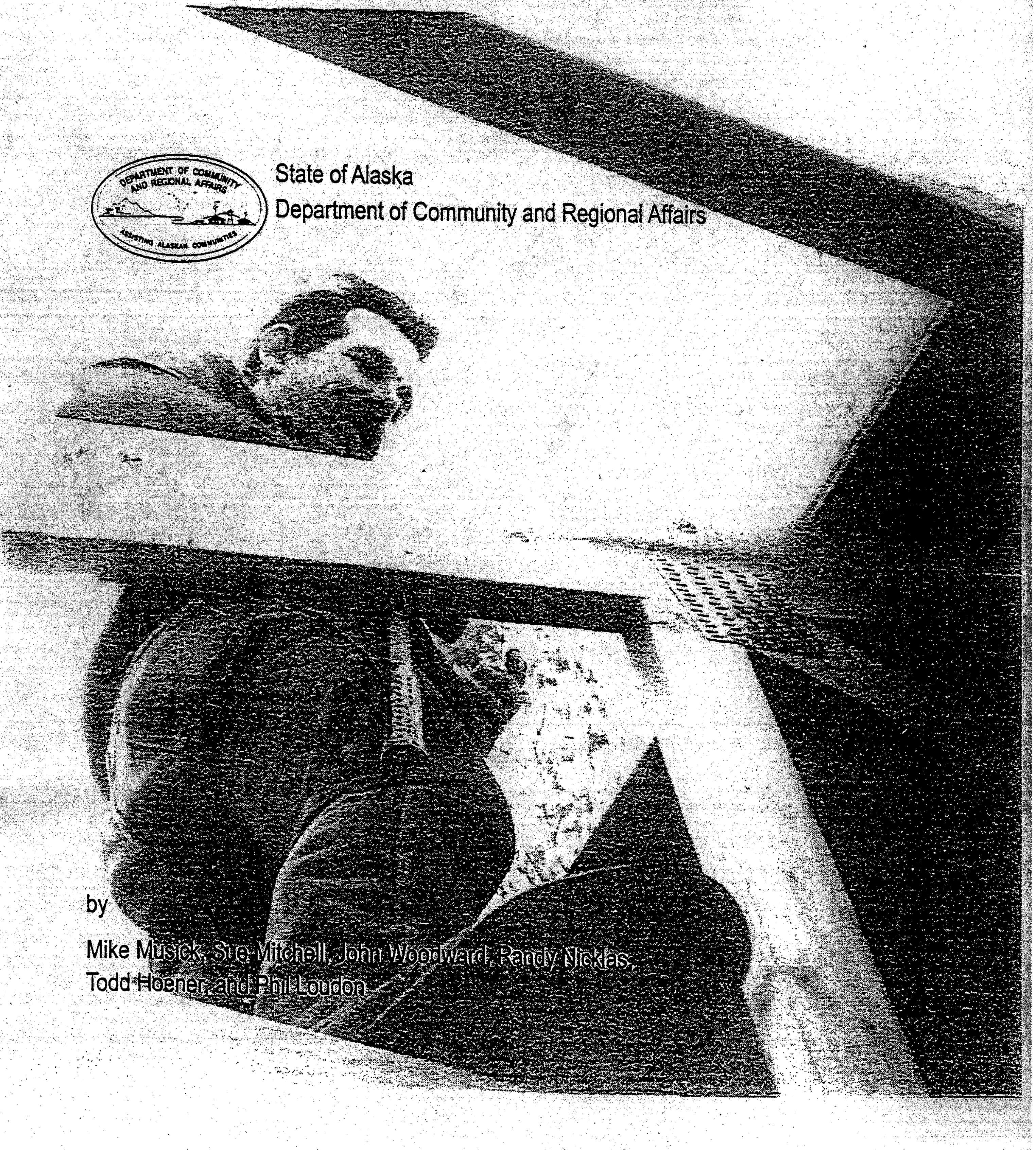
Grant Recipient Construction Manual



State of Alaska
Department of Community and Regional Affairs

by

Mike Musick, Sue Mitchell, John Woodward, Randy Nicklas, Todd Hoener, and Phil Loudon

Grant Recipient Construction Manual

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October 1995

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Much of the information in the heating chapter was taken from a series of articles extracted from the Brookhaven National Laboratory's *Efficiency Training Manual,* as published in the periodical *Fuel Oil News.* We also used information from personal communications with John D. Marran and Stan Boghosian and information from the U.S. Department of Energy, National Institute of Standards, and the Hot 2000 computer program, Version 6.02g.

Appendices A, B, and C are taken from the State of Alaska *Building Energy Efficiency Standard* by Stuart Brooks. We have amended them to be applicable to community buildings. Appendix D is reprinted with the permission of the Canadian Log Builders Association, International.

Dedication

This book is dedicated to the memory of Jennifer Long.

How to Use This Manual

This book has three parts: the introduction, statewide considerations, and regional considerations. If you are in charge of a community building project using money from the Alaska Department of Community and Regional Affairs, you should read and follow the instructions in the introduction, the statewide considerations, and the colored pages for your region. You can also read the information about other regions for information that might apply to you.

Part I
Introduction

This book is written for people involved in the building industry in rural Alaska: architects, engineers, materials suppliers, contractors, construction crews, municipal grant recipients, and permitting and regulatory agencies. It was developed under contract to the Alaska Department of Community and Regional Affairs (DCRA) to provide design and performance standards for DCRA-funded community buildings in accordance with state law, along with guidelines to achieve these standards. These new requirements, along with the information on how to implement them, are intended for everyone involved with design, construction, and management of DCRA-funded community buildings. The requirements in this book are for buildings built under grants by DCRA. The book is also intended as useful information for anyone interested in constructing energy-efficient, comfortable, and good quality community buildings in Alaska. We suggest you read this book if you are planning to retrofit an existing building or construct a new public facility in rural Alaska.

You must follow all local building codes and standards. Many smaller communities in Alaska have not adopted local codes. We recommend that these communities do so, since codes help protect people's health and safety. Also, many grant opportunities require that local codes be in place in order to apply. This book is not intended to supersede either local or national building codes.

This book and its requirements grew out of a realization that many existing community buildings in rural Alaska suffer from chronic problems. These problems are divided into three main areas: (1) inappropriate design, (2) poor quality control during construction, and (3) inadequate maintenance.

Design

These problems begin with the design and planning stages, and can be avoided by using appropriate building techniques and materials. You only get a comfortable and energy efficient building by designing and constructing it so that it works as a system. The building system includes foundation, walls, floors, ceilings, windows, doors, heating appliances, ventilation systems, electric lighting, the people who use the building, and the environment outside its walls. A change in one of these parts of the system affects the performance of the other parts and therefore affects the comfort, health, energy use, and durability of the building. Design, construction, and maintenance of the building must take into account these interactions. All mechanical system and building products must be of the highest quality to eliminate costly repairs and maintenance.

Many places in rural Alaska have unstable soils, seasonal flooding, and harsh weather conditions. Differential settlement caused by permafrost, seasonal frost, and flooding is the single most destructive problem in rural buildings. Inadequate site preparation and foundations that are not designed to compensate for settlement will cause the building to move, causing breaks in plumbing lines, windows and doors that leak and don't close, gaps in interior finishes, breaks in the fasteners holding the building together, and more air leakage because of damage to the air/vapor retarder. Seasonal flooding in coastal and river communities causes water damage to foundations and the rest of the structure.

Weather conditions in Alaska can include high winds, blowing snow, extreme low temperatures, extended periods of darkness, and in some places lots of snow or rain. Failure to install an outside weather retarder, such as Tyvek, may lead to water entering the walls and wetting the insulation, reducing its insulating value. This water may also rot the structural members. The outside weather retarder works much like a Gortex raincoat: it keeps the rain and wind out but allows water vapor to leave the building. Blowing snow can enter attics, where it melts and also wets the insulation and rafters or trusses. This can lead to collapsed ceilings and roofs. Inadequate amounts or poorly installed insulation in the attic allow too much heat to be lost through the roof, causing ice dams, dangerous overhangs of ice, and higher heating bills. In areas such as southeast Alaska, lots of rain and high relative humidity can constantly wet the siding of a building, causing wood siding to warp and cup if it is not carefully finished on both sides and installed so that both sides dry out quickly. Long hours of darkness in the winter (when community buildings often see their heaviest use) and low solar angles in summer create a need for adequate energy-efficient lighting and special attention to proper solar orientation of the windows.

A public building in a small community often must be used for several purposes: it may house the local clinic, community meeting hall, public safety offices, city government offices, and be the only place for visitors to stay overnight. Many of these uses require additional ventilation for good indoor air quality. Building design must take all these factors into account.

Construction

Even if a building is properly designed for the regional climate and is designed to operate as a system, the construction must be done right. The builder must use high-quality materials and install them properly. Often a desire to save money or not having enough money budgeted for a project leads to using poor quality materials and components that have to be replaced in a few years. Untrained construction workers may not know how to properly install a window or door so that there are no air leaks around the frame. Not knowing safety practices and accepted building codes often leads to exposed wiring, leaks in exhaust vents, improper clearance to combustible materials, back drafting of furnaces, no fire-rated doors, etc. All of these situations could be life-threatening. Project managers must know enough about accepted building practices to convey to the contractor what is needed for proper construction. Both the project manager and the builder must understand the special logistics needed in rural Alaska. For example, where there are no roads and all materials are shipped by barge, longer lead times are necessary. The construction season in many places in Alaska is severely shortened by winter weather.

Maintenance

After the building is finished, there is often little or no money budgeted for maintenance and often no one who understands the operation and maintenance of the building, so small problems become large and expensive to repair before anything is done. Maintenance should be addressed in the grant process along with design and construction funds.

The Solution

The solution to these problems is education. The first step is knowing how to design a building that functions as a system where each part works in harmony with the others. Such a building must be appropriate for the climate, the site, and its intended uses. The second step is knowing how to construct a building using care, proper construction methods, and quality materials. The third and last step is knowing how to maintain the building so that it continues to function as a system and will be comfortable and energy-efficient for a long time to come.

Everyone wants to make the most efficient use of the money available. Spending a little more up front for quality construction, good materials, and energy-efficient design costs less in the long run. The cost of fuel in rural Alaska can be two to four times higher than in urban areas. This makes energy-efficient buildings even more important. Transportation costs for materials are also high, but it doesn't cost any more to transport high-quality materials than to transport low-quality materials. It is important to understand that **low-quality materials will typically end up being replaced in only a few years,** doubling the cost of transportation and negating any initial cost savings for the material.

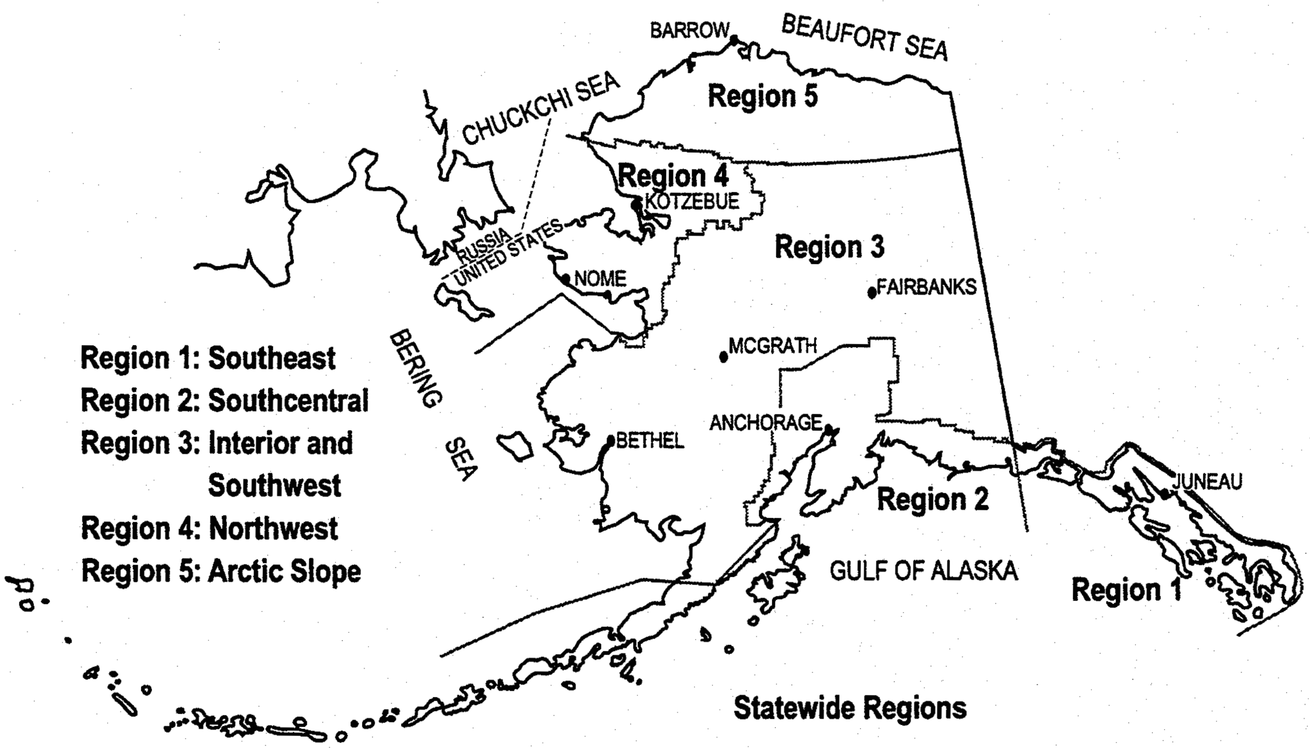
An appropriately designed energy-efficient building will not only have lower heating bills, but it will last longer, because the same practices that prevent heat loss also prevent moisture from migrating into the walls and causing damage. The same building will be more comfortable during its lifetime, because it will not be drafty, will not have cold floors, and can be heated to a comfortable temperature with reasonable cost. The building will be healthier to be in, too, since airtight, energy-efficient buildings must incorporate controlled mechanical ventilation. Indoor air pollutants like cigarette smoke, fumes from cleaners and construction products, excess humidity, radon, viruses from sick people, etc. will be replaced with clean, fresh air on a continuous basis.

