg. Mult. (Table B.3)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad \quad (\text{B-2a})$$

$$\text{Cooling: } \frac{\text{Ceiling Area}}{\text{Ceiling Area}} \times \frac{\text{DESIGN Clg. Mult. (Table B.3)}}{\text{Ceiling Area}} = \frac{\quad}{1000} = \quad \quad (\text{B-2b})$$

Table B.2 TARGET Ceiling Insulation Multipliers

<u>Heating Equipment Type</u>	<u>Multiplier</u>	
	<u>Heating</u>	<u>Cooling</u>
Oil	[]	[]
Natural Gas	[]	[]
L. P. Gas	[]	[]
Electric Res.	[]	[]
Elec. Heat Pump	[]	[]

Table B.3 DESIGN Ceiling Insulation Multipliers

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-11	R-19	[]	[]
R-19	R-30	[]	[]
R-30	R-38	[]	[]
R-38	R-49	[]	[]
R-49	R-60	[]	[]
R-60	--	[]	[]

B.3 Wall Insulation Point Computation

To estimate the wall insulation points, follow the steps described below:

- 1) Enter the area of that part of the insulated portion of the wall under the four "Wall Area" entries. All four entries shall be equal.
- 2) Determine the type of wall construction (wood frame, medium or high thermal mass masonry (see definition, Section 3.3), or solid wood (log)).
- 3) Based on the primary heating equipment type selected, obtain the heating multiplier for the target home from Table B.4. Place this value in the "Target Heating Multiplier" entry and multiply by the component area. To determine the "Target Points: Heating" divide by 1000.
- 4) Obtain the cooling multiplier for the target home from Table B.4. Place this value in the "Target Cooling Multiplier" entry and multiply by the component area. To determine the "Target Points: Cooling" divide by 1000.
- 5) Obtain the heating multiplier for the design home from the appropriate of Tables B.5a-d. Place this value in the "Design Heating Multiplier" entry and multiply by the component area. To determine the "Design Points: Heating" divide by 1000.
- 6) Obtain the cooling multiplier for the design home from the appropriate of Tables B.5a-d. Place this value in the "Design Cooling Multiplier" entry and multiply by the component area. To determine the "Design Points: Cooling" divide by 1000.
- 7) Insert these values in the appropriate boxes in Table B.1 (see Note 2).

Note 2: If the walls of the Design home have different constructions proposed in different areas; then equation B-4 should be repeated for each area using the appropriate values from Tables B.5a-B.5d. The Design Points for each wall type are summed to obtain the Design Heating Points and Design Cooling Points for wall insulation. These total point values are entered in the appropriate boxes on Table B.1. (For example, if part of the wall area is frame construction with R-19 insulation, and another part is medium weight concrete block with R-10 insulation, the Heating and Cooling points are calculated by multiplying the frame wall area by the Multiplier for R-19 (Table B.5a) and adding the result to the product of the concrete wall area and the R-10 Multiplier from Table B.5b.

Point Calculation - Wall Insulation

<u>TARGET HOME:</u>		<u>TARGET POINTS</u>	
Heating:	$\frac{\text{Net Wall Area}}{\text{TARGET Htg. Mult. (Table B.4)}} \times \frac{\text{TARGET Htg. Mult. (Table B.4)}}{\text{TARGET Htg. Mult. (Table B.4)}} = \frac{\text{TARGET Htg. Mult. (Table B.4)}}{\text{TARGET Htg. Mult. (Table B.4)}} / 1000 = \text{TARGET POINTS}$		(B-3a)
Cooling:	$\frac{\text{Net Wall Area}}{\text{TARGET Clg. Mult. (Table B.4)}} \times \frac{\text{TARGET Clg. Mult. (Table B.4)}}{\text{TARGET Clg. Mult. (Table B.4)}} = \frac{\text{TARGET Clg. Mult. (Table B.4)}}{\text{TARGET Clg. Mult. (Table B.4)}} / 1000 = \text{TARGET POINTS}$		(B-3b)
<u>DESIGN HOME:</u>		<u>DESIGN POINTS</u>	
Heating:	$\frac{\text{Net Wall Area}}{\text{DESIGN Htg. Mult. (Table B.5)}} \times \frac{\text{DESIGN Htg. Mult. (Table B.5)}}{\text{DESIGN Htg. Mult. (Table B.5)}} = \frac{\text{DESIGN Htg. Mult. (Table B.5)}}{\text{DESIGN Htg. Mult. (Table B.5)}} / 1000 = \text{DESIGN POINTS}$		(B-4a)
Cooling:	$\frac{\text{Net Wall Area}}{\text{DESIGN Clg. Mult. (Table B.5)}} \times \frac{\text{DESIGN Clg. Mult. (Table B.5)}}{\text{DESIGN Clg. Mult. (Table B.5)}} = \frac{\text{DESIGN Clg. Mult. (Table B.5)}}{\text{DESIGN Clg. Mult. (Table B.5)}} / 1000 = \text{DESIGN POINTS}$		(B-4b)

Table B.4 TARGET Wall Insulation Multipliers

<u>Heating Equipment Type</u>	<u>Multiplier</u>	
	<u>Heating</u>	<u>Cooling</u>
Oil	[]	[]
Natural Gas	[]	[]
L. P. Gas	[]	[]
Electric Res.	[]	[]
Elec. Heat Pump	[]	[]

Table B.5a DESIGN Frame Wall Insulation Multipliers

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-11	R-13	[]	[]
R-13	R-19	[]	[]
R-19	R-23	[]	[]
R-23	R-26	[]	[]
R-26	--	[]	[]

Table B.5b DESIGN Mass Wall Insulation Multipliers
Medium Weight (up to 110 lb/sf)

R-value		Multiplier	
<u>At least</u>	<u>but less than</u>	<u>Heating</u>	<u>Cooling</u>
R-0_Medium_Wt	R-5_Medium_Wt	[]	[]
R-5_Medium_Wt	R-10_Medium_Wt	[]	[]
R-10_Medium_Wt	R-15_Medium_Wt	[]	[]
R-15_Medium_Wt	R-30_Medium_Wt	[]	[]
R-30_Medium_Wt	-----	[]	[]

Table B.5c DESIGN Mass Wall Insulation Multipliers
Heavy Weight (greater than 110 lb/sf)

R-value		Multiplier	
<u>At least</u>	<u>but less than</u>	<u>Heating</u>	<u>Cooling</u>
R-0_Heavy_Wt	R-5_Heavy_Wt	[]	[]
R-5_Heavy_Wt	R-10_Heavy_Wt	[]	[]
R-10_Heavy_Wt	R-15_Heavy_Wt	[]	[]
R-15_Heavy_Wt	R-30_Heavy_Wt	[]	[]
R-30_Heavy_Wt	-----	[]	[]

Table B.5d DESIGN Solid Wood (Log) Wall Multipliers

Nominal Thickness (inches)		Multiplier	
<u>At least</u>	<u>but less than</u>	<u>Heating</u>	<u>Cooling</u>
6	8	[]	[]
8	10	[]	[]
10	12	[]	[]
12	----	[]	[]

B.4 Floor/Foundation Insulation Point Computation

To estimate the floor/foundation insulation points, follow the steps described below:

- 1) Enter the size of that part of the floor or foundation to be insulated under the four "Component Size" entries. For unheated basements and crawlspaces enter the floor area. For slabs and heated basements enter the perimeter length. All four entries shall be equal.
- 2) Based on the primary heating equipment type selected and the type of foundation, obtain the heating multiplier for the target home from Table B.6. Use the multiplier corresponding to the floor/foundation type of the design home. Place this value in the

"Target Heating Multiplier" entry and multiply by the component size. To determine the "Target Points: Heating" divide by 1000.

