LONG TERM SUPER GOOD CENTS
PART I
TECHNICAL SPECIFICATIONS
FOR SITE-BUILT SINGLE AND MULTIFAMILY HOMES
October 1, 2003
TABLE OF CONTENTS

Index to Sections

Chapter		Page
1.	**DESIGN QUALIFICATION AND CERTIFICATION**	43
1.1	General	43
1.2	MCS Reference Path for Electrically Heated Residences	43
1.3	Existing Codes and Regulations	44
1.4	Qualification	44
1.5	Solar Access	45
1.6	Certification	45
1.7	Optional Non-Qualification Measures	45
2.	**THERMAL EFFICIENCY**	46
2.1	Insulation Coverage	46
2.2	Doors and Glazing	47
2.3	Air-Leakage Control	47
2.4	Backdraft Dampers	48
2.5	Recessed Fixtures	48
2.6	Wood Stoves, Fireplaces and Other Combustion Appliances	48
2.7	Electric Water Heaters	49
3	**HEATING SYSTEMS**	50
3.1	General	50
3.2	Control Requirements	50
3.3	HVAC Ducts	51
4.	**MOISTURE AND AIR-QUALITY CONTROL**	54
4.1	Moisture Vapor Transfer	54
4.2	Attic and Crawlspace Ventilation	54
4.3	Mechanical Ventilation	55
4.4	Formaldehyde Reduction Measures	59
Appendix A	Prescriptive Options for Site-Built, Single Family Homes	60

Appendix B Blower Door Test Protocol 61

CHAPTER 1: DESIGN QUALIFICATION AND CERTIFICATION

1.1 **General**: Electrically heated residences meeting the Long-Term Super Good Cents® (LTSGC) requirements meet or exceed the energy efficiency levels specified by the Northwest Power Planning Council in the Model Conservation Standards (MCS) amendment for New Residential and Commercial Construction, published April 1991. These requirements are listed in section 1.2.

Both the Northwest Conservation and Electric Power Plan and the MCS amendment are available from the Northwest Power Planning Council, 851 SW. 6th, Suite 1100, Portland, Oregon 97204, Telephone (503) 222-5161:

1.2 MCS Reference Path for Electrically Heated Residences:

COMPONENT		Zone 1	Zone 2	Zone 3
		(< 6000 HDD)	(6-7500 HDD)	(> 7500 HDD)
Ceilings 1/	Attic	R-49 Adv.	R-49 Adv.	R-49 Adv.
	Vaults	R-38	R-38	R-38
Walls 1/	Above Grade	R-26 Adv.	R-26 Adv.	R-26 Adv.
	Below Grade Interior with R-5 thermal break 4/	R-21	R-21	R-21
Floors	Over Crawlspaces and Unheated Basements	R-30	R-30	R-38
	Slab-on-Grade Perimeter	R-15	R-15	R-15
Glazing 3/	Maximum tested U-value Reference Area (% of Floor)	U-0.35	U-0.35	U-0.35
	Single Family	15%	15%	15%
	Multifamily	12%	12%	12%
Exterior Doors		U-0.19	U-0.19	U-0.19
Assumed Infiltration Rate 2/ (ACH)		0.35	0.35	0.35
Duct Insulation	Rigid	R-11	R-11	R-11
	Flexible	R-8	R-8	R-8
Water Heaters		***See Section 2.7, Table B***		
Mechanical ventilation and pollutant source control in all Climate Zones.				

1/ Adv. indicates advanced framing techniques. Use standard wall framing and advanced attics for Multifamily structures (6 or more units). Duplexes qualify as Single Family structures.

2/ The assumed infiltration rate (ACH) is for heat-loss calculations only.

3/ Unlimited glazing is acceptable IF all components meet the requirements of this table. Area weighted U-factors for individual components which meet the component requirements of this table are acceptable.

4/ A thermal break having a minimum value of R-5 is required between slab floors and all walls and footings.

Table A - REFERENCE U-FACTORS

Component	Maximum Heat Loss Rate	
Attics	0.020	
Vaults	0.027	
Above-grade Walls	0.041 for single family	0.044 for multifamily
Below-grade Walls (Depth below grade)	U-value	F-value
2 ft.	0.042	0.592
3.5 ft	0.040	0.556
7 ft	0.035	0.503
Floors over unheated spaces	Heating Zones 1 & 2	Heating Zone 3
(U-value)	0.029	0.025
Slab-on-grade (F-value)		0.52

The reference U-factors are both single family and multifamily except as noted.

Advanced-frame walls have studs on 24-inch centers with a double top plate and a single bottom plate. The corners use 2 studs or other means of fully insulating the corners, and 1 stud is used to support each header. The headers have double 2X material with R-10 insulation. The exterior wall cavity is fully insulated at intersections with partition walls. Standard and intermediate wall framing are described in ***Part II of these specifications "Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes."***

An advanced-frame attic is any combination of heel height, insulation material and baffles that provides the required ventilation space and a minimum of R-38 at the interior edge of exterior walls. The insulation shall increase to the full R-value at the highest rate allowed by the roof pitch and taper down to reach the outside edge of the exterior wall or to blocking between rafters.

1.3 Existing Codes and Regulations: These specifications are intended to meet or exceed applicable existing building codes and Federal regulations. In any case where a Federal, State or local code or regulation exceeds these requirements, that code or regulation applies.

1.4 Qualification: To qualify in the Long-Term Super Good Cents Program, a building design must be reviewed and qualified by a representative of a Super Good Cents utility. Unless otherwise stated, "approved" means approved by the Super Good Cents utility.

The building shall meet the MCS energy performance requirements established by the Northwest Power Planning Council (see section 1.2) through one of the following three approaches:

1. Thermal Performance Standards calculated with WATTSUN, Sunday, or other approved methods using the heat-loss coefficients in ***Part II of these specifications "Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes,"*** Except NFRC certified fenestration products which shall use the NFRC labeled U-factor;

2. Energy Budgets calculated with WATTSUN, Sunday, or other approved methods using the heat-loss coefficients in ***Part II of these specifications "Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily***

Homes," Except NFRC certified fenestration products which shall use the NFRC labeled U-factor; and

3. Prescriptive paths using section 1.2 OR developed by the customer using the prototype houses and instructions in Appendix A of this reference.

1.5 Solar Access: If passive solar design is used to qualify the house, the effective solar glazing shall be 8 percent or more of floor area, there shall be increased thermal mass, common living areas shall be on south side, and solar gains shall be based upon actual sun and shading conditions at the site. Solar designs shall be accompanied by a sun chart, or approved equal, to document actual size conditions for current solar access.

A plot plan shall document future solar access by indicating on the site plan that the solar aperture will not be shaded by a hypothetical 6-foot fence at the southern property line or by a hypothetical "pole" representing average building heights of houses, located at the center of the buildable area of adjacent lots to the south.

Solar glazing shall receive a minimum of 80 percent direct solar exposure between 9 a.m. and 3 p.m. during the heating season.

1.6 Certification: To be certified, the building shall be verified by the Super Good Cents customer to comply with the requirements in this document.

1.7 Additional Utility Requirements: Super Good Cents utilities may add requirements more stringent than those in this specification.

CHAPTER 2: THERMAL EFFICIENCY

2.1 Insulation Coverage: All insulation materials shall be installed according to the manufacturer's instructions to achieve proper densities, avoid compression and voids, and maintain uniform R-values. To the maximum extent possible, insulation shall extend over the full component area to the intended R-value.

2.1.1 General: All insulating materials shall comply with sections 1713 and 1714 of the 1991 Uniform Building Code (UBC) and be installed to meet all applicable fire codes.

2.1.2 Chimneys: Insulation installed around chimneys shall comply with Chapter 37 of the Uniform Building Code (UBC).

2.1.3 Vents and Baffles: Ventilation baffles in attics shall be permanent, weather-resistant retainers and allow insulation to be installed to the outer edge of the exterior wall to the fullest depth possible. All vents for attic/roofs and crawlspaces shall be clear of insulation.

2.1.4 Recessed Fixtures: Recessed fixtures (e.g., medicine cabinets, electrical panels, recessed lights, heating equipment, etc.) shall be covered by the full depth of insulation required by the component assembly. (See section 2.5 for air sealing requirements.)

EXCEPTION: One percent of the component area (e.g., vaulted ceiling, wall) may have a minimum of R-10 insulation between the fixture and the building exterior IF required ventilation clearances are maintained.

2.1.5 Hatches: Hatches connecting conditioned spaces to attics and crawlspaces shall be insulated to at least the requirement for the appropriate component and climate zone except R-38 is allowed for ceiling hatches.

2.1.6 Below-Grade Walls: Below-grade wall insulation shall extend from the top of the wall to the floor on the interior, or to the top of the footing on the exterior.

2.1.7 Rim Joists: All rim joists in heated basements or crawlspaces, or between floors, shall be insulated to the above-grade wall R-value.

2.1.8 Slabs: On-grade slab floor insulation shall be installed along the entire perimeter, and shall extend downwards from the top of the slab a minimum of 24 inches. A combination of vertical and horizontal insulation totaling 24 inches is acceptable.

Slabs in heated spaces shall have an R-5 thermal break between footings and slabs in adjacent unconditioned spaces.

Below-grade slabs shall have an R-5 thermal break between below-grade walls and footings.

Radiant slabs (those heated by hydronic piping or other active slab heating methods) shall have R-15 perimeter insulation and a minimum of R-10 under the remainder of the slab, beneath the heating system.

2.1.9 Hydronic-Heating Pipe Insulation: All exposed pipes in unheated areas used for hydronic heating shall be insulated to a minimum of R-4 using preformed insulation.

2.2 Doors and Glazing: Doors and glazing shall meet the following requirements.

2.2.1 Thermal Ratings: Windows, skylights and sliding glass doors shall be NFRC certified and labeled.

Exterior doors that have not been tested shall use the default U-factors in ***Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes,*** Table 6-1. Entry doors with glazing shall use door default U-factors in ***Long-Term Super Good Cents Program Default Heat Loss Coefficients for Site Built Single Family and Multifamily Homes***, Table 6.2.

