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KODIAK ISLAND BOROUGH
RESOLUTION NO. 87-71-R

A RESOLUTION OF THE KODIAK ISLAND BOROUGH ASSEMBLY SUPPORTING THE ALASKA CRAFTSMAN HOME PROGRAM.

WHEREAS, high quality energy efficient building technology developed by the Alaska Craftsman Home Program would substantially reduce home energy construction, improve the health and safety of the occupants, improve indoor air quality, reduce the contributions of dwellings to outdoor air pollution, increase home durability, reduce home maintenance needs, and increase the economic stability of the owner; and

WHEREAS, Alaska state lawmakers have introduced legislation in the form of Senate Bill 308 and House Bill 318 and 319 that support the Alaska Craftsman Home Program. And that these bills will help improve and stimulate the homebuilding industry in Alaska through incentives and education and thereby improve the local economy of the Kodiak Island Borough; and

WHEREAS, the citizens of the Kodiak Island Borough will benefit substantially from the building of energy efficient homes as developed by the Alaska Craftsman Home Program.

NOW, THEREFORE, BE IT RESOLVED by the Kodiak Island Borough Assembly that it is the policy of the Kodiak Island Borough to encourage the building of homes to the energy efficiency standards of the Alaska Craftsman Home Program;

AND BE IT FURTHER RESOLVED that the Kodiak Island Borough supports Alaska State Senate Bill 308 and House Bill 318 and 319 to establish similar state policy and state support for the Alaska Craftsman Home Program.

PASSED AND APPROVED this 5 day of November, 1987.

KODIAK ISLAND BOROUGH

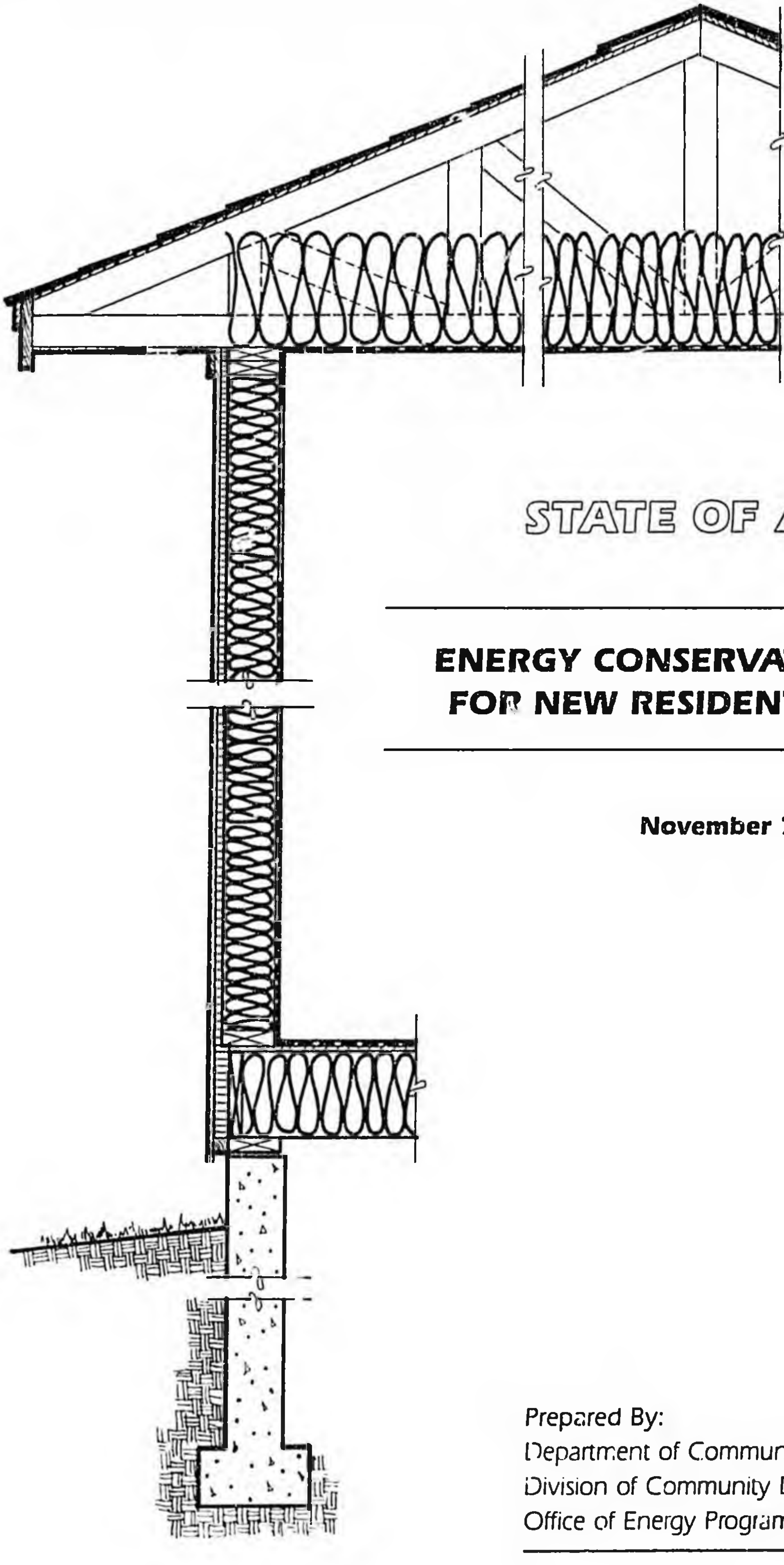
By Jerome M. Selby
Borough Mayor

By [signature]
Presiding Officer

ATTEST:

By [signature] CMC/AAE
Borough Clerk

Mickie — (hope the spelling is correct!)
This is regarding SB 308, HB 318 & 319
I told the mayor of Kodiak Island Borough, Jerome Selby, I would pass this on to the pertinent committees. Tks for your referral.
— Heather — Rep. Davidson
PS — HAPPY FRIDAY!



STATE OF ALASKA

ENERGY CONSERVATION STANDARD FOR NEW RESIDENTIAL BUILDINGS

November 7, 1986

Prepared By:
Department of Community & Regional Affairs
Division of Community Development
Office of Energy Program

ENERGY CONSERVATION STANDARD FOR NEW RESIDENTIAL BUILDINGS

STATE OF ALASKA

BILL SHEFFIELD, GOVERNOR

DEPT. OF COMMUNITY & REGIONAL AFFAIRS

OFFICE OF THE COMMISSIONER

☐ P.O. BOX B
JUNEAU, ALASKA 99811
PHONE: (907) 465-4700

☐ 949 EAST 36TH AVENUE, SUITE 400
ANCHORAGE, ALASKA 99508
PHONE: (907) 563-1073

November 7, 1986

In accordance with Alaska Statute 46.11.040, the Department of Community and Regional Affairs hereby adopts the "Energy Conservation Standard for New Residential Buildings."

Alaska Statute 46.11.040 states that State financial assistance may not be approved or granted for the construction of new residential buildings unless the building is in compliance with the Standard. The statute does allow for exemptions when it can be proved that local standards meet or exceed the State standard or when local conditions are not cost effective to implement this Standard. Regulations on the issuing of exemptions are contained in the Alaska Administrative Code.

The Standard provides different requirements for each of five statewide regions to better account for climatic and cost differences experienced across the state.

The energy efficiency levels specified in the Standard require higher quality construction. In part, this means homes must be constructed with materials and methods that substantially reduce outside air leaking into the house. Through reduction of air leaks means reduced heating costs, it also means indoor air quality becomes more of a concern. This topic is covered in more detail in Chapters 2 and 6, which the user of this Standard is advised to read carefully.

Chapter 1 gives the purpose, policies, scope and establishment of the Standard. Please pay particular attention to the scope and establishment sections.

Chapter 2 specifies mandatory energy efficiency requirements such as flow control devices, air infiltration control, vapor retarders, and others that are just as significant as good envelope insulation for a complete residential conservation effort.

Chapters 3, 4, and 5 provide three different methods of complying with envelope requirements. The builder is free to choose any one of these methods most appropriate to the building situation.

Chapter 6 provides a few brief recommendations for those wishing to go beyond the minimum requirements of this Standard for even greater energy efficiency.

Chapter 7 lists definitions of terms used in the Standard.

The Appendices contain information useful for complying with the Standard.

The minimum energy conservation standard given in this document is the result of two years of intensive research. This research showed the minimum standards to be cost effective. This research also showed that higher levels of envelope insulation are also cost effective but over a longer period of time. These higher levels of insulation will be discussed in an energy education manual to be produced by the Department of Community and Regional Affairs in 1987.

Planning for the future has always made sense. With the average life of a home being 55 years, it makes sense to plan and build energy efficient homes now to insure their future value. Retrofitting a home later as energy costs increase will always cost more than building it energy efficiently now. And, many things cannot be retrofitted; they can only be done at the time of initial construction. These Standards will help you build now for energy efficiency. Your home will be more comfortable, affordable, and less expensive to heat every day.

The Department of Community and Regional Affairs sincerely believes the Energy Conservation Standard for New Residential Buildings will result in a better built, more energy efficient housing stock throughout Alaska.

Sincerely,

Emil Notti
Commissioner

CORRECTION

THIS DOCUMENT
HAS BEEN REPHOTOGRAPHED
TO ASSURE LEGIBILITY

ENERGY CONSERVATION STANDARD FOR NEW RESIDENTIAL BUILDINGS

This pamphlet was prepared with the support of the U.S. Department of Energy, SECP Grant No. [illegible]. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of DOE.

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ACKNOWLEDGEMENT

The Energy Conservation Standard For New Residential Buildings could not have been possible without the help of many, many Alaskans. The key group however, was a 16 member advisory committee who guided and reviewed the work done by the state. This advisory committee included Bob Taylor, Maniilaq Association, Kotzebue; Axel Carlson, professor emeritus, University of Alaska, Fairbanks; Lauri Aylaian, engineer, Fairbanks North Star Borough, Fairbanks; Peter Poray, energy coordinator, Municipality of Anchorage, Anchorage; Steve Shows, Juneau Energy Committee, Juneau; Rob Balivet, architect, American Institute of Architects, Anchorage; Conrad Zipperian, RuALCAP, Anchorage; Vayla Colonell, engineer, Golden Valley Electric Association, Fairbanks; Wayne Mundy, review appraiser, Alaska Housing Finance Corporation, Anchorage; Nancy Lord, legislative aide, Homer; Clark Boston, director, Housing Assistance Division, Anchorage; Gale Cipra, Alaska Mortgage Bankers Association, Anchorage; Johnny Adams, energy planner, North Slope Borough, Barrow; Don Long, Utilities Department, North Slope Borough, Barrow; Rick Wike, Alaska Home Builders Association, Wasilla; Lee Sanders and Richard Potzger, Associated General Contractors, Anchorage; and Gene Bjornstad, engineer, American Society of Heating, Refrigeration, and Air Conditioning Engineers, Anchorage. Thank you, advisory committee.

Acknowledgement and gratitude are also expressed to Frank D'Elia, Steve Daden, Kathy Rentzel and Gloria Carrizales, State Office of Energy Programs.

Stuart Brooks
Project Coordinator and
Principal Author
Lighting and Thermal
Efficiency Standards

CHAPTER 1
PURPOSE, POLICIES, ESTABLISHMENT, AND SCOPE

1.1 PURPOSE

This document shall be known as the "Energy Conservation Standard for New Residential Buildings." It will be referred to herein as the "Standard."

The purpose of this Standard is to promote the construction of energy-efficient residential structures.

1.2 POLICIES

In the implementation, administration, and enforcement of the Standard the policy of the State of Alaska is to:

1. Develop public awareness of energy conservation building designs, technologies, and systems;
2. Establish acceptable and appropriate thermal standards for residential buildings based upon practical and cost-effective measures that will reduce the energy consumption of each home throughout the home's many years of use;
3. Permit flexibility in compliance by allowing alternative methods of meeting the energy conservation requirements of this Standard and encourage innovative design;
4. Provide review and monitoring of this Standard and its administration, at appropriate times, to make it responsive to users, technological developments, and change.

1.3 ESTABLISHMENT

The effective date of this Standard shall be January 1, 1988.

1.4 SCOPE

1. The Standard applies to residences that meet either of the following two criteria:

   o Detached single-family dwellings;

- Residential dwelling units in buildings measuring 36 feet (four stories) or less in vertical distance from the floor of the lowest habitable story to the floor of the highest habitable story which are provided with an individual heating appliance(s) for each dwelling unit or a single heating appliance intended to heat no more than six dwelling units.

2. The Standard does <u>not</u> apply to:

   - Transient housing such as hotels, motels, nursing homes, jails, barracks, or other similar use structures.

   - Additions, alterations, or repairs to existing residential buildings.

     Exception: An addition of habitable space 50 percent or greater in floor area than the existing dwelling floor area must comply with the Standard. The existing dwelling, however, need not comply.

3. Mobile homes shall be governed by thermal standards adopted by the Federal Department of Housing and Urban Development (HUD) and known as 24 CFR Part 3280 "Manufactured Home Construction and Safety Standards."

4. In order for a new residential building to receive State financial assistance, the Standard must be used in its design. Compliance with requirements must be identifiable in the preconstruction stage through examination of design plans and specifications. Compliance is accomplished when the building meets or exceeds the requirements of the Standard.

5. The Standard shall not be used to abridge any safety, health, or environmental requirements found in the current Uniform Building, Mechanical, and Plumbing Codes, the National Electrical and Fire Codes, or the ventilation requirements of the American Society of Heating, Refrigeration, and Air-conditioning Engineers' (ASHRAE) Standard 62. The Standard is intended to supplement these codes.

6. Lighting requirements are <u>not</u> a part of the Standard.

7. The requirements of the Standard may be satisfied by using any one of the following three compliance methods. The choice of which method to apply is left to the user.

- Prescriptive Method - Chapter 3. This method provides the easiest path for determining compliance with the Standard. Minimum insulation R-values are given for each building envelope assembly. For walls, ceilings, and floors the R-values given are for insulation requirements through the cavity space only - in other words, insulation between wall studs and between floor or ceiling joists. Only the insulation is counted. R-values for interior finish materials such as sheetrock, paint, carpeting, or paneling and exterior finish materials such as plywood sheathing, siding, or brick facing cannot be counted.

  Use of the Prescriptive Method does not require extensive calculations. However, this method is the least flexible of the three because it cannot be used to trade off R-value requirements between different envelope assemblies or between different elements of the same assembly.

  When using the Prescriptive Method, all mandatory measures given in Chapter 2 must also be accomplished.

- Performance Method - Chapter 4. The Performance Method allows the designer to trade off insulation requirements between elements of a particular building envelope assembly. For example, if window area above the allowed 15 percent prescriptive maximum is desired, the performance method allows such an increase as long as the wall insulation R-value is also increased. Compliance is accomplished when the wall R-value increases enough to off set the extra heat loss resulting from the increased window area.

  Trade-offs between the different envelope assemblies are not allowed with this method. In other words, more insulation in the ceiling will not allow for decreased insulation in the wall. For this kind of trade-off Chapter 5, Building Budget Method, should be used.

  Some calculations are necessary with the Performance Method but these calculations are not difficult.

When using the Performance Method, all mandatory measures given in Chapter 2 must also be accomplished.

- Building Budget Method - Chapter 5. This method is the most complicated as well as the most flexible of the three compliance methods. Insulation requirements are not given. Instead, a total maximum building heat loss allowance must be calculated. The designer may choose any design, provided the building does not exceed the maximum heat loss value stated. Despite the extensive calculations and substantiation of data required with this method, freedom of design and innovation will make it attractive.

  When using the Building Budget Method, all mandatory measures given in Chapter 2 must also be accomplished.

A workbook will be available after April 30, 1987, to help you through some sample calculations and procedures for complying with the Standard.

CHAPTER 2
MANDATORY DESIGN MEASURES

Energy conservation for a home involves more than just insulating exterior walls, ceilings, and floors. As significant is good vapor retarder installation, controlled ventilation, high efficiency heating appliances, caulking and sealing, weather stripping, and many other measures that, together with envelope insulation, make a complete energy conservation package.

This chapter provides mandatory energy conservation measures that will reduce a home's energy costs. These measures must be complied with regardless of which method (Chapters 3, 4, or 5) is used to demonstrate compliance with the Standard. Chapter 6 recommends other ways to further reduce energy costs.

2.1 Insulation

Thermal insulation is the primary material that resists the flow of heat out of a warm house. There are many kinds of insulation materials. Ability to resist heat flow and flammability vary for each. Not only is the type of insulation important, careful attention should also be paid to the place as well as the manner in which insulation is used.