- 3) Based on the type of foundation, obtain the cooling multiplier for the target home from Table B.6. Use the multiplier corresponding to the floor/foundation type of the design home. Place this value in the "Target Cooling Multiplier" entry and multiply by the component size. To determine the "Target Points: Cooling" divide by 1000.
- 4) Obtain the heating multiplier for the design home from the appropriate of Tables B.7a-d. Place this value in the "Design Heating Multiplier" entry and multiply by the component size. To determine the "Design Points: Heating" divide by 1000.
- 5) Obtain the cooling multiplier for the design home from the appropriate of Tables B.7a-d. Place this value in the "Design Cooling Multiplier" entry and multiply by the component size. To determine the "Design Points: Cooling" divide by 1000.
- 6) Insert these values in the appropriate boxes in Table B.1 (see Note 2).

Note 3: If the floor/foundation of the Design home has different levels of insulation proposed in different areas, then equation B-6a and B-6b should be repeated for each area of floor/foundation using the appropriate values from Table B.7. The Design Points for each ceiling area are summed to obtain the Design Heating Points and Design Cooling Points are entered in the appropriate boxes on Table B.1. (For example, if part of the floor/foundation area is crawl space with R-11 insulation and the other part an unheated basement beneath R-19 insulation, the Heating and Cooling points are calculated by multiplying the crawl space floor area by the Multiplier for R-11, and adding that value to the product of the basement floor area times the Multiplier for R-19.)

Point Calculation - Floor/Foundation Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Component Size}}{\text{Component Size}} \times \frac{\text{TARGET Htg. Mult. (Table B.6)}}{\text{Component Size}} = \frac{\quad}{1000} = \quad \quad (\text{B-5a})$$

$$\text{Cooling: } \frac{\text{Component Size}}{\text{Component Size}} \times \frac{\text{TARGET Clg. Mult. (Table B.6)}}{\text{Component Size}} = \frac{\quad}{1000} = \quad \quad (\text{B-5b})$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Component Size}}{\text{Component Size}} \times \frac{\text{DESIGN Htg. Mult. (Table B.7)}}{\text{Component Size}} = \frac{\quad}{1000} = \quad \quad (\text{B-6a})$$

$$\text{Cooling: } \frac{\text{Component Size}}{\text{Component Size}} \times \frac{\text{DESIGN Clg. Mult. (Table B.7)}}{\text{Component Size}} = \frac{\quad}{1000} = \quad \quad (\text{B-6b})$$

Table B.6 TARGET Floor/Foundation Insulation Multipliers

Heating Equipment Type	Slab	Heating Multiplier		
		Crawl Space	Unheated Basement	Heated Basement
Oil	[]	[]	[]	[]
Natural Gas	[]	[]	[]	[]
L. P. Gas	[]	[]	[]	[]
Electric Res.	[]	[]	[]	[]
Elec. Heat Pump	[]	[]	[]	[]

Heating Equipment Type	Slab	Cooling Multiplier		
		Crawl Space	Unheated Basement	Heated Basement
Oil	[]	[]	[]	[]
Natural Gas	[]	[]	[]	[]
L. P. Gas	[]	[]	[]	[]
Electric Res.	[]	[]	[]	[]
Elec. Heat Pump	[]	[]	[]	[]

Table B.7a DESIGN Slab Insulation Multipliers

Insulation at least 2 feet deep:

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-0	R-5	[]	[]
R-5	R-10	[]	[]
R-10	---	[]	[]

Insulation to depth of footing:

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-0	R-5	[]	[]
R-5	R-10	[]	[]
R-10	---	[]	[]

Table B.7b DESIGN Floor-Over-Crawlspace Insulation Multipliers

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-0	R-11	[]	[]
R-11	R-19	[]	[]
R-19	R-30	[]	[]
R-30	R-38	[]	[]
R-38	R-49	[]	[]
R-49	--	[]	[]

Table B.7c DESIGN Floor-Over-Unheated-Basement Insulation Multipliers

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-0	R-11	[]	[]
R-11	R-19	[]	[]
R-19	R-30	[]	[]
R-30	R-38	[]	[]
R-38	R-49	[]	[]
R-49	--	[]	[]

Table B.7d DESIGN Basement Wall Insulation Multipliers

Insulation at least 4 feet deep:

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-0	R-5	[]	[]
R-5	R-10	[]	[]
R-10	---	[]	[]

Insulation at least 8 feet deep:

<u>At least</u>	<u>R-value but less than</u>	<u>Multiplier</u>	
		<u>Heating</u>	<u>Cooling</u>
R-0	R-5	[]	[]
R-5	R-10	[]	[]
R-10	---	[]	[]

B.5 Air Infiltration Points Computation

To calculate the points for the air infiltration reduction strategies, follow the steps described below:

- 1) Enter the total floor area of the design home under the four "Floor Area" entries. All four entries shall be equal.
- 2) Based on the primary heating equipment type selected, obtain the heating multiplier for the target home from Table B.8. Place this value in the "Target Heating Multiplier" entry and multiply by the floor area. To determine the "Target Points: Heating" divide by 1000.
- 3) Obtain the cooling multiplier for the target home from Table B.8. Place this value in the "Target Cooling Multiplier" entry and multiply by the floor area. To determine the "Target Points: Cooling" divide by 1000.
- 4) Enter the heating multiplier (from Table B.9 for the infiltration level as defined in 5.2.5 for the design) in the "Design Heating Multiplier" entry and multiply by the floor area. To determine the "Design Points: Heating" divide by 1000.
- 5) Enter the cooling multiplier (from Table B.9 for the infiltration level as defined in 5.2.5 for the design) in the "Design Cooling Multiplier" entry and multiply by the floor area. To determine the "Design Points: Cooling" divide by 1000.
- 6) Insert these values in the appropriate boxes in Table B.1.

Point Calculation - Air Infiltration

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{TARGET Htg. Mult. (Table B.8)}}{\text{Htg. Mult. (Table B.8)}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-7a})$$

$$\text{Cooling: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{TARGET Clg. Mult. (Table B.8)}}{\text{Clg. Mult. (Table B.8)}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-7b})$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{DESIGN Htg. Mult. (Table B.9)}}{\text{Htg. Mult. (Table B.9)}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-8a})$$

$$\text{Cooling: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{DESIGN Clg. Mult. (Table B.9)}}{\text{Clg. Mult. (Table B.9)}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-8b})$$

Table B.8 TARGET Infiltration Multipliers

Heating Equipment Type	Multiplier	
	Heating	Cooling
Oil	[]	[]
Natural Gas	[]	[]
L. P. Gas	[]	[]
Electric Res.	[]	[]
Elec. Heat Pump	[]	[]

Table B.9 DESIGN Air Infiltration Multipliers

Infiltration Package*	Multiplier	
	Heating	Cooling
Average	[]	[]
Tight	[]	[]

*(see Section 5.2.5 of Standard)

B.6 Fenestration Layers and Sash Material Points Computation

To estimate the fenestration layer and sash material points, follow the steps described below:

- 1) Enter the floor area of the design under the Target Floor Area entries and the total window area of the design home under the two "Window Area" entries.
- 2) Based on the primary heating equipment type selected, obtain the heating multiplier for the target home from Table B.10. Place this value in the "Target Heating Multiplier" entry and multiply by the floor area. To Determine the "Target Points: Heating" divide by 1000.
- 3) Obtain the cooling multiplier for the target home from Table B.10. Place this value in the "Target Cooling Multiplier" entry and multiply by the floor area. To Determine the "Target Points: Cooling" divide by 1000.
- 4) Enter the heating multiplier (from Table B.11 for the fenestration type of the design) in the "Design Heating Multiplier" entry and multiply by the window area. To determine the "Design Points: Heating" divide by 1000.
- 5) Enter the cooling multiplier (from Table B.11 for the fenestration type of the design) in the "Design Cooling Multiplier" entry and multiply by the window area. To determine the "Design Points: Cooling" divide by 1000.
- 6) Insert these values in the appropriate boxes in Table B.1 (see Note 3).