2.2.2 Infiltration Ratings: Manufactured doors shall be tested for air infiltration using the ANSI/ASTM E-283-84 "Standard Test Method for Rating of Air-Leakage through Exterior Windows, Curtain Walls, and Doors." The tests shall be conducted at a differential pressure of 1.57 lbf/ft^2 (equivalent to 25 mph wind speed). Doors shall not exceed 0.2 CFM/linear foot of perimeter for swinging doors or 0.25 CFM/ft^2 of door area for sliding doors.

2.2.3 Site-Built Glazing: Where allowed by the utility, site-built, wooden-sash windows shall have a an emissivity coating of 0.2 or less and fit tightly. Fixed lites shall be retained by stops, and sealed. The window frame-to-framing joint shall be sealed. Double-glazed units shall be argon filled and have a minimum space of 1/2-inch between lites. Triple-glazed units shall be argon filled and have a minimum spacing of 1/4-inch between lites.

2.2.4 Site-Built Doors: Where allowed by the utility, site-built doors are exempt from thermal conduction and air infiltration testing, but shall fit tightly. The door frame-to-framing joint shall be sealed.

2.2.5 Weatherstripping: All operable joints in windows and doors shall be weather-stripped.

2.3 Air-Leakage Control: All Long-Term SGC buildings shall use either standard or advanced air-leakage control in section 2.3.1 or 2.3.2 for qualification:

2.3.1 Standard: Each building shall have a tested air-leakage of 7.0 air-changes per hour or less at 50 Pascals, using the procedures in Appendix B of this reference OR comply with the following prescriptive requirements:

All penetrations through the building envelope, including the following, shall be sealed (e.g., caulking, expanding foam, house wrap permeable to water vapor, tape, backer rod, gasket material, etc.) to limit air-leakage.

1. around glazing and door frames, between the unit and the interior sheet rock or the rough framing;

2. over all framing joints where floors intersect exterior walls (e.g., at rim and band joists);

3. at the top and bottom of the mudsill on homes with basements or heated crawlspaces;

4. around openings in the building envelope for access hatches, ducts, plumbing, electricity, telephone, cable television lines in walls, ceilings and floors, and through-the-wall vents;

5. at openings in the ceiling, (e.g., where ceiling panels meet interior and exterior walls, at exposed beams, masonry fireplaces, woodstove flues, etc.); and

6. around all outlet, switch, or other electrical boxes in the exterior walls, ceilings, or floors.

In addition to the above, multifamily buildings (6 or more units) shall also be sealed at all penetrations into joist spaces between floors.

2.3.2 Advanced: Buildings shall have tested air for leakage according to the procedures in Appendix B of this reference and shall have 1.8 air-changes per hour at 50 Pascals.

2.4 Backdraft Dampers: Intermittently-operated fans, or other non-heat-recovery systems, exhausting air from the building shall be ducted to the outside and have a backdraft or automatic damper in the exhaust duct.

2.5 Recessed Fixtures: Recessed fixtures (e.g., wall heaters, fans, medicine cabinets, electrical panels, etc.) shall be sealed to the component assembly to restrict air-leakage.

Recessed light fixtures shall meet ONE of the following requirements:

1. they must be IC-rated, double-can units sealed around the exterior to be air tight,

2. IC-rated units or fluorescent fixtures installed in a sealed "box" that extends the ceiling above the light fixture, or

3. type IC-rated units, certified under ASTM E-283 to have no more than 2.0 cfm air movement from the conditioned space to the ceiling cavity. The lighting fixture shall be tested without the trim at 75 Pascals or 1.57 lbs/ft^2 pressure difference, and have an attached label showing compliance.

The mounting flange on the exterior of the can, or the sealed "box," must be caulked to the ceiling finish/air barrier.

2.6 Wood stoves, Fireplaces and Other Combustion Appliances: Vented combustion appliances inside the heated space shall meet the requirements of sections 2.6.1 through 2.6.3 below. Unvented combustion appliances are NOT acceptable.

2.6.1 Woodstoves and Fireplaces: Masonry and factory-built fireplaces and woodstoves shall be installed with the following features:

1. Doors: Closeable metal or glass doors covering the entire opening of the firebox.

2. Combustion Air: Combustion-air intakes supplying primary combustion air to the appliance shall be sized as follows:

a. for factory-built wood-burning stoves, inserts, or fireplaces as specified by the manufacturer, but not less than 4 inches in diameter and not more than 20-feet in length.

b. for site-built appliances (e.g., masonry fireplaces, etc.), at least 4 inches in diameter and not more than 20-feet in length.

3. Fireplace Flue Dampers: For solid-fuel burning fireplaces only, a tight-fitting flue damper with a readily accessible control.

2.6.2 Other Combustion Appliances: All other combustion appliances inside the heated space shall be provided with outside primary combustion-air ducted directly to the appliance.

EXCEPTION: Gas cooking appliances without outside combustion-air shall have an exhaust fan directly serving those appliances that exhausts air to the outside.

EXCEPTION: Gas clothes dryers.

2.6.3 Combustion Exhaust: All combustion exhausts shall be separated by a minimum of 3-feet vertically or 10-feet horizontally.

2.7 Electric Water Heaters: Water heaters shall have GAMA certified minimum EF (Energy Factor) not less than specified in the Table B for the appropriate tank storage volume.

Table B - Electric Water Heater Efficiency Standards

Tank Size (gallons)*	Energy Factor
30	0.96
40	0.94
50	0.93
65	0.91
80	0.89
120	0.84
*The rated storage volume, which equals the storage capacity of the water heater, in gallons, as specified by the manufacturer.	

Water heaters on concrete basement or slab-on-grade floors shall be placed on a noncompressible insulating pad of R-10 or greater if full underslab insulation is not present. R-10 insulation shall also be placed under water heaters on raised platforms in unheated spaces.

Gas water heaters are exempt from the efficiency and insulating pad requirements.

CHAPTER 3: HEATING SYSTEMS

3.1 General: The primary heating system in Long-Term Super Good Cents homes shall be electric. The heating contractor is responsible for designing and installing the heating system to meet all UMC, NEC, applicable local codes and equipment manufacturer's requirements.

3.2 Control Requirements: Each separate heating system shall have at least one thermostat per zone mounted on an interior wall, at the manufacturer's recommended height, to regulate temperature. Each thermostat shall have numerical degree settings.

3.2.1 Central Systems (Non-Heat Pump): For central furnace or similar type systems, a low-voltage, heat-anticipating or microprocess-controlled electronic thermostat shall be installed.

3.2.2 Zonal Systems: There shall be one heat-anticipating, bi-metal thermostat OR a microprocessor-controlled electronic thermostat per zone.

3.2.3 Heat Pumps:

3.2.3.1 Installation

Indoor thermostats should be located and installed according to the manufacturer's instructions and recommendations. Thermostats generally are installed 5 feet off the floor on an inside wall in the return airflow pattern, and where they are not in the sun or any other heat source at any time.

3.2.3.2 Heating and Cooling

Thermostats used for both heating and cooling shall have a manual changeover feature or heating/cooling lockout to prevent cross-cycling between heating and cooling.

3.2.3.3 Automatic Setback (optional)

Indoor thermostats may have the capability of automatically reducing heating thermostats set point during unoccupied hours, and lockout strip heat during warmup by outdoor thermostats or an electronic programmed thermostat which shall control the strip heat on warm up.

3.2.3.4 Energy Heat Relay

All indoor thermostats shall include a manual selector switch to permit all supplemental heaters or the furnace to be energized under control of the indoor thermostat (with the compressor and outdoor thermostats bypassed) when the compressor or refrigerant system is inoperative. An indicator light, which is energized whenever the system is operating on emergency heat, shall be provided.

3.2.3.5 Microprocessor Thermostats

The first stage of electric heat shall be controlled by the second stage of the indoor thermostat. Thermostats should indicate auxiliary stage and emergency heat.

3.3 HVAC Ducts: HVAC ducts shall meet the following requirements:

3.3.1 Design Requirements

All duct work should be designed and installed in accordance with recommended practice as outlined in Air Conditioning Contractors of America (ACCA) Manual G, "Selection of Distribution Systems"; Manual E, "Room Air Distribution Consideration" and Manual D, "Residential Duct Design and Equipment Selection" or Sheet Metal and Air Conditioning Contractors National Association (SMACNA) "HVAC Duct System Design" or American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) handbooks. Duct sizing calculations and conclusions should be thoroughly documented and provided to the Customer and the Utility. Installation of balancing dampers is recommended.

3.3.1.1 Flex Duct

Flex duct shall not be used for main supply trunks in crawl spaces or areas that could be subject to physical damage from normal occupant activities, weather or animals. When flex duct is used for main trunks or run outs the size shall be determined by using the "Wire Helix Flexible Duct" scale on an ACCA Duct Sizing Slide Rule, or equivilent and all other requirements in Section 3.3 of these specifications shall be met.

3.3.1.2 Building Cavities As Ducts

Building cavities shall not be used as ducts to convey return or supply air.

3.3.1.3 Static Losses

Supply and return ducts shall be designed on the basis of not more than 0.10 and 0.08 inches loss per 100 feet respectively. Supply and Return Ducts shall be designed so that the total system static pressure does not exceed the available static pressure provided by the air handler at design CFM. Flex duct shall be supported in a manner that does not create restrictions in air flow and located to minimize bending.

3.3.1.4 Maximum Velocities

New duct work shall be designed so air velocities do not exceed the following:

Supply Ducts

Main Ducts	900 FPM
Branch Ducts	600 FPM
Supply Outlet Face Velocity	700 FPM
Return Grills Face Velocity	500 FPM
Filter Grille Face Velocity	300 FPM

Velocity shall not create unaceptable noise levels and return air shall be sufficient size to meet requirements of installed systems.

3.3.1.5 Diffusers and Registers

Proper diffusers and registers shall be selected and installed in the proper locations.

3.3.1.6 Branch Ducts

Branch out runs should be a minimum of 6 inches in diameter except to bathrooms.

3.3.1.7 Duct Connections

Ducts shall be properly supported before insulation is installed. All duct joints, plenum drives, metal joints to include all slips and drives shall be mechanically fastened with screws. Flexible ducts shall be attached using nylon/plastic straps tightened with a manufacturer approved tool (hand tightening is not acceptable) or stainless steel worm drive clamps. Mastic and/or tape shall not be used as mechanical fasteners.