The following requirements govern the use of thermal insulation materials.

a. Insulation materials installed within 3 inches of a recessed light fixture enclosure or ballast or installed above the fixture may create a fire hazard by entrapping heat and preventing the free circulation of air. Follow practices recommended by the light fixture manufacturer and the insulation manufacturer for these conditions.

b. Insulation materials must not be installed within 2 inches of any concrete or masonry chimney unless the insulation is designated as noncombustible and approved for such installation by the insulation manufacturer. Check manufacturer's recommendations.

c. Clearance around gas vents or metal chimneys must comply with provisions of the current Uniform Mechanical and Plumbing Codes.

d. A permanent sleeve of fine wire mesh screen, sheet metal, or other noncombustible material shall be installed to maintain required clearances.

e. Objects such as piping, wiring, or electric boxes in insulated cavities should have insulation installed completely around them.

f. Insulation materials must not be installed in a manner that would obstruct openings required for attic ventilation. If airflow through attic vents is blocked, water vapor may condense on the underside of the roof, causing ice to form during cold periods. During warming periods the ice will melt and drip into the attic insulation and reduce its insulating effectiveness, possibly also causing structural as well as cosmetic damage.

g. Where baffles are made necessary to maintain required eave ventilation, they shall be of a fixed, rigid, and noncollapsible material such as wood, metal, polystyrene, or corrugated cardboard. Eave baffles shall provide a minimum clear space of 1½ inches above the baffle for the full width between roof rafters.

h. Loose fill insulation may be used in attic spaces where there is at least 30 inches of clear headroom at the roof ridge. Clear headroom is defined as the distance from the top of the bottom chord of the roof truss or ceiling joists to the underside of the roof sheathing. Loose insulation may not be used where ceilings slope more than 2½ in 12 inches. This requirement ensures that workers have adequate room to move around in the attic space to install insulation properly and that the insulation will not slump out of place over time.

i. The minimum installed weight per square foot of loose fill insulation must conform to the insulation manufacturer's installed design density per square foot at the manufacturer's labeled R-value.

j. Special care must be taken to prevent wind or blowing snow from entering attic vents and disturbing the original distribution of any insulation.

k. Some roof/ceiling insulation strategies will create "warm roof" situations. In much of Alaska, warm roofs will usually result in moisture-related problems. Designers and builders should learn the difference between warm and cold roofs and the appropriate application of each.

2.2 Vapor Retarders

Vapor retarders perform two functions: 1) they retard the diffusion of water vapor into building envelope assemblies, and 2) a well-installed vapor retarder prevents airflow into and out of building envelope assemblies.

Airflow through breaks in the vapor retarder is especially serious because they will reduce the effectiveness of insulation (thereby increasing heat loss) and is also a major cause of water vapor moving into envelope assemblies. Water vapor within an envelope assembly can lead to structural and cosmetic damage over time.

About 3 to 5 gallons of water are dispersed into the air of a home each day as water vapor. With this much water vapor potentially leaking into envelope assemblies, it is easy to see that vapor retarders must be installed very carefully and without any breaks.

The following requirements govern vapor retarders:

a. A continuous vapor retarder must be installed in all building envelope assemblies (ceilings, walls, and floors).

b. Installation must be between the room interior surface and the theoretical winter design condition dew point within each assembly. In most assemblies, installation of a polyethylene (plastic) type vapor retarder would be over the stud, joist, or truss, which is then covered over with an interior finish material. In assemblies like a double wall, a rule of thumb for Regions 1 and 2 would be to locate the vapor retarder so that no less than 2/3 of the insulation R-value is on the cold side and no more than 1/3 is on the warm side of the vapor retarder. For the other three regions these ratios should be 3/4 and 1/4, respectively.

c. All punctures, tears, or joints, regardless of size or location (except for staples on studs), must be properly sealed. Examples of where this could occur is at pipe penetrations, electrical outlet boxes, and corners. Sealing can be done with acoustical sealant, caulk, special tapes, polyethylene material, or gaskets. Caution must be taken to select proper sealing materials for the intended application. For example, regular latex, oil-based, or silicone caulks may lose their seals over time. In many situations, acoustical sealant has proved to be more effective. Polyethylene tape has also proved to be more effective than duct tape.

d. Vapor retarders must have a perm rating of 0.5 or less. Materials specifically designed for vapor retardant purposes usually come with a perm rating supplied by the manufacturer. Perm ratings for other materials are listed in various reference sources such as the ASHRAE Handbook of Fundamentals. Perm ratings for some materials are also listed in Appendix D.

Vapor retarder materials such as polyethylene must have all joints overlapped a minimum of 6 inches or one structural member (stud, joist, or truss) space, whichever is greater. Polyethylene material shall not be drawn tightly across structural members before fastening to such members. Flexibility for expansion, contraction and movement of structural members and the polyethylene attached to them must be provided. All joints in the vapor retarder must be backed with solid blocking.

The vapor retarder material need not be an integral part of the insulation material.

Different vapor retarder materials may be used throughout the structure provided they meet the above listed requirements. For example, the ceiling and wall vapor retarder may be polyethylene while the floor vapor retarder may be exterior grade plywood. All joints between material changes, however, must be sealed, gasketed, or overlapped to provide for continuous coverage.

e. Vapor retarders are not required for crawl space walls. Basement walls insulated on the interior, however, must comply with all vapor retarder requirements.

2.3 Air Infiltration Control

Cracks, joints, and openings in a building's exterior and interior can be the cause of as much as 40 to 50 percent of a building's total heat loss. The Standard contains a number of measures to minimize uncontrolled air infiltration. Controlling random air infiltration, then providing controlled ventilation, is the best way to reduce heating costs while providing needed fresh air.

Three alternative methods of providing for air infiltration control may be used. These are:

a. Sealing Measures. To minimize uncontrolled air infiltration all cracks, joints, and openings where it is possible for air to leak through the thermal shell must be caulked, gasketed, taped, weather-stripped, or otherwise sealed. Such locations include, but are not limited to:

- Around window and door frames (between the unit and rough framing), between wall sole (bottom) plates and floors, between mudsills and foundation walls;

- Around penetrations for plumbing, electricity, telephone and gas lines;
- Around penetrations in the ceiling such as chimneys, flues, vents, or attic access doors;
- At breaks, punctures or tears in the vapor retarder (as stated in paragraph 2.2, vapor retarders);
- At holes in studs and top and bottom plates of interior or exterior partitions where piping or electric wiring passes through at the exterior envelope plane;
- At all other such openings in the building envelope.

Electrical outlet boxes that interrupt the continuity of the vapor retarder must be sealed by either caulking or poly taping around the box to bridge the crack space between the vapor retarder and the box, by using poly pans to set the electric box into, or by applying electrical outlet gaskets under the switch or outlet cover plates.

Caulking, gaskets, and sealing materials and the manner in which they are applied must conform to requirements given in the current Uniform Building, Mechanical, and Plumbing Codes, the National Electrical Code, and manufacturers' recommendations. Stuffing fiberglass insulation into cracks is not an adequate sealing method. Stuffing fiberglass into cracks is acceptable only if the crack has also been sealed with a material such as caulking, gaskets, or urethane foam.

Exhaust systems must be provided with positive closure backdraft or automatic dampers.

Fireplaces shall be provided with a readily accessible, tight-closing damper.

Exception: Gas burning fireplaces shall have a minimum position stop on the damper as specified by the fireplace manufacturer and the Uniform Mechanical Code.

Doors, windows, and skylights must be fully weather stripped. Weather-stripping material must be appropriate to its manner of use, long lasting even under conditions of hard wear or frequent use and be made of appropriate weather-resistant materials.

Windows and doors must comply with the air infiltration rates shown below. ASTM E283-84 "Standard Test Method for Rate of Air Leakage Through Exterior Windows and Doors" shall be used to establish window and door infiltration rates.

Maximum allowable air infiltration rates are:

- o Windows: 0.2 cubic feet per minute per linear foot of operable sash crack;
- o Swinging Doors: 0.1 cubic feet per minute per linear foot of operable sash crack;
- o Sliding Doors: 0.22 cubic feet per minute per linear foot of perimeter.

Compliance can be accomplished through specification of air leakage ratings in manufacturer's product literature.

Exception: Site-built window and skylight units with fixed lights are exempt from infiltration requirements but must be made tight fitting. Fixed lights must be retained by stops with sealant, gaskets, or caulking all around.

b. Blower Door Testing. Air infiltration control may be established in any manner provided total air changes per hour (ACH) per dwelling unit does not exceed the values given in Table 2.1 when tested in accordance with the American ASTM E779-86 "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization" or the Canadian CAN/CGSB-149.10-M "Standard for Determination of Airtightness of Buildings by the Fan Depressurization Method."

TABLE 2.1 Airtightness Requirements

Building Type	ACH @ 50PA
Detached single-family and duplex dwellings	4
Other residential buildings	3

c. Tracer Gas Testing. Air infiltration control may be established in any manner provided seasonal average natural ACH per dwelling unit does not exceed 0.4 when tested in accordance with ASTM E741 "Practice for Measuring Air Leakage Rate by the Tracer Dilution Method."

2.4. Ventilation Requirements

Vapor retarder and air infiltration control measures given in the Standard will substantially reduce natural air ventilation. Proper design for adequate indoor air ventilation then becomes very important. Improper design can lead to health and moisture condensation problems. Though proper design cannot guarantee the home will be free of air-quality problems, it is the first step toward their elimination. Proper building construction and homeowner use/maintenance of the home are the other two most important criteria for a healthy, condensation-free home. The importance of proper ventilation ha long been recognized by Alaska's native peoples. In the Arctic Slope region, for example, ventilation in traditional housing was provided for by the use of the kinguk.

The following measures go rn ventilation design equirements.

a. Mechanical systems that exhaust interior air must provide a duct to contain and transport the exhaust air directly to the outdoors rather than into another room or space. Backdraft or automatic dampers must be used to provide positive closure of the duct during periods of standby to minimize heat loss.

b. Dwellings must be designea to provide ventilation air capability at rates specified for residential structures in the current ASHRAE 62-1981 Standard "Ventilation for Acceptable Indoor Air Quality." Revisions to ASHRAE Standard 62-1981 shall immediately become a part of this Standard.

   The following minimum ventilation rates, as excerpted from ASHRAE Standard 62-1981, can be used as a guide. These ventilation rates can be accomplished easiest by installing and using exhaust fans.

o	Bathrooms and toilet rooms	50 CFM
o	Kitchens	100 CFM
o	All other living spaces	10 CFM

   Excess condensation on windows is usually the first sign of a ventilation problem. Every effort should be made by the occupant to maintain relative humidity levels at a point where little or no condensation collects on windows.

c. FOR REGIONS 1 AND 2: The ventilation system may be through natural (passive) means, through forced mechanical means, or both. When natural infiltration rates are insufficient to meet ventilation air requirements, forced mechanical ventilation must be provided.

d. FOR REGIONS 3, 4 and 5: A forced mechanical ventilation system capable of providing indoor air ventilation rates as stated in paragraph b above must be installed in each residential unit. This may be a single, centralized exhaust-only system, an air-to-air heat exchanger, or a combination of systems such as bathroom and kitchen exhaust fans along with a centralized exhaust system for other areas of the house. The builder must provide written operating instructions to the homeowner for each mechanical ventilating system.

e. Combustion appliances and fireplaces must be provided with sufficient combustion and venting air requirements as recommended by the appliance manufacturer. Care should be taken to prevent backdrafting of dangerous combustion gases into the house - especially when exhaust fans are operating.

2.5 Thermal Breaks for Windows, Doors, and Skylights

Metal sashes, frames, and thresholds for windows, doors, and skylights must have thermal breaks between inside and outside surfaces.

2.6. Crawl Space Vents

Crawl space vents must be equipped with a mechanism to allow the vents to be closed tightly during the heating season.

2.7. Permeability of Outer Envelope Surfaces

Water vapor penetrating through the interior vapor retarder must be able to pass on through the building's outer envelope surfaces to the outdoors. Water vapor not passing through to the outdoors will condense into liquid water (then ice) when temperatures within the assembly are cold enough. Temperatures as high as 42°F may be enough to begin condensation. Continued conditions like this may damage the insulation and the building's structure.

Permeability of outer envelope surfaces determine how easily water vapor within the envelope passes on through to the outdoors. Outer envelope surfaces should be approximately 10 times more permeable than the inside vapor retarder or be constructed to pass water to the outdoors. For example, do not use plastic vapor retarders on the exterior face of envelope walls and don't tape joints of rigid insulation boards installed on the exterior face of envelope walls.

2.8 Attached Garages

Garages are major heat losers. They usually leak more air than any other enclosed space of a residence. The garage temperature often approaches that of the outdoor and the garage door opens so wide that the entire volume of air in the garage is exchanged with the cold outside air in a matter of seconds. Because of this leakiness even heated garages are cold.

For this reason walls, ceilings, and floors of conditioned spaces adjoining garages should also be well insulated. To accomplish this, attached and built-in garages shall be considered an unconditioned space, regardless if provided with a source of heating, for the purpose of determining insulation and vapor retarder requirements for walls, ceilings, and floors of adjoining conditioned spaces.

2.9 Conservation of Hot Water

Hot water is usually the second most demanding use of energy in a home. In a highly insulated home, hot water can be the most demanding use of energy. Conservation of hot water, therefore, can lower a home's energy costs significantly. The following mandatory measures will effect good hot water conservation:

a. Showerheads must be equipped with flow control devices that limit water flow to a maximum of 2.5 gallons per minute at main line distribution pressures rated from 20 to 80 pound per square inch. Flow control devices are not required where water turbidity or the distribution pressure at the showerhead may render them unusable.

b. Toilets must be plumbed to use the least amount of heated water necessary to prevent condensation on the tank and bowl. Alternatively, toilet tank insulating liners may be used to prevent condensation.

c. Electric and gas storage hot-water heaters with capacities of 120 gallons or less must have the tank top and side surfaces insulated to at least R-16 or must have a standby loss rate not exceeding 3.0 watts per square foot of external tank surface area. Insulation may be inside the outer tank jacket or wrapped outside the outer tank jacket. In no case can the combined internal and external insulation be less than R-16. Internal tank insulation must be labeled on the tank exterior by the manufacturer. External wrap insulation must not cover the control panel nor interfere with relief or drain valves, drain pipes, or incoming and outgoing plumbing lines.

The following requirements govern heating systems:

General Requirements

All heating appliances must be installed and adjusted per manufacturers' recommendations. Adequate combustion air must be provided to the appliance for proper operation. Failure to do so will create unsafe conditions.

Chimney/Flue Requirements

a. Chimneys must be installed per manufacturers' recommendations for proper operation, maintenance, and safety to eliminate condensation or backdrafting problems.

b. Condensing heating appliances should use only approved plastic flues per manufacturer's recommendations.

Steady-state Efficiency Requirements

a. Noncondensing oil heating appliances must be adjusted for maximum steady-state efficiency within the range of 80 to 84 percent (inclusive).

b. Noncondensing gas heating appliances must be adjusted for maximum steady-state efficiency within the range of 79 to 82 percent (inclusive).

Exception: Noncondensing gas heating appliances may be adjusted to operate at efficiencies exceeding 82 percent if substantial documentation is provided to approving officials to prove that such appliances will not create condensation problems.

Flue Test Requirements

a. Flue tests for condensing heating appliances are not required. Condensing appliances must be so identified on manufacturer's literature.

b. Flue tests for noncondensing heating appliances are required. Heating appliances not identified in manufacturer's literature as condensing will be considered noncondensing.

Exception: Flue tests are not required for noncondensing appliances nominally rated at 40,000 Btu and less.

c. Flue tests for noncondensing appliances are required before initial occupancy and must have test results documented and posted on or close to the heating appliance. The format and information to be included on the posted document must be as follows:

Flue Test For Noncondensing Heating Appliances

OIL Required	OIL Actual		GAS Required	GAS Actual
0.06 or less	______	Draft (in inches of water at the breach)	0.01 to 0.03	______
0 or 1	______	Smoke Number (per ASTM D2165-65)	N/A	N/A
6% to 13%	______	Carbon Dioxide (percent), or,	6% to 10%	______
13% to 3.5%	______	O[illegible] (percent)	10.5% to 3%	______
375°F to 550°F	______	Actual Stack Temperature (°F)	375°F to 525°F	______
80% to 84%	______	Steady State Efficiency (percent)	79% to 82%	______
N/A	N/A	Carbon Monoxide (ppm below 100)	Yes	______

Name of person performing test ______________________________

Name of testing company ______________________________

Address of testing company ______________________________

Date of test (month, day and year) ______________________________

Recommendations or other comments ______________________________

____

____

CORRECTION

THIS DOCUMENT
HAS BEEN REPHOTOGRAPHED
TO ASSURE LEGIBILITY

2.8 Attached Garages

Garages are major heat losers. They usually leak more air than any other enclosed space of a residence. The garage temperature often approaches that of the outdoor and the garage door opens so wide that the entire volume of air in the garage is exchanged with the cold outside air in a matter of seconds. Because of this leakiness even heated garages are cold.

For this reason walls, ceilings, and floors of conditioned spaces adjoining garages should also be well insulated. To accomplish this, attached and built-in garages shall be considered an unconditioned space, regardless if provided with a source of heating, for the purpose of determining insulation and vapor retarder requirements for walls, ceilings, and floors of adjoining conditioned spaces.