Heat, Air, and Moisture

An energy-efficient building controls the movement of **heat**, **air**, and **moisture**. Heat movement out of the building is a direct cost in energy dollars. Movement of air causes convective heat loss and carries moisture into places it should not be, such as walls and attics. Movement of moisture causes rotting, mold, bacteria growth, and eventually structural failure. In general, poor design and construction create uncomfortable buildings that are drafty, expensive to heat and maintain, and have cold floors and poor indoor air quality.

Energy-efficient buildings, on the other hand, are comfortable, cheaper to heat and maintain, have good air quality, and last longer.

The remainder of this book sets energy efficiency standards for community buildings and explains how to construct a new building or retrofit an existing building to meet these standards. First, it describes standards and practices that apply to the entire state of Alaska, including a brief discussion of building science, design considerations, and construction management and sequencing. Second, the book sets out standards and specific building practices that apply to each of the five climatic regions of Alaska: Southeast, Southcentral, Interior and Southwest, Northwest, and Arctic Slope (see map below).



Because Alaska is a huge state and the problems encountered in different regions vary depending on local climate, we treat it regionally. Readers can refer to the statewide section and to the section for their region without needing to read the entire book. Within these sections, the text is organized in the order of construction. Energy-efficient standards are treated first, then how to meet the standards for each building component: foundations, walls, windows and doors, roofs, and appliances such as heating, ventilation, and hot water. Throughout, we emphasize why building a quality, energy-efficient structure is more affordable in the long run.

Part II
Statewide Considerations

Alaska is a land of such extreme variation in weather, topography, solar access, soils, seismic activity, and other geographic determinants (see climatic zones map) that we have established a regionalized building energy efficiency standard. For purposes of this manual, the state is divided into five geographic regions, each of which has its own set of building requirements, which are detailed in Part III. This section details requirements for all regions in the state.

Statewide Mandatory Design Measures

All buildings constructed with DCRA grant money must also comply with Appendix A, which sets forth the minimum thermal standards that must be incorporated in residential structures. Most of these mandatory energy conservation measures are applicable to community buildings, but some are not. Perhaps the greatest difference between residential and community buildings is occupant levels and time of occupancy. Ventilation requirements are affected the most by this difference.

There are two methods of compliance with the energy standard: the **prescriptive method** or the **energy budget method.** Both methods must meet minimum standards of balanced mechanical ventilation.

Prescriptive Method

The prescriptive method requires minimum R-values for all six sides of the building envelope: the ceiling, floor, and four walls, including windows and doors (see Table 1). This method is very much like following a recipe in a cookbook. If you design in all of the required insulation levels, fulfill all the statewide mandatory measures, and pass a blower door airtightness test, your project can be funded by DCRA grant programs.

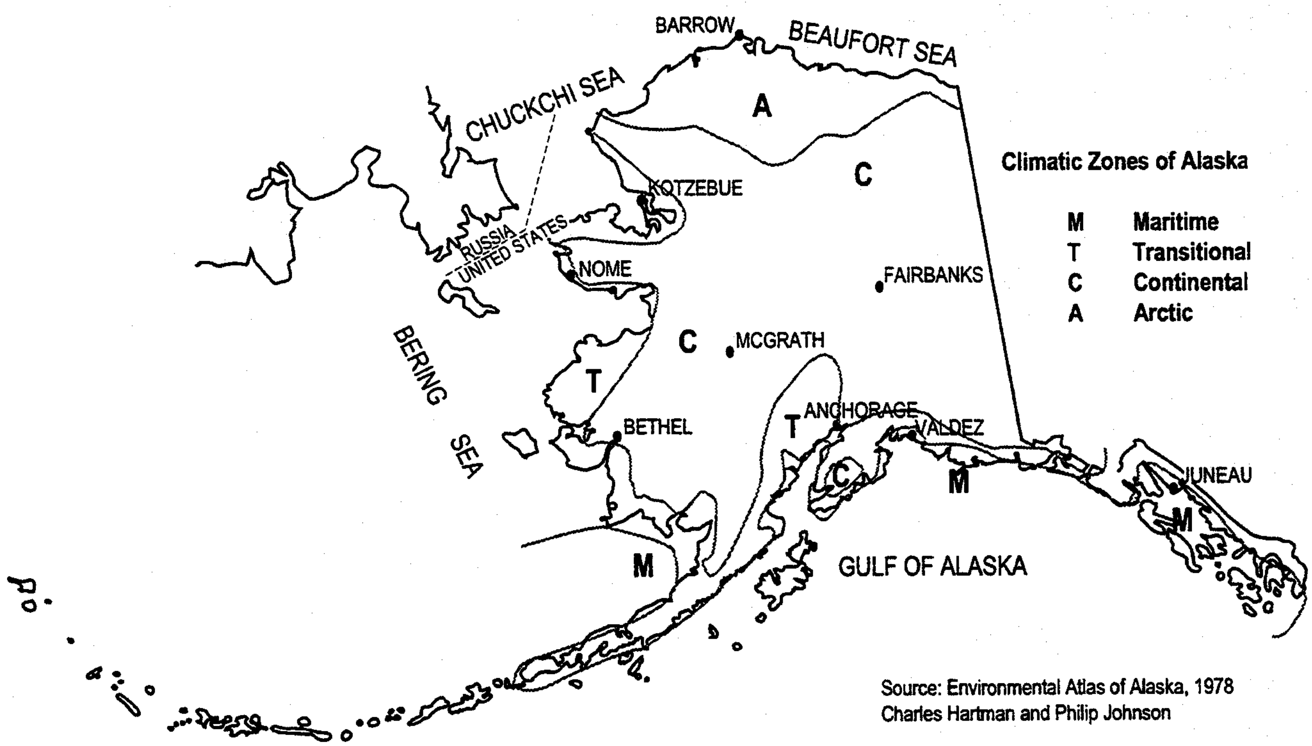


Table 1
Prescriptive Standards
Nominal Insulation Values
(Based on HOT 2000 6.02g*)

Location	Ceiling	Above-Grade Wall	Below-Grade Wall	Floor Above Unheated Space	Slab	Window	Door
Region 1 Southeast	R-38	R-21	R-20	R-30	R-10	R-3	R-7
Region 2 Southcentral	R-40	R-25	R-20	R-38	R-20	R-3	R-7
Region 3 Interior & Southwest	R-50	R-30	R-30	R-40	R-25	R-4	R-10
Region 4 Northwest	R-55	R-30	N/A	R-40	N/A	R-4	R-10
Region 5 Arctic Slope	R-60	R-40	N/A	R-50	N/A	R-4	R-10

Caution: if building on permafrost, you should have an engineering analysis done.
* Based on heat recovery ventilation eight hours a day. Add 10 percent to R-values if non-heat-recovery ventilation is used. Max. 1.5 air changes per hour at 50 Pascals air leakage rate.

The prescriptive standards were developed using one city in each region. If the climate in your community differs greatly from the city used to develop the standard, you may be better off using the energy budget method (Hot 2000).

Energy Budget Method

The energy budget method requires the use of the Hot 2000 energy analysis software, version 6.02g. This method allows for more flexibility in design and allows the designer to optimize insulation levels. The Hot 2000 program calculates an annual energy target for a structure. The program takes into account all of the systems in the building: the heating system, the ventilation system, air leakage, domestic hot water use, electrical use, the building envelope efficiency, as well as solar gain and internal heat generated by occupants and electrical equipment. If your design meets the Hot 2000 energy target, fulfills all the statewide mandatory measures, is mechanically ventilated, and will pass a blower door airtightness test, your project can be funded by DCRA grant programs. A copy of the Hot 2000 computer program can be purchased from:

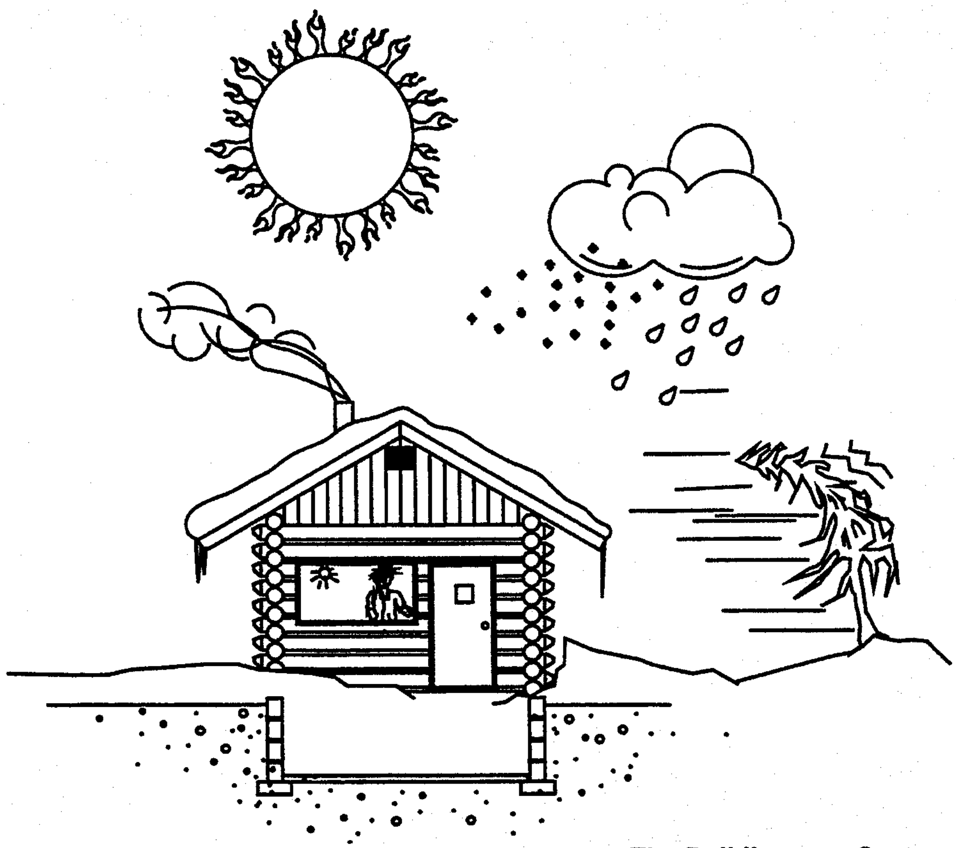
Alaska Building Science Network
P.O. Box 74279
Fairbanks, AK 99707
phone (907) 452-8333
or
Alaska Craftsman Home Program
900 West Fireweed Lane, Suite 201
Anchorage, AK 99503
phone (907) 258-2247

The Building as a System

The designer must look at the building as a system of interconnected components or subsystems, each of which contribute to a unified whole. These subsystems include the building envelope, mechanical systems, building occupants, and the external environment. These subsystems must operate in balance. Any change in any of these components will have an effect on the performance of all the other parts of the system.

Building Science

Building science is the study of how buildings work. There are 10 fundamental concepts that must be understood before designing a new structure or retrofitting an existing building. Every subsystem should be designed with these concepts in mind to minimize the flows of heat, air, and moisture through the building envelope. Heat flow out of a building wastes precious fuel, air leaking out carries

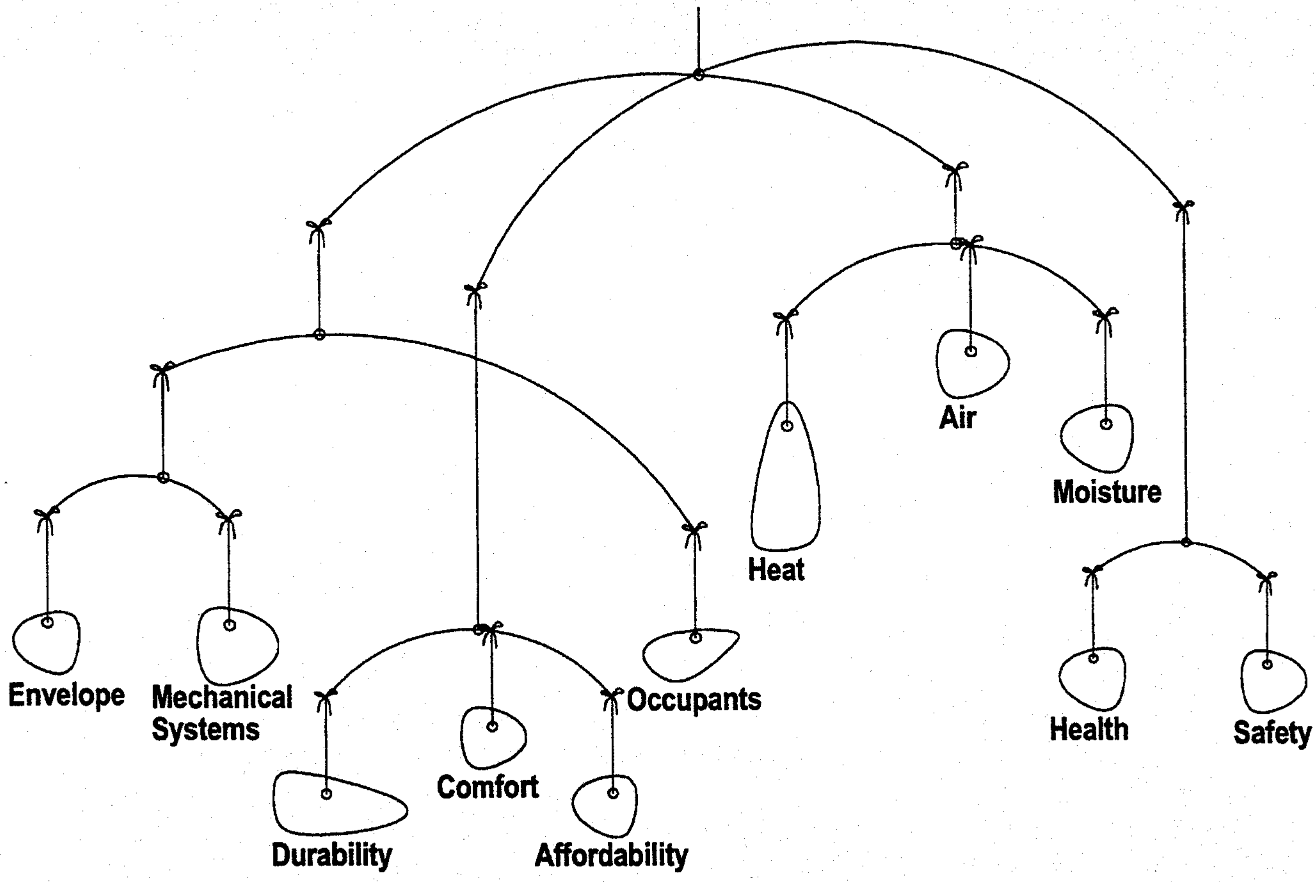


The Building as a System

both heat and moisure, and moisture that escapes from the interior of a building can condense or freeze in the insulation, reducing the effectiveness of the insulation and causing damage by mold and rot. The following concepts of building science provide the foundation for designing a building as a system.