Note 4: If more than one type of glazing is used in the Design home, then equations B-10a and B-10b should be repeated for each glazing type using the appropriate values from Table B.11. The Design Points for each glazing area are summed to obtain the Design Heating Points and Design Cooling Points. These total points values are entered in the appropriate boxes on Table B.1. (For example, if part of the glazing area is double pane with a thermal break, and part is single pane, the Heating and Cooling points are calculated by multiplying the double pane area by the Double_TB option multiplier, and adding that value to the product of the single glazed area and the Multiplier for the single glazed option.

Point Calculation - Glazing Layers and Sash Material

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{TARGET Htg. Mult. (Table B.10)}}{\text{Floor Area}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-9a})$$

$$\text{Cooling: } \frac{\text{Floor Area}}{\text{Floor Area}} \times \frac{\text{TARGET Clg. Mult. (Table B.10)}}{\text{Floor Area}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-9b})$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{\text{Window Area}}{\text{Window Area}} \times \frac{\text{DESIGN Htg. Mult. (Table B.11)}}{\text{Window Area}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-10a})$$

$$\text{Cooling: } \frac{\text{Window Area}}{\text{Window Area}} \times \frac{\text{DESIGN Clg. Mult. (Table B.11)}}{\text{Window Area}} = \frac{\quad}{1000} = \quad \quad \quad (\text{B-10b})$$

Table B.10 TARGET Glazing Layers and Sash Multipliers

<u>Heating Equipment Type</u>	<u>Multiplier</u>	
	<u>Heating</u>	<u>Cooling</u>
Oil	[]	[]
Natural Gas	[]	[]
L. P. Gas	[]	[]
Electric Res.	[]	[]
Elec. Heat Pump	[]	[]

Table B.11 DESIGN Glazing Layers and Sash Multipliers

<u>Glazing Type</u>	<u>Multiplier</u>	
	<u>Heating</u>	<u>Cooling</u>
Single_w/o_Thermal_Break	[]	[]
Single_Thermal_Break	[]	[]
Single_Heat_abs	[]	[]
Double_w/o_Thermal_Break	[]	[]
Double_Thermal_Break	[]	[]
Double_Heat_abs	[]	[]
Triple_w/o_Thermal_Break	[]	[]
Triple_Thermal_Break	[]	[]
Triple_Heat_abs	[]	[]
Double_Low-E	[]	[]
Double_Low-E_sun	[]	[]
Triple_Low-E	[]	[]

B.7 Glazing Area and Orientation Point Computation

To estimate the glazing area and orientation points, follow the steps described below:

- 1) Determine from Table B.12 the TARGET Heating and Cooling Points that correspond to the floor area of the design. Insert these values in the appropriate boxes in Table B.1.
- 2) Estimate the total glazed area (including all windows and doors) on each orientation of the design house. (Glazing facing within 22.5° of an orientation is assumed to be facing that orientation.) Enter these areas under the glazing area entries for the appropriate orientations on both the Point Calculation Heating and Cooling worksheets.
- 3) For the proposed glazing type, enter the heating energy option multiplier (Table B.13) for each orientation. Obtain for each orientation the overhang multiplier (Table B.14) and enter in the appropriate spaces on the worksheet. Multiply these values and the component area together and divide the result by 100 to find the Fenestration Factor (F) for each orientation. Add the individual Fenestration Factors together to find the "Total HEATING Fenestration Factor".
- 4) For the proposed glazing type, enter the cooling energy option multiplier (Table B.13) for each orientation. Obtain for each orientation the overhang multiplier (Table B.14) and enter in the appropriate spaces on the worksheet. Multiply these values and the component area together and divide the result by 100 to find the Fenestration Factor (F) for each orientation. Add the individual

Fenestration Factors together to find the "Total Energy COOLING Fenestration Factor".

- 5) From Table B.15, identify the range that includes the calculated Total HEATING Fenestration Factor (F). Read across to obtain "DESIGN POINTS: HEATING" and enter this value in the appropriate box in Table B.1.
- 6) From Table B.15, identify the range that includes the calculated Total COOLING Fenestration Factor (F). Read across to obtain "DESIGN POINTS: COOLING" and enter this value in the appropriate box in Table B.1.

TARGET Point Calculation - Fenestration Area and Orientation

TARGET HOME:

TARGET POINTS

Heating: (B-11a)
 Floor
 Area (Table B.12)

Cooling: (B-11b)
 Floor
 Area (Table B.12)

Table B.12 TARGET Fenestration Area and Orientation Points

Heated Floor Area (sf)	Points									
	Gas Furnace		Oil Furnace		LPG Furnace		Electric Furnace		Heat Pump	
	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling
Less than 500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
500 to 750	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
750 to 1000	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
1000 to 1250	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
1250 to 1500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
1500 to 1750	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
1750 to 2000	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
2000 to 2250	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
2250 to 2500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
2500 to 2750	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
2750 to 3000	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
3000 to 3250	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
3250 to 3500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
3500 to 3750	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
3750 to 4000	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
4000 to 4250	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
4250 to 4500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
4500 to 4750	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
4750 to 5000	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
5000 to 5250	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
5250 to 5500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]
Greater than 5500	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]

DESIGN Point Calculation - Fenestration Area and Orientation

DESIGN HOME: HEATING CALCULATION

Orientation	Glazing Area	Energy Option Multiplier (Table B.13)	Overhang Multiplier (Table B.14)	Fenestration Factor (F)
North	_____ x _____	_____ x _____	/ 100 = _____	_____
Northwest	_____ x _____	_____ x _____	/ 100 = _____	_____
East	_____ x _____	_____ x _____	/ 100 = _____	_____
Southeast	_____ x _____	_____ x _____	/ 100 = _____	_____
South	_____ x _____	_____ x _____	/ 100 = _____	_____
Southwest	_____ x _____	_____ x _____	/ 100 = _____	_____
West	_____ x _____	_____ x _____	/ 100 = _____	_____
Northwest	_____ x _____	_____ x _____	/ 100 = _____	_____
+				
Total HEATING Fenestration Factor (F)				_____
DESIGN POINTS:				_____ (B-12a)
				(Table B.15)

DESIGN HOME: COOLING CALCULATION

Orientation	Glazing Area	Energy Option Multiplier (Table B.13)	Overhang Multiplier (Table B.14)	Fenestration Factor (F)
North	_____ x _____	_____ x _____	/ 100 = _____	_____
Northwest	_____ x _____	_____ x _____	/ 100 = _____	_____
East	_____ x _____	_____ x _____	/ 100 = _____	_____
Southeast	_____ x _____	_____ x _____	/ 100 = _____	_____
South	_____ x _____	_____ x _____	/ 100 = _____	_____
Southwest	_____ x _____	_____ x _____	/ 100 = _____	_____
West	_____ x _____	_____ x _____	/ 100 = _____	_____
Northwest	_____ x _____	_____ x _____	/ 100 = _____	_____
+				
Total COOLING Fenestration Factor (F)				_____
DESIGN POINTS:				_____ (B-12b)
				(Table B.15)

Table B.13 DESIGN Fenestration Area and Orientation Multipliers

Orientation	Shading Coefficient					
	1.0 to 0.8		0.79 to 0.5		less than 0.5	
	Heat	Cool	Heat	Cool	Heat	Cool
North	[]	[]	[]	[]	[]	[]
NorthEast	[]	[]	[]	[]	[]	[]
East	[]	[]	[]	[]	[]	[]
SouthEast	[]	[]	[]	[]	[]	[]
South	[]	[]	[]	[]	[]	[]
SouthWest	[]	[]	[]	[]	[]	[]
West	[]	[]	[]	[]	[]	[]
NorthWest	[]	[]	[]	[]	[]	[]

Typical Shading Coefficients:

Single_w/o_Thermal_Break	[]
Single_Thermal_Break	[]
Single_Heat_abs	[]
Double_w/o_Thermal_Break	[]
Double_Thermal_Break	[]
Double_Heat_abs	[]
Triple_w/o_Thermal_Break	[]
Triple_Thermal_Break	[]
Triple_Heat_abs	[]
Double_Low-E	[]
Double_Low-E_sun	[]
Triple_Low-E	[]