2.9 Conservation of Hot Water

Hot water is usually the second most demanding use of energy in a home. In a highly insulated home, hot water can be the most demanding use of energy. Conservation of hot water, therefore, can lower a home's energy costs significantly. The following mandatory measures will effect good hot water conservation:

a. Showerheads must be equipped with flow control devices that limit water flow to a maximum of 2.5 gallons per minute at main line distribution pressures rated from 20 to 80 pound per square inch. Flow control devices are not required where water turbidity or the distribution pressure at the showerhead may render them unusable.

b. Toilets must be plumbed to use the least amount of heated water necessary to prevent condensation on the tank and bowl. Alternatively, toilet tank insulating liners may be used to prevent condensation.

c. Electric and gas storage hot-water heaters with capacities of 120 gallons or less must have the tank top and side surfaces insulated to at least R-16 or must have a standby loss rate not exceeding 3.0 watts per square foot of external tank surface area. Insulation may be inside the outer tank jacket or wrapped outside the outer tank jacket. In no case can the combined internal and external insulation be less than R-16. Internal tank insulation must be labeled on the tank exterior by the manufacturer. External wrap insulation must not cover the control panel nor interfere with relief or drain valves, drain pipes, or incoming and outgoing plumbing lines.

Hot-water piping leading from the water heater must be insulated with at least R-4 insulation for the first 3 feet of pipe closest to the water heater. It is not necessary, however, to netrate a fire wall with the pipe insulation. Also, check the Mechanical and Plumbing codes for required clearances of any combustible pipe insulation to vent pipes.

Exception: Storage hot water heaters in conditioned spaces that use the same energy source as used for space heating need not be insulated, nor does the hot water piping need to be insulated.

d To minimize conduction heat loss, electric water heaters cannot be set in direct contact with concrete floors. A minimum of 10 inches, measured vertically from the concrete floor up to the bottom of the heater, or R-10 insulation between the floor and the bottom of the heater must be installed.

e. All storage-type water heaters must be provided with thermostats capable of varying the heater's temperature settings. Water temperatures in excess of 120°F are not necessary for dishwashers when good detergent products are used. Water at 140°F takes only five seconds to develop third degree skin burns. Therefore, thermostats shall be set at time of installation to 130°F or less (120°F is preferable). For most gas water heaters, thermostats set between "medium" and "low" will obtain 130°F. Electric water heaters are generally equipped with degree temperature settings.

f. Water heaters must be equipped with heat traps on both the inlet and outlet piping. A heat trap may take the form of a bent piece of tubing which forms a loop of 360 degrees, a check valve, or any other means which effectively restricts the natural tendency of hot water to rise in vertical pipes during periods of standby.

2.10 Heating Systems

Poor or improperly functioning equipment can easily increase heating costs by 25 percent. Savings gained from better equipment, properly installed for maximum efficiency, will more than offset the extra cost of that equipment. The following requirements give the homeowner documented assurance that good equipment and proper installation have been provided.

The following requirements govern heating systems:

General Requirements

All heating appliances must be installed and adjusted per manufacturers' recommendations. Adequate combustion air must be provided to the appliance for proper operation. Failure to do so will create unsafe conditions.

Chimney/Flue Requirements

a. Chimneys must be installed per manufacturers' recommendations for proper operation, maintenance, and safety to eliminate condensation or backdrafting problems.

b. Condensing heating appliances should use only approved plastic flues per manufacturer's recommendations.

Steady-state Efficiency Requirements

a. Noncondensing oil heating appliances must be adjusted for maximum steady-state efficiency within the range of 80 to 84 percent (inclusive).

b. Noncondensing gas heating appliances must be adjusted for maximum steady-state efficiency within the range of 79 to 82 percent (inclusive).

   Exception: Noncondensing gas heating appliances may be adjusted to operate at efficiencies exceeding 82 percent if substantial documentation is provided to approving officials to prove that such appliances will not create condensation problems.

Flue Test Requirements

a. Flue tests for condensing heating appliances are not required. Condensing appliances must be so identified on manufacturer's literature.

b. Flue tests for noncondensing heating appliances are required. Heating appliances not identified in manufacturer's literature as condensing will be considered noncondensing.

   Exception: Flue tests are not required for noncondensing appliances nominally rated at 40,000 Btu and less.

c. Flue tests for noncondensing appliances are required before initial occupancy and must have test results documented and posted on or close to the heating appliance. The format and information to be included on the posted document must be as follows:

Flue Test For Noncondensing Heating Appliances

OIL Required	OIL Actual		GAS Required	GAS Actual
0.06 or less	______	Draft (in inches of water at the breach)	0.01 to 0.03	______
0 or 1	______	Smoke Number (per ASTM D2165-65)	N/A	N/A
6% to 13%	______	Carbon Dioxide (percent), or,	6% to 10%	______
13% to 3.5%	______	Oxygen (percent)	10.5% to 3%	______
375°F to 550°F	______	Actual Stack Temperature (°F)	375°F to 525°F	______
80% to 84%	______	Steady State Efficiency (percent)	79% to 82%	______
N/A	N/A	Carbon Monoxide (ppm below 100)	Yes	______

Name of person performing test____

Name of testing company____

Address of testing company____

Date of test (month, day and year)____

Recommendations or other comments____

____

____

CHAPTER 3
PRESCRIPTIVE METHOD

This chapter establishes design criteria in terms of minimum prescribed (given) insulation requirements for the building envelope, plumbing, and heating air ducts.

The Prescriptive Method does not require extensive calculations. It is the least flexible of the three possible compliance methods but is the easiest way to comply with the Standard. This method cannot be used to trade-off R-value requirements between different envelope assemblies or different elements of the same assembly. For example, you cannot put more insulation in the ceiling in order to put less insulation in the wall. If this is desired, Chapters 4 or 5 should be used as the means of compliance.

The Prescriptive Method does not dictate specific building methods. Any method of constructing the residence may be used provided clear compliance with the minimum insulating requirements can be shown. For example, to meet a minimum R-18 wall insulation requirement, the builder may use an R-19 fiberglass batt in a 2x6 framed wall, an R-13 fiberglass batt in a 2x4 framed wall with R-5 rigid insulation over the framing, or foamed-in-placed urethane between 2x4 framing.

When using the Prescriptive Method as the means of compliance, all mandatory measures given in Chapter 2 must also to be accomplished.

Design and insulation requirements are given below and also shown on Table 3.2, page 22.

3.1 Insulation Minimums

R-value minimums given in this chapter are for insulation installed between or over structural members. Only the insulation is counted. R-values for materials such as sheetrock, paneling, plywood, siding, air films, or earth backfill for example, cannot be included.

R-value minimums refer to the <u>installed</u> R-value. Compression of some insulating products will result in lower R-values. For example, placing an R-30 batt into a 2x8 wall will compress the batt from 9½ inches down to 7¼ inches. This will result in a decreased R-value from the listed R-30 down to approximately R-26. Table 3.1 shows nominal examples of resultant R-values when fiberglass batts are compressed.

TABLE 3.1

Resultant R-value when fiberglass batt insulation is compressed into a confined space. Resultant R-values differ among manufacturers.

Nominal Lumber Size	Actual Lumber Width	Initial R-value/Thickness R-38 12"	R-30 9½"	R-22 6 3/4"	R-19 6 1/8"	R-13 3 5/8"	R-11 3½"
		Installed R-value					
2" x 12"	11¼"	37	-	-	-	-	-
2" x 10"	9¼"	32	30	-	-	-	-
2" x 8"	7¼"	27	26	-	-	-	-
2" x 6"	5½"	-	21	20	18	-	-
2" x 4"	4"	-	-	15	14	-	-
2" x 4"	3½"	-	-	14	13	13	-
2" x 3"	2½"	-	-	-	-	9.8	8.8
2" x 2"	1½"	-	-	-	-	6.3	6.0
2" x 1"	1½"	-	-	-	-	-	-

3.2 Ceilings

Envelope ceilings must be insulated to the minimum R-value shown in Table 3.2.

Insulation located over perimeter walls cannot be less than R-30.

Insulated shed, flat, cathedral, and dome-type ceilings require special attention to ventilation and vapor retarder requirements.

3.3 Walls Above Grade

Envelope walls above grade must be insulated to the minimum R-value shown in Table 3.2.

Rim joist areas must be insulated to a minimum of 1/3 the R-value required for above-grade walls.

3.4 Walls Below Grade (Foundation Walls)

Insulation must cover a minimum of the top 2 feet of a crawl space wall and the top 4 feet of a basement wall. Minimum insulation R-value is shown in Table 3.2.

Exception: Crawl space walls need not be insulated provided the floor above the crawl space is insulated to the minimum R-value shown in Table 3.2 for floors and there is no danger of foundation damage from frost heaving.

Insulation materials should have appropriate weather resistant properties for the intended use and must be applied as recommended by the insulation manufacturer.

Vapor retarders are not required for crawl space or uninsulated basement walls.

Vapor retarders are required for basement walls insulated on the interior.

3.5 Floors

Envelope floors must be insulated to the minimum R-value shown in Table 3.2.

Exception: Floors over a crawl space need not be insulated provided the crawl space walls are insulated as required for "Below-grade Walls."

Rim joist areas must be insulated to the same requirement as the wall above it.

3.6 Slab-on-grade Floors

Slab-on-grade floors of conditioned spaces (or unconditioned spaces when a monolithic pour is made) must be provided with perimeter insulation. The minimum R-value required is shown in Table 3.2.

Insulation materials should have appropriate weather-resistant properties for below-grade application and must be applied as recommended by the manufacturer.

Insulation must extend downward from the top of the slab to the bottom of the footing, then extend horizontally beneath or away from the footing for a minimum total distance of 24 inches.

Permafrost areas require engineering analysis for proper application of insulation in contact with the ground. Improper application may result in severe damage to the structure.

3.7 Glazing

Glazing is the single most important element of a building's envelope. Glazing can account for as much as 25 percent of the total envelope (conductive) heat loss in a home, although it generally accounts for only 3 to 5 percent of the total envelope area. A double glazed window loses 10 times more heat per square foot than a 2x6 insulated wall. Glazing R-value and area limitations given below will substantially reduce envelope heat loss.

All glazing units must have a tested R-value not less than specified below. Testing must be conducted by a certified testing laboratory. Manufacturer's product literature must specify the tested R-value and the name of the testing laboratory.

a. Exterior wall glazing may not exceed the limitations set forth below:

Glazing Area *	Minimum R-value Required			
	Regions 1 and 2	Region 3	Region 4	Region 5
up to 8%	2.10	2.30	2.80	2.80
greater than 8% and up to 11%	2.80	2.80	2.80	2.80
greater than 11% and up to 15%	4.00	4.00	4.00	4.00

glazing area greater than 15% not allowed in any region

* As a percent of the total gross above-grade wall envelope area. For example, if total wall area equals 1184 sq. ft. and total glazed area equals 112 sq. ft., then glazing area is 9½ percent (112 ÷ 1184 = 0.095). Since 9½ percent is in the 8 to 11 percent category, all glazing in the exterior wall must then have an R-value of 2.8 or greater.

Exception: Wall glazing for special architectural or decorative features is allowed but must have a minimum R-value of 1.5 and may not exceed 5 percent of the allowable window glazing area. For example, if allowable window area equals 130 square feet, then:

130 sq. ft. x 0.05 = 6.50 sq. ft.

In this example, no more than 6.50 square feet of special glazing is allowed.

b. Skylight glazing area may not exceed 1 percent of the total insulated ceiling area per dwelling unit and must have a minimum R-value of 2.0. For example, if the insulated ceiling area equals 1500 square feet, then:

1500 sq. ft. x 0.01 = 15 sq. ft.

In this example, no more than 15 square feet of skylight is allowed.

Note that ceilings with skylights will require increased insulation R-values in order to offset the additional heat loss through the skylight. Therefore:

- o For each square foot of skylight area, the R-value per 100 square feet of insulated ceiling area must be increased according to the schedule shown in Table 3.2 for ceiling #2.

c. Door glazing area may not exceed 10 square feet total for all exterior doors in Regions 1 and 2, nor 5 square feet total for all exterior doors in Regions 3, 4 and 5. Minimum R-value of door glazing must be 2.10.

3.8 Doors

Unglazed portions of exterior doors must have a minimum R-value of 7.0.

Exception: One exterior door in Regions 1 and 2 may have an R-value less than 7 but no less than 2.5.

3.9 Plumbing

Hydronic and domestic hot-water pipes located outside of conditioned spaces and not intentionally used to heat the space or, if within 3 inches of a cold-water pipe, must be insulated to a minimum R-value of 4.0.

Plumbing must comply with the current Uniform Plumbing Code.

3.10 Air Ducts

For Region 1: Air ducts transporting conditioned air through attics, garages, and crawl spaces must be sealed at all joints and insulated to a minimum R-value of 6.0.

For Regions 2, 3, 4, and 5: Air ducts not intended to heat a space directly or through transmission losses must be sealed at all joints and insulated to a minimum R-value of 6.0.

Air ducts transporting air of 70°F or more are not permitted in unconditioned attic spaces unless the air is being exhausted directly to the outdoor environment.

Air ducts must comply with the current Uniform Mechanical Code.

3.11 Log House

Though the walls of a log house may not meet the prescriptive insulation values of Table 3.2, the house can be made to meet the maximum heat loss budget values of Table 5.1. This can be done by adding more insulation in the ceiling and floor, reducing window area, increasing window R-values, and doing other measures so that total building heat loss does not exceed the maximum given in Table 5.1.

TABLE 3.2 PRESCRIPTIVE ENVELOPE R-VALUE REQUIREMENTS

This table lists minimum prescribed insulation requirements for the building envelope. The builder may use any method of constructing the building envelope provided clear compliance with the listed R-values can be shown and is acceptable to approving officials.

CAUTION: Permafrost areas require engineering analysis for proper application of insulation in contact with the ground.

Region Number / Region Name / Heating Fuel	Prescriptive Envelope R-Value Requirements						
	Ceiling[1] #1	Ceiling[1] #2	Above-grade Wall	Floor	Below-grade Wall	Slab-on-grade Floor	Door[2]
Region 1							
Southeast							
All Fuels	38	48	21	30	15	15	2.5, 7
Region 2							
Southcentral, Aleutian, Kodiak							
Natural Gas	38	45	18	19	10	10	2.5, 7
All Other Fuels	38	48	25	30	15	15	2.5, 7
Region 3							
Interior, Southwest							
All Fuels	38	48	25	43	19	15	7
Region 4							
Northwest							
All Fuels	38	48	30	43	19	15	7
Region 5							
Arctic Slope							
All Fuels	52	NA[3]	35	52	--	--	7

Notes:

1. Ceiling #1: R-values listed are for ceilings with no skylights.
   Ceiling #2: R-values listed are for ceilings with skylights. See paragraph 3.7b.
2. One exterior door in Region 1 may have an R-value less than 7 but no less than 2.5.
3. Not allowed.

CHAPTER 4
PERFORMANCE METHOD

The Performance Method allows the designer to trade off insulation requirements between elements of a particular building envelope assembly. For example, if window area above the allowed maximum (as given in Chapter 3) is desired, the Performance Method allows such an increase provided the opaque wall R-value is also increased. Compliance is met when the opaque wall R-value increases enough to offset the extra heat loss resulting from the increased window area.

Trade-offs between different envelope assemblies are not allowed under this method. In other words, more insulation in the ceiling will not allow for decreased insulation in the wall. For this kind of trade-off Chapter 5, Building Budget Method, should be used.

The Performance Method can be used together with the Prescriptive Method. For example, if ceilings and floors will be insulated as specified in the Prescriptive Method but changes are desired for wall R-values, then the ceiling and floor can use the Prescriptive Method for compliance but the wall needs to show compliance through the Performance Method.

The Performance Method requires some calculations, but they are not difficult if careful application is used. R-values for materials such as sheetrock, paneling, plywood, siding, and air films, for example, may be included when calculating the overall transmittance value of an assembly. R-value for earth backfill at below-grade walls, however, cannot be included.

When using the performance method, all mandatory measures given in Chapter 2 must also be accomplished.

Design and insulation requirements are given below and also shown in Table 4.1, page 31.

4.1 Relationship of U-values and R-values

Although U-values may seem more difficult to understand than R-values, they are very simply related. The relationship is: R = 1/U and U = 1/R. For example, the U-value for an R-38 fiberglass batt is equal to: U = 1/38 = 0.026.

When R-values are converted to U-values, only the first three decimal places should be used. Do not round the third digit. For example, the U-value of R-19 insulation carried to four decimal places is: U = 1/19 = 0.0526; use U = 0.052.

An example of how to calculate the overall thermal transmittance value (U_o) of a ceiling envelope assembly is given in paragraph 4.11. Calculations for wall and floor assemblies would be similar.

4.2 Overall U_o-Values

The stated U-value of any one element of an envelope assembly may be increased while another element is decreased, provided the overall U_o-value of the entire assembly does not increase.

Equations 1, 2, and 3 must be used to determine U_o.

4.3 Ceilings

The overall thermal transmittance value (U_o) for the gross ceiling envelope area cannot exceed those values shown in Table 4.1.

Insulation located over perimeter walls cannot be less than R-30.

Insulated shed, flat, cathedral, and dome-type ceilings require special attention to ventilation and vapor retarder requirements.

Equation 1 must be used to determine acceptable combinations to meet the required ceiling U_o-values.

Equation 1

$$U_o = \frac{[U_{ceiling} \times A_{ceiling}] + [U_{skylight} \times A_{skylight}]}{A_o}$$

Where:

U_o = the overall thermal transmittance value of the gross ceiling envelope area expressed as $Btu/(ft^2 \cdot hr \cdot °F)$.

A_o = the gross overall ceiling envelope area in ft^2.