Top Ten Building Science Concepts

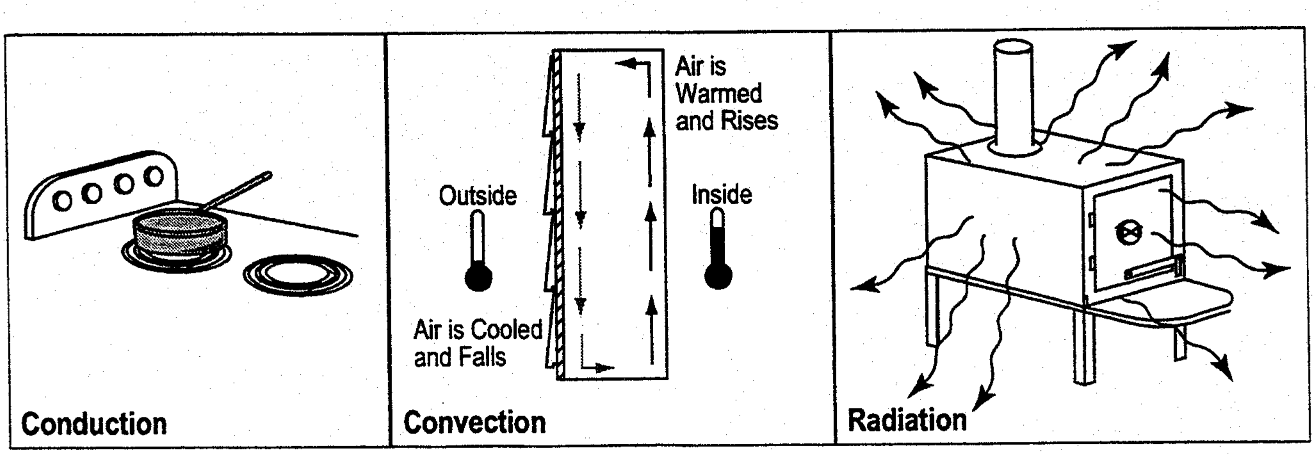
1. Heat flows from hot to cold.
2. Heat does not rise—warm air rises.
3. Heat is transferred by conduction, convection, and radiation.
4. Heat flow through insulation is slowed by trapped air or other gases.
5. Airtightness prevents major loss of heat.
6. Air flows from higher pressure to lower pressure.
7. Air leakage is the primary moisture transport mechanism.
8. Diffusion is a secondary moisture transport mechanism.
9. Dew point is the temperature at which airborne water vapor condenses into liquid water. Water vapor is not a problem—liquid water is.
10. The vapor retarder should be placed on the warm side of the thermal envelope.



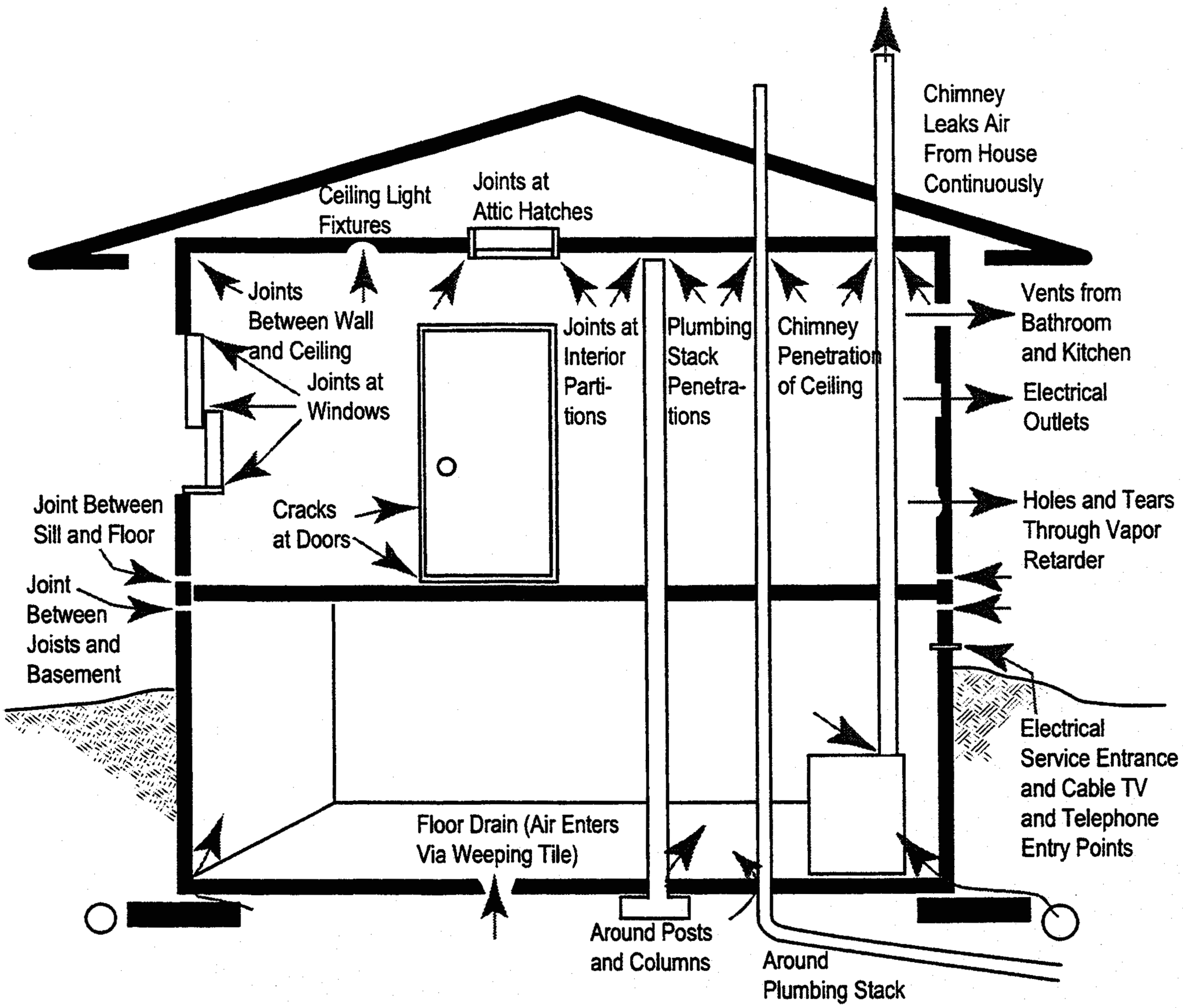
The total performance of the house as a system depends on a balance of envelope, mechanical systems, and occupants. All these parts of the house affect the flow of heat, air, and moisture into and out of the house.

The TwoThirds/ One Third Rule

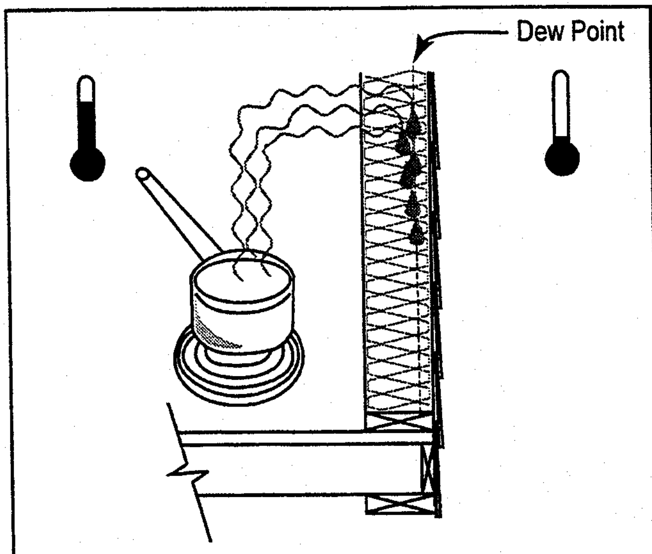
To prevent moisture from reaching the dew point inside the wall, no more than one third of the total R-value of the wall should be on the warm side of the vapor retarder in areas with less than 12,000 heating degree days. Heating degree days is a measure of the need for heating based on the number of days the outside temperature is lower than 65 dgrees F and by how much (see glossary). In areas with heating degree days of 12,000 to 14,000, no more than one

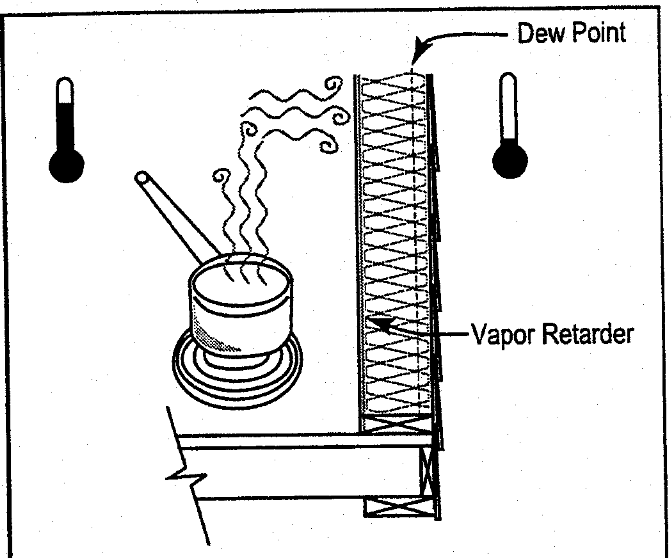


Air Leakage is the Primary Moisture Transport Mechanism



quarter of the insulation should be on the warm side of the vapor retarder, and in climates of over 14,000 heating degree days, no more than one fifth of the insulation should be on the warm side of the vapor retarder. Following this rule prevents moisture from getting too cold and condensing before it is stopped by the vapor retarder. (For the heating degree days inyour location, see map on page 14).



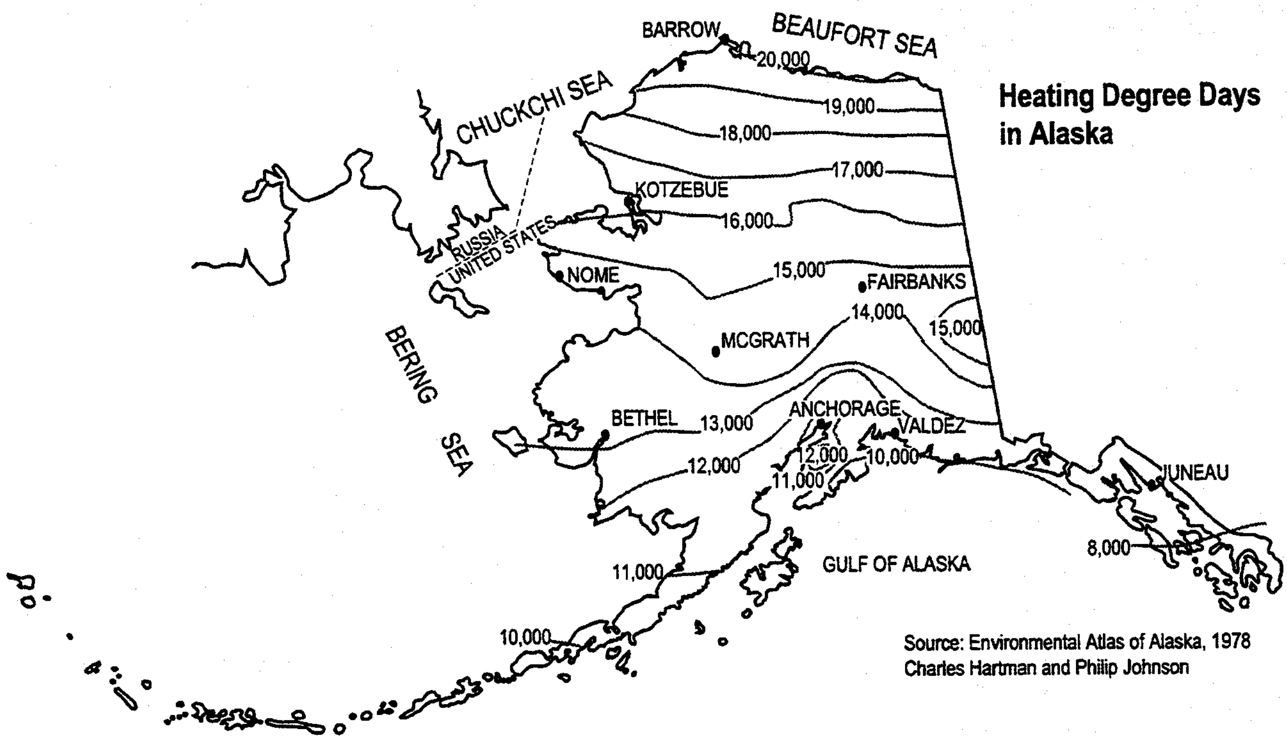


Design

There are a number of design considerations that apply to buildings funded by DCRA. All construction must comply with local building codes and the Uniform Building Code, the Uniform Mechanical Code, the Uniform Plumbing Code, the Americans With Disabilities Act, and the National Electrical Code as well as the energy efficiency standards set forth here.