Table B.14 DESIGN Overhang Multipliers

	Overhang Ratio (L/H)			
	0.000 to 0.548	0.549 to 0.999	1.0 to 1.999	2.0 and above
<u>Heating</u>				
North	[]	[]	[]	[]
NorthEast	[]	[]	[]	[]
East	[]	[]	[]	[]
SouthEast	[]	[]	[]	[]
South	[]	[]	[]	[]
SouthWest	[]	[]	[]	[]
West	[]	[]	[]	[]
NorthWest	[]	[]	[]	[]
<u>Cooling</u>				
North	[]	[]	[]	[]
NorthEast	[]	[]	[]	[]
East	[]	[]	[]	[]
SouthEast	[]	[]	[]	[]
South	[]	[]	[]	[]
SouthWest	[]	[]	[]	[]
West	[]	[]	[]	[]
NorthWest	[]	[]	[]	[]

Table B.15 DESIGN Fenestration Area and Orientation Points

<u>Heating F-Factor*</u>	<u>Heating Points</u>	<u>Cooling F-Factor*</u>	<u>Cooling Points</u>
Less than 20	[]	Less than 9	[]
20 to 40	[]	9 to 18	[]
40 to 60	[]	18 to 27	[]
60 to 80	[]	27 to 36	[]
80 to 100	[]	36 to 45	[]
100 to 120	[]	45 to 54	[]
120 to 140	[]	54 to 63	[]
140 to 160	[]	63 to 72	[]
160 to 180	[]	72 to 81	[]
180 to 200	[]	81 to 90	[]
200 to 220	[]	90 to 99	[]
220 to 240	[]	99 to 108	[]
240 to 260	[]	108 to 117	[]
260 to 280	[]	117 to 126	[]
280 to 300	[]	126 to 135	[]
300 to 320	[]	135 to 144	[]
320 to 340	[]	144 to 153	[]
340 to 360	[]	153 to 162	[]
360 to 380	[]	162 to 171	[]
380 to 400	[]	171 to 180	[]
400 to 420	[]	180 to 189	[]
420 to 440	[]	189 to 198	[]
440 to 460	[]	198 to 207	[]
460 to 480	[]	207 to 216	[]
480 to 500	[]	216 to 225	[]
500 to 520	[]	225 to 234	[]
520 to 540	[]	234 to 243	[]
540 to 560	[]	243 to 252	[]
560 to 580	[]	252 to 261	[]
580 to 600	[]	261 to 270	[]
Greater than 600	[]	Greater than 270	[]

* Use Heating F-Factor from equation B-13a. Use Cooling F-Factor from equation B-13b.

B.8 Base Point Computation

To estimate the Base Points, follow the steps described below:

- 1) Enter the floor area of the home under the two "Floor Area" entries.
- 2) Multiply the "Floor Area" by the "Heating Multiplier" for the appropriate foundation type (see Table B.16) and divide by 1000 to determine the Base Heating Points. Enter this value in Table B.1 under the Heating column for the Base Points for both the Target and Design Homes.

- 3) Multiply the "Floor Area" by the "Cooling Multiplier" for the appropriate foundation type (see Table B.16) and divide by 1000 to determine the Base Cooling Points. Enter this value in Table B.1 under the Cooling column for the Base Points for both the Target and Design Homes.

Note: If the Base Load Multiplier is negative, the TOTAL POINTS should also be negative.

Point Calculation - Base Load

				<u>TOTAL POINTS</u>				
Heating:	<div style="border-bottom: 1px solid black; width: 100px; margin: 0 auto;"></div> Floor Area	x	<div style="border: 1px solid black; width: 50px; height: 20px; margin: 0 auto;"></div> Heating Multiplier (Table B.16)	=	<div style="border-bottom: 1px solid black; width: 100px; margin: 0 auto;"></div> /1000	=	<div style="border-bottom: 1px solid black; width: 100px; margin: 0 auto;"></div>	(B-13a)
Cooling:	<div style="border-bottom: 1px solid black; width: 100px; margin: 0 auto;"></div> Floor Area	x	<div style="border: 1px solid black; width: 50px; height: 20px; margin: 0 auto;"></div> Cooling Multiplier (Table B.16)	=	<div style="border-bottom: 1px solid black; width: 100px; margin: 0 auto;"></div> /1000	=	<div style="border-bottom: 1px solid black; width: 100px; margin: 0 auto;"></div>	(B-13b)

Table B.16 TARGET and DESIGN Base Load Multipliers

<u>Foundation Type</u>	<u>Multiplier</u>	
	<u>Heating</u>	<u>Cooling</u>
Slab	[]	[]
Crawlspace	[]	[]
Unheated Basement	[]	[]
Heated Basement	[]	[]

B.9 HVAC Equipment and System Efficiency Point Computation

Equipment using different energy types can be specified for heating and cooling. Points for both the Design and Target homes shall be computed assuming the same combination of equipment types, although efficiencies may be varied.

To estimate the points for the space heating and cooling system, follow the steps described below:

- 1) Obtain the TARGET Heating Points from Table B.17 corresponding to the heating equipment to be used in the DESIGN. Divide the TARGET HVAC Heating Equipment Multiplier by the TARGET Heating Efficiency Indicator to obtain the TARGET HVAC Heating Factor. Enter the TARGET HVAC Heating Points in the appropriate space on Table B.1.

- 2) Select the type of heating equipment and distribution system to be used in the DESIGN. For this equipment configuration, obtain the HVAC Heating Equipment Multiplier from Table B.18 and enter it in the appropriate space for the DESIGN.
- 3) Obtain the DESIGN Heating Efficiency Indicator for the equipment to be used. The efficiency indicator is provided in manufacturers' literature in units listed below:

<u>Heating Equipment</u>	<u>Efficiency Indicator</u>
Natural Gas Furnace or Boiler	Annual Fuel Utilization Efficiency (AFUE)
LP-Gas Furnace or Boiler	Annual Fuel Utilization Efficiency (AFUE)
Oil Furnace or Boiler	Annual Fuel Utilization Efficiency (AFUE)
Electric Resistance	Seasonal Efficiency
Heat Pump	Heating Seasonal Performance Factor (HSPF)

Insert the DESIGN Heating Efficiency Indicator in the appropriate space. Divide the DESIGN HVAC Heating Equipment Multiplier by the DESIGN Heating Efficiency Indicator to obtain the DESIGN HVAC Heating Points. Enter the DESIGN HVAC Heating Points in the appropriate space on Table B.1.

If a cooling system is to provide in the DESIGN home, follow steps 4 through 6 below. If cooling is not provided, calculations of TARGET and DESIGN Cooling Points are not required.

- 4) Obtain the TARGET Cooling Points from Table B.18 corresponding to the cooling equipment to be used in the DESIGN. Enter the TARGET HVAC Cooling Points in the appropriate space on Table B.1.
- 5) Select the type of cooling equipment and distribution system to be used in the DESIGN. For this equipment configuration, obtain the HVAC Cooling Equipment Multiplier from Table B.18 and enter it in the appropriate space for the DESIGN.
- 6) Obtain the DESIGN Cooling Efficiency Indicator for the equipment to be used. The efficiency indicator is provided in manufacturers' literature in units listed below:

Cooling EquipmentEfficiency Indicator

Heat Pump

Seasonal Energy Efficiency
Ratio (SEER)Central Air
ConditionerSeasonal Energy Efficiency
Ratio (SEER)

Insert the DESIGN Cooling Efficiency Indicator in the appropriate space. Divide the DESIGN HVAC Cooling Equipment Multiplier by the DESIGN Cooling Efficiency Indicator to obtain the DESIGN HVAC Cooling Points. Enter the DESIGN HVAC Cooling Points in the appropriate space on Table B.1.