3.3.2.1 Zonal Pressure Relief

Sufficient return pathways should be provided bewteen axial zones (e.g. bedrooms) and the main body of the dwelling to limit pressurization of these zones to 3 Pa or less when the system is operating at maximum system airflow. Return pathways include return ducts, pass-through grilles, pressure-relief ducts, or similar devices.

3.3.2 Duct Installation

3.3.2.1 Insulation

3.3.2.1.1 All new rigid metal ducts and plenums and accessible existing rigid metal ductwork outside the heated space shall be insulated to an installed value of at least R-8. A vapor barrier meeting a flame spread rating of 25 or less and smoke developed rating of 50 or less (in accordance with ASTM E-84-88) shall be installed on the outside surface of the insulation.

3.3.2.1.2 All new ducts and plenums that are internally lined with insulation outside the heated space shall be installed in accordance with SMACNA's Duct Liner Application Standard, second edition. The total R-value of this duct work shall be no less than R-8.

3.3.2.1.3 All flexible HVAC ducts outside the heated space shall have an Air Diffusion Council (ADC) certified minimum R-value of R-8.

3.3.2.1.4 All HVAC ducts routed within exterior wall cavities shall be insulated to a minimum of R-14 between the duct and the exterior wall sheathing.

3.3.2.1.5 All duct insulation shall be installed and supported using mechanical fasteners such as permanent plastic straps or nylon twine. Tape is not a mechanical fastener. Tape may be used at insulation seams to provide a continuous barrier.

3.3.2.2 Air Tightness

All HVAC supply and return ducts, air handlers, and plenums inside and outside the heated space shall be sealed at all joints and corners, including prefabricated joints, with duct mastic. UL181A-M or UL181B-M mastic shall be used on rigid metal ducts. UL 181B-M mastic shall be used on flex ducts. It is unnecessary to seal longitudinal seams unless they are damaged. Tape is not allowed except for use on operable doors in the system such as on the air handler. In this case, foil tape with a 15-mil butyl sealant shall be used; alternately, the joints can be cleaned with a suitable solvent and sealed with a UL-181 listed tape.

3.3.3 Additional Duct Requirements for Heat Pump Installations

3.3.3.1 Minimum Air Volume

The air distribution system design and installation shall be such that air flow across the indoor coil is as specified in the heat pump manufacturer's literature or at least 400 cfm per 12000 BTU ARI conditions if the manufacturer's literature is not specific. Airflow should be between 425 and 450 cfm at start up.

3.3.3.2 Start-up Tests and Measurements

After installation and start-up, a total airflow in the heat pump mode across the heat pump coil shall be made and recorded at the air handler. This, along with the temperature difference across the coils and outdoor ambient air temperature at the outdoor coil, should be reported to the customer.

The CFM shall be measured with a flow plate, or by combining the temperature rise test with measurement of element voltage and amperage in emergency heat mode and making the needed calculations.

CHAPTER 4: MOISTURE AND AIR QUALITY

4.1 Moisture Vapor Transfer: The following shall be installed to limit moisture transfer:

4.1.1 General: A vapor retarder of not more than 1.0 perm shall be installed in, or applied to, exterior walls, ceilings, and floors. It shall be installed according to the manufacturer's specifications, on the warm side (in winter) of all insulation. The retarder shall be considered to be on the warm side if the R-value of the materials between it and the heated space is not more than 33 percent of the total R-value of the component section at the insulated cavity.

4.1.2 Slab Floors: Slab floors shall have a minimum of 4 inches of sub-slab gravel meeting ONE of the following requirements:

1. ASTM Standard C33, "Standard Specifications for Concrete Aggregates," or any successor standards, and shall be size Number 67 or larger size aggregate as listed in Table 2, Grading Requirements for Coarse Aggregates; or,

2. the 1988 Washington State Department of Transportation specifications 9-0.31(3), "Coarse Aggregate for Portland Cement Concrete," or any successor standards, and aggregate size shall be of Grade 5 or larger size aggregate as listed in 9-03.1(c), "Grading;" or,

3. is screened, washed, free of deleterious substances in a manner consistent with ASTM C33, with 100 percent of the gravel passing a 1-inch sieve and less than 2 percent passing a #4 sieve. Sieve characteristics shall conform to those acceptable under ASTM C33.

4.1.3 Crawlspace Ground Cover: In crawlspaces, a ground moisture barrier of 6-mil black polyethylene, or equal approved by the utility, shall be installed covering the entire ground surface of the crawlspace.

4.2 Attic and Crawlspace Ventilation: Outdoor air ventilation shall be provided in the following places, at the following rates:

4.2.1 Attics/Ceilings: Adequate cross ventilation shall be maintained above all ceiling insulation by providing both low and high vents. At least 1 ft^2 of net-free vent area shall be provided for every 300 ft^2 of ceiling area with 50-to-60 percent of the vent area located near the roof ridge and 40-to-50 percent located near the eaves. One-level venting may be used if at least 1 ft^2 of net-free vent area is provided for every 150 ft^2 of ceiling area and adequate cross ventilation can be maintained.

4.2.2 Crawlspaces: Crawlspaces shall be ventilated by openings in at least two opposing exterior foundation walls with a net-free vent area of not less than 1 ft^2 for each 150 ft^2 of underfloor area. Where local code allows, this ventilating area may be reduced to 1 ft^2 for every 300 ft^2 of underfloor area if the crawlspace soil is dry, well drained and a ground cover meeting the provisions of 4.1.3 has been installed.

Where allowed by code, mechanical ventilation of 2 ACH or higher is acceptable.

4.3 Mechanical Ventilation: Whole-house ventilation systems, which include exhaust-air fans and outside-air intakes, are required and shall be designed and controlled to provide adequate ventilation for the occupants while minimizing energy penalties.

Whole-house ventilation systems shall use remotely-mounted exhaust fans (i.e. more than 4-feet from the pick-up grille) or surface-mounted fans (i.e. exhaust fan motors within 4-feet of the pick-up grille). Surface-mounted fans shall have a sone rating of 1.5 or less for intermittently-operating systems and 1.0 or less for continuously-operating systems. Both remotely and surface-mounted fans shall installed to limit the transmission of fan vibrations to the building structure. Intermittently-operating whole-house ventilation fans shall be controlled by 24-hour timers, with a minimum of 2 on-periods per day, and shall be set to operate for a minimum of 8 hours per day.

Multifamily buildings (6 or more units) shall have one of the following ventilation systems for each unit:

1. a continuously-operating ventilation system providing a measured minimum airflow of 0.35 air-changes per hour (ACH) or 15 cfm for each bedroom and 15 cfm for the main living area with a maximum rate of 0.5 ACH, or meet the prescriptive requirements using the HVI certified fan flows in the following table.

TABLE C: Multifamily Continuous Ventilation

Number of Bedrooms	Minimum Certified Fan Flow at 0.25 in W.G.	Maximum Certified Fan Flow at 0.25 in W.G.
1	30 cfm	60 cfm
2	50 cfm	75 cfm
3	60 cfm	90 cfm
4	80 cfm	120 cfm

When the whole-house fan provides pickups in, or is located in, the bathroom or kitchen in lieu of spot ventilation fans, the whole-house fan shall exhaust 20 cfm from the bathroom and/or 25 cfm from the kitchen. A single, continuously-operating, integrated and whole-house fan, or fan pickup, in one bathroom is acceptable if spot ventilation fans are provided in the kitchen and in the other bathrooms.

2. an integrated HVAC ventilation system (option 4) described below for single family ventilation if it is provided by a separate HVAC system for each unit, or

3. an intermittently-operating system exhausting not less than 1.5 times the minimum prescriptive flow rates in Table A above. Intermittent exhaust devices may replace one more spot ventilation devices IF all spot ventilation requirements are met.

Single-family buildings (5 or fewer units) shall provide whole-house ventilation systems which exhaust indoor air at the rates specified in section 4.3.1 for each unit. The four general system designs for single-family residences are:

1. Integrated Spot and Whole-House Design: This system uses one or more exhaust fans to provide spot and whole-house ventilation. The fan(s) is controlled by both

a manual switch, crank timer, or dehumidistat in the bathroom for spot ventilation AND a 24-hour timer to provide whole-house ventilation.

2. Continuous Ventilation: This system uses a continuously-operating fan to exhaust air at a minimum rate of 25 cfm for the kitchen and 20 cfm per bathroom, with a maximum rate of 0.5 ACH.

   A fan exhausting air from the kitchen and from each bathroom also provides spot ventilation. An integrated spot and whole-house fan is acceptable if spot ventilation is also provided for the kitchen and for all bathrooms.

3. Discrete Spot and Whole-House Design: This system uses separate exhaust fans and control systems to provide spot and whole-house ventilation.

Spot Ventilation is provided by standard bath fans controlled by a manual switch, crank timer or dehumidistat, and a kitchen range hood. Whole-house ventilation is provided by a fan, controlled by a 24-hour timer, that exhausts air from a central hallway near the bedrooms.

4. Forced-Air Heating/Cooling System Integrated Design: In this system, the forced-air heating/cooling system is used to bring outside air into the return-air plenum and distribute it through the supply ducts. Spot ventilation is provided by bathroom and kitchen exhaust fans

   A 24-hour timer, controls the heating/cooling system air handler, a motorized damper in the outside-air supply duct, and an exhaust fan to provide ventilation and to reduce building pressurization.

   An outside-air supply duct meeting the diameter and length requirements in section 4.3.7.2, is connected to the return-air plenum within 36 inches of the air handler. The outside-airflow is controlled by a balancing damper or constant airflow regulator in the outside-air supply duct to meet the airflow specified in section 4.3.1.

4.3.1 Exhaust Airflow Rates: Exhaust airflow rates shall meet either the following Performance or Prescriptive requirements.

Performance Path: The minimum combined measured airflow capacity for whole-house exhaust systems shall be 0.35 ACH, but not less than 15 cfm per bedroom and 15 cfm for the main living area. The maximum ventilation rate for non-heat recovery ventilation systems shall not exceed 0.5 ACH for houses of 1400 ft^2 or larger or 0.65 ACH for houses smaller than 1400 ft^2.