All mechanical components, including doors and windows, should have the manufacturer's name, the model, and a customer service phone number clearly marked on a visible surface. This identification will help if repairs are necessary.

One of the first things a plan reviewer will look for is a clear definition of the thermal envelope, including details of a truly continuous vapor retarder, air retarder, weather retarder, and insulation details. The designer should provide details for a continuous vapor retarder over partition top plates, at the end of partition walls, and through the rim joist area on multilevel structures. The plans and specifications must indicate the insulation values for the foundation



Heating Degree Days in Alaska

Source: Environmental Atlas of Alaska, 1978
Charles Hartman and Philip Johnson

or floor, walls, windows and doors, and ceilings, and these values must equal or exceed the R-values required by the standard. If you use the energy budget method, you must include a copy of the Hot 2000 printout.

Face windows south toward the mid-day winter sun for natural light and passive solar heat.

Site Plan

A site plan of the structure should include details of water supply and waste disposal complying with Department of Environmental Conservation regulations. Note telephone wires and electrical service details. Access roads, trails, paths, driveways, parking, and water drainage considerations should be on the site plan. Note compass directions on the plan along with solar considerations. Indicate prevailing winds and snow drifting potential. Note any other buildings nearby and locate water wells and septic systems on adjacent property.

Soils Investigation

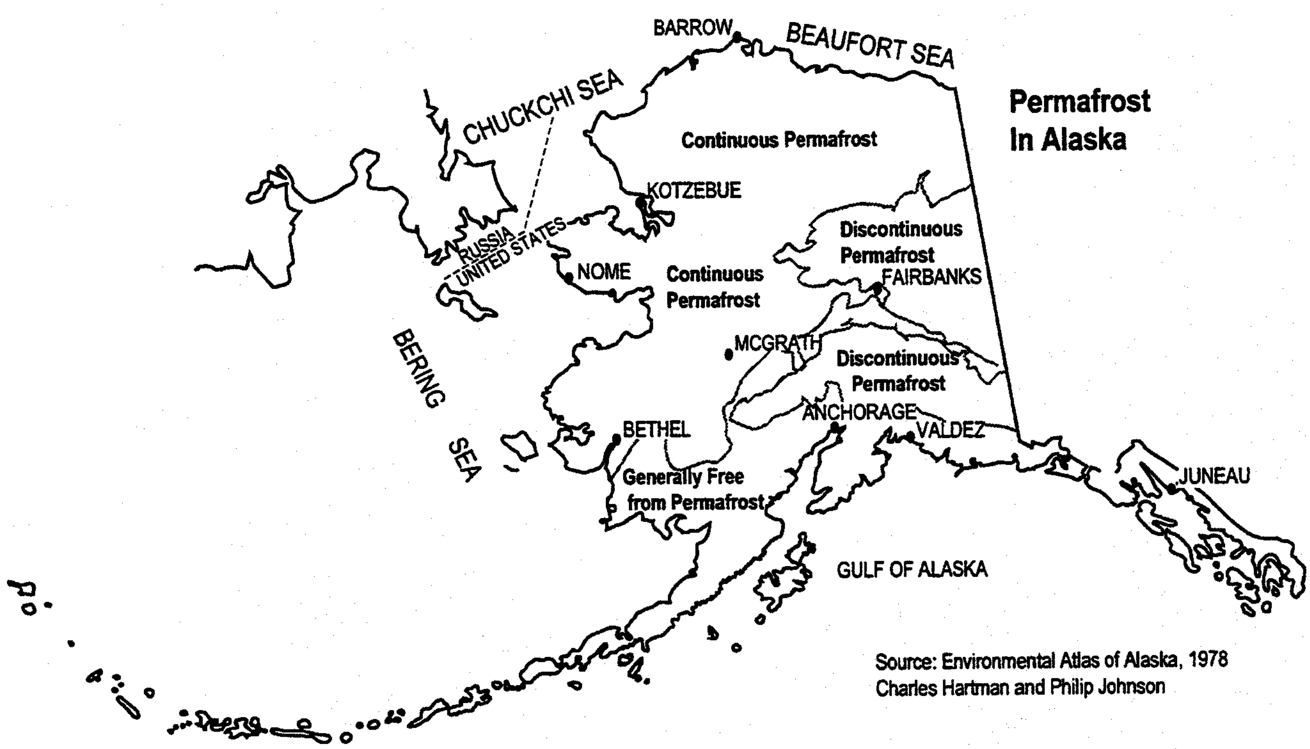
Find out what the soil conditions are where you intend to build. Either drill, or trench with a backhoe, or at least dig with a shovel or drive a steel pipe with a big hammer. You can learn a lot from a simple hole in the ground. If you uncover relatively clean river rock or even better yet, bedrock, just about any structurally sound foundation type will work. Free-draining gravels will not hold water and will not cause frost heaving when the ground temperature is below freezing. This is the kind of gravel we refer to when we specificy non-frost-susceptible material. If you have to keep adding on sections to the pipe, or if you are driving into the muskeg and still can't find solid ground after 20 or 30 feet, you may want to look elsewhere for a building site. Or just keep on driving for solid bearing if you can afford very long pilings. Fine-grained soils such as wind-blown silt or loess are usually acceptable for building on when dry but require special considerations for septic systems and are subject to rapid and severe erosion. The larger, heavier, and more costly the building, the more important it is to have accurate soils information for designing the foundation. Ask questions of your neighbors and ask to see neighboring water well drill logs or highway or airport drill logs. Gather as much information as you possibly can before you design the foundation. Find out what foundations worked in this neighborhood and what foundations failed and find out why. If site-specific soils testing is not done, the building must have a foundation type engineered to prevent differential settlement. The Corps of Engineers are a valuable source of information for projects being built on or near wetlands.

Foundations

The greatest cause of failure in Alaskan buildings is improper foundation design, which leads to differential settlement. Once the foundation begins to shift, the envelope wracks, tears, and loses its integrity. The cracks in the envelope begin an ever-accelerating course of self-destruction as warm, moisture-laden air condenses inside the walls. Fiberglass becomes saturated and loses its insulation value, and ice may form in the attic or on the inside surface of exterior siding. Sooner or later this moisture causes drywall ceilings to come crashing down or comes pouring out of ceiling light fixtures. Soggy bottom plates of walls become a breeding ground for microbes, bacteria, mold, mildew, and fungi. The walls and floors may rot out in less than 10 years.

Soil conditions in Alaska vary from nearly bottomless muskeg bogs to permanently frozen ground; from ice-rich silts to solid bedrock. The only way to know for sure is to test. A preliminary soils test should be undertaken before designing the foundation. Test holes should be drilled within the footprint of the structure to a depth determined by a soil scientist or geologist. If ice lenses are suspected, test holes should be drilled at least 40 feet deep. Gather all the local information possible. Build higher than known flood levels, beware of eroding river banks or wave-cut cliffs, look out for avalanche chutes, and avoid building on permafrost. If you must build on permafrost, design a foundation that keeps it frozen (see permafrost map).

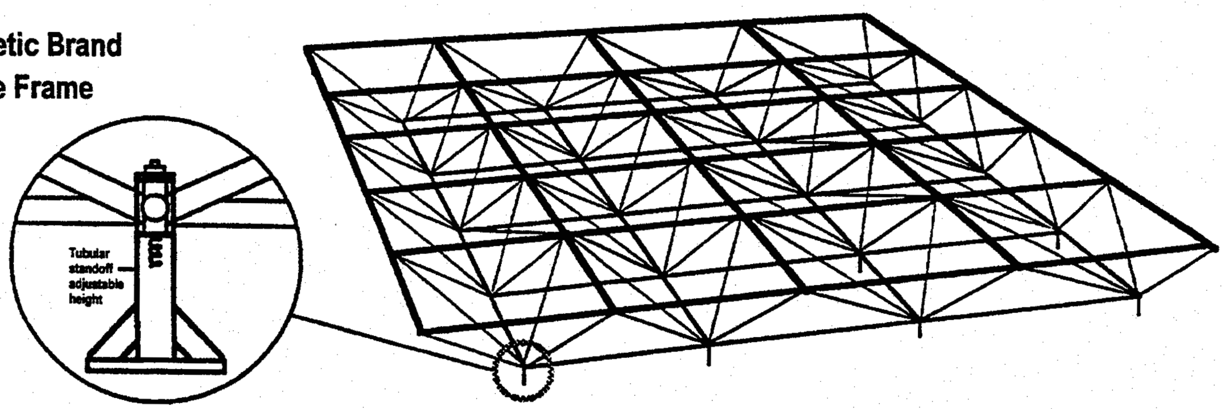
All foundations must be kept dry. Positive drainage away from the building can be assured by proper berming, drainage swales, and control of underground water flow with French drains or with drain tiles and backfilling with clean, non-frost-susceptible sand and gravels.

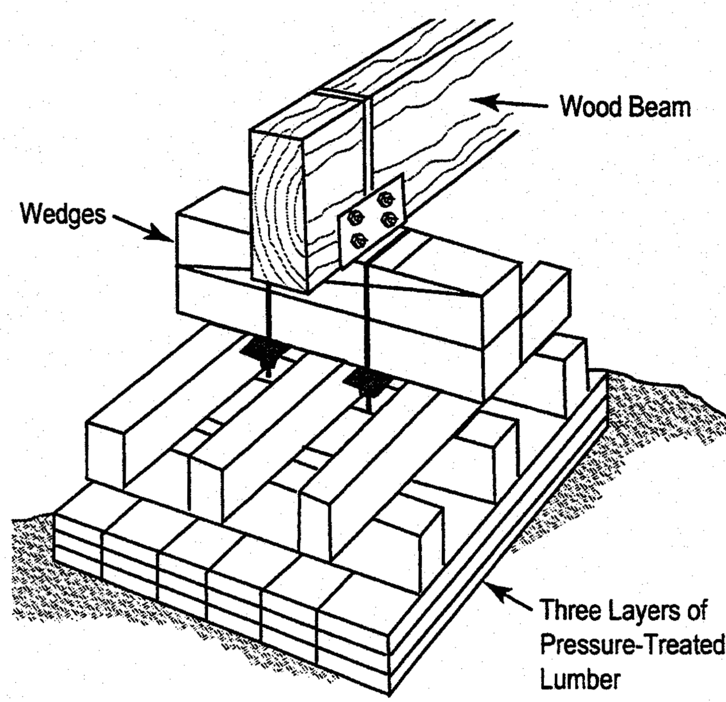


Unstable soils can be held in place with geotextiles such as Geoweb or equivalent. Geoweb is a trademark for a web of three-dimensional polyethylene cells, usually four to six inches high. It collapses for easy shipment and can be layered as needed. This web confines and reinforces your fill, increases its load-bearing capacity, reduces settling, and forms a flexible bridge that distributes the load over a wider area. It preserves natural drainage.

Successful foundation types are as varied as the geography and geology of Alaska. In Southeast coastal communities, many buildings are built on pilings like docks or bridge supports. Away from the waterfront, they may have conventional stem wall foundations with concrete footers or pressure-treated wood foundations resting on compacted sand and gravel. Further inland, on the muskeg, pilings may once again be the foundation of choice. On the North Slope and northwest coast, pilings are used to avoid melting the permafrost. In Southcentral and in the Interior, standard concrete foundations with heated crawl spaces or full basements are quite common. In the Southwest and the rural Interior, we find a number of post and pad or crib foundations or pilings in permafrost areas. A promising new foundation type called the space frame is being tried in several of these areas (see drawing below).