Point Calculation - Mechanical Equipment

TARGET HOME:TARGET POINTS

Heating: _____ (B-14a)
(Table B.17)

Cooling: _____ (B-14a)
(Table B.17)

DESIGN HOME:

Heating: _____ ÷ _____ = _____ (B-15b)
Equipment Efficiency
Multiplier Indicator
(Table B.18)

Cooling: _____ ÷ _____ = _____ (B-15b)
Equipment Efficiency
Multiplier Indicator
(Table B.18)

Table B.17 TARGET HVAC Equipment Points

Heating Equipment Type	Heating	Cooling
Oil	[]	[]
Natural Gas	[]	[]
L. P. Gas	[]	[]
Electric Res.	[]	[]
Elec. Heat Pump	[]	[]

Table B.18 DESIGN HVAC Equipment Multipliers

	Heating Equipment Type					Cooling Equipment Type
	Gas	Oil	LPG	Elec. Res.	Heat Pump (Heating)	DX, Heat Pump (Cooling)
Ducted	[]	[]	[]	[]	[]	[]
Hydronic	[]	[]	[]	[]	[]	[]
Baseboard	--	--	--	[]	--	--

B.10 Domestic Hot Water Point Calculation

If the DESIGN has a nonsolar domestic hot water system, follow the procedure in B.10.1. If a solar assisted hot water system is to be used, follow the procedure in B.10.2.

B.10.1 Nonsolar Domestic Hot Water Systems

- Obtain the DHW TARGET POINTS from the entry in Table B.19 corresponding to the water heating fuel to be used in the DESIGN. Enter this number in the appropriate space on Table B.1.
- Obtain the DESIGN DHW Factor from the entry in Table B.20 corresponding to the water heating fuel to be used in the DESIGN.
- Obtain the DESIGN Energy Factor of the proposed water heater. The Energy Factor is available in manufacturers' literature or in the GAMA directory.
- Divide the DESIGN DHW Factor by the DESIGN Energy Factor to obtain the DHW DESIGN POINTS. Enter this number in the appropriate space on Table B.1.

Point Calculation - Nonsolar Domestic Hot Water

TARGET HOME:

TARGET POINTS

$$\frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} = \frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} \quad (\text{B-16a})$$

DESIGN HOME:

DESIGN POINTS

$$\frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} \div \frac{\text{Energy Factor}}{\text{Energy Factor}} = \frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} \quad (\text{B-16b})$$

Point Calculation - Solar Domestic Water Heating

TARGET HOME:

TARGET POINTS

$$\frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} = \frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} \quad (\text{B-17a})$$

DESIGN HOME:

DESIGN POINTS

$$\frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} \div \frac{\text{Energy Factor}}{\text{Energy Factor}} = \frac{\text{DHW Factor (Table B.20)}}{\text{Energy Factor}} \quad (\text{B-17b})$$

Table B.19 TARGET Domestic Hot Water Points

<u>Water Heating Fuel</u>	<u>TARGET POINTS</u>
Oil	[]
Gas	[]
LPG	[]
Electric	[]

Table B.20 DESIGN Domestic Hot Water Factor

<u>Water Heating Fuel</u>	<u>DESIGN DHW FACTOR</u>
Oil	[]
Gas	[]
LPG	[]
Electric	[]

B.10.2 Solar Domestic Hot Water Systems

- a) Obtain the DHW TARGET POINTS from the entry in Table B.21 corresponding to the **space heating** fuel to be used in the DESIGN. Enter this number in the appropriate space on Table B.1.

- b) Determine the type of solar collector to be used in the DESIGN. Options available in the point system are:

One- and two-panel active systems;
 One- and two-panel passive thermosyphon systems;
 One- and two-panel passive integral (batch) systems.

A panel is defined as a collector having at least 20 ft² of solar aperture.

- c) Obtain the DHW DESIGN POINTS from the appropriate column of Table B.21, using the entry corresponding to the **space heating** fuel to be used in the DESIGN. Enter this number in the appropriate space in Table B.1.

Table B.21 TARGET and DESIGN Solar Domestic Hot Water Points

<u>Space Heating Fuel</u>	<u>TARGET POINTS</u>	<u>DESIGN POINTS</u>					
		<u>Active</u>		<u>Integral</u>		<u>Thermosyphon</u>	
		<u>1-Panel</u>	<u>2-Panel</u>	<u>1-Panel</u>	<u>2-Panel</u>	<u>1-Panel</u>	<u>2-Panel</u>
Oil	[]	[]	[]	[]	[]	[]	[]
Gas	[]	[]	[]	[]	[]	[]	[]
LPG	[]	[]	[]	[]	[]	[]	[]
Electric	[]	[]	[]	[]	[]	[]	[]

APPENDIX C

REFERENCES

APPENDIX C - REFERENCES

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11. Simplified Energy Analysis Using the Modified Bin Method, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., 1983.

APPENDIX D
SAMPLE POINTS COMPLIANCE ANALYSIS

APPENDIX D - SAMPLE POINTS COMPLIANCE ANALYSIS

This appendix contains a worked example of the point system. ARES was run for a single family detached house in South Bend, Indiana, with oil space heating and direct expansion cooling. The house was assumed to be a two-story, center-hall home with the following characteristics:

Floor Area:	2504 sq. ft.
Ceiling Area:	1224 sq. ft.
Opaque Wall Area:	2088 sq. ft.
Fenestration Area	
Total:	248 sq. ft.
North:	50 sq. ft.
East:	120 sq. ft.
South:	25 sq. ft.
West:	53 sq. ft.
Foundation Type:	Unheated Basement
Basement Floor Area:	1280 sq. ft.

All page numbers that follow refer to Section 7 of this Volume.

ARES version 1.1

Point System (Section 7)

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

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Table 7.2 TARGET Ceiling Insulation Multipliers

Housing Type: Single Family Detached
 Jurisdiction: Volume 4 Example

Heating Equipment Type	Multiplier	
	Heating	Cooling
Oil	51	6
Natural Gas	N/A	N/A
L. P. Gas	N/A	N/A
Electric Res.	N/A	N/A
Elec. Heat Pump	N/A	N/A

Table 7.3 DESIGN Ceiling Insulation Multipliers

Housing Type: Single Family Detached
 Jurisdiction: Volume 4 Example

R-value		Multiplier	
At least	but less than	Heating	Cooling
-----	-----	-----	-----
R-11	R-19	112	13
R-19	R-30	79	9
R-30	R-38	51	6
R-38	R-49	40	5
R-49	R-60	32	4
R-60	--	27	3

Table 7.4 TARGET Wall Insulation Multipliers

Housing Type: Single Family Detached
 Jurisdiction: Volume 4 Example

Heating Equipment Type	Multiplier	
	Heating	Cooling
Oil	78	5
Natural Gas	N/A	N/A
L. P. Gas	N/A	N/A
Electric Res.	N/A	N/A
Elec. Heat Pump	N/A	N/A

Table 7.5a DESIGN Frame Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

R-value		Multiplier	
At least	but less than	Heating	Cooling
-----	-----	-----	-----
R-11	R-13	140	8
R-13	R-19	120	7
R-19	R-23	96	6
R-23	R-26	78	5
R-26	--	68	4

Table 7.5b DESIGN Mass Wall Insulation Multipliers
Medium Weight (40 to 110 lb/sf)

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

R-value		Multiplier	
At least	but less than	Heating	Cooling
-----	-----	-----	-----
R-0_Medium_Wt	R-5_Medium_Wt	422	17
R-5_Medium_Wt	R-10_Medium_Wt	199	7
R-10_Medium_Wt	R-15_Medium_Wt	118	4
R-15_Medium_Wt	R-30_Medium_Wt	84	3
R-30_Medium_Wt	--	44	1

Table 7.5c DESIGN Mass Wall Insulation Multipliers
Heavy Weight (greater than 110 lb/sf)