Prescriptive Path: Whole-house ventilation systems that do not meet the performance path shall meet the HVI certified fan flow requirements, minimum duct diameters, and maximum duct lengths listed in this section.

TABLE D: Single Family Intermittent Ventilation

Number of Bedrooms	Minimum Certified Fan Flow at 0.25 in W.G.	Maximum Certified Fan Flow at 0.25 in W.G.

2 or less	50 cfm	75 cfm
3	80 cfm	120 cfm
4	100 cfm	150 cfm
5	120 cfm	180 cfm

Fans shall be certified by HVI at 0.25 inches water gauge as determined by HVI 916 (July 1993)..

The following table gives the minimum duct diameter, maximum duct length and maximum number of elbows for smooth ducts or 90 degree bends in flexible ducts based upon fan size.

TABLE E: Exhaust-Fan Duct Length vs. Diameter

	FLEX DUCT		SMOOTH DUCT		
FAN TEST Max CFM @ .25 W.G.	Flex Duct Diameter	Maximum Length Feet	Smooth Duct Diameter	Maximum Length Feet	MAXIMUM # 90° Elbows*
50	4"	25	4"	70	3
50	5"	90	5"	100	3
50	6"	No limit	6"	No limit	3
80	4"	Not allowed	4"	20	3
80	5"	15	5"	100	3
80	6"	90	6"	No limit	3
100	5"	Not allowed	5"	50	3
100	6"	45	6"	No limit	3
125	6"	15	6"	No limit	3
125	7"	70	7"	No limit	3

* Subtract 10-feet from the maximum duct length for each additional elbow

4.3.2 Exhaust-Duct Insulation: All exhaust ducts in unheated spaces shall be insulated to at least R-4.

4.3.3 Exhaust Duct Termination: Exhaust ducts shall terminate outside the residence in a fitting with an area not less than the area of the duct.

4.3.4 Spot Ventilation: Spot ventilation fans, ducted to the outside of the envelope and meet the minimum capacities listed in the following table. The fan shall be certified at 0.25 inches of water gauge as determined by HVI 916 (July 1993). Kitchen range hoods or down-draft range exhaust fans may be rated at 0.1 inches of water gauge.

TABLE F: Spot-Ventilation Fan Capacity

Location	Certified Fan Capacity
Each bathroom	50 cfm
Kitchen	100 cfm

Exception: Separate spot ventilation is not required for a continuously-operating system which exhausts 25 cfm from the kitchen and 20 cfm from each bathroom.

4.3.5 Backdraft Dampers: A tight-fitting backdraft damper, capable of closing when intermittently-operating fans are not in use, shall be provided in each exhaust duct.

4.3.6 Controls: Intermittently-operating, whole-house exhaust fans shall have both automatic and manual controls. Automatic controls shall include a time clock or cycle timers with a minimum of two on-periods per day and be set to provide at least 8 hours of mechanical ventilation per day.

A manual override switch accessible to, and controllable by, occupants allows occupants to run the fan continuously or disable it if desired.

Parallel Wiring: The spot and whole-house ventilation controls may be wired in parallel, allowing the same fan to perform both functions. A whole-house exhaust fan, for example, may be wired to both the manual spot-ventilation switch in the bathroom and to a time clock.

4.3.7 Outside-Air Supply: The outside-air may be supplied by following the requirements of section 4.3.7.1 OR section 4.3.7.2 below.

1. Fresh-Air Inlets: Individual outside-air inlets shall:

   - be located to avoid drafts,
   - have a controllable and secure opening,
   - be sleeved or otherwise designed to prevent compromising the thermal integrity of the wall or window into which it is placed, and
   - provide a total opening area of at least 4 in^2 of net-free area or be HVI certified to provide 10 cfm at 10 Pascals for each bedroom and for each 300 ft^2 of combined living area.

2. Central Outside-Air Duct: A central duct providing outside-air directly to the return plenum of a forced-air heating/cooling system which circulates fresh air to the required rooms (used with Forced Air Heating/Cooling System Integrated Design). This duct shall have a motorized damper and a flow-control device to provide a supply airflow equal to the exhaust airflow rates specified in section 4.3.1. Duct diameter and length shall meet the following requirements:

TABLE G: Option 4 Air-Inlet Duct Length vs. Diameter

Number Of Bedrooms	Minimum Smooth Duct Diameter	Minimum Flex Duct Diameter	Maximum Duct Length 1/	Maximum Number of Elbows 2/
2 or less	6"	7"	20 ft	3
3	7"	8"	20 ft	3
4 or more	8"	9"	20 ft	3

1/ For lengths over 20-feet, increase the duct diameter by 1-inch.
2/ For more than 3 elbows, increase the duct diameter by 1-inch.

4.3.8 Outside-Air Source: The outside-air shall come from outside the building envelope and shall not be taken from the following locations:

- within 10-feet of an exhaust vent or combustion appliance flue outlet unless the vent/outlet is at least 3-feet above the air inlet

- where it will pick up objectionable odors, fumes, or flammable vapors
- a hazardous or unsanitary location
- a room or space containing any fuel-burning appliance
- within 10-feet of a plumbing vent unless the vent is at least 3-feet above the air inlet
- attics, crawlspaces, or garages

Protection: The outside-air source shall have adequate protection from entry by rain, insects, leaves, and other objects.

Flow Control: The outside-air source shall limit excessive airflows under normal operation.

4.3.9 Outside-Air Distribution: Adequate outside-air distribution shall be provided by individual room inlets, separate duct systems, or a forced-air system.

Where outside-air supplies are separated from the exhaust points, undercut doors, door or wall grilles, transoms grilles, or other approved means shall be provided to allow air circulation between spaces.

4.4 Formaldehyde Reduction Measures: All structural panel components of the house such as softwood plywood, particle board, wafer board, and oriented strand board shall be identified as "EXPOSURE 1," "EXTERIOR," or "HUD-Approved."

APPENDIX A

PRESCRIPTIVE OPTIONS FOR SITE-BUILT, SINGLE FAMILY HOUSING

1. Scope: This Appendix describes how utilities can develop prescriptive paths for Single Family residences in their service areas. Each prescriptive path must equal or exceed the base case for the appropriate climate zone and be approved by Bonneville. Each trade-off item must be an approved SGC measure.

2. Procedure: Using WATTSUN, SUNDAY, or other approved software, calculate the Thermal Performance or Energy Budget for ALL THREE prototype houses in the following table. All three prototypes must equal or exceed the base case for each prescriptive path.

PROTOTYPE COMPONENT AREAS

Component	Rambler 1344 ft^2	Split Level 1848 ft^2	Daylight Basement 2356 ft^2
Crawlspace floor	1344	1288	468
On-grade slab			30 lin. ft.
Below-grade wall @ 3.5 ft. average			544
Below-grade slab @ 3.5 ft. average			124 lin. ft.
Above-grade wall	1136	1732	1489
Windows	200	276	353
Doors	40	40	40
Flat ceiling	1344	1288	1160
Vaulted Ceiling			270
Volume	10752	14784	19833

APPENDIX B

BLOWER DOOR TEST PROTOCOL

1. Scope: This Appendix describes the blower door test protocol for testing the air-leakage of a single family house and representative residences in multifamily structures to meet the requirements of sections 2.3 of the Specifications.

2. When to Test: Testing shall occur after everything is roughed-in/ installed that will penetrate the building envelope (e.g., plumbing, electrical, HVAC, ventilation, combustion appliances, etc.) and the air barrier has been installed.

   Do not test when the outside wind speed exceeds 15-20 miles per hour.

3. House/Residence Preparation: All single family houses and representatives residences in multifamily structures shall be checked before testing to assure that following preparation measures have been completed.

   3.1 Building envelope: All windows and doors shall be properly closed, including pass-through wood-box doors and pet doors. All interior doors shall be left open.

   3.2 Ventilation openings: All exhaust fan openings, vent openings, and intake-air vents with backdraft dampers (e.g., dryer vents and kitchen, bathroom, utility room, whole-house, range vents, etc.) shall NOT be sealed.

   Exterior vent openings without backdraft dampers (e.g., some continuous ventilation systems) shall be temporarily sealed for the test. Heat recovery ventilator supply openings shall be sealed. Heat recovery ventilator exhaust openings should have backdraft dampers and shall not be sealed.

   3.3 Forced-air heating systems: Supply and return registers shall NOT be sealed and the heating system shall be turned off. HVAC ducts shall be tested with the envelope. Dampers in the outside-air supply duct into the return plenum shall be closed.

   3.4 Combustion appliances: All flue dampers, fireplace doors, and wood burning stove doors shall be closed, but NOT sealed.

4. Equipment Set-up: The blower door equipment shall be set-up using the following procedure:

   a. Keep the gauges at room temperature if possible. Cold temperatures may affect gauge accuracy.

   b. Install the blower-door assembly and seal all cracks and holes.

   c. Set up the gauge assembly with the gauges plumb and level.

   d. Attach a hose to the indoor pressure tap. Place the free end of the hose indoors away from the fan airflow path at the approximate height of the fan centerline.

   e. Exercise the gauges by blowing and sucking on the hoses to drive the gauges over their entire range six to eight times. Install the fan orifice plate, plug or seal all holes, and adjust the gauges to zero..

   f. Start the fan and depressurize the house to check for anomalies in the building envelope.

5. Performing the Test: Perform the test using the following procedures:

   a. Depressurize the house to 55 Pascals and reduce the pressure to 50 Pascals (0.205 inches of water).

   b. Tap the gauge to reduce stored spring energy from the gauge needle and wait for the needle to stabilize before recording the readings.

   c. View the gauge from directly in front when taking a reading. Maintain a consistent line of sight to avoid parallel errors or distortions from the gauge cover.

   d. Increase the pressure again and then retest at 50 Pascals.

6. Multifamily Structures: In multifamily structures, one corner and one middle apartment on each floor shall be tested according to the above protocol as representative residences. The apartment weighted average of the ACH @ 50 Pascals for the tested apartments shall be calculated for compliance with section 2.3 of the specifications.