Triodetic Brand Space Frame

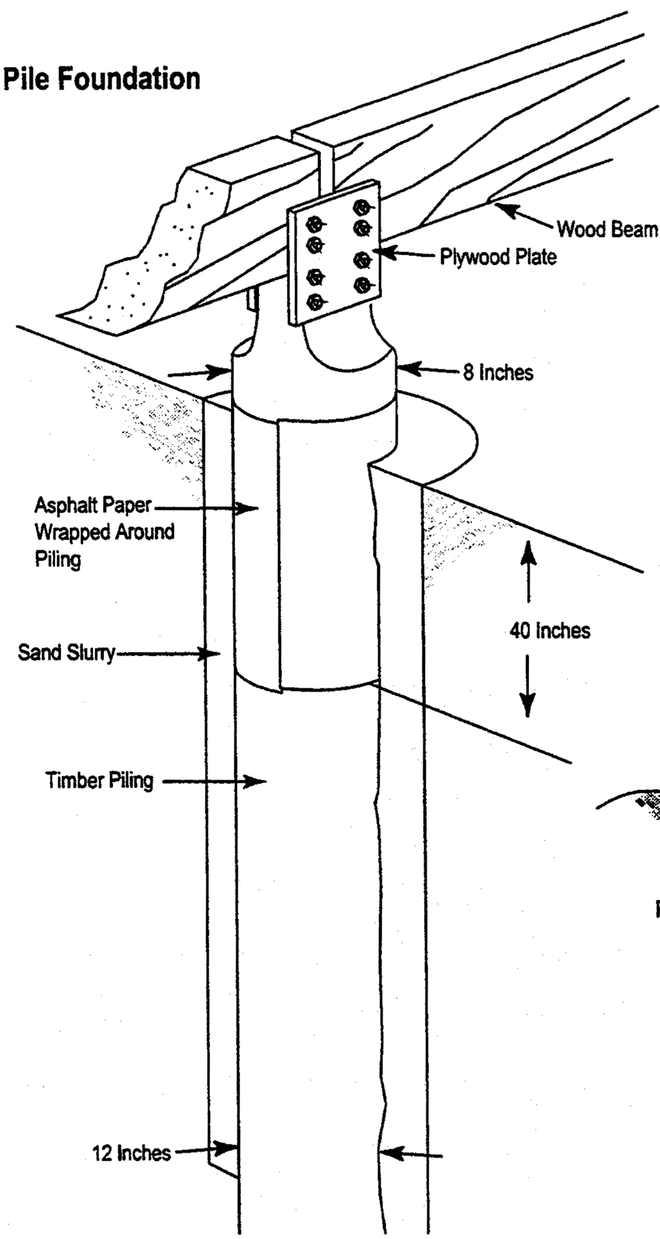




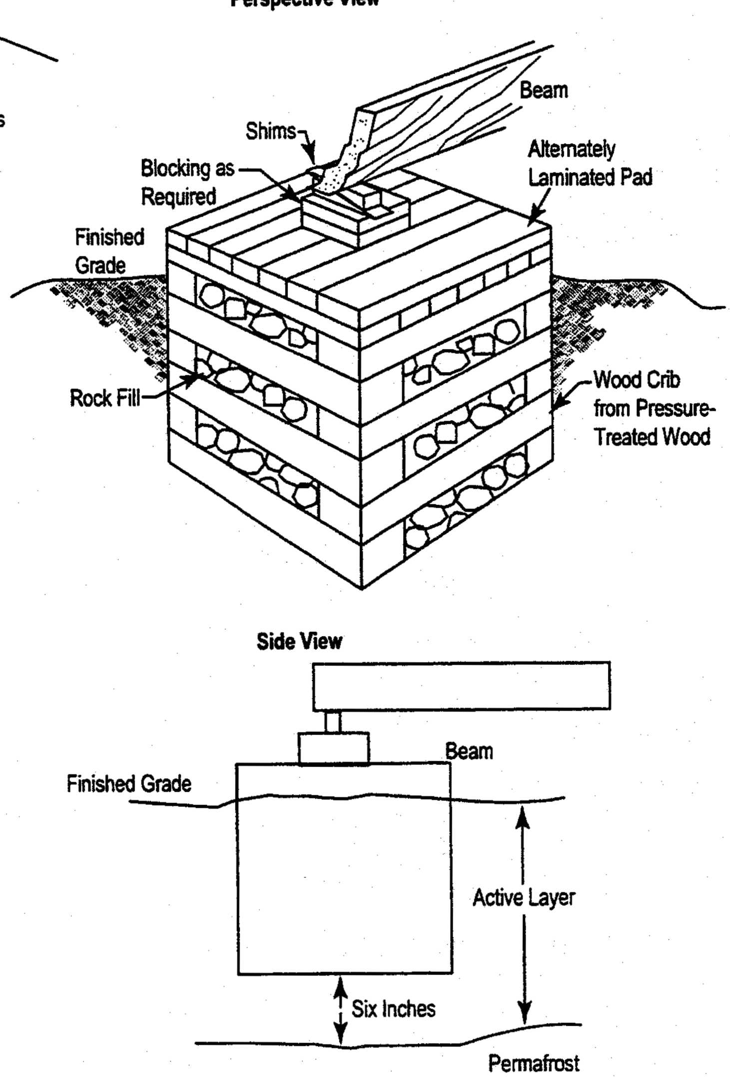
Wood Pad Foundation

The foundation must be level and square—check the diagonal measurements from corner to corner. These measurements should differ by no more than 1/4". The accuracy and effectiveness of the foundation sets the tone for the rest of the structure. Good finish work begins with a good foundation.

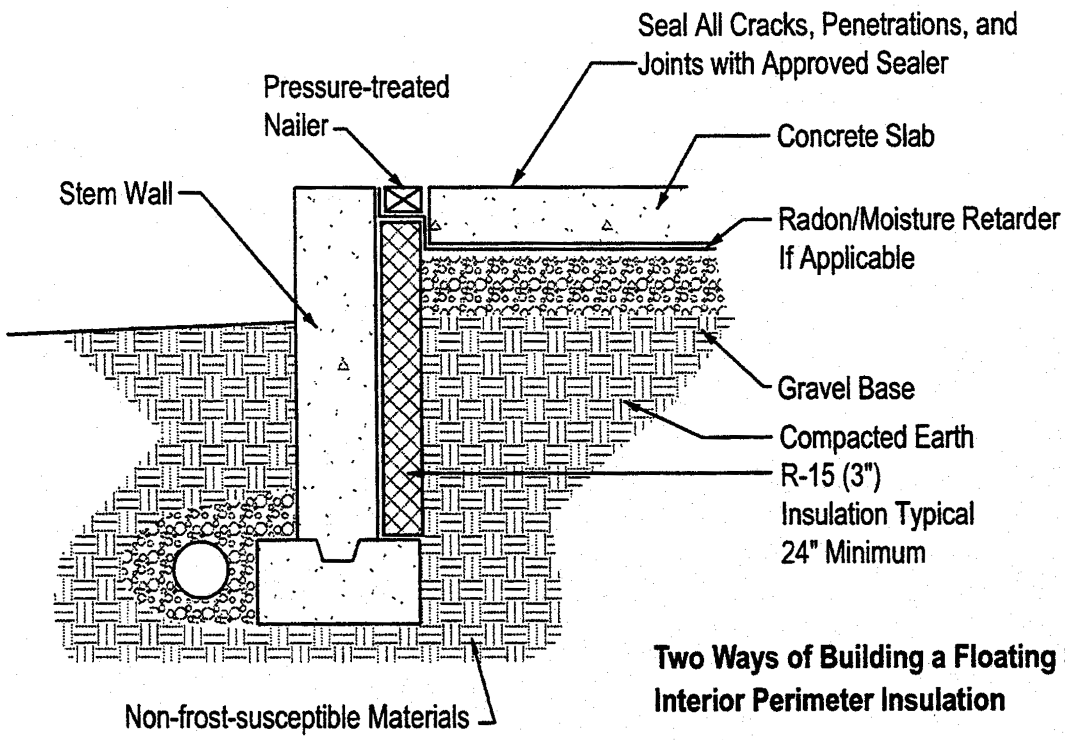
Pile Foundation



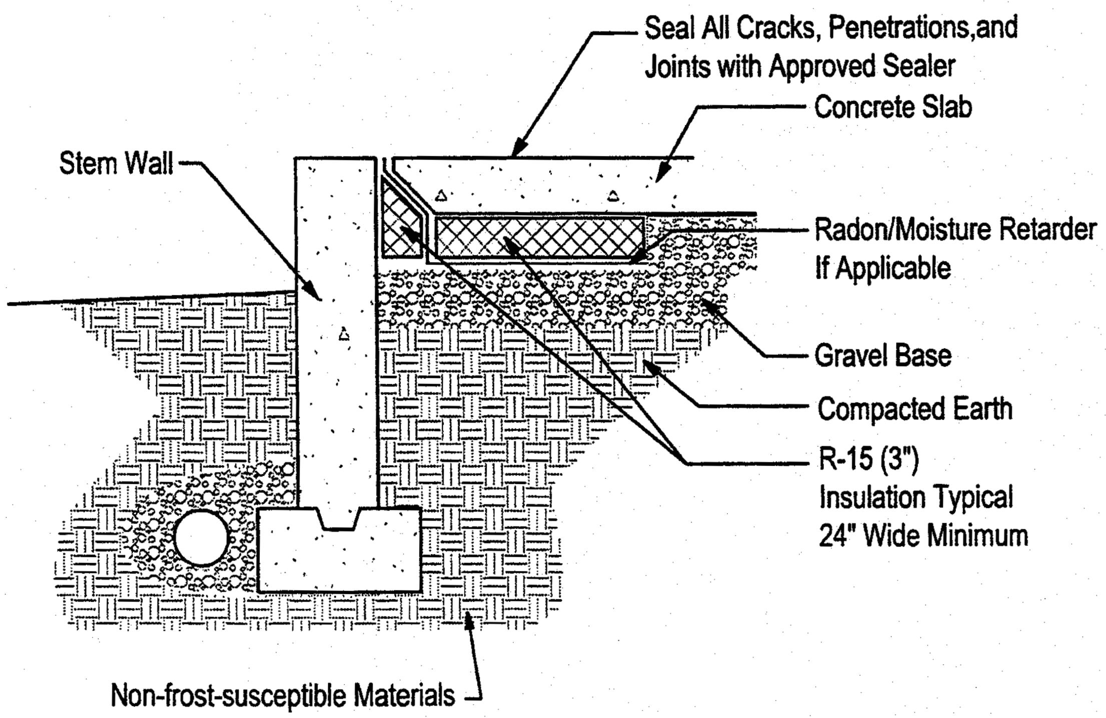
Crib Foundation

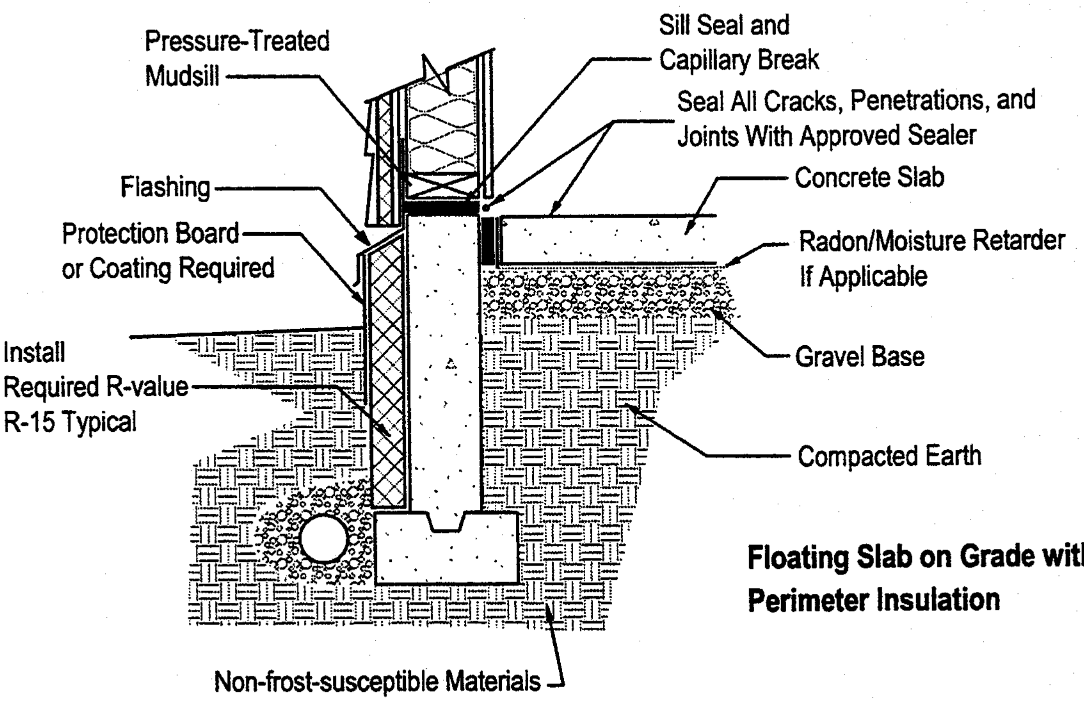


Regardless of the type of foundation (except open crawl spaces), the designer must include the foundation as part of the thermal envelope with appropriate measures specified to resist the flows of heat, air, and moisture. The plans must show how the insulation, vapor retarder, and air or weather retarder are to be installed and how they are integrated with the wall system.