$U_{ceiling}$ = the composite thermal transmittance of all elements of the opaque ceiling expressed as $Btu/(ft^2 \cdot hr \cdot °F)$.

$A_{ceiling}$ = the gross opaque ceiling envelope area in ft^2.

$U_{skylight}$ = the composite thermal transmittance of all elements of the skylight, including the frame, expressed as $Btu/(ft^2 \cdot hr \cdot °F)$.

$A_{skylight}$ = the gross area of all skylights, including the frame in ft^2.

NOTE: Where more than one type of envelope ceiling and/or skylight is used, the U x A term for that exposure shall be expanded into its subelements, as:

Equation 1.1

$$[U_{ceiling_1} \times A_{ceiling_1}] + [U_{ceiling_2} \times A_{ceiling_2}] + \ldots, \text{etc.}$$

4.4 Walls

The overall thermal transmittance value (U_o) for the gross above-grade envelope wall areas cannot exceed those values shown in Table 4.1. for above-grade walls.

The overall thermal transmittance value (U_o) for the gross below-grade envelope wall areas cannot exceed those values shown in Table 4.1 for below-grade walls. Insulation must cover a minimum of the top 2 feet of a crawl space wall and the top 4 feet of a basement wall.

Exception: Crawl space walls need not be insulated provided the floor above the crawl space is insulated to the minimum R-value shown in Table 4.1 for floors and there is no danger of foundation damage from frost heaving.

Insulation materials should have appropriate weather-resistant properties for the intended use and must be applied as recommended by the insulation manufacturer.

Vapor retarders are not required for crawl space or uninsulated basement walls.

Vapor retarders are required for basement walls insulated on the interior.

R-value for earth backfill cannot be included when calculating U_o for below-grade walls.

Equation 2 must be used to determine acceptable combinations to meet the required wall U_o-values. Above-, and below-grade walls should be calculated separately.

Equation 2

$$U_o = \frac{[U_{wall} \times A_{wall}] + [U_{glazing} \times A_{glazing}] + [U_{door} \times A_{door}]}{A_o}$$

Where:

U_o	=	the overall thermal transmittance value of the gross wall envelope area expressed as Btu/(ft^2·hr·°F).
A_o	=	the gross overall wall envelope (above or below grade) area in ft^2.
U_{wall}	=	the composite thermal transmittance of all elements of the opaque wall expressed as Btu/(ft^2·hr·°F).
A_{wal}	=	the gross opaque wall envelope (above or below grade) area in ft^2.
$U_{glazing}$	=	the composite thermal transmittance of all elements of the glazed area, including the framing and sash expressed as Btu(ft^2·hr·°F).
$A_{glazing}$	=	the gross glazed wall envelope area, including the framing and sash in ft^2.
U_{door}	=	the composite thermal transmittance of all elements of the door expressed as Btu/(ft^2·hr·°F).
A_{door}	=	the gross area of the door in ft^2.

NOTE: Where more than one type of wall, window, or door is used, the U x A term for that exposure shall be expanded into its subelements, as:

Equation 2.1

$$[U_{wall_1} \times A_{wall_1}] + [U_{wall_2} \times A_{wall_2}] + \ldots \quad, \text{etc..}$$

4.5 Floors

The overall thermal transmittance value (U_o) for the gross envelope floor areas cannot exceed those values shown in Table 4.1.

Exception: Floors over a crawl space need not be insulated provided the crawl space walls are insulated as required for "Walls Below Grade."

Rim joist areas must be insulated to the same requirement as the wall above it.

Equation 3 must be used to determine acceptable combinations to meet the required floor U_o-values.

Equation 3

$$U_o = \frac{[U_{floor} \times A_{floor}]}{A_o}$$

Where:

U_o = the overall thermal transmittance value of the gross floor envelope area expressed as Btu/(ft^2·hr·°F).

A_o = the gross overall floor envelope area in ft^2.

U_{floor} = the composite thermal transmittance of all elements of the floor expressed as Btu/(ft^2·hr·°F).

A_{floor} = the gross floor envelope area in ft^2.

NOTE: Where more than one type of floor is used, the U x A term for that exposure shall be expanded into its sub-elements, as:

Equation 3.1

$$[U_{floor_1} \times A_{floor_1}] + [U_{floor_2} \times A_{floor_2}] + \ldots \quad , \text{etc.}$$

4.6 Slab-on-grade Floors

Slab-on-grade floors of conditioned spaces must be provided with perimeter insulation. The maximum overall U_o-value is shown in Table 4.1.

Insulation materials should have appropriate weather-resistant properties for below-grade application and must be applied as recommended by the manufacturer.

Insulation must extend downward from the top of the slab to the bottom of the footing, then extend horizontally beneath or away from the footing for a minimum total distance of 24 inches.

Permafrost areas require engineering analysis for proper application of insulation in contact with the ground. Improper application may result in severe damage to the structure.

4.7 Glazing

All glazing units must have a tested R-value. Testing must be conducted by a certified testing laboratory. Manufacturers' product literature must specify the tested R-value and the name of the testing laboratory.

4.8 Plumbing

Hydronic and domestic hot-water pipes located outside of conditioned spaces and not intentionally used to heat the space or, if within 3 inches of a cold-water pipe, must be insulated to a minimum R-value of 4.0.

Plumbing must comply with the current Uniform Plumbing Code.

4.9 Air Ducts

For Region 1: Air ducts transporting conditioned air through attics, garages, and crawl spaces must be sealed at all joints and insulated to a minimum R-value of 6.0.

For Regions 2, 3, 4, and 5: Air ducts not intended to heat a space directly or through transmission losses must be sealed at all joints and insulated to a minimum R-value of 6.0.

Air ducts transporting air of 70°F or more are not permitted in unconditioned attic spaces unless the air is being exhausted directly to the outdoor environment.

Air ducts must comply with the current Uniform Mechanical Code.

4.10 Framing Factors

The following factors should be used for wood framed walls when calculating the overall U_o-values required in this chapter. Framing factors account for the estimated amount of framing contained in opaque envelope areas.

Ceilings and Floors:

13 percent for 2-inch joists at 12 inches on center
10 percent for 2-inch joists at 16 inches on center
6 percent for 2-inch joists at 24 inches on center
10 percent for 2-inch plank and 4-inch beams at 48 inches on center

Walls:

15 percent for 2-inch studs at 16 inches on center
12 percent for 2-inch studs at 24 inches on center

4.11 U_o Calculation Example

This is an example of how to calculate a U_o-value for a ceiling with one skylight. U_o-values for walls and floors would be calculated in a similar manner.

Step 1: Calculate the composite thermal transmittance of all elements of the opaque (nonglazed) ceiling. R-values for each element of the opaque ceiling can be found in Appendix C or in other reference sources.

Ceiling R-Values

Between Framing		At Framing
0.61	inside air film	0.6_
0.55	5/8" gypsum wall board	0.55
38.00	R-38 fiberglass insulation	N/A
N/A	2x4 truss bottom chord @ 24" oc.	4.35
N/A	fiberglass insulation above truss bottom cord	27.00
0.61	attic air film	0.61
39.77		33.12

Therefore:

$$U_{ceiling} = \frac{0.94}{39.77} + \frac{0.06}{33.12}$$

$$= 0.023 + 0.001$$

$$= \underline{0.024}$$

* Remember to always include the effect of framing factors.

Step 2: Find the U-value of the skylight being used. Look in manufacturer's literature for the specified U-value or R-value. Remember, U = 1/R and R = 1/U. In this case, let's assume an R-2.0 skylight.

Therefore:

$$U_{skylight} = 1/R = 1/2.0 = \underline{0.500}$$

Step 3: Calculate the area of the opaque ceiling and the skylight.

a) only one skylight is being used and the area is given by the manufacturer as 8 sq. ft.

b) the gross ceiling area is:

30 ft. x 44 ft. = 1320 sq. ft.

So, the net ceiling (opaque) area is:

1320 sq. ft. - 8 sq. ft. = 1312 sq. ft.

Step 4: Calculate the overall thermal transmittance value (U_o) of the ceiling envelope.

$$U_o = \frac{[U_{ceiling} \times A_{ceiling}] + [U_{skylight} \times A_{skylight}]}{A_o}$$

$$= \frac{[0.024 \times 1312] + [0.500 \times 3]}{1320}$$

$$= \frac{31.488 + 4}{1320}$$

$$= \underline{\underline{0.026}}$$

You can see from this example that performance calculations are not difficult. Also, this simple calculation shows that the resultant ceiling U_o-value of 0.026 exceeds the maximum allowable U_o-value of 0.024 given in Table 4.1. Therefore, the R-value of the R-38 ceiling insulation should be increased, or the skylight R-value should be increased, or the skylight should be eliminated. Compliance is accomplished when the calculated U_o-value equals or is less than the maximum allowable U_o-value given in Table 4.1.

TABLE 4.1 MAXIMUM ALLOWABLE ENVELOPE U_o-VALUES

Caution: Permafrost areas require engineering analysis for proper application of insulation in contact with the ground.

Region Number Region Name Heating Fuel	ENVELOPE PERFORMANCE CRITERIA, U_o				
	Ceiling	Above-grade Wall	Floor	Below-grade Wall	Slab-on-grade Floor
Region 1 Southeast All Fuels	0.024	0.089	0.032	0.066	0.066
Region 2 Southcentral, Aleutian, Kodiak Natural Gas	0.024	0.099	0.046	0.100	0.100
All Other Fuels	0.024	0.085	0.032	0.066	0.066
Region 3 Interior, Southwest All Fuels	0.024	0.078	0.022	0.059	0.066
Region 4 Northwest All Fuels	0.024	0.073	0.022	0.059	0.066
Region 5 Arctic Slope All Fuels	0.018	0.069	0.018	---	---

Chapter 5
BUILDING BUDGET METHOD

This chapter establishes design criteria in terms of the total amount of energy used by a building in all its systems. The Building Budget Method requires extensive calculations and substantiation of data. This method is the most complicated path to compliance with the Standard but is also the most flexible. The designer is free to design the building in any way, provided the building does not exceed the maximum net heat loss values given in this chapter.

5.1 Building Heat Loss Budget

Buildings designed in accordance with this chapter must not exceed the total building net heat loss budget given in Table 5.1, page 35, expressed in Btu per square foot of conditioned floor area per year. Net building heat loss means total building heat loss less any internal and solar gains.

5.2 Calculation Procedures

Calculation procedures must be documented, contain full details, and be based upon accepted engineering practices such as those used by ASHRAE.

5.3 Infiltration Calculation

Infiltration heat loss calculations are limited to no less than 0.5 air change per hour when deriving the building's total heat loss budget for comparison with Table 5.1. requirements.

5.4 Submission Requirements

Submissions must include plans and specifications showing details of all pertinent data, features, equipment, and systems of the building including complete descriptions of materials, engineering data, test data, manufacturer's data, and all other data necessary to allow proper identification of the proposed building's energy components. Submissions lacking sufficient detail to verify a building's energy budget may be rejected.

5.5 Framing Factors

The following factors should be used for wood-framed walls when calculating overall U_o-values. Framing factors account for the estimated amount of framing contained in opaque envelope areas. Chapter 4 shows an example of how framing factors are used.

Ceilings and Floors:

13 percent for 2-inch joists at 12 inches on center
10 percent for 2-inch joists at 16 inches on center
6 percent for 2-inch joists at 24 inches on center
10 percent for 2-inch plant and 4-inch beams at 48 inches on center

Walls:

15 percent for 2-inch studs at 16 inches on center
12 percent for 2-inch studs at 24 inches on center

5.6 Design Parameters

The following design parameters shall be used for heat loss calculations required under this chapter:

a. Temperatures:

- o Indoor design dry bulb temperature shall not be set less than 65°F when calculating heat loss;
- o Select outdoor design dry bulb temperature from the weather station given in Appendix B, Weather Data that is most representative of the proposed building site;
- o Select heating degree days from the weather station given in Appendix B, Weather Data that is most representative of the proposed building site.

b. Relative Humidity:

- o Indoor winter design relative humidity shall not exceed 30 percent.

c. Internal Heat Gain:

In the absence of verifiable data, internal heat gain for an average household may be assumed at:

- o Men 480 Btu/person/hour of occupancy
- o Women 410 Btu/person/hour of occupancy
- o Children 360 Btu/person/hour of occupancy
- o Appliances 37,400 Btu/day total all appliances

d. Solar Gains:

Solar heat gains may be included provided substantial documentation, using proven methodologies, are used. Documentation must be submitted for evaluation.

TABLE 5.1 MAXIMUM HEAT LOSS BUDGET ALLOWABLE

Region No. Region Name Heating Fuel	Maximum Allowable Net Heat Loss (BTU/SF of floor area* /year)	
	Detached Single-family & Duplex Units	All Other Applicable Residential Units (Multi-family)
Region 1 Southeast		
All Fuels	33,000	24,000
Region 2 Southcentral, Aleutian, Kodiak		
Natural Gas	43,800	30,700
All Other Fuels	37,000	28,700
Region 3 Interior, Southwest		
All Fuels	55,200	43,300
Region 4 Northwest		
All Fuels	6[illegible],700	48,000
Region 5 Arctic Slope		
All Fuels	82,000	65,400

* The gross floor area of all conditioned spaces.

CHAPTER 6
RECOMMENDED MEASURES

This Chapter recommends further energy conservation measures as a guide for homeowners, designers, or builders who desire increased energy-efficiency levels in their homes. These measures are NOT mandatory.

6.1 Air Infiltration Barriers

Alaskan homes lose as much as 40 to 50 percent of heated interior air to the outdoors every hour due to uncontrolled air infiltration. Wind blowing into exterior walls and floors contributes to this heat loss.

Air infiltration barriers on exterior envelope surfaces can reduce heat loss. Infiltration barrier material is applied on the exterior side of joists, studs, rigid insulation, or structural sheathing, then covered over with finished siding material. The air infiltration barrier should be highly permeable so that it does not entrap moisture within the wall or floor cavity yet tight enough to prevent wind from blowing into the cavity. 'Parsec' and 'Tyvek' are names of two products used as air infiltration barriers. Their appearance and manner of installation is similar to that of a tough, white paper that is rolled onto the house from a 9 ft. wide x 100 ft. long roll.

6.2 Indoor Air Quality

Indoor air quality in "tight," energy efficient homes is of greater concern than in "leaky" energy-inefficient homes. Tight homes can concentrate existing indoor pollutants because of low air exchange rates, but tight homes do not "produce" pollutants. Pollutants come from the materials the builder selects to construct the home, the home's site, and the goods the homeowner brings into the home. These things are controllable to a large extent by the builder and homeowner. Identifying possible sources and strengths of pollutants before construction and minimizing their use or impact is the best way to reduce indoor air pollution levels. Increasing the leakiness of a home without minimizing pollutant sources will not necessarily assure good indoor air quality, but will certainly increase energy costs.

Using ventilation devices such as central exhaust systems, bathroom and kitchen range hood fans, and air-to-air heat exchangers will substantially improve indoor air quality and are recommended as a means to control house ventilation with greater accuracy but without excessive heat loss. As a guide, ventilation systems (natural or mechanical) should collectively be capable of providing the following minimum ventilation rates, as excerpted from ASHRAE Standard 62 -1981.

- o Bathrooms and toilet rooms 50 CFM
- o Kitchens 100 CFM
- o All other living spaces 10 CFM

Moisture accumulation is the most prevalent indoor air quality problem in Alaska. Bathrooms and kitchens usually produce the most moisture. A 50 CFM exhaust fan in a 6 ft. x 9 ft. x 8 ft. height bathroom will provide one complete room air change in about 4½ minutes. A 100 CFM kitchen range hood fan in a 9 ft. x 14 ft. x 8 ft. height kitchen will provide one complete room air-change in about 10 minutes. Obviously, most of a home's potential moisture problems can be eliminated by simply using these exhaust fans whenever moisture is generated in these rooms. Exhaust fans in bathrooms and kitchens are recommended even if openable windows are provided in these rooms.

Whenever exhaust fans are used in living spaces care must be taken to prevent dangerous backdrafting of combustion gases into living spaces from appliances such as furnaces and fireplaces. Make sure combustion appliances are always provided with adequate air supplies as recommended by the appliance manufacturer even when operating exhaust fans as mentioned above.

6.3 Air-To-Air Heat Exchangers

Air-to-air heat exchangers provide a positive means of controlling indoor air quality while also recovering heat energy that would otherwise be exhausted to the outdoors.

An air-to-air heat exchanger is a ventilation device capable of transferring heat from the air being exhausted to the fresh, cold air being pulled into the house. Heat exchangers do not produce heat; they only exchange heat from one air stream to another. As much as 50 to 70 percent of the heat in stale, warm air can be recovered. Also, since most exchangers do not mix air streams, good indoor air quality is attained even with low air exchange rates.

Consumers are advised to choose heat exchangers carefully as some exchangers have exhibited freezing and maintenance problems in the extreme cold of Alaska.

6.4 Arctic Entries

Arctic entries control excessive heat loss to the outdoors by allowing only the small amount of heated air in the entry to be lost to the outdoors each time the exterior door is opened.

6.5 Clock Thermostats

Clock thermostats provide automatic temperature setback when comfort space heating is reduced or not desired. In Anchorage, for example, if the thermostat is set back from 72°F to 60°F during the night and during the day when the house is unoccupied there can be as much as a 16% reduction in energy costs.