LONG-TERM SUPER GOOD CENTS PROGRAM
PART II
DEFAULT HEAT-LOSS CO-EFFICIENTS
FOR SITE-BUILT SINGLE AND MULTIFAMILY HOMES

TABLE OF CONTENTS

SECTION		Page
1.	General	64
2.	Below-Grade Walls and Slabs	65
3.	On-Grade Slab Floors	67
4.	Crawlspace Floors	68
5.	Above-Grade Walls	72
6.	Doors	80
7.	Glazing	83
8.	Ceilings	87
9.	Air Infiltration	89
10.	Mass	74

CHAPTER 1: GENERAL

1.1 Scope: This Reference includes tables of seasonal average heat-loss coefficients for specified nominal insulation levels in the Super Good Cents program.

It also includes default U-values for windows and doors (15 mph table), which may be used as substitutes for the tested U-values required for glazing in section 2.2 in the Technical Specifications.

The heat-loss coefficients may also be used for heating system sizing.

1.2 Description: These coefficients were developed primarily from data and procedures in the 1989 ASHRAE Handbook of Fundamentals. Additional procedures, developed by Ecotope Inc., are detailed in the Super Good Cents Heat-Loss Reference Manual.

Co-efficients not contained in this Reference may be computed using the procedures listed in these references if the assumptions in the following sections and the SGC Heat-Loss Reference Manual are used, along with data from the sources referenced above.

CHAPTER 2: BELOW GRADE WALLS and SLABS

2.1 General: Table 2.1 lists heat-loss coefficients for below-grade walls and floors.

Co-efficients for below-grade walls are given as U-values (BTU/°F-hr per square foot of wall area). Co-efficients for below-grade slabs are listed as F-values (BTU/°F-hr per lineal foot of slab perimeter). They are derived from simulations using models and procedures developed by Ecotope, Inc., which are described in more detail in Volume I of the Super Good Cents Heat-Loss Reference.

Below-grade wall U-values are only valid when used with the accompanying below-grade slab F-value, and vice versa.

2.2 Component Description: All below-grade walls are assumed to be 8-inch concrete. The wall is assumed to extend from the slab upward to the top of the mud sill for the distance specified in Table 2.1, with 6 inches of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2x4 framing on 24-inch centers with 1/2-inch of gypsum board as the interior finish material. Exterior insulation is assumed to be applied directly to the exterior of the below-grade wall from the top of the wall to the footing. The exterior case does not assume any interior framing or sheetrock.

In all cases, the entire wall surface is assumed to be insulated to the indicated nominal level with the appropriate framing and insulation application. Co-efficients are listed for wall depths of 2, 3.5, and 7-feet below grade. Basements shallower than 2-feet should use on-grade slab coefficients.

Heat-loss calculations for wall areas above grade should use above-grade wall U-values, beginning at the mudsill.

2.3 Insulation Description: Co-efficients are listed for the following four configurations:

1. Uninsulated: No insulation or interior finish.

2. Interior insulation: Interior 2x4 insulated wall without a thermal break between concrete wall and slab.

3. Interior insulation w/thermal break: Interior 2x4 insulated wall with R-5 rigid board providing a thermal break between the concrete wall and the slab.

4. Exterior insulation: Insulation applied directly to the exterior surface of the concrete wall.

TABLE 2-1
DEFAULT WALL U-VALUES AND SLAB F-VALUES FOR BASEMENTS

	Below Grade Wall U-value	Below Grade Slab F-value
2-Foot Depth Below Grade		
Uninsulated	0.350	0.59
R-11 Interior	0.066	0.68
R-11 Interior w/tb	0.070	0.60
R-19 Interior	0.043	0.69
R-19 Interior w/tb	0.045	0.61
R-10 Exterior	0.070	0.60
3.5-Foot Depth Below Grade		
Uninsulated	0.278	0.53
R-11 Interior	0.062	0.63
R-11 Interior w/tb	0.064	0.57
R-19 Interior	0.041	0.64
R-19 Interior w/tb	0.042	0.57
R-10 Exterior	0.064	0.57
7-Foot Depth Below Grade		
Uninsulated	0.193	0.46
R-11 Interior	0.054	0.56
R-11 Interior w/tb	0.056	0.42
R-19 Interior	0.037	0.57
R-19 Interior w/tb	0.038	0.43
R-10 Exterior	0.056	0.42

CHAPTER 3: ON-GRADE SLAB FLOORS

3.1 General: Table 3.1 lists heat-loss coefficients for heated on-grade slab floors, in units of BTU/°F-hr per lineal foot of perimeter. They are derived from simulations using models and procedures developed by Ecotope, Inc., and described in more detail in Volume I of the Super Good Cents Heat Loss Reference.

3.2 Component Description: All on-grade slab floors are assumed to be 6-inch concrete poured directly onto the earth. The bottom of the slab is assumed to be at grade line. Monolithic and floating slabs are not differentiated.

Soil is assumed to have a conductivity of 0.75 BTU/Hr-°F-ft^2. Slabs 2-feet or more below grade should use basement coefficients.

3.3 Insulation Description: Co-efficients are provided for the following three configurations:

2-Foot (or 4-foot) vertical: Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2-feet (or 4-feet) below grade.

2-Foot (or 4-Foot) horizontal: Insulation is applied directly to the underside of the slab, and run horizontally from the perimeter inward for 2-feet or 4-feet. The slab edge is exposed in this configuration.

Note: A horizontal installation with a thermal break of at least R-5 at the slab edge should use the vertical-case F-values.

Fully insulated slab: Insulation extends from the top of the slab, along the entire perimeter, and completely covers the area under the slab.

TABLE 3-1

DEFAULT F-VALUES FOR ON-GRADE SLABS

Insulation Type	R-0	R-5	R-10	R-15
Uninsulated slab	0.73	--	--	--
2-ft Horizontal (No thermal break)	--	0.70	0.70	0.69
4-ft Horizontal (No thermal break)	--	0.67	0.64	0.63
2-ft Vertical (or Horiz. w/T.B.)	--	0.58	0.54	0.52
4-ft vertical (or Horiz. w/T.B.)	--	0.54	0.48	0.45
Fully insulated slab	--	--	0.36	--

CHAPTER 4: CRAWLSPACE FLOORS

4.1 General: Tables 4.1 through 4.3 list heat-loss coefficients for floors over crawlspaces in units of BTU/°F-hr per square foot of floor.

They are derived from procedures listed in the 1989 ASHRAE Handbook of Fundamentals assuming an average outdoor temperature of 45°F, an average indoor temperature of 65°F, and a crawlspace area of 1350 ft^2 and 150 ft of perimeter. The crawlspace is assumed to be 2.5-feet high, with 24 inches below grade and 6 inches above grade.

4.2 Crawlspace Description: Four crawlspace configurations are considered: vented, unvented, enclosed and heated plenum.

Vented crawlspaces: Assumed to have three air-changes per hour, with at least 1 ft^2 of net-free ventilation in the foundation for every 300 ft^2 of crawlspace floor area. The crawlspace is not actively heated.

Floors over unheated areas, such as garages, may only use those values which have R-0 perimeter insulation.

Unvented crawlspaces: Assumed to have 1.5 air changes per hour, with less than 1 ft^2 of net-free ventilation in the foundation for every 300 ft^2 of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated basements may only use those values which have R-0 perimeter insulation.

Heated-plenum crawlspaces: Assumed to have 0.25 air-changes per hour, with no foundation vents. Heated supply air from central furnace is blown into a crawlspace and allowed to enter the living space unducted via holes cut into the floor.

Enclosed floors: Assumes no buffer space, and a covering of 1/2-inch of T1-11 on the exterior of the cavity exposed to the outside air.

4.3 Construction Description: Floors are assumed to be either joisted floors framed on 16-inch centers, or post and beam on 4 by 8 foot squares. Insulation is assumed to be installed under the subflooring between the joists or beams with no space between the insulation and the subfloor. Insulation is assumed to be uncompressed.

Perimeter insulation is assumed to extend from the the top of the rim joist to the crawlspace floor and then inward along the ground (on top of the ground cover) for at least 24 inches.

Floor coverings are assumed to be light carpet with rubber pad.

TABLE 4-1

DEFAULT U-VALUES FOR FLOORS OVER VENTED CRAWLSPACE

Nominal R-value		U-value	
Floor	**Perimeter**	**Post & Beam**	**Joists**
0	0	0.112	0.134
	11	0.100	0.116
	19	0.098	0.114
	30	0.093	0.107
11	0	0.052	0.056
	11	0.048	0.052
19	0	0.038	0.041
	11	0.036	0.038
22	0	0.034	0.037
	11	0.033	0.035
25	0	0.032	0.034
	11	0.031	0.033
30	0	0.028	0.029
	11	0.027	0.028
38	0	0.024	0.025
	11	0.024	0.024

TABLE 4-2

DEFAULT U-VALUES FOR FLOORS OVER UNVENTED CRAWLSPACE OR BASEMENT

Nominal R-value		U-value	
Floor	**Perimeter**	**Post & Beam**	**Joists**
0	0	0.101	0.119
	11	0.080	0.090
	19	0.076	0.085
	30	0.073	0.082
11	0	0.049	0.053
	11	0.044	0.047
	19	0.042	0.045
	30	0.042	0.044
19	0	0.037	0.040
	11	0.034	0.036
	19	0.033	0.035
22	0	0.033	0.035
	11	0.031	0.033
25	0	0.031	0.033
	11	0.029	0.030
30	0	0.027	0.029
	11	0.026	0.027

TABLE 4-3

DEFAULT U-VALUES FOR FLOORS OVER HEATED PLENUM CRAWLSPACES

Nominal R-value Perimeter	U-value
11	0.085
19	0.075
30	0.069

Note: Crawlspaces used as heated plenums have approximately 30 percent higher heat-loss rate than unvented crawlspaces with the same assumed ACH. Default U-values in Table 4-3 reflect this higher rate of heat loss.

TABLE 4-4

DEFAULT U-VALUES FOR ENCLOSED FLOORS

Nominal R-value		U-value	
Floor	Perimeter	Post & Beam	Joists
0	0.223	21	0.042
11	0.067	22	0.043
13	0.060	25	0.037
15	0.055	30	0.033
19	0.046	38	0.027

CHAPTER 5: ABOVE-GRADE WALLS

5.1 General: Table 5.1 lists heat-loss coefficients for the opaque portion of above-grade walls (BTU/°F-hr per square foot). They are derived from procedures listed in the 1989 ASHRAE Handbook of Fundamentals assuming exterior air films at 7.5-mph wind speed.