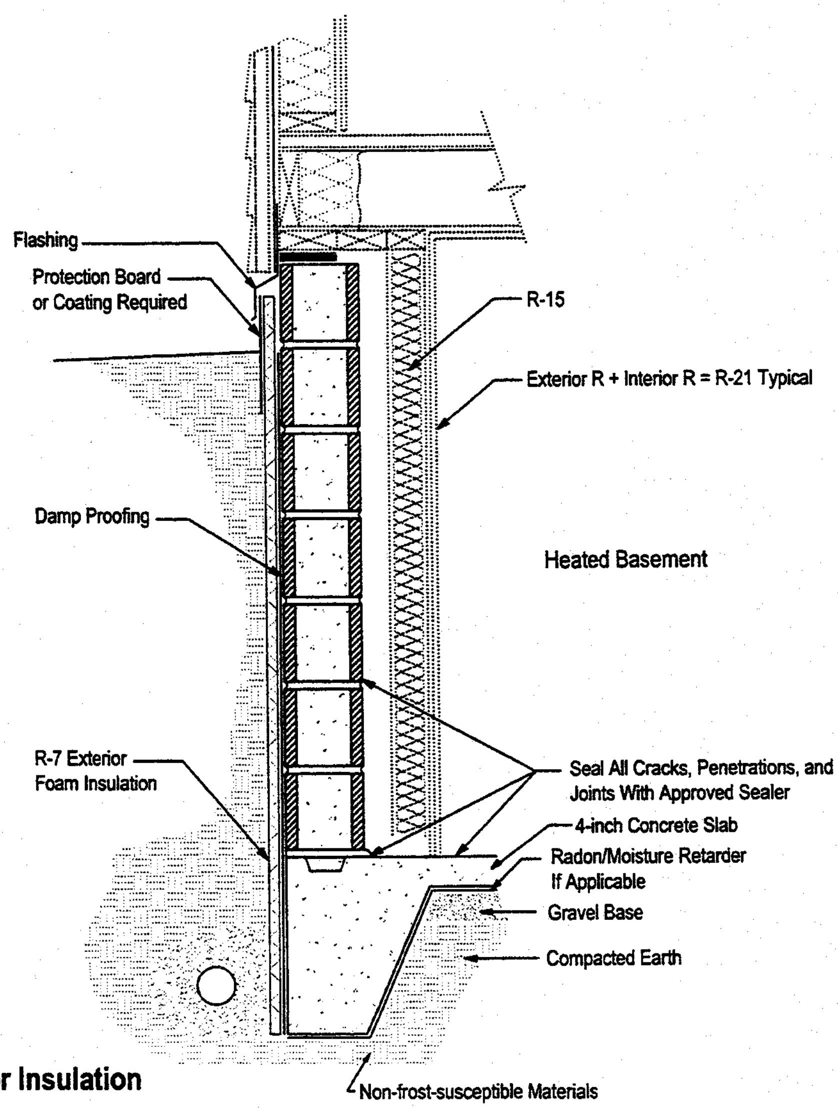


Two Ways of Building a Floating Slab on Grade with Interior Perimeter Insulation

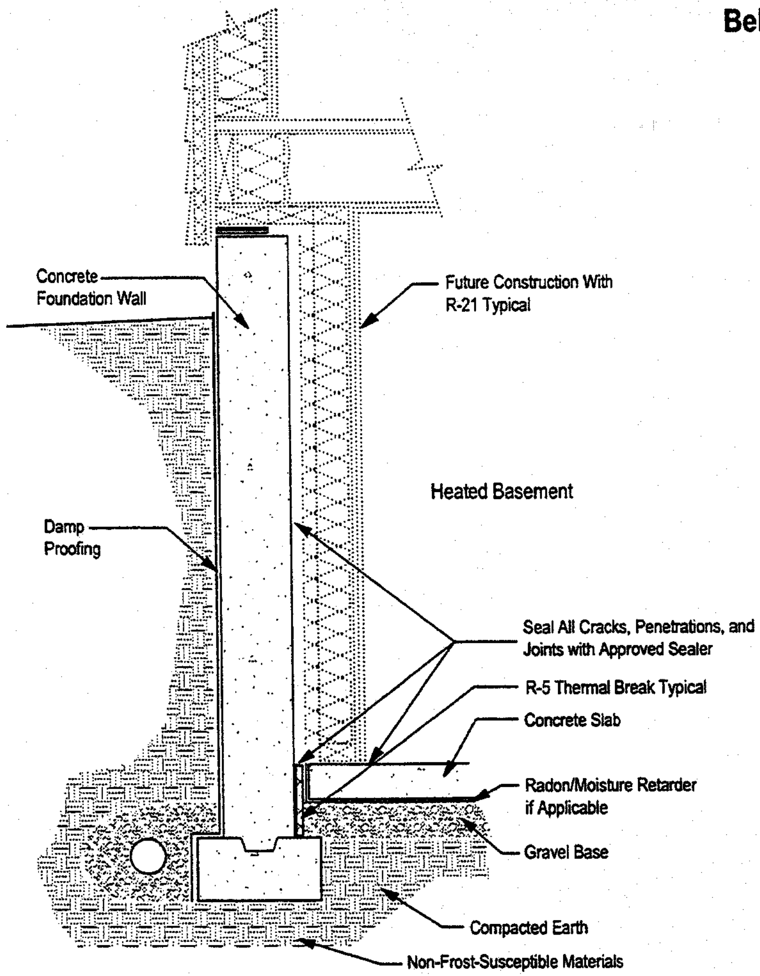




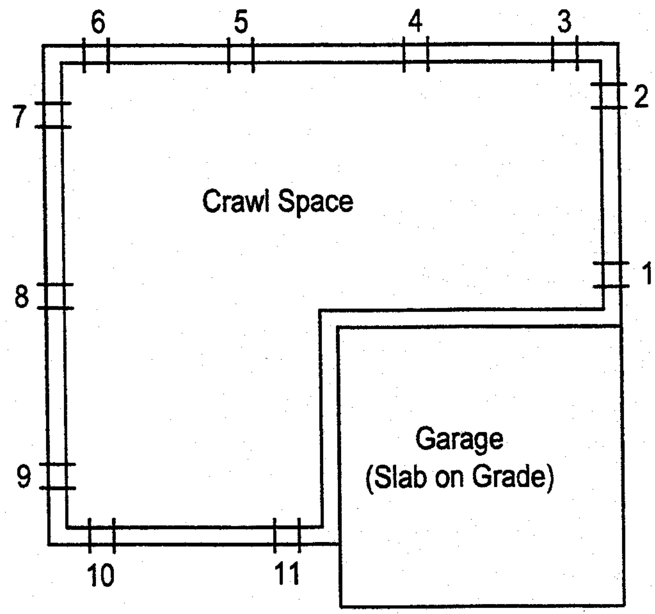
Floating Slab on Grade with Exterior Perimeter Insulation



Below Grade Wall with Exterior Insulation



Below Grade Wall with Interior Insulation



Crawl Space Ventilation Calculation

Sample Venting Calculation

Per UBC Section 2516(c)6:
1 sq. ft. net free area/150 sq. ft. underfloor area

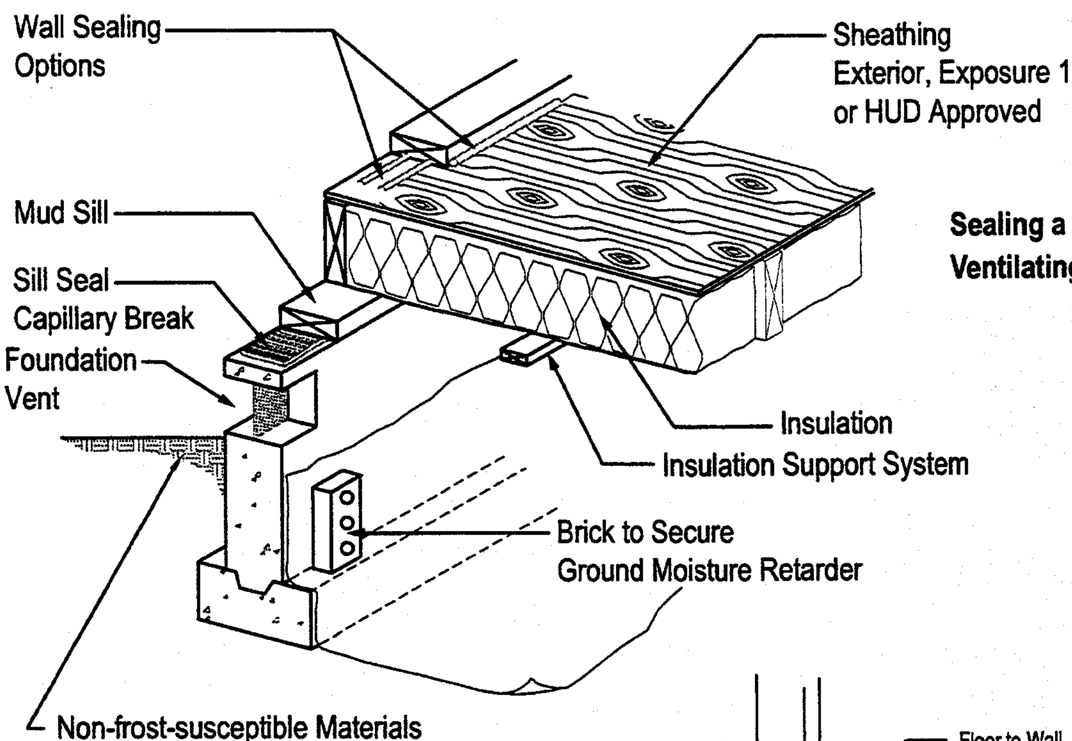
$$\frac{1400 \text{ (crawl area)}}{150} = 9 \text{ sq. ft. (total vent area required)}$$

$$\frac{9 \text{ sq. ft. (total area required)}}{8 \text{ sq. ft. (net area per vent)}} = 11 \text{ vents}$$

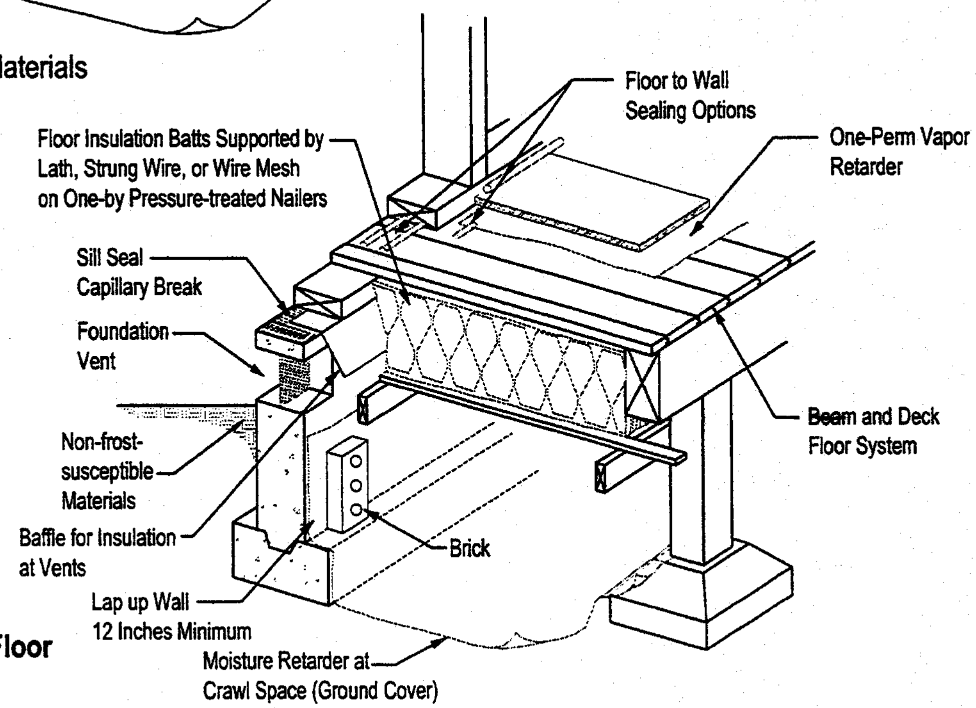
Note: In most of Alaska, temperatures are often well below freezing, and the crawl space is heated. We recommend that you ventilate a heated crawl space mechanically through the heat recovery ventilation system. One suppy and one exhaust, at opposite sides, will usually get the job done.

Design the Thermal Envelope

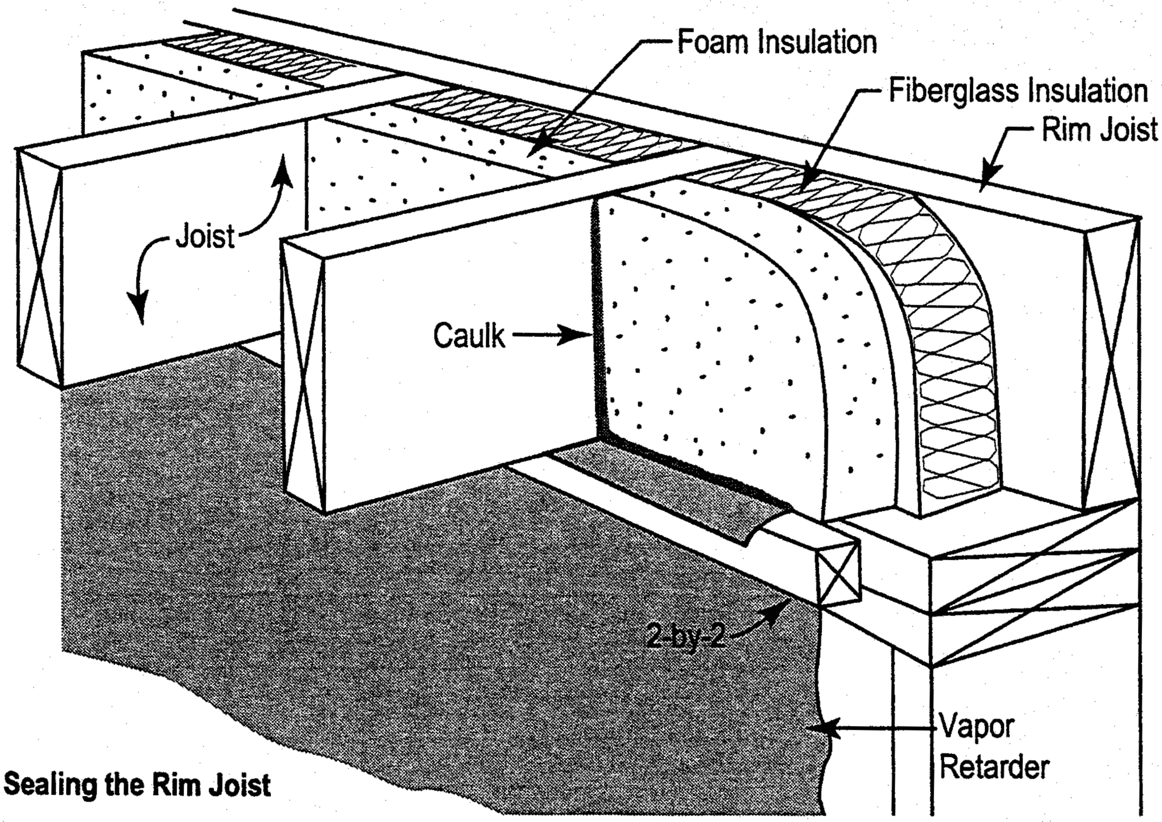
Now that you know what foundation you intend to use, next you must design the thermal envelope from the foundation through the floor, wall, and ceiling systems and back again to the foundation. You must be able to detail a truly continuous air/vapor retarder, insulation system, and weather retarder that meets all of the building science principles outlined earlier in this manual as well as meets the mandatory measures outlined in Appendix A. We urge you to use Hot 2000 energy analysis software. It will guide you in choosing optimal levels of insulation to meet an annual energy target. If you do not use Hot 2000, then you must use Table 1 (on page 8).