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

R-value		Multiplier	
At least	but less than	Heating	Cooling
-----	-----	-----	-----
R-0_Heavy_Wt	R-5_Heavy_Wt	419	14
R-5_Heavy_Wt	R-10_Heavy_Wt	197	5
R-10_Heavy_Wt	R-15_Heavy_Wt	117	2
R-15_Heavy_Wt	R-30_Heavy_Wt	83	1
R-30_Heavy_Wt	--	43	0

Table 7.5d DESIGN Solid Wood (Log) Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Nominal Thickness (inches)		Multiplier	
At least	but less than	Heating	Cooling
-----	-----	-----	-----
6_inch_Log	8_inch_Log	179	11
8_inch_Log	10_inch_Log	138	9
10_inch_Log	12_inch_Log	112	8
12_inch_Log	--	95	7

 Table 7.6 TARGET Floor/Foundation Insulation Multipliers

Housing Type: Single Family Detached

Jurisdiction: Volume 4 Example

Heating Equipment Type	Slab	Heating Multiplier		
		Crawl Space	Unheated Basement	Heated Basement
-----	----	-----	-----	-----
Oil	N/A	N/A	27	N/A
Natural Gas	N/A	N/A	N/A	N/A
L. P. Gas	N/A	N/A	N/A	N/A
Electric Res.	N/A	N/A	N/A	N/A
Elec. Heat Pump	N/A	N/A	N/A	N/A

Heating Equipment Type	Slab	Cooling Multiplier		
		Crawl Space	Unheated Basement	Heated Basement
-----	----	-----	-----	-----
Oil	N/A	N/A	14	N/A
Natural Gas	N/A	N/A	N/A	N/A
L. P. Gas	N/A	N/A	N/A	N/A
Electric Res.	N/A	N/A	N/A	N/A
Elec. Heat Pump	N/A	N/A	N/A	N/A

Table 7.7a DESIGN Slab Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Not Included

Table 7.7b DESIGN Floor-Over-Crawlspace Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Not Included

Table 7.7c DESIGN Floor-Over-Unheated-Basement Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

R-value		Multiplier	
At least	but less than	Heating	Cooling
-----	-----	-----	-----
R-0	R-11	154	2
R-11	R-13	39	13
R-13	R-19	27	14
R-19	R-30	15	15
R-30	--	0	16

Table 7.7d DESIGN Basement Wall Insulation Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Not Included

Table 7.8 TARGET Air Infiltration Multipliers

Housing Type: Single Family Detached
 Jurisdiction: Volume 4 Example

Heating Equipment Type	Heating	Multiplier Cooling
-----	-----	-----
Oil	215	9
Natural Gas	N/A	N/A
L. P. Gas	N/A	N/A
Electric Res.	N/A	N/A
Elec. Heat Pump	N/A	N/A

Table 7.9 DESIGN Air Infiltration Multipliers

Housing Type: Single Family Detached
 Jurisdiction: Volume 4 Example

	Multiplier	
Infiltration Package *	Heating	Cooling
	-----	-----
Normal	215	9
Tight	153	6

*(see Section 5.2.5 of Standard)

Table 7.10 TARGET Glazing Layers and Sash Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Heating Equipment Type	Multiplier	
	Heating	Cooling
Oil	56	1
Natural Gas	N/A	N/A
L. P. Gas	N/A	N/A
Electric Res.	N/A	N/A
Elec. Heat Pump	N/A	N/A

Table 7.11 DESIGN Glazing Layers and Sash Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Glazing Type	Multiplier	
	Heating	Cooling
Single_w/o_TB	1673	19
Double_w/o_TB	910	10
Double_TB	690	8
Triple_TB	543	6
Single_Heat_abs	1673	19
Double_Heat_abs	910	10
Triple_Heat_abs	690	8
Double_Low-E	469	5
Triple_Low-E	367	4

Table 7.12 TARGET Fenestration Area and Orientation Points

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Heated Floor Area (sf)	Points	
	Oil Furnace Heating	Cooling
Less than 500	30	15
500 to 750	44	22
750 to 1000	58	30
1000 to 1250	72	38
1250 to 1500	85	46
1500 to 1750	98	55
1750 to 2000	111	63
2000 to 2250	123	72
2250 to 2500	135	81
2500 to 2750	146	91
2750 to 3000	157	100
3000 to 3250	168	110
3250 to 3500	178	120
3500 to 3750	188	130
3750 to 4000	197	140
4000 to 4250	206	151
4250 to 4500	215	162
4500 to 4750	224	173
4750 to 5000	232	184
5000 to 5250	239	195
5250 to 5500	246	207
Greater than 5500	246	207

 Table 7.13 DESIGN Fenestration Area and Orientation Multipliers

Housing Type: Single Family Detached
 Jurisdiction: Volume 4 Example

Orientation	Shading Coefficient					
	1.0 to 0.8		0.79 to 0.5		less than 0.5	
	Heat	Cool	Heat	Cool	Heat	Cool
North	38	18	30	14	18	9
Northeast	56	25	44	19	28	12
East	75	32	59	25	37	16
Southeast	107	30	85	24	52	15
South	139	28	110	22	68	14
Southwest	104	31	82	25	51	15
West	69	35	55	27	34	17
Northwest	53	26	42	21	26	13
Northwest	53	26	42	21	26	13

Typical Shading Coefficients:

Single_w/o_TB	1.000
Double_w/o_TB	0.880
Double_TB	0.880
Triple_TB	0.740
Single_Heat_abs	0.750
Double_Heat_abs	0.660
Triple_Heat_abs	0.560
Double_Low-E	0.710
Triple_Low-E	0.600

Table 7.14 DESIGN Overhang Multipliers

Jurisdiction: Volume 4 Example

	Overhang Ratio (L/H)			
	0.000 to 0.548	0.549 to 0.999	1.0 to 1.999	2.0 and above
Heating				
North	10	10	10	10
NorthEast	10	10	9	9
East	11	9	8	6
SouthEast	11	9	7	4
South	12	8	6	3
SouthWest	11	9	7	4
West	11	9	8	6
NorthWest	10	10	9	9
Cooling				
North	10	10	10	9
NorthEast	11	9	8	7
East	12	9	7	6
SouthEast	12	8	7	6
South	13	8	7	7
SouthWest	12	8	7	6
West	12	9	7	6
NorthWest	11	9	8	7

Table 7.15 DESIGN Glazing Area and Orientation Points

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Heating F-Factor	Heating Points	Cooling F-Factor	Cooling Points
-----	-----	-----	-----
Less than 270	28	Less than 60	6
270 to 540	56	60 to 120	12
540 to 810	86	120 to 180	19
810 to 1080	117	180 to 240	25
1080 to 1350	150	240 to 300	32
1350 to 1620	183	300 to 360	39
1620 to 1890	218	360 to 420	46
1890 to 2160	253	420 to 480	53
2160 to 2430	290	480 to 540	60
2430 to 2700	328	540 to 600	68
2700 to 2970	368	600 to 660	75
2970 to 3240	408	660 to 720	83
3240 to 3510	450	720 to 780	91
3510 to 3780	493	780 to 840	99
3780 to 4050	537	840 to 900	107
4050 to 4320	582	900 to 960	116
4320 to 4590	628	960 to 1020	124
4590 to 4860	676	1020 to 1080	133
4860 to 5130	724	1080 to 1140	142
5130 to 5400	774	1140 to 1200	151
5400 to 5670	825	1200 to 1260	160
5670 to 5940	877	1260 to 1320	169
5940 to 6210	930	1320 to 1380	179
6210 to 6480	985	1380 to 1440	188
6480 to 6750	1041	1440 to 1500	198
6750 to 7020	1097	1500 to 1560	208
7020 to 7290	1155	1560 to 1620	218
7290 to 7560	1215	1620 to 1680	228
7560 to 7830	1275	1680 to 1740	238
7830 to 8100	1336	1740 to 1800	249
8100 to 8370	1399	1800 to 1860	260
8370 to 8640	1463	1860 to 1920	270
8640 to 8910	1528	1920 to 1980	281
8910 to 9180	1594	1980 to 2040	293
Greater than 9180	1594	Greater than 2040	293