6.6 Water-heater Timers

Automatic water-heater timers reduce heat loss from water heaters during periods of standby. Timers should be installed only on water heaters in semiconditioned or unconditioned spaces if there is no danger of freezing or excess condensation on the tank surface. Timers should be installed on water heaters in conditioned spaces if the heater uses a fuel of significantly greater cost than that used to provide space heat.

6.7 Crawl Space Vents

Crawl space vents should be closed and covered with insulation during the heating season to prevent heat loss except in areas of permafrost conditions.

6.8 Appliances

Consumers should be aware of energy requirements for appliances. Though an individual appliance may not seem to have much of an impact on energy costs, today's homes usually have many appliances and, all together, their energy demands do have a noticeable impact upon the energy costs of the home.

Choose appliances that are energy efficient. Check the "Energy Guide" label of comparable appliances before buying. Properly maintain all appliances, and they will remain efficient.

6.9 Lighting

Many lighting design considerations can lower energy costs significantly. Use reflector type fixtures and bulbs for more light at less wattage. Use task instead of general lighting fixtures when possible. Fluorescent fixtures last 7 to 10 times longer than incandescent fixtures and use about one-third as much energy for the same light output. Timers can be installed to automatically turn lights off when not needed. Keep fixtures clean; dust and dirt on fixtures can lower lighting levels as much as 50%. The easiest way to save on lighting costs is to simply turn lights off when not needed and use natural lighting whenever possible.

Avoid recessing light fixtures into exterior walls or ceilings. These fixtures make installation of the vapor retarder and insulation difficult. Such difficulties often lead to moisture, structural, and heat loss problems.

6.10 Floor Protection

Insulation in floors over piling or post and pad type foundations needs to be protected from direct exposure to the outdoor environment or from destruction by animals. This can be done by covering the underside of the floor with an appropriate material such as plywood sheathing. Without a covering, high winds or animals may pull floor insulation out of place or destroy it altogether. In areas free of permafrost, foundation perimeter skirting will afford similar protection.

6.11 Fireplaces

At best, most fireplaces return only 10 percent of the burning wood's energy to the room while exhausting about 90 percent of the energy up the chimney. To be even 10 percent efficient, the average fireplace will consume about 2400 cubic feet of air (the amount in an average living room) every six minutes!

When fireplaces are not in use, or when a smoldering fire is left to die out overnight, dampers left in the open position will continuously exhaust a tremendous amount of interior air.

To minimize this heat loss, the following recommendations are provided for masonry fireplaces and factory built metal fireplaces:

a. Provide a combustion air intake duct to draw air from outside the building directly into the firebox. The air intake should have six square inches minimum clear cross sectional area and should be equipped with a readily accessible, operable, and tight-fitting damper;

b. Provide a tight fitting, closeable metal or glass door(s) covering the entire opening of the firebox;

c. Some fireplaces are significantly more efficient than others. Check efficiency ratings when shopping.

6.12 Adjustable Door Frames and Thresholds

Expansion and contraction movements and differential settling of the house will render door frames and thresholds out-of-plumb with the door. Adjustable door frames and thresholds allow the homeowner the chance to square the frame and door for a continued tight, effective seal against air leakage.

6.13 Building Design

The following building concepts are examples of good energy conservation design:

a. Orient heat-producing spaces such as kitchens and furnace rooms on the north side of the house;

b. Orient least-used rooms such as bedrooms, closets, and storage spaces on the north side of the house;

c. Orient living spaces on the south side of the house to take advantage of solar energy;

d. Minimize north-facing windows;

e. Locate plumbing fixtures as close to the water heater as possible to minimize heat loss from long pipe runs;

f. Locate water supply and wastewater pipes on interior walls instead of exterior walls to reduce heat loss and potential freeze-up problems;

g. Locate built-ins such as medicine cabinets, towel bars, phone and television outlet boxes on inside walls. This avoids installation difficulties for the vapor retarder and insulation in exterior walls which could lead to moisture, structure, and heat loss problems.

h. Thermal mass such as concrete, bricks, water, steel, tile, or masonry blocks help to store heat and even temperature differences between night and day. Place as much mass as possible where the sun coming through south-facing windows may strike it directly.

i. Darker exterior building colors absorb more solar heat than lighter colors. However, lighter interior colors distribute light throughout the house better than darker colors.

6.14 Site Design

The following site design considerations will help to minimize building heat loss.

a. Minimize the building's exposed envelope area while maximizing interior volume;

b. In areas where solar heat gains can be substantial, it is generally better to shape the building longer on the east/west axis and shorter on the north/south axis;

c. Utilize surrounding surfaces and landscaping materials such as hills, trees, and shrubbery to deflect or reduce winter winds while at the same time increasing summer ventilation possibilities (if needed) and solar heat gains.

d. Utilize ponds, lakes and clear, flat surfaces to the south of the building to enhance reflected solar gains.

CHAPTER 7
DEFINITIONS

The following definitions apply to this Standard.

1. Above-grade Wall. Any portion of a wall more than 12 inches above the adjacent finished grade shall be considered an above grade-wall.

2. Approved. Refers to approval by building officials of materials and types of construction as the result of investigations and tests by them, or by reason of accepted principles or tests by recognized authorities, technical or scientific organizations.

3. ASHRAE. The American Society of Heating, Refrigeration, and Air Conditioning Engineers.

4. ASTM. The American Society for Testing and Materials.

5. Below-grade Wall. Any portion of a wall which extends no more than 12 inches above the adjacent finished grade shall be considered a below grade-wall.

6. British Thermal Unit (Btu). Btu means the approximate amount of heat energy required to raise the temperature of one pound of water by one degree Farenheit.

7. Ceiling. Any group of members which define the boundaries of a space and has a slope of 60 degrees or less with the horizontal plane.

8. CFM. A unit of measure - Cubic Feet per Minute.

9. Conditioned Space. A room or other enclosed space which is intentionally or unintentionally heated and capable of maintaining a temperature of 50 degrees Farenheit or higher. Bedrooms, living rooms, and kitchens are examples of conditioned space.

10. Dry-bulb temperature. Temperature of air as indicated by a standard thermometer, as contrasted with wet-bulb temperature which depends upon atmospheric humidity.

11. Dwelling Unit. A single unit providing complete, independent living facilities for one or more persons, including provisions for sleeping, eating, cooking, and sanitation. Sanitation facilities may be detached from the dwelling unit.

12. **Exterior Envelope.** Those surfaces of a structure which are exposed to conditioned or semiconditioned space on one side and the outdoor environment on the other. This does not include roof eaves/soffits projecting beyond the exterior wall of the structure.

13. **Glazed Area.** Is equal to the frame dimensions for sliding glass doors, windows, or skylights, including the glazing and the sash.

14. **Glazing.** All transparent or translucent materials in the exterior envelope that lets in natural light, including windows, skylights, sliding glass doors, glass brick walls, and the glazed portions of doors.

15. **Gross Ceiling Envelope Area.** The sum of all ceiling envelope areas including the area directly above exterior walls.

16. **Gross Floor Envelope Area.** The sum of all floor envelope areas including basements, mezzanines, and intermediate floored tiers of headroom height, measured from the exterior face of envelope walls or from the center line of walls separating buildings, but not including:

    - o Covered walkways, open roofed-over areas, porches, and similar spaces;

    - o Exterior terraces or steps, chimneys, roof overhangs, and similar features.

17. **Gross Wall Envelope Area.** The sum of all wall envelope areas including opaque wall areas, window areas, and door areas and measured from the structural subfloor elevation for above grade walls or from the top of the footing for below grade walls up to the junction point with roof/ceiling structural members.

18. **Habitable Space.** Is space in a structure for living, sleeping, eating, or cooking, or which has the potential for such uses, and has a ceiling height of not less than 7 feet 6 inches. Bathrooms, toilet compartments, closets, halls, foyers, storage or utility space, and similar areas are <u>not</u> considered habitable space.

19. **Habitable Story.** The horizontal divisions of a building, extending from the floor to the ceiling or roof lying directly above it, and having the uses of habitable space.

20. **Heating Degree Day $_{65}$ (HDD $_{65}$).** A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying the nominal heating load of a building in winter. For any one day, when the mean temperature is less than 65 degrees Farenheit, there are as many Heating Degree Days as degrees Farenheit difference in temperature between the mean temperature for the day and 65 degrees Farenheit.

21. **Infiltration.** The uncontrolled flow of air through holes, openings, cracks and crevices in and around any building element caused by pressure effects of wind and/or the effect of differences in indoor and outdoor air density.

22. **New Residential Building.** Means a residential building whose construction begins after December 31, 1987 and has been occupied less than one year.

23. **Opaque Envelope Area.** All exterior envelope areas except openings for glazed area (windows, skylights, or sliding glass doors) or door area.

24. **R-value.** See "Thermal Resistance (R)."

25. **R_o-value.** See "Thermal Resistance, overall (R_o)."

26. **Semiconditioned Space.** A room or other enclosed space which is heated directly or indirectly by the presence of components of a heating system or by thermal transmission from an adjoining conditioned space and kept at a temperature less than 50 degrees Farenheit. Crawl spaces, attached garages, mechanical rooms, and basements are examples of semiconditioned space.

27. **Skylight.** Any opening in the roof surface which is glazed with a transparent or translucent material, including the frame.

28. **Slab-on-grade.** Horizontally placed concrete in direct or indirect (as when placed over rigid insulation) contact with the ground and used as a floor within the building envelope.

29. **Steady State Efficiency.** A measurement taken when the heating system is warmed up and in a state of unchanging ("steady") temperatures throughout the heating appliance and distribution system.

30. **Thermal Resistance (R).** A measure of the ability of a given material to resist heat flow. R is the numerical reciprocal of U. Thus, $R = 1/U$. The higher the R, the higher the insulating value. All insulation products having the same R, regardless of material or

thickness, are equal in insulating value; expressed as $(ft^2 \cdot hr \cdot °F)/Btu$. R-values for individual elements can be added to give a total R-value for an assembly.

31. **Thermal Resistance, overall (R_o).** A measure of the overall ability of a gross area to resist heat flow. Heat may flow through various materials along various parallel paths. R_o is the numerical reciprocal of U_o. Thus, $R_o = 1/U_o$; expressed as $(ft^2 \cdot hr \cdot °F)/Btu$.

32. **Thermal Transmission (Q).** The quantity of heat flowing from one space to another through an intermediary element (walls, ceilings, floors, pipes, and studs are examples) due to all mechanisms, in unit time, under the conditions prevailing at that time; expressed as Btu/hr.

33. **Thermal Transmittance (U).** The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films, expressed as $Btu/(ft^2 \cdot hr \cdot °F)$. The U-value applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity air spaces, and surface air films on both sides of a building element (as applicable). U values cannot be added together to give a total U-value for an assembly.

34. **Thermal Transmittance, overall (U_o).** The overall thermal transmittance of a gross area of the exterior building envelope, expressed as $Btu/(ft^2 \cdot hr \cdot °F)$. The U_o-value applies to the combined effect of the time rate of heat flow through the various parallel paths, such as windows, doors, and opaque construction areas, comprising the gross area of one or more exterior building envelope assembly such as walls, floors, or roof/ceilings.

35. **Thermostat.** An automatic device used to control heating or cooling appliances. Thermostats are actuated by temperature and designed to be responsive to temperature.

36. **U-value.** See "Thermal Transmittance (U)."

37. **U_o-value.** See "Thermal Transmittance, overall (U_o)."

38. **Wall.** Any group of members which define the boundaries of a building or space and has a slope of 60 degrees or greater with the horizontal plane.

39. **Window.** Any opening (other than a door) in the wall surface which is glazed with a transparent or translucent material, including the framing and sash.


APPENDIX A
STATEWIDE
REGIONAL INDEX MAP
REGION 5
REGION 4
REGION 3
REGION 2
REGION 1
BEAUFORT
SEA
CHUKCHI SEA
BERING STRAIT
NORTON SOUND
BERING SEA
KUSKOKWIM BAY
BRISTOL BAY
GULF OF ALASKA
ALEXANDER ARCHIPELAGO
DIXON ENTRANCE
ST. ELIAS MOUNTAINS
COAST MOUNTAINS
SEWARD PENINSULA
BROOKS RANGE
ALASKA RANGE
KUSKOKWIM MTS
YUKON
U.S.S.R.

APPENDIX A continued

Statewide Regional Index

For your convenience, the following cities/villages have been grouped according to their appropriate regions. These regions determine the requirements necessary for compliance with the Standard.

REGION 1
SOUTHEAST

Angoon
Annette
Annex Creek
Auke Bay
Baranof
Beaver Falls
Bell Island
Calder
Canyon Island
Chenega
Chichagof
Coffman Cove
Cordova
Craig
Edna Bay
Eldred Rock
Elfin Cove
Five Finger Light Station
Glacier Bay
Gull Cove
Gustavus
Haines
Hollis
Hoonah
Hydaburg
Hyder
Juneau
Kake
Kasaan
Ketchikan
Klawock
Klukwan
Kupreanof
Metlakatla
Myers Chuck
La Touche
Lincoln Rock Light
Little Port Walter
Moose Valley
Ocean Cape
Pelican
Petersburg
Port Alexander
Port Baker
Port Protection
Saxman
Seclusion Harbor
Sitka
Skagway #2
Smuggler Cove
Snettisham
Tatitlek
Tenakee Springs
Thorne Bay
View Cove
Wrangell
Yakutat

REGION 2
SOUTHCENTRAL, ALEUTIAN, KODIAK

Adak
Afognak
Akhiok
Akutan
Anchor Point
Anchorage
Anderson
Atka
Attu
Belkofski
Big Lake
Cape Sarichef
Caswell
Chickaloon
Chignik
Chignik Lake
Chiniak
Chulita
Clam Gulch
Cold Bay
Cold Harbor
Cooper Landing
Cordova
Curry
Diamond Ridge
Driftwood Bay
Dutch Harbor
Eklutna
Elmendorf
English Bay
False Pass
Fort Glenn
Fort Richardson
Girdwood
Homer
Hope
Houston
Ivanoff Bay
Iguigig
Kachemak
Kaguyak
Karluk
Kasigluk
Kasilof
Kenai
Kenney Lake
King Cove
King Salmon
Kipnuk
Knik
Kodiak
Kokhanok
Koliganek
Kotlik
Kulis ANGB
Kwethluk
Kwigillingok
Larsen Bay
Latouche
Lime Village
Lower Kalskag
Manokotak
Marshall
Mat. Ag. Exp.
McGrath
Middleton Island
Moose Pass
Mountain Village
Napakiak
Napamiute
Napaskiak
Naptowne
Nelson Lagoon
Newhalen
New Stuyahok
Newtok
Nightmute
Nikiski Terminal
Ninilchik
Nikolski
Old Harbor
Ouzinkie
Palmer
Perryville
Petersville
Pillar Mountain
Pitka's Point
Portage
Port Graham
Port Heiden
Port Lions
Port Moller
Portlock
Rabbit Creek
Roswell Bay
Salamatof
Sanak
Sand Point
Sawmill
Seldovia
Seward
Shemya
Swentna
Soldotna
Squaw Harbor
Starisky Creek
Sterling
Summit
Susitna
Sutton
Tehneta Pass
Talkeetna
Thompson Pass
Trappers Creek Camp
Tyonek
Unalaska
Unga
Unnak Island
Valdez
Wasilla
Whittier
Willow
Womens Bay
Yakataga Bay

Statewide Regional Index

REGION 3
INTERIOR, SOUTHWEST

Akiak
Akiachak
Alakanuk
Aleknagik
Allakaket
Anderson
Aniak
Anvik
Atmautluak
Aurora
Bear Creek
Beaver
Beaver Creek
Bethel
Bettles
Big Delta
Big Mountain
Bill Moore's
Birch Creek
Black Rapids
Boundary
Canyon Creek
Cape Newenham
Cape Romanzof
Cathedral Rapids
Creek #2
Cantwell
Central
Chalkyitsik
Chandalar
Chandalar Lake
Chatanika
Chauthbaluk
Chefornak
Chena Hot Springs
Chevak
Chicken
Chistochina
Chitina
Chuloonawick
Circle
Circle Hot Springs
Clark's Point
Clear
Coldfoot Camp
College
Copper Center
Crooked Creek
Delta Junction
Dillingham
Donnelly
Dot Lake
Dry Creek
Eagle
Eek
Egegik
Eielson
Ekuk
Ekwok
Emmonak
Ernestine
Ester
Eureka
Evansville
Fairbanks
Farewell
Ferry
Fort Greeley
Fort Wainwright
Fort Yukon
Fox
Flat
Gakona
Galena
Gerstle River
Georgetown
Glennallen
Gold King Creek
Goodnews Bay
Grayling
Gulkana
Hamilton
Harding Lake
Healy
Healy Lake
Holy Cross
Hooper Bay
Hughes
Huslia
Iguigig
Iliamna
Indian Mountain
Kalskag
Kaltag
Kanatak
Kasigluk
Kennicott
Kenny Lake
King Salmon
Kipnuk
Knob Ridge
Kokhanok
Koliganek
Kongiganak
Kotlik
Koyukuk
Kwethluk
Kwigillingok
Lake Munchumina
Lime Village
Livengood
Lower Kalskag
Lower Tonsina
Manley Hot Spring
Manokotak
Marshall
May Creek
McCallum
McCarthy
McGrath
McKinley Park
Medfra
Mekoryuk
Mentasta Lake
Minto
Mountain Village
Murphy Dome
Naknek
Napakiak
Napamiute
Napaskiak
Nebesna
Nenana
Newhalen
New Stuyahok
Newtok
Nightmute
Nikolai
Nondalton
North Pole
Northway
Northway Junction
Nulato
Nunapitchuk
Ohogamiute
Ophir
Oscarville
Paimuit
Paxson
Paxson Lake
Pedro Dome
Pilot Point
Pilot Station
Platinum
Port Alsworth
Quinhagak
Rampart
Red Devil
Richardson
Russian Mission
Ruby
Saint George
Saint Mary's
Saint Mathew
Saint Paul Island
Salchaket
Scammon Bay
Shageluk
Sheldon Point
Slana
Sleetmute
Slide Mountain
South Naknek
Sparrevohn
Stevens Village
Stony River
Suntrana
Summit
Takotna
Tanacross
Tanana
Tatalina
Telida
Tetlin
Togiak
Tok
Toksook Bay
Tonsina
Tuluksak
Tununak
Tuntutuliak
Twin Hills
Ugaskik
Upper Kalskag
Usibelli
Unkumiute
Venetie
Wisemen