Sealing a Joisted Floor and Ventilating the Crawl Space



Sealing a Post and Beam Floor with a Decking Subfloor



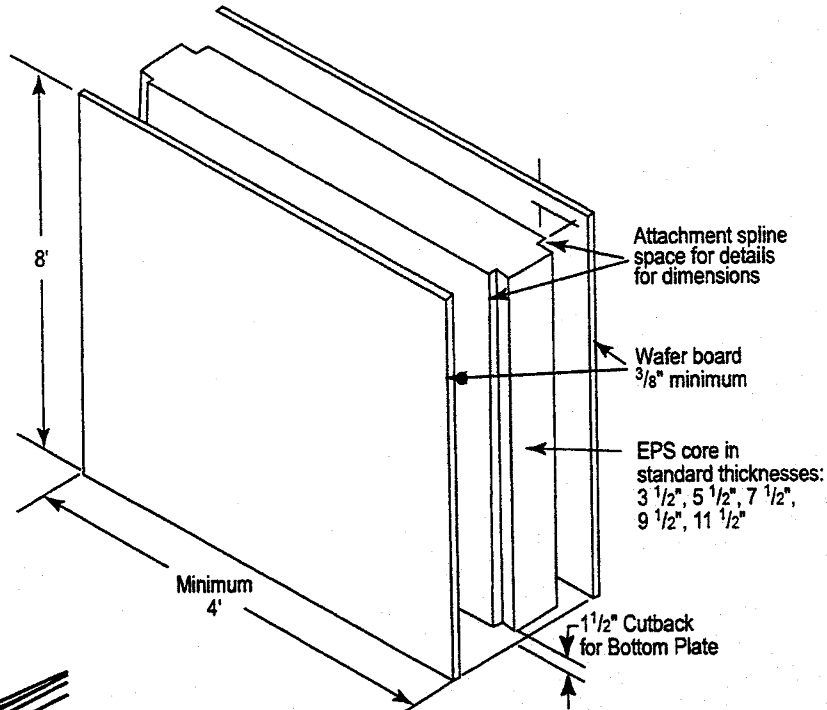
Sealing the Rim Joist

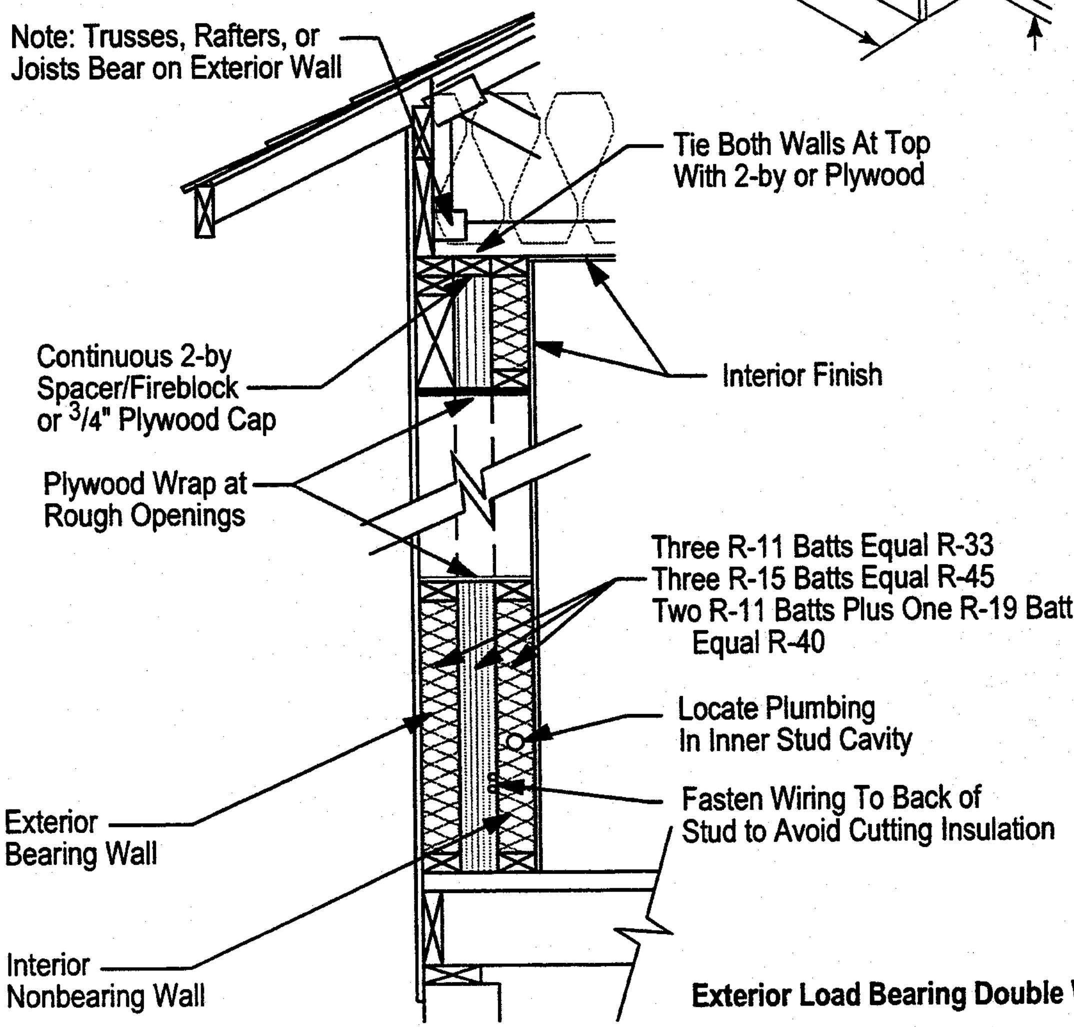
Walls

Walls must of course hold up the roof. Beyond that, walls need to keep the weather outside and must resist the flows of heat, air, and moisture from the inside. Walls are attached to the ceiling as well the floor and must be detailed to maintain the continuity of the thermal envelope. In the southern part of the state, two-by-six walls with high R-value insulation will meet the thermal standard. Farther north, higher R-values will be necessary to meet the standard. A number of wall systems have been perfected for increased R-values, including simply applying a layer of rigid foam to the interior or the exterior of the studs or else furring the walls in or out and insulating with fiberglass. Beyond about R-30, the double-stud wall has proven to be one of the most cost-effective ways to obtain high R-values using lower-cost materials such as fiberglass or cellulose insulation. Various spray foams can be blown into the wall cavity to obtain higher R-values, improve airtightness, and add structural rigidity, but all this comes with a price, since most spray foams cost more per R-value per square foot. There are now spray foams on the market that do not contribute greenhouse gases to the atmosphere. Greenhouse gases are responsible for creating holes in the ozone layer, resulting in global warming. Foam panels have been used successfully in all areas of the state for walls, floors, and ceilings, but we recommend that you install a separate vapor retarder.

Full ceiling R-values must extend completely over the wall top plate. A continuous vapor retarder must extend over the entire ceiling and be sealed to the wall vapor retarder.

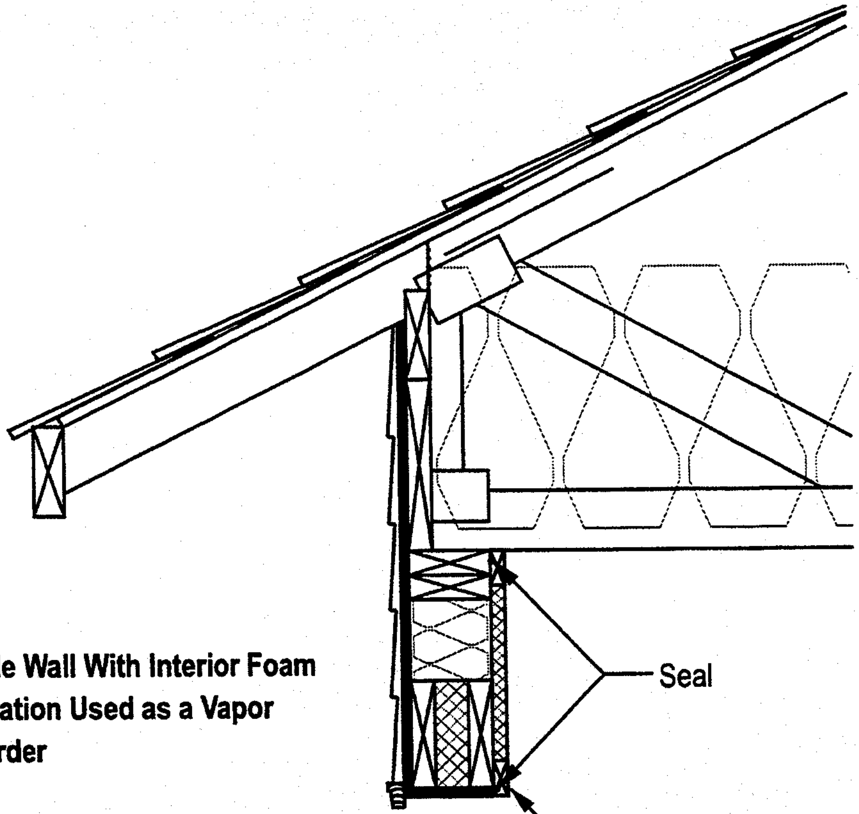
EPS Panel for Use as Structural Wall

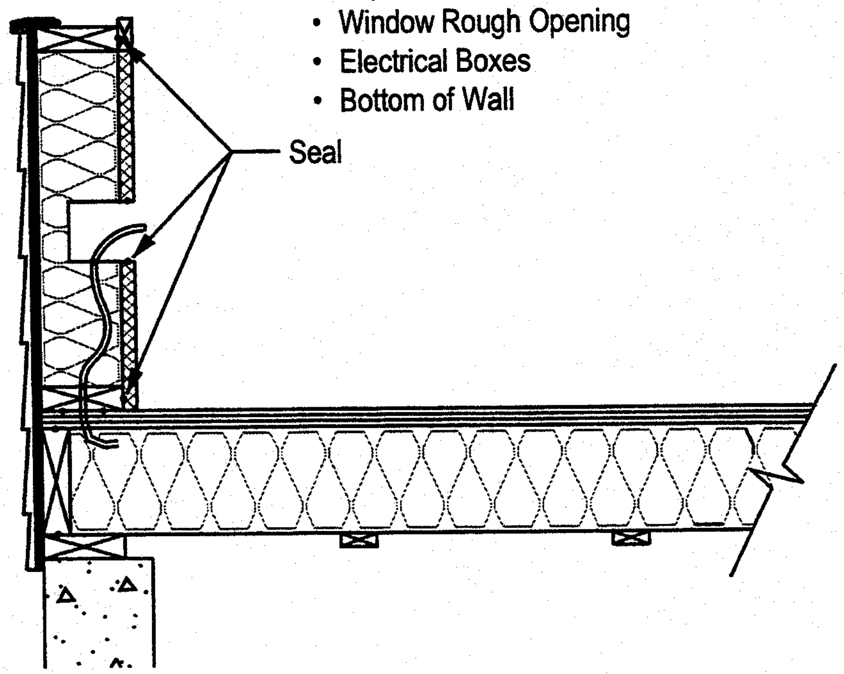




Exterior Load Bearing Double Wall

Single Wall With Interior Foam Insulation Used as a Vapor Retarder



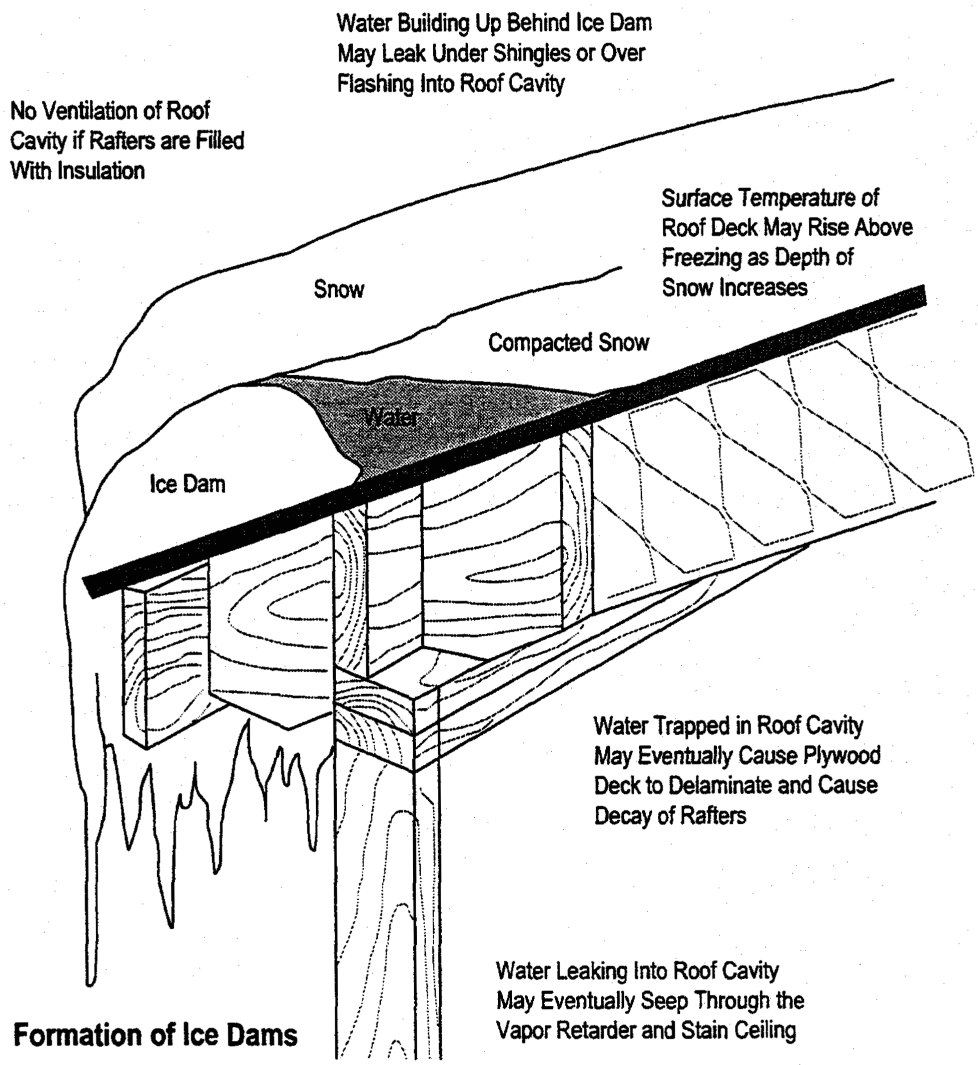


Attics and Roofs

The designer must decide whether to build a hot (unventilated) or a cold (ventilated) roof. This decision is usually based on the likelihood of snow building up on the roof during the course of the winter. If snow will accumulate, then a cold roof is in order. Snow buildup insulates the roof, causing snow near the roof surface to melt from the heat of the building. This melted snow runs down the roof and refreezes at the edge, forming ice dams. These dams cause water to back up underneath the shingles. The solution is to provide ventilation in the attic, so heat from the building does not melt the snow.