Insulation is assumed to uniformly fill the entire cavity and to be installed as per manufacturer's directions. All walls are assumed to be finished on the inside with 1/2-inch gypsum wallboard, and on the outside with either beveled wood siding over 1/2-inch plywood sheathing or with 5/8-inch T1-11 siding. Insulated sheathing (either interior or exterior) is assumed to cover the entire opaque wall surface.

5.2 Framing Description: Three framing types are considered, and defined as follows:

Standard: Studs framed on 16-inch centers with double top plate and single bottom plate. Corners use 3 studs and each opening is framed using 2 studs. Headers consist of double 2X or single 4X material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use 2 studs in the exterior wall.

Framing weighting factors:	Studs and plates	.19
	Insulated cavity	.77
	Headers	.04

Intermediate: Studs framed on 16-inch centers with double top plate and single bottom plate. Corners use 2 studs or other means of fully insulating corners, and each opening is framed by 2 studs. Headers consist of double 2X material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Framing weighting factors:	Studs and plates	.18
Insulated cavity		.78
Headers		.04

Advanced: Studs framed on 24-inch centers with double top plate and single bottom plate. Corners use 2 studs or other means of fully insulating corners, and 1 stud is used to support each header. Headers consist of double 2X material with R-10 insulation between the header and exterior sheathing. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Framing weighting factors:	Studs and plates	.13
Insulated cavity		.83
Headers		.04

5.3 Component Description: Default coefficients for three types of walls are listed: single stud walls, strap walls, and double-stud walls.

Single Stud Wall: Assumes either 2x4 or 2x6 studs framed on 16 or 24-inch centers. Headers are solid for 2x4 walls and double 2x for 2x6 walls, with either dead-air or rigid-board insulation in the remaining space.

Strap Wall: Assumes 2x6 studs framed on 16 or 24-inch centers. 2x3 or 2x4 strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

Double-Stud Wall: Assumes an exterior structural wall and a separate interior, nonstructural wall. Insulation is placed in both wall cavities and in the space between the two walls. Stud spacing is assumed to be on 24-inch centers for both walls.

TABLES 5-1

DEFAULT U-VALUES FOR ABOVE-GRADE WALLS

2 x 4 Single Stud: R-11 Batt

	Siding Material/Framing Type				
				T1-11	
	R-value of Foam Board	Lapped Wood			
		STD	ADV	STD	ADV
NOTE:	0	.088	.084	.094	.090
Nominal Batt R-value:					
R-11 at 3.5-inch thickness					
	1	.080	.077	.085	.082
Installed Batt R-value:	2	.074	.071	.078	.075
R-11 in 3.5-inch cavity	3	.069	.066	.072	.070
	4	.064	.062	.067	.065
	5	.060	.058	.063	.061
	6	.056	.055	.059	.057
	7	.053	.052	.055	.054
	8	.051	.049	.052	.051
	9	.048	.047	.050	.049
	10	.046	.045	.047	.046
	11	.044	.043	.045	.044
	12	.042	.041	.043	.042

2 x 4 Single Stud: R-13 Batt

	Siding Material/Framing Type			
			T1-11	
R-value of Foam Board	Lapped Wood			
	STD	ADV	STD	ADV
NOTE: 0	.082	.078	.088	.083
Nominal Batt R-value:				
R-13 at 3.63-inch thickness				
1	.075	.072	.080	.076
Installed Batt R-value: 2	.069	.066	.073	.070
R-12.7 in 3.5-inch cavity 3	.065	.062	.068	.065
4	.060	.058	.063	.061
5	.057	.055	.059	.057
6	.053	.052	.056	.054
7	.051	.049	.052	.051
8	.048	.047	.050	.048
9	.046	.045	.047	.046
10	.044	.043	.045	.044
11	.042	.041	.043	.042
12	.040	.039	.041	.040

2 x 4 Single Stud: R-13 Blown In Blanket System

	Siding Material/Framing Type			
			T1-11	
R-value of Foam Board	Lapped Wood			
	STD	ADV	STD	ADV
NOTE:				
Nominal Batt R-value 0	.080	.076	.086	.080
R-3.8 per inch thickness				
1	.074	.070	.077	.074
Installed Batt R-value 2	.068	.065	.071	.068
R-13.3 in 3.5-inch cavity 3	.063	.060	.066	.063
4	.059	.057	.062	.059
5	.056	.053	.058	.056
6	.052	.051	.054	.052
7	.050	.048	.051	.050
8	.047	.046	.049	.047
9	.045	.044	.046	.045
10	.043	.042	.044	.043
11	.041	.040	.042	.041
12	.039	.038	.041	.039

2 x 6 Single Stud: R-19 Batt

		Siding Material/Framing Type					
		Lapped Wood			T1-11		
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
Nominal Batt R-value	0	.062	.058	.055	.065	.061	.058
R-19 at 6-inch thickness							
	1	.058	.055	.052	.060	.057	.055
Installed Batt R-Value	2	.054	.052	.050	.056	.054	.051
R-18 in 5.5-inch cavity	3	.051	.049	.047	.053	.051	.049
	4	.048	.046	.045	.050	.048	.046
	.5	.046	.044	.043	.048	.046	.044
	.6	.044	.042	.041	.045	.044	.042
	.7	.042	.040	.039	.043	.042	.040
	.8	.040	.039	.038	.041	.040	.039
	.9	.038	.037	.035	.039	.038	.037
	10	.037	.036	.035	.038	.037	.036
	11	.036	.035	.034	.036	.035	.035
	12	.034	.033	.033	.035	.034	.033

2 x 6 Single Stud: R-21 High Density Batt or Blown In Blanket System

		Siding Material/Framing Type					
		Lapped Wood			T1-11		
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
Nominal Batt R-value	0	.057	.054	.051	.060	.056	.053
R-21 at 5.5-inch thickness							
	1	.054	.051	.048	.056	.053	.050
Installed BIBS R-value	2	.050	.048	.045	.052	.050	.047
R-21 in 5.5-inch cavity	3	.048	.045	.043	.049	.047	.045
	4	.045	.043	.041	.047	.045	.043
Installed BIBS R-value	5	.043	.041	.040	.044	.042	.041
R-3.8 per inch thickness							
	6	.041	.039	.038	.042	.041	.039
BIBS Installed R-Value	7	.039	.038	.036	.040	.039	.037
R-20.9 in 5.5-inch cavity	8	.038	.036	.035	.039	.037	.036
	9	.036	.035	.034	.037	.036	.035
	10	.035	.034	.033	.036	.035	.033
	11	.033	.033	.032	.034	.033	.032
	12	.032	.031	.031	.033	.032	.031

2 x 6 Single Stud: R-22 Batt

	Siding Material/Framing Type					
		Lapped Wood			T1-11	
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
NOTE:						
Nominal Batt R-value	0	.059	.055	.052	.062	.058	.054
R-22 at 6.75-inch thickness							
	1	.055	.052	.049	.057	.054	.051
Installed Batt R-value	2	.052	.049	.047	.054	.051	.048
R-20 in 5.5-inch cavity	3	.049	.046	.044	.050	.048	.046
	4	.046	.044	.042	.048	.046	.044
	5	.044	.042	.041	.045	.043	.042
	6	.042	.040	.039	.043	.042	.040
	7	.040	.039	.037	.041	.040	.038
	8	.038	.037	.036	.039	.038	.037
	9	.037	.036	.035	.038	.037	.035
	10	.035	.034	.033	.036	.035	.034
	11	.034	.033	.032	.035	.034	.033
	12	.033	.032	.031	.034	.033	.032

2 x 6 Single Stud: 2 R-11 Batts

	Siding Material/Framing Type					
		Lapped Wood			T1-11	
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
NOTE:						
Nominal Batt R-value	0	.060	.057	.054	.063	.059	.056
R-22 at 7-inch thickness							
	1	.056	.053	.051	.059	.056	.053
Installed Batt R-value	2	.053	.050	.048	.055	.052	.050
R-18.9 in 5.5-inch cavity	3	.050	.048	.046	.052	.049	.047
	4	.047	.045	.044	.049	.047	.045
	5	.045	.043	.042	.046	.045	.043
	6	.043	.041	.040	.044	.043	.041
	7	.041	.040	.038	.042	.041	.039
	8	.039	.038	.037	.040	.039	.038
	9	.038	.037	.036	.039	.038	.036
	10	.036	.035	.034	.037	.036	.035
	11	.035	.034	.033	.036	.035	.034
	12	.034	.033	.032	.034	.034	.033

2 x 8 Single Stud: R-25 Batt

R-value of Foam Board	Siding Material/Framing Type: Lapped Wood STD	Lapped Wood INT	Lapped Wood ADV	T1-11 STD	T1-11 INT	T1-11 ADV
0	.051	.047	.045	.053	.049	.046
1	.048	.045	.043	.049	.046	.044
2	.045	.043	.041	.047	.044	.042
3	.043	.041	.039	.044	.042	.040
4	.041	.039	.037	.042	.040	.038
5	.039	.037	.036	.040	.038	.037
6	.037	.036	.035	.038	.037	.036
7	.036	.035	.033	.037	.035	.034
8	.035	.033	.032	.035	.034	.033
9	.033	.032	.031	.034	.033	.032
10	.032	.031	.030	.033	.032	.031
11	.031	.030	.029	.032	.031	.030
12	.030	.029	.028	.031	.030	.029

NOTE:
Nominal Batt R-value
R-25 at 8-inch thickness

Installed Batt R-value
R-23.6 in 7.25-inch cavity

2 x 6: Strap Wall

	Siding Material/Frame Type: Lapped Wood STD	Lapped Wood ADV	T1-11 STD	T1-11 ADV
R-19 + R-11 Batts	.036	.035	.038	.036
R-19 + R-8 Batts	.041	.039	.042	.040

2 x 6 + 2 x 4: Double Stud

Batt Configuration Exterior	Middle	Interior	Siding Material/Frame Type: Lapped Wood STD	Lapped Wood ADV	T1-11 STD	T1-11 ADV
R-19	------	R-11	.040	.037	.041	.038
R-19	------	R-19	.034	.031	.035	.032
R-19	R-8	R-11	.029	028	.031	.029
R-19	R-11	R-11	.027	.026	.028	.027
R-19	R-11	R-19	.024	.023	.025	.023
R-19	R-19	R-19	.021	.020	.021	.020