Statewide Regional Index

REGION 4
NORTHWEST
Ambler
Anvil Mountain
Brevig Mission
Buckland
Candle
Council
Deering
Diomede
Elim
Gambell
Golovin
Granite Mountain
Haycock
Kalakaket Creek
Kiana
King Island
Kivalina
Kobuk
Kotzebue
Koyuk
Mary's Igloo
Moses Point
Noatak
Nome
Noorvik
Northeast Cape
North River
Savoonga
Selawik
Shaktoolik
Shishmaref
Shungnak
Solomon
Stebbins
St. Michael
Teller
Tin City
Unalakleet
Wales
White Mountain

REGION 5
ARCTIC SLOPE
Anaktuvuk Pass
Arctic Village
Atqasut
Barrow
Cape Lisburne
Deadhorse
Kaktovik
Nuiqsut
Oliktok
Point Hope
Point Lay
Prudhoe Bay
Sagwon
Umiat
Wainwright

APPENDIX B
Statewide Climate Data

REGION NUMBER REGION NAME STATION	LATITUDE DEG-MIN	LONGITUDE DEG-MIN	ANNUAL HEATING DEGREE DAYS, 65°F	WINTER DESIGN DRY BULB TEMP.,°F	MEAN ANNUAL TEMP.,°F	97½ % WIND PVLG DIR	97½ % WIND MEAN SPEED MPH
1 SOUTHEAST							
Angoon	57-30	134-35	8,511 ***	----	41.6	SE	----
Annette WSO AP	55-02	131-34	7,132 *	17	45.7	SSE	10.8
Annex Creek	58-19	134-06	9,312 *	----	39.8	SE	----
Auke Bay	58-23	134-39	8,906 ***	----	40.6	---	----
Baranof	57-05	134-50	8,651 ***	----	41.3	---	----
Beaver Falls	55-23	131-28	7,557 *	----	44.2	---	----
Bell Island	55-56	131-34	7,811 ***	----	43.6	---	----
Calder	56-10	133-27	7,994 ***	----	43.1	---	----
Canyon Island	58-43	133-40	9,417 ***	----	39.2	---	----
Chichagof	57-39	136-05	8,432 ***	----	41.9	---	----
Craig	55-22	133-09	7,337 ***	----	44.9	SE	----
Eldred Rock	58-58	135-13	8,651 ***	----	41.3	SW	----
Five Finger Light Station	57-16	133-37	8,080 *	----	42.9	SSE	----
Glacier Bay	58-22	136-00	9,271 ***	----	39.6	---	----
Gull Cove	58-12	136-09	8,687 ***	----	41.2	---	----
Gustavus	58-24	135-44	8,797 ***	----	40.9	---	----
Hollis	55-29	132-40	7,264 ***	----	45.1	---	----
Hoonah	58-07	135-25	9,552 **	0	----	---	----
Hydaburg	55-12	132-49	7,008 ***	----	45.8	---	----
Juneau WSO AP	58-22	134-35	9,105 *	1	40.3	ESE	8.6
Kake	56-58	133-56	8,359 ***	----	42.1	---	----
Ketchikan	55-21	131-39	7,065 *	----	46.2	SE	----
Klukwan	59-24	135-53	10,476 ***	----	36.3	---	----
Lincoln Rock Light	56-03	132-41	7,373 ***	----	44.8	---	----
Little Port Walter	56-23	134-39	8,119 *	----	42.8	N	----
Moose Valley	59-26	136-05	10,658 ***	----	35.8	---	----
Ocean Cape	59-32	139-51	9,533 **	5	----	---	----
Pelican	57-57	136-13	8,833 ***	----	40.8	---	----
Petersburg	56-49	132-57	8,508 *	----	41.9	SW	----
Port Alexander	56-15	133-38	7,702 ***	----	43.9	---	----
Skagway #2	59-27	135-18	8,833 ***	----	40.8	---	----
Seclusion Harbor	56-33	133-52	7,957 ***	----	43.2	---	----
Sitka FAA AP	57-04	135-21	7,509 *	17	44.1	---	----
Smuggler Cove	55-05	131-35	7,053 **	17	----	---	----
Snettisham	57-59	133-47	10,366 ***	----	36.6	---	----
Tenakee Springs	57-46	135-13	8,359 ***	----	42.1	---	----
View Cove	55-03	132-59	6,826 ***	----	46.3	---	----
Wrangell	56-28	132-23	8,197 *	----	43.0	SE	----
Yakutat WSO AP	59-31	139-40	9,605 *	5	38.8	E	7.7

Statewide Climate Data

REGION NUMBER REGION NAME STATION	LATITUDE DEG-MIN	LONGITUDE DEG-MIN	ANNUAL HEATING DEGREE DAYS, 65°F	WINTER DESIGN DRY BULB TEMP., °F	MEAN ANNUAL TEMP., °F	97½ % WIND PVLG DIR	MEAN SPEED MPH
2 SOUTHCENTRAL, ALEUTIAN, KODIAK							
Anchorage WSO AP	61-10	150-01	10,816 *	- 18	35.0	NNE	6.7
Big Lake	61-33	149-52	11,753 ***	----	32.8	---	----
Caswell	61-58	150-02	12,410 ***	----	31.0	---	----
Chickaloon	61-47	148-28	11,790 ***	----	32.7	---	----
Clam Gulch	60-13	151-25	11,375 **	- 21		---	----
Cordova FAA AP	60-30	145-30	9,837 *	- 2	38.2	---	----
Curry	62-37	150-00	10,987 ***	----	34.9	---	----
Diamond Ridge	59-41	151-37	10,394 **	2		---	----
Eklutna	61-28	149-22	10,987 ***	----	34.9	---	----
Elmendorf AFB	61-15	149-48	10,940 *	- 16	35.1	---	----
Fort Richardson/ Bryant AAF	61-16	149-39	10,722 **	- 16		---	----
Girdwood	60-56	149-10	10,478 ***	----	36.3	---	----
Homer WSO	59-38	151-30	10,349 *	- 2	36.5	NE	6.5
Kasilof	60-19	151-15	11,502 *	----	34.1	---	----
Kenai FAA AP	60-34	151-15	11,609 *	- 23	33.1	N	6.6
Kenney Lake	61-43	144-56	14,199 ***	----	26.1	---	----
Kulis ANGB	61-10	149-59	10,911 **	- 18		---	----
Latouche	60-03	147-54	8,614 ***	----	41.4	---	----
Mat. Ag. Exp.	61-34	149-16	10,849 ***	----	35.2	NE	----
Middleton Island	59-27	146-18	8,188 **	21	42.3	ESE	13.8
Moose Pass	60-29	149-22	11,315 ***	----	34.0	----	----
Naptowne	60-32	150-35	12,054 **	- 26		---	----
Neklason Lake	61-37	149-15	11,220 **	- 22		---	----
Nikiski Terminal	60-41	151-24	11,060 ***	----	34.7	---	----
Ninilchik	60-03	151-40	11,352 ***	- 24	33.9	---	----
Palmer AAES	61-36	149-06	11,081 *	----		---	----
Portage	60-50	148-58	10,293 ***	----	36.8	---	----
Rabbit Creek	61-05	149-44	10,814 **	- 13		---	----
Roswel Bay AFS	60-25	146-09	9,765 **	0		---	----
Sawmill	61-48	148-19	13,531 **	- 18		---	----
Seward	60-07	149-27	9,350 *	7	39.6	---	----
Soldotna	60-32	151-05	11,615 **	- 23	32.5	---	----
Starisky Creek	59-33	151-47	10,855 **	- 20		---	----
Sterling	60-32	150-45	12,118 ***	- 24	31.8	---	----
Summit WSO	63-19	149-07	14,368 ***	----	25.5	NE	9.7
Susitna	61-32	150-30	10,731 ***	----	35.6	---	----
Tahneta Pass	61-50	149-19	14,361 **	- 18		---	----
Talkeetna WSO	62-18	150-06	11,804 *	----	32.8	---	----
Thompson Pass	61-07	145-43	13,323 ***	----	28.5	---	----
Trappers Creek Camp	61-51	150-22	11,863 ***	----	32.5	---	----
Valdez WSO	61-08	146-21	9,711 *	----	36.0	---	----
Whittier	60-47	148-41	9,444 **	5	38.7	---	----
Yakataga	60-04	142-25	9,222 **	10	34.1	ESE	7.1

Statewide Climate Data

REGION NUMBER REGION NAME STATION	LATITUDE DEG-MIN	LONGITUDE DEG-MIN	ANNUAL HEATING DEGREE DAYS, 65°F	WINTER DESIGN DRY BULB TEMP.,°F	MEAN ANNUAL TEMP.,°F	97½ % WIND PVLG DIR	97½ % WIND MEAN SPEED MPH
2 SOUTHCENTRAL, ALEUTIAN, KODIAK (continued)							
Adak	51-53	176-39	8,938 *	23	40.8	W	14.5
Atka	52-12	174-12	9,054 ***	----	40.2	---	----
Attu/Casco Cove CGS	52-50	173E10	8,339 **	22		---	----
Cape Sarichef	54-36	164-55	9,985 **	12		---	----
Chignik	56-18	158-24	10,001 ***	----	37.6	---	----
Cold Bay AFS	55-12	162-43	9,877 *	9	37.9	---	----
Cold Harbor	55-20	160-36	9,490 ***	----	39.0	---	----
Driftwood Bay AFS	53-58	166-53	10,637 **	11		---	----
Dutch Harbor	53-53	166-32	9,197 **	16	40.5	SE	11.0
Nikolski AFS	52-58	168-51	9,555 **	21		---	----
Port Heiden	56-59	158-38	10,441 **	- 6	35.7	S	----
Port Moller	55-59	160-30	10,290 **	- 1	34.3	---	10.0
Sand Point	55-20	160-30	9,271 ***	----	39.6	---	----
Shemya AFB	52-43	174E05	9,573 **	24	39.7	SE	----
Kodiak WSO	57-45	152-30	8,837 *	13	40.7	---	----
Larsen Bay	57-32	153-58	9.160 ***	----	39.9	---	----
Old Harbor	57-12	153-18	8,614 ***	----	41.4	---	----
Pillar Mountain	57-47	152-26	9,925 **	10		---	----

Statewide Climate Data

REGION NUMBER REGION NAME STATION	LATITUDE DEG-MIN	LONGITUDE DEG-MIN	ANNUAL HEATING DEGREE DAYS, 65°F	97½ % WINTER DESIGN DRY BULB TEMP., °F	MEAN ANNUAL TEMP., °F	WIND PVLG DIR	WIND MEAN SPEED MPH
3 INTERIOR, SOUTHWEST							
Allakaket	66-34	152-32	16,608 ***	---	19.5	E	----
Aurora	62-24	145-02	13,593 **	- 37	---	---	----
Bear Creek	65-15	151-55	13,861 **	- 35	---	---	----
Beaver Creek	63-03	141-49	14,770 **	- 47	---	---	----
Bettles WSO AP	66-55	151-31	15,959 *	- 45	---	NNW	6.7
Big Delta	64-00	145-44	13,697 *	- 43	---	---	----
Black Rapids	63-29	145-50	12,553 **	- 30	---	---	----
Boundary	64-04	141-06	15,586 ***	---	22.3	---	----
Canyon Creek	64-18	146-32	13,298 **	- 37	---	---	----
Cathedral Rapids Creek #2	63-23	143-47	15,275 **	- 51	23.9	---	----
Chandalar Lake	67-30	143-30	17,739 ***	---	16.4	---	----
Chena Hot Springs	65-03	146-03	15,403 ***	---	22.8	---	----
Chistochina	62-34	144-40	13,834 ***	---	27.1	---	----
Chitina	61-31	144-26	13,140 ***	---	29.0	---	----
Circle Hot Springs	65-29	144-38	15,671 ***	---	22.0	SW	----
Clear	64-20	149-10	15,330 ***	---	23.0	---	----
Coldfoot Camp	67-15	150-11	18,068 ***	---	15.5	---	----
Delta Junction	64-02	145-44	14,235 ***	- 43	26.0	ESE	8.1
Donnelly	63-47	145-51	12,683 **	- 30	---	---	----
Dot Lake	63-39	144-04	14,162 ***	---	26.2	---	----
Eielson AFB	64-40	147-06	14,498 **	- 48	25.1	W	3.5
Ernestine	61-26	145-06	13,980 ***	---	26.7	---	----
Eureka	65-11	150-13	14,892 ***	---	24.2	---	----
Fairbanks WSO AP	64-49	147-52	14,274 *	- 47	25.7	SW	5.3
Fort Greely	63-58	145-44	13,698 **	- 43	---	---	----
Fort Wainwright	64-50	147-37	14,345 **	- 47	---	---	----
Fort Yukon AFS	66-34	145-15	16,084 **	- 57	20.4	NE	8.1
Gakona	62-18	145-18	15,038 ***	---	23.8	---	----
Galena	64-44	156-56	15,087 **	- 46		---	----
Gerstle River	63-48	145-00	13,398 **	- 41	---	---	----
Glennallen	62-07	145-33	14,892 ***	---	24.2	---	----
Gold King Creek	64-12	149-55	13,364 **	- 35	---	---	----
Gulkana	62-16	145-23	13,938 ***	---	26.8	NE	----
Gulkana WSO	62-09	145-27	14,004 *	- 40	---	NE	6.8
Harding Lake	64-24	146-57	13,398 **	- 41	---	---	----
Healy	63-51	148-58	12,775 ***	---	30.0	---	----
Indian Mountain AFS	66-00	153-42	15,169 **	- 40	23.5	ENE	5.8
Kennicott	61-29	142-53	12,702 ***	---	30.2	---	----
Knob Ridge	63-38	144-03	15,080 **	- 49	---	---	----
Manley Hot Springs	65-00	150-38	14,783 ***	---	24.5	N	----
May Creek	61-21	142-41	14,381 ***	---	25.6	---	----
McCallum	63-14	145-38	13,343 **	- 26	---	---	----

Statewide Climate Data

REGION NUMBER REGION NAME STATION	LATITUDE DEG-MIN	LONGITUDE DEG-MIN	ANNUAL HEATING DEGREE DAYS, 65°F	97½ % WINTER DESIGN DRY BULB TEMP.,°F	MEAN ANNUAL TEMP.,°F	WIND PVLG DIR	WIND MEAN SPEED MPH
3 INTERIOR, SOUTHWEST (continued)							
McCarthy	61-26	142-55	11,899 ***	---	32.4	---	----
McGrath WSO AP	62-58	155-37	14,574 *	- 47	25.2	N	4.9
McKinley Park	63-43	148-58	14,152 *	----	26.9	SE	----
Murphy Dome AFS	64-57	148-21	13,795 **	- 32	---	---	----
Nenana	64-33	149-05	14,539 **	- 50	25.1	---	----
Nikolai	62-58	154-09	15,075 ***	---	23.7	---	----
North Pole	64-45	147-21	15,403 ***	---	22.8	---	----
Northway FAA AP	62-57	141-56	15,855 *	- 53	22.4	---	----
Paxson Lake	62-58	145-28	13,483 **	- 25		---	----
Pedro Dome	65-02	147-30	13,600 **	- 33		---	----
Slide Mountain	62-01	146-50	15,148 ***	---	25.3	---	----
Summit	63-20	149-08	14,368 **	- 30		NE	9.7
Tanana WSO	65-10	152-06	15,229 *	- 48		---	----
Tatalina AFS	62-54	155-58	13,453 **	- 28	28.1	---	----
Tok	63-20	142-59	15,732 ***	- 54	24.9	---	----
Aniak	61-35	159-32	13,412 **	- 39	28.2	ESE	6.9
Bethel	60-47	161-47	13,213 ***	- 39	28.7	NNE	12.9
Bethel WSO AP	60-47	161-48	13,334 *	- 28		NNE	12.9
Big Mountain	59-23	155-13	12,144 **	- 13		---	----
Cape Newenham AFS	58-39	162-04	11,481 **	- 11		---	----
Cape Romanzof	61-47	166-02	13,130 **	- 14		---	----
Crooked Creek	61-52	158-06	13,432 ***	---	28.2	---	----
Dillingham	59-02	158-27	11,279 ***	---	34.1	N	----
Holy Cross	62-12	159-46	13,067 ***	---	29.2	NW	----
Iliamna	59-45	154-55	12,144 **	- 19	33.3	ESE	10.4
Kalskag	61-32	160-18	13,323 ***	---	28.5	NE	----
Kanatak	57-34	156-02	8,468 ***	---	41.8	---	----
King Salmon WSO AP	58-41	156-39	11,716 *	- 22	33.2	N	11.0
Mekoryuk	60-23	166-11	13,031 ***	---	29.3	---	----
Naknek	58-45	157-00	11,133 **	- 12		---	----
Port Alsworth	60-12	154-19	11,607 ***	---	33.2	---	----
Sparrevohn AFS	61-06	155-35	12,982 **	- 26	29.4	---	----
St. George	56-36	169-32	10,476 ***	---	36.3	---	----
St. Mary's	62-04	163-11	12,870 ***		29.7		
St. Paul Island WSO AP	57-09	170-13	11,178 *	4	34.5	NW	18.4