Table 7.16 TARGET and DESIGN Base Load Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

Foundation Type	Multiplier	
	Heating	Cooling
Crawlspace	N/A	N/A
Unheated Basement	27	-26
Heated Basement	N/A	N/A
Slab	N/A	N/A

Table 7.17 TARGET HVAC Equipment Points

Heating Equipment Type	Heating Multiplier			Cooling Multiplier	
	Ducted	Hydronic	Baseboard	Ducted	Hydronic
Oil	77	76	N/A	60	59
Natural Gas	N/A	N/A	N/A	N/A	N/A
L. P. Gas	N/A	N/A	N/A	N/A	N/A
Electric Res.	N/A	N/A	N/A	N/A	N/A
Heat Pump	N/A	N/A	N/A	N/A	N/A

Table 7.18 TARGET and DESIGN HVAC Equipment Multipliers

Housing Type: Single Family Detached
Jurisdiction: Volume 4 Example

	Heating Equipment Type					Cooling
	Oil	Gas	LPG	Elec. Res.	Heat Pump (Heating)	DX, Heat Pump (Cooling)
Ducted	7344	N/A	N/A	N/A	N/A	598
Hydronic	7194	N/A	N/A	N/A	N/A	586
Baseboard	--	--	--	N/A	--	--

Table 7.19 TARGET Domestic Hot Water Points

Water Heating Fuel	TARGET POINTS
Oil	24553
Gas	17394
LPG	29804
Electric	34149

Table 7.20 DESIGN Domestic Hot Water Factor

Water Heating Fuel	DESIGN DHW FACTOR
-----	-----
Oil	12129
Gas	9462
LPG	16213
Electric	32261

Table 7.21 TARGET and DESIGN Solar Domestic Hot Water Points

Space Heating Fuel	TARGET POINTS	DESIGN POINTS					
		Active		Integral		Thermosyphon	
		1-Panel	2-Panel	1-Panel	2-Panel	1-Panel	2-Panel
Oil	24553	21846	19678	22409	20758	21913	20129
Gas	17394	15283	13591	15721	14434	15335	13943
LPG	29804	26186	23287	26938	24732	26275	23890
Electric	34149	26951	21183	28447	24057	27128	22383

Table 7.1. Point Computation Summary Form

Component	Source Equation	TARGET		DESIGN	
		Heating	Cooling	Heating	Cooling
Ceiling Insulation	7-1,7-2	<u>62</u>	<u>7</u>	<u>62</u>	<u>7</u>
Wall Insulation	7-3,7-4	<u>163</u>	<u>10</u>	<u>251</u>	<u>15</u>
Floor Insulation	7-5,7-6	<u>35</u>	<u>18</u>	<u>35</u>	<u>18</u>
Air Infiltration	7-7,7-8	<u>538</u>	<u>23</u>	<u>383</u>	<u>15</u>
Glazing Layers	7-9,7-10	+ <u>140</u>	+ <u>3</u>	+ <u>226</u>	+ <u>2</u>
SUBTOTAL 1	Note (a)	<u>938</u>	<u>61</u>	<u>957</u>	<u>57</u>
Glazing Orientation	7-11,7-12	- <u>146</u>	+ <u>91</u>	- <u>253</u>	+ <u>107</u>
SUBTOTAL 2	Note (b)	<u>792</u>	<u>152</u>	<u>704</u>	<u>164</u>
Base Points	7-13	* <u>+68</u>	* <u>-65</u>	* <u>+68</u>	* <u>-65</u>
SUBTOTAL 3	Note (c)	<u>860</u>	<u>87</u>	<u>772</u>	<u>99</u>
HVAC Efficiency Heating Cooling	7-14,7-15	x <u>77</u>	x <u>60</u>	x <u>84</u>	x <u>60</u>
TOTAL HEATING AND COOLING POINTS	Note (d)	<u>66220</u>	<u>5220</u>	<u>64848</u>	<u>5940</u>
TOTAL SPACE CONDITIONING POINTS	Note (e)	$\begin{array}{c} \downarrow \quad \quad \downarrow \\ \boxed{71440} \end{array}$		$\begin{array}{c} \downarrow \quad \quad \downarrow \\ \boxed{70788} \end{array}$	
Domestic Hot Water Points	7-16,7-17	+ <u>24553</u>		+ <u>19678</u>	
TOTAL POINTS	Note (f)	<u>95993</u>		<u>90466</u>	

Notes for Table 7.1:

Complies

- a) Sum the points in each column to obtain entries for the four SUBTOTAL 1 boxes.
- b) Subtract the Glazing Layers Heating points and add Glazing Layers Cooling points to obtain entries for the four SUBTOTAL 2 boxes.

- c) Sum the Base Points and SUBTOTAL 2 to obtain SUBTOTAL 3 entries. Note: Some Base Points may be negative. In this case, subtract them from SUBTOTAL 2.
- d) Multiply Heating SUBTOTAL 3 by HVAC Heating Points to obtain TOTAL HEATING POINTS. Multiply Cooling SUBTOTAL 3 by HVAC Cooling Points to obtain TOTAL COOLING POINTS.
- e) Sum TOTAL HEATING and TOTAL COOLING POINTS to obtain TOTAL SPACE CONDITIONING POINTS.
- f) Sum TOTAL SPACE CONDITIONING POINTS and Domestic Hot Water Points to obtain TOTAL POINTS.

7.3 Ceiling Insulation Points Computation

The equations below are provided to determine the number of Ceiling Insulation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Ceiling Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{1224}{\text{Ceiling Area}} \times \frac{51}{\text{TARGET Htg. Mult. (Table 7.2)}} = \frac{62424}{1000} = \underline{62} \quad (7-1a)$$

$$\text{Cooling: } \frac{1224}{\text{Ceiling Area}} \times \frac{6}{\text{TARGET Clg. Mult. (Table 7.2)}} = \frac{7344}{1000} = \underline{7} \quad (7-1b)$$

DESIGN HOME:

DESIGN POINTS

$$\text{Heating: } \frac{1224}{\text{Ceiling Area}} \times \frac{51}{\text{DESIGN Htg. Mult. (Table 7.3)}} = \frac{62424}{1000} = \underline{62} \quad (7-2a)$$

$$\text{Cooling: } \frac{1224}{\text{Ceiling Area}} \times \frac{6}{\text{DESIGN Clg. Mult. (Table 7.3)}} = \frac{7344}{1000} = \underline{7} \quad (7-2b)$$

7.4 Wall Insulation Point Computation

The equations below are provided to determine the number of Wall Insulation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Wall Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{2088}{\text{Wall Area}} \times \frac{78}{\text{TARGET Htg. Mult. (Table 7.4)}} = \frac{162864}{1000} = \underline{163} \quad (7-3a)$$

$$\text{Cooling: } \frac{2088}{\text{Wall Area}} \times \frac{5}{\text{TARGET Clg. Mult. (Table 7.4)}} = \frac{10440}{1000} = \underline{10} \quad (7-3b)$$

DESIGN HOME: (R-13)

DESIGN POINTS

$$\text{Heating: } \frac{2088}{\text{Wall Area}} \times \frac{120}{\text{DESIGN Htg. Mult. (Table 7.5)}} = \frac{250560}{1000} = \underline{251} \quad (7-4a)$$

$$\text{Cooling: } \frac{2088}{\text{Wall Area}} \times \frac{7}{\text{DESIGN Clg. Mult. (Table 7.5)}} = \frac{14616}{1000} = \underline{15} \quad (7-4b)$$

7.5 Floor/Foundation Insulation Point Computation

The equations below are provided to determine the number of Floor/Foundation, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Floor/Foundation Insulation

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{1280}{\text{Component Size*}} \times \frac{27}{\text{TARGET Htg. Mult. (Table 7.6)}} = \frac{34560}{1000} = \underline{35} \quad (7-5a)$$

$$\text{Cooling: } \frac{1280}{\text{Component Size*}} \times \frac{14}{\text{TARGET Clg. Mult. (Table 7.6)}} = \frac{17920}{1000} = \underline{18} \quad (7-5b)$$

DESIGN HOME: (R-13)

DESIGN POINTS

$$\text{Heating: } \frac{1280}{\text{Component Size*}} \times \frac{27}{\text{DESIGN Htg. Mult. (Table 7.7)}} = \frac{34560}{1000} = \underline{35} \quad (7-6a)$$

$$\text{Cooling: } \frac{1280}{\text{Component Size*}} \times \frac{14}{\text{DESIGN Clg. Mult. (Table 7.7)}} = \frac{17920}{1000} = \underline{18} \quad (7-6b)$$

* Enter the area (sqft) for a floor over a crawlspace or unheated basement.
Enter the perimeter length (ft) for slabs and heated basements.