2 x 4 + 2 x 4: Double Stud

Batt Configuration			Siding Material/Frame Type				
			Lapped Wood		T1-11		
			STD	ADV	STD	ADV	
Exterior	Middle	Interior					
R-11	------	R-11	.050	.046	.052	.048	
R-19	------	R-11	.039	.037	.043	.039	
R-11	R-8	R-11	.037	.035	.036	.036	
R-11	R-11	R-11		.032	.031	.033	.032
R-13	R-13	R-13	.029	.028	029	.028	
R-11	R-19	R-11		.026	.026	.027	.026

Log Walls

NOTE:
R-value of wood:
R-1.25 per inch thickness

Average Wall Thickness
90% average log diameter

Average Log Diameter	U-value
6-inch	0.148
8-inch	0.111
10-inch	0.089
12-inch	0.074
14-inch	0.063
16-inch	0.056

Stress Skin Panel

NOTE:

R-value of expanded polystyrene:
R-3.85/inch

Framing: 6%
Spline: 8%
No thermal bridging between interior and exterior splines

Panel Thickness	U-value
3 1/2-inch	.071
5 1/2-inch	.040
7 1/4-inch	.037
9 1/4-inch	.030
11 1/4-inch	.025

CHAPTER 6.0: DOORS

6.1 General: Table 6.1 lists heat-loss coefficients for exterior doors in units of BTU/°F-hr per ft^2 of door. They are derived from data provided in the 1989 ASHRAE Handbook of Fundamentals, Chapter 22, and from a compilation of U-values tested according to AAMA or ASTM standards.

6.2 Component Description: Doors are assumed to be wood or metal with no glazing. These defaults may be used for the opaque portions of doors with less than 50 percent of their total area in glass.

Glazing areas in doors shall use the appropriate default U-value in Chapter 7 for the specific glazing type. Doors with more than 50 percent glazing area are considered entirely window and must use window default U-values in Chapter 7 for the entire door area.

Metal doors are assumed to have thermally broken frames and coefficients include heat loss through frames.

Storm door material is assumed to be the same as the primary door.

6.3 7.5-MPH Adjustment: Coefficients listed under Table 6.1 "15 mph Default Door U-values" shall be used for compliance. When qualifying homes using the Thermal Performance or Energy Budget methods, the Default U-values shall be adjusted to 7.5-mph equivalent values using the following equation:

$$U(7.5mph) = U(15mph) \times 0.931 + .0126$$

where:
U(7.5mph) = default U-value adjusted to 7.5-mph wind speed conditions
U(15mph) = default U-value at 15-mph wind speed conditions

Note: This adjustment is made automatically in the WATTSUN program. Therefore, use the 15-mph U-values when running WATTSUN.

TABLE 6-1: DEFAULT U-VALUES FOR EXTERIOR DOORS
15-mph Default U-VALUES

Type		w/storm
Metal, 1 3/4-inch, solid core urethane flush	0.14	--
Wood, 1 3/8-inch, solid core flush	0.39	0.26
Wood, 1 3/8-inch, solid core panel	0.57	0.33
Wood, 1 3/8-inch, hollow core flush	0.47	0.30
Wood, 1 3/4-inch, solid core flush	0.33	0.28
Wood, 1 3/4-inch, solid core panel	0.57	0.33
Wood, 1 3/4-inch, hollow core flush	0.46	0.29
Wood, 2 1/4-inch, solid core flush	0.27	0.20

TABLE 6-2
GLAZED ENTRY DOOR DEFAULT U-FACTORS

15-mph Default U-factors

	DOOR MATERIAL			
	INSULATED		WOOD	
DESCRIPTION	**35-50% Glass[8]**	**Below 35% Glass**	**35-50% Glass[8]**	**Below 35% Glass**
Single	0.67	0.53	0.81	0.72
Double, Clear 1/4"	0.39	0.31	0.47	0.42
Double, Clear 1/4" + Argon	0.37	0.30	0.45	0.41
Double, Low-e4 1/4"	0.36	0.30	0.44	0.41
Double, Low-e2 1/4"	0.35	0.29	0.43	0.40
Double, Low-e1 1/4"	0.24	0.28	0.41	0.39
Double, Low-e4 1/4" + Argon	0.33	.028	0.41	0.39
Double, Low-e2 1/4" + Argon	0.31	0.26	0.39	0.38
Double, Low-e1 1/4" + Argon	0.31	0.26	0.38	0.37
Double, Clear 3/8"	0.37	0.30	0.45	0.41
Double, Clear 3/8" + Argon	0.36	0.29	0.44	0.41
Double, Low-e4 3/8"	0.34	0.28	0.42	0.40
Double, Low-e2 3/8"	0.33	0.28	0.41	0.39
Double, Low-e1 3/8"	0.21	0.26	0.38	0.37
Double, Low-e4 3/8" + Argon	0.32	0.27	0.40	0.38
Double, Low-e2 3/8" + Argon	0.29	0.25	0.37	0.37
Double, Low-e1 3/8" + Argon	0.29	0.25	0.36	0.36
Double, Clear 1/2"	0.36	.029	.044	0.41
Double, Clear 1/2" + Argon	0.34	0.28	0.42	0.40
Double, Low-e4 1/2"	0.32	0.27	0.40	0.38
Double, Low-e2 1/2"	0.30	0.26	0.38	0.37
Double, Low-e1 1/2"	0.29	0.25	0.36	0.36
Double, Low-e4 1/2" + Argon	0.30	0.26	0.38	0.37
Double, Low-e2 1/2" + Argon	0.28	0.25	0.36	0.36
Double, Low-e1 1/2" + Argon	0.28	0.24	0.34	0.35
Triple, Clear, 1/4"	0.31	0.26	0.39	0.38
Triple, Clear 1/4" + Argon	0.29	0.25	0.37	0.37
Triple, Low-e4 1/4"	0.30	0.26	0.38	0.37
Triple, Low-e2 1/4"	0.29	0.25	0.37	0.36
Triple, Low-e4 1/4" + Argon	0.27	0.24	0.35	0.35
Triple, Low-e2 1/4" + Argon	0.26	0.24	0.34	0.35

_____

1. Subtract 0.02 from the listed U-factors for insulated spacers (fiber glass, wood, butyl or equivalent k-value).
2. Low-e4, emissivity = 0.4 or less: Low-e2, emissivity = 0.2 or less; Low-e1, emissivity = 0.1 or less.
3. Add 0.05 for insulated doors without a thermal break and more than 35 percent glazing.
4. Add 0.06 for insulated doors without a thermal break and less than 35 percent glazing.
5. Add 0.03 for dividers between the glazing with less than 1/8" between the divider and each lite.
6. Argon includes CO_2, SF_6, and argon/SF_6 mixtures.
7. Krypton with a space of 1/4" or more equals argon with a space of 1/2" or more.
8. Use window default U-factors for more than 50% glazing.

CHAPTER 7.0: GLAZING

7.1 General: Table 7.1 lists heat-loss coefficients for exterior windows and skylights in units are BTU/°F-hr per square foot of glazing. They are derived from data provided in the 1989 ASHRAE Handbook of Fundamentals, Chapter 27, the 1958 ASHAE Guide, and a compilation of actual tested U-values taken from the Seattle Department of Construction and Land Use Client Assistance Memo #403 "Glazing U-Values Acceptable For Demonstrating Compliance With The 1986 Energy Code," December 1988.

7.2 Framing Description: Coefficients are listed for framing meeting the following descriptions:

Wood or Vinyl: Wood and vinyl-framed windows having wood and/or vinyl as the primary material of the frame.

Wood with Exterior Aluminum Cladding (Wood w/EAC): Wood-framed windows having an exterior aluminum surface.

Aluminum (Alum): Nonthermally improved metal-framed windows without a thermal break between interior and exterior frame surfaces.

Aluminum with Thermal Break (Alum w/T.B.): Thermally-improved, metal-framed windows having a continuous thermal break with a minimum of 0.25-inches of low-conductivity material installed between the sealed glazing unit and the exterior surfaces of any metal retaining frame, sash, and center pieces (mullions, etc.). If the window is not constructed with a sealed glazing unit, a thermal barrier shall be installed between the layers of glazing.

7.3 Glazing Description: Coefficients are listed for units with a minimum 1/2-inch air space between glazing layers. All coefficients include window-frame and sash heat loss. Window area is based on rough opening dimensions. Storm windows are considered an additional layer of glazing. Windows with metal or other decorative mullions placed between glazing layers must be tested with mullions in place, and are not covered in these default values. Door glazing and side lites are considered windows and calculated separately from the opaque portions of doors. Doors with over 50-percent glazing are considered all window, and shall use window defaults for the entire opaque and nonopaque area. Window default U-values include patio doors, sliding glass doors and storm doors.

2Gl: Double-glazed windows

3Gl: Triple-glazed windows

Ar: Sealed insulated glass unit with argon gas filling the space between glazing layers.

Low-E: Low emittance coating applied to the #2 or #3 glazing surface of a sealed insulated glass unit, or applied to a film suspended between two glazing layers.

7.4 7.5-MPH Adjustment: Coefficients listed under Table 7.1(a) "15 mph Default Window U-values" and "15-mph Default Skylight U-values" shall be used for compliance. When qualifying homes

using the Thermal Performance or Energy Budget methods, the Default U-values shall be adjusted to 7.5-mph equivalent values with the following equation:

U(7.5mph) = U(15mph) x 0.931 + .0126

where:
U(7.5mph) = default U-Value adjusted to 7.5-mph wind speed conditions
U(15mph) = default U-Value at 15-mph wind speed conditions

Note: This adjustment is made automatically in the WATTSUN program. Use 15-mph U-values when running WATTSUN.