Statewide Climate Data

REGION NUMBER REGION NAME STATION	LATITUDE DEG-MIN	LONGITUDE DEG-MIN	ANNUAL HEATING DEGREE DAYS, 65°F	97½ % WINTER DESIGN DRY BULB TEMP., °F	MEAN ANNUAL TEMP., °F	WIND PVLG DIR	WIND MEAN SPEED MPH
4 NORTHWEST							
Anvil Mountain	64-34	165-22	14,555 **	- 27		---	----
Candle	65-55	161-56	16,462 ***	---	19.9	N	----
Gambell	63-47	171-45	14,892 ***	---	24.2	N	16.8
Golovin	64-33	163-02	13,943 ***	---	26.8	NW	----
Granite Mountain	65-26	161-14	14,986 **	- 32		---	----
Kalakaket Creek	64-26	156-50	13,942 **	- 32		---	----
Kobuk	66-55	156-52	16,133 ***	---	20.8	---	----
Kotzebue WSO AP	66-52	162-38	16,032 *	- 37	20.9	E	13.0
Moses Point	64-42	162-03	14,505 **	- 35	24.9	NNE	----
Nome WSO AP	64-30	165-26	14,371 *	- 27	25.6	WSW	11.0
Noorvik	66-50	161-30	------ ***	---	----	---	----
Northeast Cape	63-18	168-42	14,418 ***	- 20	25.5	SE	12.9
North River	63-53	160-31	14,027 **	- 33		---	----
Savoonga	63-42	170-29	15,148 ***	---	23.5	---	----
Shishmaref	66-15	166-04	16,316 ***	---	20.3	N	----
Shungnak	66-52	157-09	15,586 ***	---	22.3	---	----
St. Michael	63-29	162-02	14,272 ***	---	25.9	N	----
Tin City AFS	65-34	167-55	16,192 **	- 27	21.0	NW	17.5
Unalakleet	63-53	160-48	14,027 **	- 34	26.4	E	12.7
Wales	65-37	168-05	15,987 ***	---	21.2	NE	----
White Mountain	64-41	163-24	13,578 ***	---	27.8	N	----
5 ARCTIC SLOPE							
Anaktuvuk Pass	-----	------	18,873 ***	----	13.3	---	----
Arctic Village	68-08	145-32	18,433 ***	---	14.5	---	----
Barrow	71-18	156-47	20,265 *	- 41	9.3	W	11.9
Cape Lisburne AFS	68-53	166-07	17,063 **	- 31	18.1	S	12.5
Oliktok	70-31	149-53	20,265 **	- 41	---	---	----
Point Hope	68-21	166-47	16,973 ***	---	18.5	---	----
Point Lay	69-44	163-01	19,194 **	- 37	12.5	NE	----
Prudhoe Bay	-----	------	19,749 ***	----	10.2	NE	10.0
Umiat	-----	------	19,966 ***	----	10.3	W	7.7
Wainwright	70-36	159-53	19,991 **	- 41	10.9	E	----

NOTES

1. Annual Heating Degree Days

*Annual heating degree day normals (Base 65°F) from "Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951 - 80 Alaska;" Climatography of the United States No. 81; National Climate Center, Asheville, N.C. Sept. 1982, except as noted. The normal of a climatological element is the arithmetic mean computed over the time period indicated. Heating degree day data from this publication was given priority over data from the following two sources for identical stations.

**Annual heating degree days from Air Force Manual of Engineering Weather Data for Facility Design and Planning (AFM-88-29), July 1, 1978. Heating degree days are the mean annual number of degree days using a base of 65°F and a 30-year period of record when available.

***Annual heating degree days from Jim Wise, State Climatologist, Arctic Environmental Information Data Center (AEIDC).

2. Design temperatures from Air Force Manual of Engineering Weather Data for Facility Design and Planning (AFM-88-29), July 1, 1978. Design temperatures for the Alaskan stations listed in ASHRAE's Handbook of Fundamentals 1981, correlate identically with those values listed in AFM-88-29.

3. Mean annual temperature from Jim Wise, State Climatologist, Arctic Environmental Information Data Center (AEIDC), Anchorage, Alaska.

4. Wind Speed and direction is coincident with average winter temperatures. From Jim Wise, AEIDC.

5. This compilation of climatological data was prepared by Stuart Brooks, Office of Energy Programs, Division of Community Development, Department of Community and Regional Affairs, State of Alaska, October 22, 1985.

APPENDIX C

Thermal Properties of Typical Building and Insulating Materials

The following tables provide information useful in determining compliance with this Standard. Much of the information was reprinted with permission from the ASHRAE Handbook of Fundamentals, 1985 edition. Information from these tables, or specific manufacturer's data may be used to verify compliance.

1. THERMAL PROPERTIES OF TYPICAL BUILDING AND INSULATING MATERIALS - (DESIGN VALUES)[1]
(These constants are expressed in Btu/ft^2·hr·°F). Resistance (R) is for the thickness listed or per inch thickness. All values are for a mean temperature of 75°F, except as noted by an (*) which have been reported at 45°F.)

Description	Density (lb/ft^3)	Resistance (R) Per Inch Thickness	Resistance (R) For Thickness listed	Specific Heat, Btu/(lb) (deg F)
Building Board				
Boards, Panels, Subflooring, Sheathing, Woodboard Panel Products				
Gypsum or plaster board ..... 0.375 in.(3/8")	50	-	0.32	0.26
Gypsum or plaster board ..... 0.5 in.(½")	50	-	0.45	
Gypsum or plaster board ..... 0.625 in.(5/8")	50	-	0.56	
Plywood (Douglas fir)	34	1.25	-	0.29
Plywood (Douglas fir) .... 0.25 in.(¼")	34	-	0.31	
Plywood (Douglas fir)........ 0.3125 in.(5/16")	34	-	0.39	
Plywood (Douglas fir) .... 0.375 in.(3/8")	34		0.47	
Plywood (Douglas fir)........ 0.4375 in.(7/16")	34	-	0.55	
Plywood (Douglas fir) .... 0.5 in.(½")	34		0.62	
Plywood (Douglas fir) .... 0.625 in.(5/8")	34	-	0.77	
Plywood or wood panels ...... 0.75 in.(3/4")	34	-	0.93	0.29
Hard Board				
Medium density	50	1.37	-	0.31
High density, service temp. service underlay	55	1.22	-	0.32
High density, std. tempered................	63	1.00	-	0.32
Particleboard				
Low density................................	37	1.85	-	0.31
Medium density	50	1.06	-	0.31
High density	62.5	0.85	-	0.31
Underlayment .... 0.625 in.	40	-	0.82	0.29
Building Membrane				
Vapor-permeable felt, 15#	0	-	0.06	
Vapor-seal, 2 layers of mopped 15-lb felt.....	-	-	0.12	
Vapor-seal, plastic film	-	-	Negl.	

Description	Density (lb/ft^3)	Resistance (R) Per Inch Thickness	For Thickness listed	Specific Heat, Btu/(lb)(deg F)
Finish Flooring Materials				
Carpet and fibrous pad......	-	-	2.08	0.34
Carpet and rubber pad	-	-	1.23	0.33
Cork tile .... 0.125 in.	-	-	0.28	0.48
Terrazzo .... 1 in.	-	-	0.08	0.19
Tile-asphalt, linoleum,				
vinyl, rubber	-	-	0.05	0.30
ceramic				0.19
Wood, hardwood fin. 0.75 in.			0.68	
Insulating Materials				
Blanket and Batt [2, 3]				
Mineral fiber, fibrous form processed				
from rock, slag or glass				
approx. 2-2.75 in.	0.3-2.0	-	7	0.17-0.23
approx. 3-3.5 in.	0.3-2.0	-	11	
approx. 3.5-6.5 in.	0.3-2.0	-	19	
approx. 6-7in.	0.3-2.0	-	22	
approx. 8.5-9 in.	0.3-2.0	-	30	
approx. 12 in.		-	38	
Board and Slabs [4]				
Cellular glass	8.5	2.63	-	0.24
Glass fiber, organic bonded..	4-9	4.00	-	0.23
Expanded polystyrene extruded				
Cut cell surface	1.8	4.00	-	0.29
Smooth skin surface	2.2	5.00	-	0.29
Smooth skin surface	3.5	5.26	-	
Expanded polystyrene, molded				
beads	1.0	3.85	-	-
	1.25	3.90-4.0	-	
	1.5	4.17	-	-
	1.75	4.17	-	-
	2.0	4.35	-	-
Cellular polyurethane				
unfaced	1.5	6.25	-	0.38
faced [10]	1.5	7.14	-	
Polysiocyanurate, faced [10]	2	7.04	-	0.22
Nominal 0.5 in.		-	3.6	
Nominal 1.0 in.			7.2	
Nominal 2.0 in.			14.4	

Description	Density (lb/ft^3)	Resistance (R) Per Inch Thickness	Resistance (R) For Thickness listed	Specific Heat, Btu/(lb)(deg F)
Loose Fill				
Cellulosic insulation (milled paper or wood pulp)	2.3-3.2	3.13-3.70	-	0.33
Perlite, expanded	5.0-8.0	2.70	-	0.26
Mineral fiber (rock, slag or glass)[3]				
approx. 3.75-5 in.	0.6-2.0		11	0.17
approx. 6.5-8.75 in.	0.6-2.0		19	
approx. 7.5-10 in.	0.6-2.0		22	
approx. 10.25-13.75 in.	0.6-2.0		30	
Vermiculite, exfoliated	7.0-8.2	2.13	-	3.20
	4.0-6.0	2.27	-	
Masonry Materials				
Concretes				
Cement mortar	116	0.20	-	
Lightweight concrete	120	0.19	-	
	100	0.28	-	
	80	0.40	-	
Perlite, expanded	40	1.08		
	30	1.41		
	20	2.00		0.32
Normal-weight concrete	135	0.11		0.22
	160	0.08		
Stucco	116	0.20		
Masonry Units				
Brick, common[5]	120	0.20	-	0.19
Brick, face[5]	130	0.11	-	
Clay tile, hollow:				
1 cell deep .... 4 in.	-	-	1.11	
2 cells deep .... 6 in.	-	-	1.52	
2 cells deep .... 8 in.	-	-	1.85	
2 cells deep .... 10 in.	-	-	2.22	
3 cells deep .... 12 in.	-	-	2.50	
Concrete blocks, three oval core:				
Sand and gravel aggregate .. 4 in.	-	-	0.71	0.22
8 in.	-	-	0.11	
12 in.	-	-	1.28	
Cinder aggregate .... 4 in.	-	-	1.11	
8 in.	-	-	1.72	
12 in.	-	-	1.89	

Description	Density (lb/ft^3)	Resistance (R) Per Inch Thickness	For Thickness listed	Specific Heat, Btu/(lb) (deg F)
Masonry Units (continued)				
Concrete blocks, rectangular core[6]				
Sand and gravel aggregate				
2 core, 8 in. 36 lb[7]	-	-	1.04	0.22
Same with filled core[8]	-	-	1.93	0.22
Stone, lime or sand	-	0.08	-	0.19
Plastering Materials				
Cement plaster, sand aggregate	116	0.20	-	0.20
Sand aggregate .... 0.375 in.	-	-	0.08	0.20
Sand aggregate .... 0.75 in.	-	-	0.15	0.20
Gypsum plaster:				
Lightweight aggregate .... 0.5 in.	45	-	0.32	
Lightweight aggregate ..... 0.625 in.	45	-	0.39	
Lightweight aggregate on metal lath .... 0.75 in.	-	-	0.47	
Perlite aggregate	45	0.67	-	0.32
Sand aggregate	105	0.18	-	0.20
Sand aggregate .... 0.5 in.	105	-	0.09	
Sand aggregate .... 0.625 in.	105	-	0.11	
Sand aggregate on metal lath .... 0.75 in.	-		0.13	
Vermiculite aggregate	45	0.59	-	
Roofing				
Asbestos-cement shingles	120	-	0.21	0.24
Asphalt roll roofing	70	-	0.15	0.36
Asphalt shingles	70	-	0.44	0.30
Built-up roofing .... 0.375 in.	70	-	0.33	0.35
Wood shingles, plain and plastic film faced	-	-	0.94	0.31
Siding Materials (On Flat Surface)				
Shingles				
Wood, 16 in., 7.5 in. exposure	-	-	0.87	0.31
Wood, double, 16-in., 12-in. exposure	-	-	1.19	0.28
Wood, plus insul. backer board, ... 0.3125 in.	-	-	1.40	0.31

Description	Density (lb/ft^3)	Resistance (R) Per Inch Thickness	Resistance (R) For Thickness listed	Specific Heat, Btu/(lb)(deg F)
Siding Materials (On Flat Surface) (continued)				
Siding				
Wood, drop, 1 x 8 in.	-	-	0.79	0.28
Wood, bevel, 0.5 x 8 in., lapped	-	-	0.81	0.28
Wood bevel, 0.75 x 10 in., lapped	-	-	1.05	0.28
Wood, plywood, 0.375 in., lapped	-	-	0.59	0.29
Wood, medium density siding, 0.4375 in.	40	0.67		0.28
Aluminum or Steel[9], over sheathing				
Hollow-backed	-	-	0.61	0.29
Insulating-board backed nominal 0.375 in.	-	-	1.82	0.32
Insulating-board backed nominal 0.375 in., foil backed			2.96	
Woods				
Maple, oak, and similar hardboards....................	45	0.91	-	0.30
Fir, pine, and similar softboards	32	1.25	-	0.33
0.75 in.	32	-	0.94	0.33
1.5 in.		-	1.89	
2.5 in.		-	3.12	
3.5 in.		-	4.35	
Logs[11]				
6" 3-Sq log	167	-	8.40	-
8" Milled log	150	-	8.90	-
8" 3-Sq log	297	-	9.20	-
9" Milled log	153	-	10.70	-
12" Turned log	199	-	11.80	-
14" Turned log	240	-	13.70	-
16" Turned log	274	-	15.70	-

NOTES:

1. Representative values for dry materials were selected by ASHRAE TC 4.4, Thermal Insulation and Moisture Retarders (Total Thermal Performance Design Criteria). They are intended as design (not specification) values for materials in normal use. Insulation materials in actual service may have thermal values which vary from design values depending on their insitu properties such as density and moisture content. For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

2. Does not include paper backing and facing, if any.

3. Conductivity varies with fiber diameter. Also, insulation is produced in different densities; therefore, there is some variation in overall batt thickness for the same nominal R-value among manufacturers. Relating specific R-values to specific thicknesses should be nominal only.

4. Values are for aged, board stock.

5. Face brick and common brick do not always have these specific densities. When density is different from that shown, there will be a change in thermal conductivity.

6. Data on rectangular core concrete block differ from the above data on oval core blocks due to core configuration, different mean temperatures, and possibly differences in unit weights. Weight data on the oval core blocks tested are not available.

7. Weights of units approximately 7.625 in. high and 15.75 in. long. These weights are given as a means of describing the blocks tested, but conductance values are all for 1 ft^2 of area.

8. Vermiculite, perlite, or mineral wood insulation. Where insulation is used, vapor barriers or other precautions must be considered to keep insulation dry.

9. Values for metal siding applied over flat surfaces vary widely, depending on amount of ventilation of air space beneath the siding; whether air space is reflective or nonreflective; and on thickness, type, and application of insulating backing-board used. Values given are averages for use as design guides, and were obtained from several guarded hotbox tests (ASTM C236) or calibrated hotbox (BSS 77) on hollow-backed types and types made using backing-boards of wood fiber, foamed plastic, and glass fiber. Departures of ±50% or more from the values given may occur.