7.6 Air Infiltration Points Computation

The equations below are provided to determine the number of Air Infiltration, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Air Infiltration

TARGET HOME:

TARGET POINTS

$$\text{Heating: } \frac{2504}{\text{Floor Area}} \times \frac{215}{\text{TARGET Htg. Mult. (Table 7.8)}} = \frac{538360}{1000} = \underline{538} \quad (7-7a)$$

$$\text{Cooling: } \frac{2504}{\text{Floor Area}} \times \frac{9}{\text{TARGET Clg. Mult. (Table 7.8)}} = \frac{22536}{1000} = \underline{23} \quad (7-7b)$$

DESIGN HOME: (Tight Package)

DESIGN POINTS

$$\text{Heating: } \frac{2504}{\text{Floor Area}} \times \frac{153}{\text{DESIGN Htg. Mult. (Table 7.9)}} = \frac{383112}{1000} = \underline{383} \quad (7-8a)$$

$$\text{Cooling: } \frac{2504}{\text{Floor Area}} \times \frac{6}{\text{DESIGN Clg. Mult. (Table 7.9)}} = \frac{15024}{1000} = \underline{15} \quad (7-8b)$$

7.7 Fenestration Layers and Sash Material Points Computation

The equations below are provided to determine the number of Fenestration Layers and Sash Material, Target and Design, Heating and Cooling Points. Values for the Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Window Layers and Sash Material

<u>TARGET HOME:</u>		<u>TARGET POINTS</u>
Heating:	$\frac{2504}{\text{Floor Area}} \times \frac{56}{\text{TARGET Htg. Mult. (Table 7.10)}} = \frac{140224}{1000} = 140$	(7-9a)
Cooling:	$\frac{2504}{\text{Floor Area}} \times \frac{1}{\text{TARGET Clg. Mult. (Table 7.10)}} = \frac{2504}{1000} = 3$	(7-9b)

<u>DESIGN HOME:</u>		<u>DESIGN POINTS</u>
Heating:	$\frac{248}{\text{Window Area}} \times \frac{910}{\text{DESIGN Htg. Mult. (Table 7.11)}} = \frac{225680}{1000} = 226$	(7-10a)
Cooling:	$\frac{248}{\text{Window Area}} \times \frac{10}{\text{DESIGN Clg. Mult. (Table 7.11)}} = \frac{2480}{1000} = 2$	(7-10b)

7.8 Glazing Area and Orientation Point Computation

The equations below are provided to determine the number of Glazing Area and Orientation Design Heating and Cooling Points. Values for the Target Heating and Cooling Points, and the Design Multipliers (Option and Overhang) are provided by the ARES Computer Program.

TARGET Point Calculation - Fenestration Area and Orientation

<u>TARGET HOME:</u>	<u>TARGET POINTS</u>
Heating: $\frac{2504}{\text{Floor Area}}$	$\frac{146}{\text{(Table 7.12)}}$ (7-11a)
Cooling: $\frac{2504}{\text{Floor Area}}$	$\frac{91}{\text{(Table 7.12)}}$ (7-11b)

DESIGN Point Calculation - Fenestration Area and Orientation

DESIGN HOME: HEATING CALCULATION

Orientation	Glazing Area	Energy Option Multiplier (Table 7.13)	Overhang Multiplier (Table 7.14)	Fenestration Factor (F)
North	50	38	10	$100 = 190$
Northwest				$100 =$
East	120	75	11	$100 = 990$
Southeast				$100 =$
South	25	139	12	$100 = 414$
Southwest				$100 =$
West	53	69	11	$100 = 402$
Northwest				$100 =$
Total HEATING Fenestration Factor (F)				1999
DESIGN Points:				253 (7-12a)
				(Table 7.16)

DESIGN HOME: COOLING CALCULATION

Orientation	Glazing Area	Energy Option Multiplier (Table 7.13)	Overhang Multiplier (Table 7.14)	Fenestration Factor (F)
North	50	18	10	$100 = 90$
Northwest				$100 =$
East	120	32	12	$100 = 461$
Southeast				$100 =$
South	25	28	13	$100 = 91$
Southwest				$100 =$
West	53	35	12	$100 = 223$
Northwest				$100 =$
Total COOLING Fenestration Factor (F)				865
DESIGN Points:				107 (7-12b)
				(Table 7.15)

7.9 Base Load Computation

The equations below are provided to determine the number of Base Load Heating and Cooling Points. Values for the Heating and Cooling Multipliers are provided by the ARES Computer Program.

Point Calculation - Base Load

$$\text{Heating: } \frac{2504}{\text{Floor Area}} \times \frac{27}{\text{Heating Multiplier (Table 7.16)}} = \frac{67608}{1000} = \frac{68}{\text{TOTAL POINTS}} \quad (7-13a)$$

$$\text{Cooling: } \frac{2504}{\text{Floor Area}} \times \frac{-26}{\text{Cooling Multiplier (Table 7.16)}} = \frac{-65104}{1000} = \frac{-65}{\text{TOTAL POINTS}} \quad (7-13b)$$

7.10 HVAC Equipment and System Efficiency Point Computation

The equations below are provided to determine the number of HVAC Systems, Target and Design, Heating and Cooling Points. Values for Target and Design Multipliers are provided by the ARES Computer Program.

Point Calculation - Mechanical Equipment

$$\text{TARGET HOME:} \quad \text{Heating: } \frac{77}{\text{(Table 7.17)}} = \frac{77}{\text{TARGET POINTS}} \quad (7-14a)$$

$$\text{Cooling: } \frac{60}{\text{(Table 7.17)}} = \frac{60}{\text{TARGET POINTS}} \quad (7-14a)$$

$$\text{DESIGN HOME:} \quad \text{Heating: } \frac{7344}{\text{Equipment Multiplier (Table 7.18)}} \div \frac{88}{\text{Efficiency Indicator}} = \frac{84}{\text{DESIGN POINTS}} \quad (7-15a)$$

$$\text{Cooling: } \frac{598}{\text{Equipment Multiplier (Table 7.18)}} \div \frac{10}{\text{Efficiency Indicator}} = \frac{60}{\text{DESIGN POINTS}} \quad (7-15b)$$

7.11 Domestic Hot Water Point Calculation

Values for the Target DHW Points and Design and Target Points for demonstrating compliance using Solar DHW System, are provided by the ARES Computer Program. The ARES Computer Program is also used to determine the DHW Multiplier in calculating the Design DHW Points.

Point Calculation - Nonsolar Domestic Water Heating

TARGET HOME:

TARGET POINTS

(Table 7.19)

(7-16a)

DESIGN HOME:

DESIGN POINTS

DHW Multiplier
(Table 7.20)

÷

~~Energy Factor~~
$$=$$

(7-16b)

Point Calculation - Solar Domestic Water Heating

TARGET HOME:

TARGET POINTS

24553

(7-17a)

(Table 7.21)

DESIGN HOME:

DESIGN POINTS

19678

(7-17b)

(Table 7.21)

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