TABLE 7.1

Default U-Factors for Glazing

Window Type	Frame Type			
	Metal	Alum. with Therm. Break	Wood/Vinyl	Al. Clad Wood/ Reinforced Vinyl
Double, clear, 1/4"	0.82	0.66	0.56	0.59
Double, clear, 3/8"	0.78	0.63	0.54	0.57
Double, clear, 1/2"	0.75	0.60	0.50	0.54
Double, Argon, 1/4"	0.77	0.63	0.53	0.56
Double, Argon, 3/8"	0.75	0.60	0.51	0.54
Double, Argon, 1/2"	0.72	0.58	0.48	0.51
Double, Low-e.2, 1/4"	0.73	0.58	0.49	0.51
Double, Low-e.2, 3/8"	0.69	0.54	0.45	0.48
Double, Low-e.2, 1/2"	0.64	0.50	0.40	0.44
Dbl., Low-e.2, Ar., 1/4"	0.66	0.52	0.43	0.46
Dbl., Low-e.2, Ar., 3/8"	0.63	0.49	0.41	0.44
Dbl., Low-e.2, Ar., 1/2"	0.6	0.46	0.37	0.40
Triple, Clear, 1/4"	0.66	0.52	0.42	0.44
Triple, Clear, 1/2"	0.61	0.46	0.37	0.40
Triple, Argon, 1/4"	0.63	0.49	0.39	0.42
Triple, Argon, 1/2"	0.59	0.45	0.36	0.38
Triple, Low-e.2, 1/4"	0.62	0.48	0.39	0.41
Triple, Low-e.2, 1/2"	0.55	0.41	0.32	0.35
Trp., Low-e.2, Ar., 1/4"	0.58	0.43	0.34	0.37
Trp., Low-e.2, Ar., 1/2"	0.52	0.38	0.30	0.32

1. If the Low-e coating has an emissivity greater than 0.2, add 0.03 to the U-factor.
2. If the Low-e coating has an emissivity of 0.1, subtract 0.02 from the U-factor.
3. Subtract 0.02 from the U-factor for windows that have an insulated spacer.

Glass Block	
6"x 6"x4" nominal	0.60
8"x 8"x4" nominal	0.56
12"x12"x4" nominal	0.52

Glazing type	15-mph Skylight U-values Frame type Vinyl or Wood	Wood w/EAC	Wood w/T.B.	Alum
2Gl	0.65	0.69	0.73	0.82
2Gl + Ar	0.60	--	0.70	0.77
2Gl + Low-E	0.52	0.52	0.64	0.70
2Gl + Ar + Low-E	--	0.45	0.50	
3Gl	0.51	--	0.64	
3Gl + Low-E	0.42	--	0.57	--

CHAPTER 8: CEILINGS

8.1 General: Table 8.1 lists heat-loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings, and roof decks in units of BTU/°F-hr per square foot of ceiling.

They are derived from procedures listed in the 1989 ASHRAE Handbook of Fundamentals. Ceiling U-values are modified for the buffering effect of the attic, assuming an indoor temperature of 65°F and an outdoor temperature of 45°F.

8.2 Component Description: The three types of ceilings are characterized as follows:

Ceilings Below a Vented Attic: Attic insulation is assumed to be blown-in, loose-fill fiberglass with a K-value of 2.6 Hr-°F-ft2/BTU per inch. Full bag count for specified R-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are 45 X 30 feet, with a gabled roof having a 4/12-pitch. The attic is assumed to vent naturally at the rate of 3 ACH through soffit and ridge vents. A void fraction of 0.002 is assumed for all attics with insulation baffles. Standard-framed, unbaffled attics assume a void fraction of 0.008.

Attic framing is either standard or advanced. Standard framing assumes tapering of insulation depth around the perimeter with resultant decrease in thermal resistance. An increased R-value is assumed in the center of the ceiling due to the effect of piling leftover insulation. Advanced framing assumes full and even depth of insulation extending to the outside edge of exterior walls.

Vented scissors truss attics assume a ceiling pitch of 2/12 with a roof pitch of either 4/12 or 5/12. Unbaffled standard framed scissors truss attics are assumed to have a void fraction of 0.016.

Vaulted Ceilings: Insulation is assumed to be fiberglass batts installed in roof joist cavities. In the vented case, at least 1.5 inches between the top of the batts and the underside of the roof sheathing is left open for ventilation in each cavity. A ventilation rate of 3 ACH is assumed. In the unvented or dense pack case, the ceiling cavity is assumed to be fully packed with insulation, leaving no space for ventilation.

Roof Decks: Rigid insulation is applied to the top of roof decking with no space left for ventilation. Roofing materials are attached directly on top of the insulation. Framing members are often left exposed on the interior side.

TABLE 8-1: DEFAULT U-VALUES FOR CEILINGS

Ceilings Below Vented Attics	Standard Frame		Advanced Frame
Flat Ceiling	Baffled	Unbaffled	
R-19	0.049	0.052	0.047
R-30	0.036	0.038	0.032
R-38	0.031	0.034	0.026
R-49	0.027	0.030	0.020
R-60	0.025	0.028	0.017
Scissors Truss			
R-30 (4/12 roof pitch)	0.043	0.049	0.031
R-38 (4/12 roof pitch)	0.040	0.046	0.025
R-49 (4/12 roof pitch)	0.038	0.044	0.020
R-30 (5/12 roof pitch)	0.039	0.046	0.032
R-38 (5/12 roof pitch)	0.035	0.042	0.026
R-49 (5/12 roof pitch)	0.032	0.039	0.020

Vaulted Ceilings	16" O.C.	24" O.C.
Vented		
R-19 2x10 joist	0.049	0.048
R-30 2x12 joist	0.034	0.033
R-38 2x14 joist	0.027	0.027
Unvented		
R-30 2x10 joist	0.034	0.033
R-38 2x12 joist	0.029	0.027
R-21 + R-21 2x12 joist	0.026	0.025

Roof Deck	4x Beams, 48" O.C.
R-12.5 2" Rigid insulation	0.064
R-21.9 3.5" Rigid insulation	0.040
R-37.5 6" Rigid insulation	0.025
R-50 8" Rigid insulation	0.019

CHAPTER 9: AIR INFILTRATION

9.1 General: Tables 9.1 and 9.2 list effective air-change rates and heat capacities for heat loss due to infiltration.

Estimated seasonal average infiltration rates in air changes per hour (ACH) are given for the two levels of air-leakage control (see section 4.6 of the Technical Specifications). The energy-effective air-change rate shall be used in calculations for compliance under Thermal Performance or Energy Budgets. Advanced air-leakage control assumes the use of a heat recovery ventilation system providing a continuous airflow of 0.25 ACH with 60 percent heat recovery.

Heat loss due to infiltration shall be computed using the following equation:

$$Q_{infil} = ACH_{eff} * HCP$$

where:

Q_{infil} = Heat loss due to air infiltration

ACH_{eff} = the effective infiltration rate as given in Table 9-1

HCP = the Heat Capacity Density Product for the appropriate elevation or climate zone as given below.

Table 9-1 ASSUMED EFFECTIVE AIR-CHANGES PER HOUR

Air-Leakage Control Package	Air-Changes per Hour Natural	Effective
Standard	0.35	0.35
Advanced	0.10	0.20

Table 9-2 DEFAULT HEAT CAPACITY/DENSITY PRODUCT FOR AIR

Heating Zone	Average Elevation	Heat Capacity/Density
1	Mean Sea Level	0.0180 BTU/Hr-°F
2	2000	0.0168
3	3000	0.0162

CHAPTER 10: MASS

10.1 General: Table 10.1 lists default mass-values for residential construction types. All calculations are based on standard ASHRAE values for heat-storage capacity as listed in 1989 Handbook of Fundamentals, Chapter 22.

Thermal capacity of furniture is ignored, as is heat storage beyond the first 4 inches of mass thickness. All mass is assumed to be in direct contact with the conditioned space. Concrete separated from the heated volume by other materials must multiply the listed concrete mass value by the result of the following formula:

Ln(R-value) x (-.221) + 0.5
Where:

Ln = Natural log
R-value = R-value of material covering concrete

Note: All default values for covered concrete slabs have been adjusted according to this procedure.

10.2 Mass Description: Mass is divided into two types, structural and additional.

Structural Mass: Includes heat-storage capacity of all standard building components of a typical residential structure, including floors, ceilings, and interior and exterior walls in Btu/°F-ft^2 of floor area. It also assumes exterior wall, interior wall and ceiling surface area approximately equals three times the floor area.

Additional Mass: Includes any additional building material not part of the normal structure, which is added specifically to increase the building's thermal-storage capability. This category includes masonary fireplaces, water or Trombe walls, and extra layers of sheetrock. Coefficients are in Btu/°F-ft^2 of surface area of material exposed to conditioned space. The coefficient for water is BTU/°F-Gallon.

10.3 Component Description: Light frame assumes 1-inch thick wood flooring with 5/8-inch sheetrock on ceilings and interior walls, and walls consisting of either 5/8-inch sheetrock or solid logs. Slab assumes a 4-inch concrete slab on or below grade, with 5/8-inch sheetrock on exterior and interior walls and ceiling, and with separate values for interior or exterior wall insulation. Adjustments for slab covering is based on R-value of material. Additional mass values are based on the density multiplied by the specific heat of the material adjusted for listed thickness.

Table 10-1 DEFAULT MASS VALUES

Structural Mass M-value	Btu/°F-Ft^2 floor area
Light frame:	
Joisted/post and beam floor, sheetrock walls and ceilings	3.0
Joisted/post and beam floor, log walls, sheetrock ceilings	4.0
Slab with interior wall insulation:	
Slab, no covering or tile, sheetrock walls and ceilings	10.0
Slab, hardwood floor covering, sheetrock walls and ceilings	7.0
Slab, carpet and pad, sheetrock walls and ceilings	5.0
Slab with exterior wall insulation:	
Slab, no covering or tile, sheetrock walls and ceilings	12.0
Slab, hardwood floor covering, sheetrock walls and ceilings	9.0
Slab, carpet and pad, sheetrock walls and ceilngs	7.0

Additional Mass M-Value	BTU/°F-Ft^2 surface area
Gypsum wallboard, 1/2-inch thickness	0.54
Gypsum wallboard, 5/8-inch thickness	0.68
Hardwood floor	1.40
Concrete/Brick, 4-inch-thickness	10.30
Concrete/Brick, 4-inch-thickness	15.40

	BTU/°F-gallon
Water, 1 gallon	8.0