10. Time-aged values for board stock with aluminum foil facers on two major surfaces.

11. Moisture content of logs at 15 percent. From Axel Carlson, Professor Emeritus, University of Alaska.

2. R-VALUES OF WOOD DOORS (U = 1/R)

Nominal Thickness	Description	Winter[1] No Storm Door	Summer[2] No Storm Door
1-3/8 in.	Solid core flush door	2.56	2.63
1-3/8 in.	Panel door with 7/16-in. panels	1.75	1.85
1-3/4 in.	Solid core flush door	3.03	3.12
	With single glazing[3]	2.17	2.72
	With insulating glass[3]	2.70	2.78
1-3/4 in.	Panel door with 7/16-in. panels[4]	1.85	1.92
	With single glazing[5]	1.49	1.58
	With insulating glass[5]	2.00	2.08
1-3/4 in.	Panel door with 1-1/8-in. panels[4]	2.56	2.63
	With single glazing[5]	1.64	1.72
	With insulating glass[5]	2.72	2.38

NOTES:

Values for doors are based on nominal 3'0" x 6'8" door size. Interpolation and moderate extrapolation are permitted for glazing areas and door thicknesses other than those specified.

1. 15 mph outdoor air velocity; 0°F outdoor air temperature; 70°F inside air temperature; natural convection.

2. 7.5 mph outdoor air velocity; 89°F outdoor air temperature; 75°F inside air temperature; natural convection.

3. 17 percent exposed glass area; insulating glass contains 0.25 inch air space.

4. 55 percent panel area.

5. 33 percent glass area; 22 percent panel area; insulating glass contains 0.25 inch air space.

3. R-VALUES OF WINDOWS, SKYLIGHTS AND LIGHT-TRANSMITTING PARTITIONS (U = 1/R)

(These values are for heat transfer from air to air)

PART A[1] - Exterior Vertical Panels (Windows, Sliding Patio Doors, and Partitions), Flat Glass, Plastic Sheet and Glass Block.

Description	No Storm Sash Winter	No Storm Sash Summer
Flat Glass[2]		
Single Glass	0.91	0.96
Insulating Glass; Double[3]		
3/16 in. air space[4]	1.61	1.54
1/4 in. air space[4]	1.69	1.64
1/2 in. air space[5]	2.04	1.76
1/2 inc. air space, low emittance coating[6]		
e = 0.20	3.12	2.63
e = 0.40	2.63	2.08
e = 0.60	2.32	1.96
Insulating Glass; Triple[3]		
1/4 in. air spaces[4]	2.56	2.72
1/2 in. air spaces[7]	3.22	2.56
Storm Windows		
1-in. to 4-in air space[4]	2.00	2.00
Plastic Sheet		
Single Glazed		
1/8 in. thick	0.94	1.02
1/4 in. thick	1.04	1.12
1/2 in. thick	1.23	1.31
Insulating Unit; Double[3]		
1/4 in. air space[4]	1.82	1.78
1/2 in. air space[3]	2.32	2.22
Glass Block[8]		
6 x 6 x 4 in. thick	1.67	1.75
8 x 8 x 4 in. thick-with cavity divider	1.78	1.85
	2.08	2.17
12 x 12 x 4 in. thick-with cavity divider	1.92	2.00
	2.72	2.38
12 x 12 x 2 in. thick	1.67	1.75

PART B-Exterior Horizontal Panels (Skylights)-Flat Glass and Plastic Domes

Description	Winter[9]	Summer[10]
Flat Glass[5]		
Single Glass	31	1.20
Insulating Glass; Double[3]		
3/16 in. air space[4]	1.43	1.75
¼ in. air space[4]	1.54	1.85
½ in. air space[3]	1.69	2.04
½ in. air space, low emittance coating[6]		
e = 0.20	2.08	2.78
e = 0.40	1.92	2.38
e = 0.60	1.78	2.17
Plastic Domes[11]		
Single walled	0.87	1.25
Double walled	1.43	2.17

PART C - Adjustment Factors for Various Window and Sliding Patio Door Types (Multiply U-values in Parts A and B By These Factors)

Description	Single Glass	Double Insulating Glass	Triple Insulating Glass	Storm Sash Over Double or Triple Insulating Glass
Windows				
All Glass[12]	1.00	1.00	1.00	1.00
Wood frame-80% glass	0.85-0.95	0.90-1.00	0.95-1.00	0.95-1.00
Wood frame-60% glass	0.80	0.85	0.80	0.80
Metal frame-80% glass	1.00-1.10	1.20-1.30	1.30-1.50	1.30-1.50
Thermally improved metal frame	0.90-1.00	0.95-1.15	1.00-1.25	0.95-1.25
Sliding Patio Doors				
Wood frame	0.95	1.00	-	
Metal frame	1.00	1.10[13]	-	

NOTES:
1. See Part C for adjustments for various window and sliding patio door types. Window manufacturers should be consulted for specific data.
2. Emittance of uncoated glass surface = 0.84.
3. Double and triple refer to the number of lights of glass.
4. 1/8 in. glass.
5. ¼ in. glass.
6. Coating on either glass surface facing air space; all other glass surfaces uncoated.
7. Window design: ¼ in. glass-1/8 in. glass-¼ in. glass.
8. Dimensions are nominal.
9. For heat flow up.
10. For heat flow down.
11. Based on area of opening, not total surface area.
12. Refers to windows with negligible opaque area.
13. Values will be less than these when metal sash and frame incorporate thermal breaks. In some thermal break designs, U-values will be equal to or less than those for the glass. Window manufacturers should be consulted for specific data.

4. RESISTANCE (R) VALUES OF AIR FILMS

Position of Surface	Direction of Heat Flow	E=0.90	E=0.20	E=0.05
Still Air				
Horizontal	Upward	0.61	1.10	1.32
45°slope	Upward	0.62	1.14	1.37
Vertical	Horizontal	0.68	1.35	1.70
45° slope	Down	0.76	1.67	2.22
Horizontal	Down	0.92	2.70	4.55
Moving Air				
(any position)				
15 mph wind	Any	0.17 (winter)	-	-
7½ mph wind	Any	0.25 (summer)	-	-

NOTES:

1. No surface has both an air space resistance value and a surface resistance value. No air space value exists for an surface facing an air space of less than 0.5 in.
2. Conductances are for surfaces of the stated emittance facing virtual blackbody surroundings at the same temperature as the ambient air. Values are based on a surface - air-temperature differences of 10 deg. F and for surface temperature of 70 deg. F.

5. RESISTANCE (R) VALUES OF AIR SPACES[1]

Position of Air Space[2] and Thickness (in.)	Direction of Heat Flow	Surface Emittance (E) E=0.82	E=0.2	E=0.05
Horizontal ½	Up	0.87	1.70	2.22
3/4		0.84	1.60	2.05
1 ½		0.89	1.81	2.40
3 ½		0.93	1.95	2.66
45° slope ½	Up	0.94	2.00	2.75
3/4		0.90	1.83	2.44
1 ½		0.94	1.99	2.74
3 ½		0.96	2.10	2.95
Verticle ½	Horizontal	1.01	2.35	3.46
3/4		0.91	1.88	2.54
1 ½		1.02	2.39	3.55
3 ½		1.01	2.32	3.40
45° slope ½	Down	1.02	2.40	3.57
3/4		0.92	1.89	2.55
1 ½		1.09	2.85	4.66
3 ½		1.08	2.73	4.36
Horizontal ½	Down	1.02	2.41	3.59
3/4		0.92	1.89	2.55
1 ½		1.15	3.27	5.90
3 ½		1.24	4.09	9.27

NOTES:

1. Values apply only to air spaces of uniform thickness bounded by plane, smooth, parallel surfaces with no leakage of air to or from the space. These conditions are not normally present in standard building construction; decrease R-values for construction situation. Thermal resistance values for multiple air spaces must be based on careful estimates of mean temperature differences for each air space.

2. Air space mean temperature at 50°F and temperature difference at 10°F. Assumes one surface of air space as non-reflective (E=.90) and other surface at stated emittance.

3. Interpolation is permissible for other values of mean temperature, temperature differences, and effective emittance E. See Chapter 23, 1981 ASHRAE Fundamentals Handbook.

4. Credit for an air space R-value cannot be taken more than once and only for the boundary conditions established.

5. R-values of horizontal spaces with heat flow downward are substantially independent of temperature difference.

6. REFLECTIVITY AND EMITTANCE VALUES OF VARIOUS SURFACES AND EFFECTIVE EMITTANCES OF AIR SPACES

Surface	Reflectivity in Percent	Average Emittance E	Effective Emittance E of Air Space	
			One Surface emittance E; the other 0.90	Both Surfaces emittances E
Aluminum foil, bright	92 to 97	0.05	0.05	0.03
Aluminum sheet	80 to 95	0.12	0.12	0.06
Aluminum coated paper, polished	75 to 84	0.20	0.20	0.11
Steel, galvanized bright ...	70 to 80	0.25	0.24	0.15
Building materials: wood, paper, masonry, ... nonmetallic paints	5 to 15	0.90	0.82	0.82
Concrete	-	0.88	-	-
Concrete, rough	-	0.97	-	-
Earth, Packed and Dry	-	0.41	-	-
Ice (32°F)	-	0.95	-	-
Paints:				
Aluminum	30 to 70	0.50	0.47	0.35
Black Lacquer	-	0.80	-	-
Flat Black Lacquer	-	0.96	-	-
White Enamel	-	0.80	-	-
Plaster, Rough White	-	0.91	-	-
Regular glass, smooth	5 to 15	0.84	0.77	0.72

APPENDIX D

Perm Ratings of Typical Building Materials

The following tables provide information useful in determining compliance with this Standard. The information was reprinted with permission from the ASHRAE Handbook of Fundamentals, 1985 edition except as noted. Information from these tables, or specific manufacturers data may be used to verify compliance.

Table 2 Permeance and Permeability of Materials to Water Vapor[a] *

Material	Thickness (in.)	Permeance (Perm)	Resistance[l] (Rep)	Permeability (Perm-in.)	Resistance/in.[l] (Rep/in.)
Materials used in construction					
Concrete (1:2:4 mix)				3.2	0.31
Brick masonry	4	0.8[f]	1.3		
Concrete block (cored, limestone aggregate)	8	2.4[f]	0.4		
Tile masonry, glazed	4	0.12[f]	8.3		
Asbestos cement board	0.12	4-8[d]	0.1-0.2		
With oil base finishes		0.3-0.5[d]	2-3		
Plaster on metal lath	0.75	15[f]	0.067		
Plaster on wood lath		11[e]	0.091		
Plaster on plain gypsum lath (with studs)		20[f]	0.050		
Gypsum wall board (plain)	0.375	50[f]	0.020		
Gypsum sheathing (asphalt impreg.)	0.5			20[d]	0.050
Structural insulating board (sheathing qual.)				20-50[f]	0.050-0.020
Structural insulating board (interior, uncoated)	0.5	50-90[f]	0.020-0.011		
Hardboard (standard)	0.125	11[f]	0.091		
Hardboard (tempered)	0.125	5[f]	0.2		
Built-up roofing (hot mopped)		0.0			
Wood, sugar pine				0.4-5.4[f,b]	2.5-0.19
Plywood (douglas fir, exterior glue)	0.25	0.7[f]	1.4		
Plywood (douglas fir, interior glue)	0.25	1.9[f]	0.53		
Acrylic, glass fiber reinforced sheet	0.056	0.12[d]	8.3		
Polyester, glass fiber reinforced sheet	0.048	0.05[d]	20		
Thermal insulations					
Air (still)				120[f]	0.0083
Cellular glass				0.0[d]	∞
Corkboard				2.1-2.6[d]	0.48-0.38
				9.5[e]	0.11
Mineral wool (unprotected)				116[e]	0.0086
Expanded polyurethane (R-11 blown) board stock				0.4-1.6[d]	2.5-0.52
Expanded polystyrene—extruded				1.2[d]	0.83
Expanded polystyrene—bead				2.0-5.8[d]	0.50-0.17
Phenolic foam (covering removed)				26	0.038
Unicellular synthetic flexible rubber foam				0.02-0.15[d]	50-6.7
Plastic and metal foils and films[c]					
Aluminum foil	0.001	0.0[d]			
Aluminum foil	0.00035	0.05[d]	20		
Polyethylene	0.002	0.16[d]	6.3		3100
Polyethylene	0.004	0.08[d]	12.5		3100
Polyethylene	0.006	0.06[d]	17		3100
Polyethylene	0.008	0.04[d]	25		3100
Polyethylene	0.010	0.03[d]	33		3100
Polyvinylchloride, unplasticized	0.002	0.68[d]	1.5		
Polyvinylchloride plasticized	0.004	0.8-1.4[d]	1.3-0.72		
Polyester	0.001	0.73[d]	1.4		
Polyester	0.0032	0.23[d]	4.3		
Polyester	0.0076	0.08[d]	12.5		
Cellulose acetate	0.01	4.6[d]	0.2		
Cellulose acetate	0.125	0.32[d]	3.1		
Plywood (various species, exterior glue)	0.375	0.80**			
	0.50	0.50**			

Table 2 Permeance and Permeability of Materials to Water Vapor[a] (Concluded)

Material	Weight[h]	Permeance (Perms) Dry-Cup	Wet-Cup	Other	Resistance[i] (Rep) Dry-Cup	Wet-Cup	Other
Building paper, felts, roofing papers[g]							
Duplex sheet, asphalt laminated, aluminum foil one side	8.6	0.002	0.176		500	5.8	
Saturated and coated roll roofing	65	0.05	0.24		20	4.2	
Kraft paper and asphalt laminated, reinforced 30-120-30	6.8	0.3	1.8		3.3	0.55	
Blanket thermal insulation back up paper, asphalt coated	6.2	0.4	0.6-4.2		2.5	1.7-0.24	
Asphalt-saturated and coated vapor retarder paper	8.6	0.2-0.3	0.6		5.0-3.3	1.7	
Asphalt-saturated but not coated sheathing paper	4.4	3.3	20.2		0.3	0.05	
15-lb asphalt felt	14	1.0	5.6		1.0	0.18	
15-lb tar felt	14	4.0	18.2		0.25	0.055	
Single-kraft, double	3.2	31	42		0.032	0.024	
Liquid-applied coating materials	**Inches**						
Commercial latex paints (dry film thickness)[j]							
Vapor retarder paint	0.0031			0.45			2.22
Primer-sealer	0.0012			6.28			0.16
Vinyl acetate/acrylic primer	0.002			7.42			0.13
Vinyl-acrylic primer	0.0016			8.62			0.12
Semi-gloss vinyl-acrylic enamel	0.0024			6.61			0.15
Exterior acrylic house and trim	0.0017			5.47			0.18
Paint-2 coats							
Asphalt paint on plywood			0.4			2.5	
Aluminum varnish on wood		0.3-0.5			3.3-2.0		
Enamels on smooth plaster				0.5-1.5			2.0-0.66
Primers and sealers on interior insulation board				0.9-2.1			1.1-0.48
Various primers plus 1 coat flat oil paint on plaster				1.6-3.0			0.63-0.33
Flat paint on interior insulation board				4			0.25
Water emulsion on interior insulation board				30-85			0.03-0.012
Paint-3 coats	Oz/ft^2						
Exterior paint, white lead and oil on wood siding		0.3-1.0			3.3-1.0		
Exterior paint, white lead-zinc oxide and oil on wood		0.9			1.1		
Styrene-butadiene latex coating	2	11			0.09		
Polyvinyl acetate latex coating	4	5.5			0.18		
Chloro-sulfonated polyethylene mastic	3.5	1.7			0.59		
	7.0	0.06			16		
Asphalt cut-back mastic, 1/16 in., dry		0.14			7.2		
3/16 in., dry		0.0			—		
Hot melt asphalt	2	0.5			2		
	3.5	0.1			10		

[a]In this chapter the permeance, resistance, permeability and resistance per unit thickness values are given in the following units:

Permeance	Perm	= gr/h·ft^2·in. Hg
Resistance	Rep	= in. Hg·ft^2·h/gr
Permeability	Perm-in.	= gr/h·ft^1·(in. Hg/in.)
Resistance/unit thickness	Rep/in.	= (in. Hg·ft^2·h/gr)/in.

[a]Table 2 gives the water vapor transmission rates of some representative materials. The data are provided to permit comparisons of materials; but in the selection of vapor retarder materials, exact values for permeance or permeability should be obtained from the manufacturer of the materials under consideration or secured as a result of laboratory tests. A range of values shown in the table indicate variations among mean values for materials that are similar but of different density, orientation, lot or source. The values are intended for design guidance and should not be used as design or specification data. The compilation is from a number of sources; values from dry-cup and wet-cup methods were usually obtained from investigations using ASTM E96 and C355; values shown under *others* were obtained from investigations using such techniques as *two-temperature, special cell,* and *air-velocity*. Values included were obtained from Ref. 14 to 29 and other sources. Some values were obtained from unpublished tests conducted by Pennsylvania State University and the Building Research Div., National Research Council of Canada.

[b]Depending on construction and direction of vapor flow.

[c]Usually installed as vapor retarders, although sometimes used as exterior finish and elsewhere near cold side where special considerations are then required for warm side barrier effectiveness.

[d]Dry-cup method.

[e]Wet-cup method.

[f]Other than dry- or wet-cup method.

[g]Low permeance sheets used as vapor retarders. High permeance used elsewhere in construction.

[h]Basic weight in lb per 100 ft^2(lb per square ft).

[i]Resistance and resistance/in. values have been calculated as the reciprocal of the permeance and permeability values.

[j]Cast at 10 mils wet film thickness.[31]

** From the American Plywood Association, Tacoma, Washington.