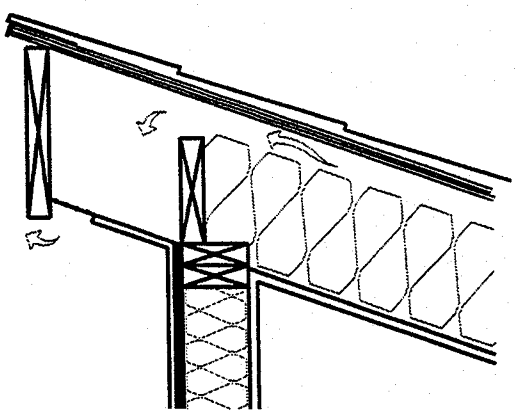
Hot Roof vs. Cold Roof

The decision to ventilate or not to ventilate the attic or roof must be based on which strategy is most likely to contribute to the longevity of the building. Once the air/vapor retarder on the warm side of the ceiling and insulation is so nearly perfect that heat, air, and moisture leaks from within are no longer a concern, then the major consideration should be whether or not ice damming can be caused by snow build-up on the roof. If the building is on a site exposed to

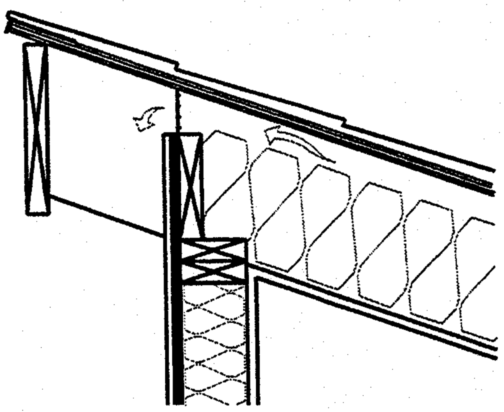


Formation of Ice Dams

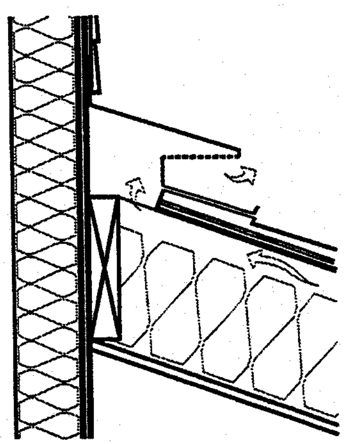
Providing Ventilation for a Cold Cathedral Ceiling Roof



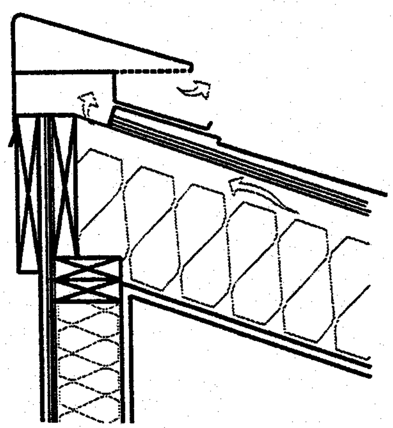
Shed Peak With Soffit



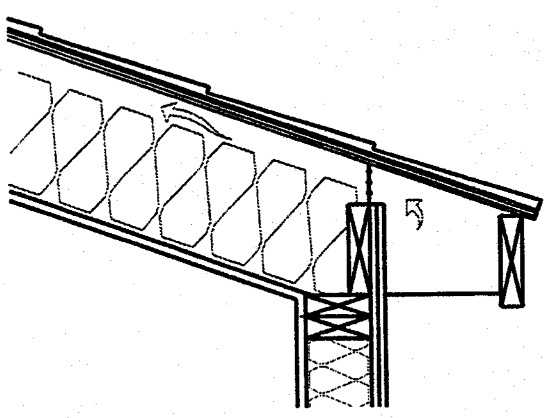
Shed Peak Without Soffit



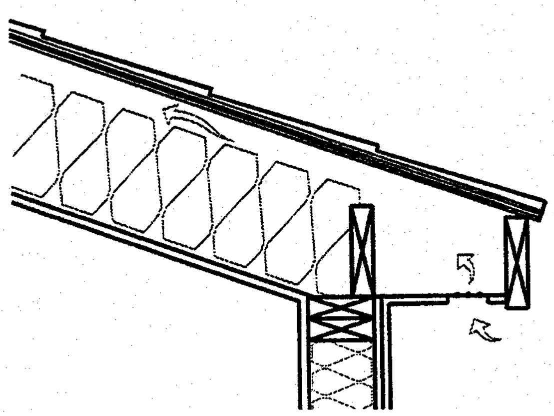
Shed Roof At Wall



Shed Peak: No Overhang

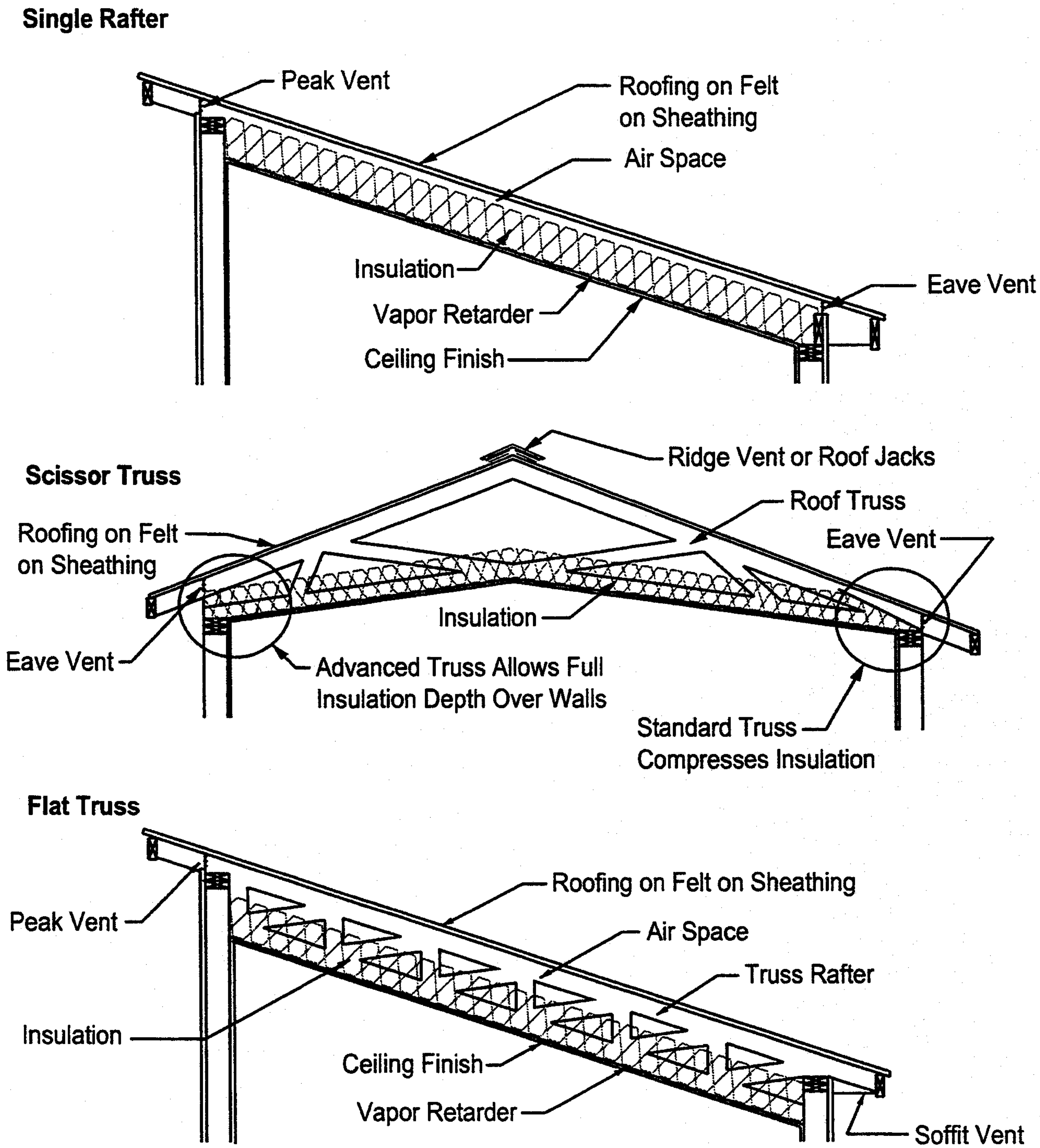


Eave Without Soffit



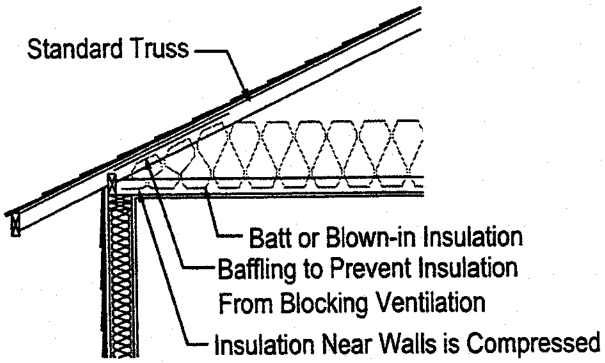
Eave With Soffit

high winds and no snow is likely to accumulate on the roof, an airtight hot roof may be desirable. A number of snow-resistant ventilated roof designs have been experimented with over the years with varying degrees of success. Whatever design you choose, keep in mind that an attic full of snow will not last long.



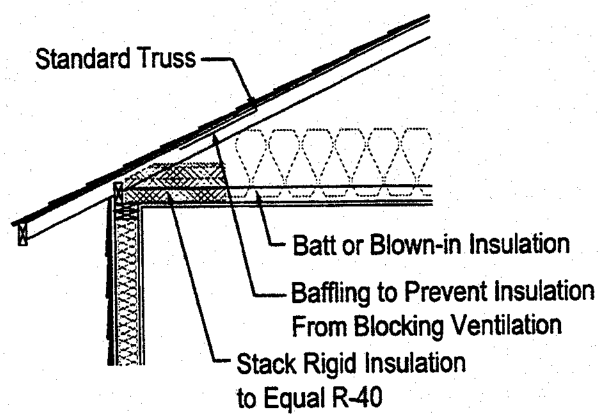
Framing for Vaulted Ceilings

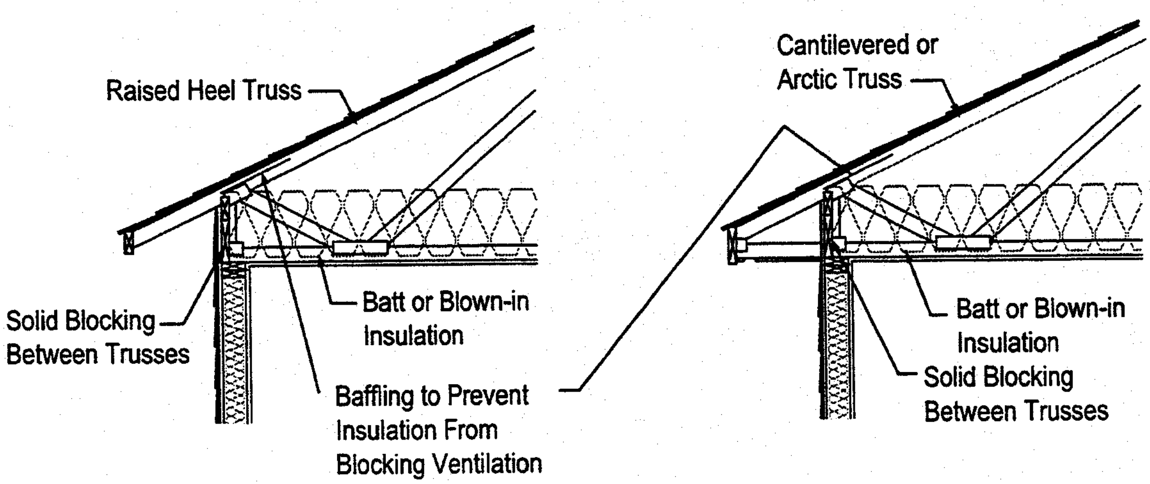
In areas where wind-blown snow or rain could be driven into the roof cavity, a hot roof may be required, but it must be tightly sealed. Roofs must be designed to accommodate snow loads and be securely anchored to resist wind and seismic loads.

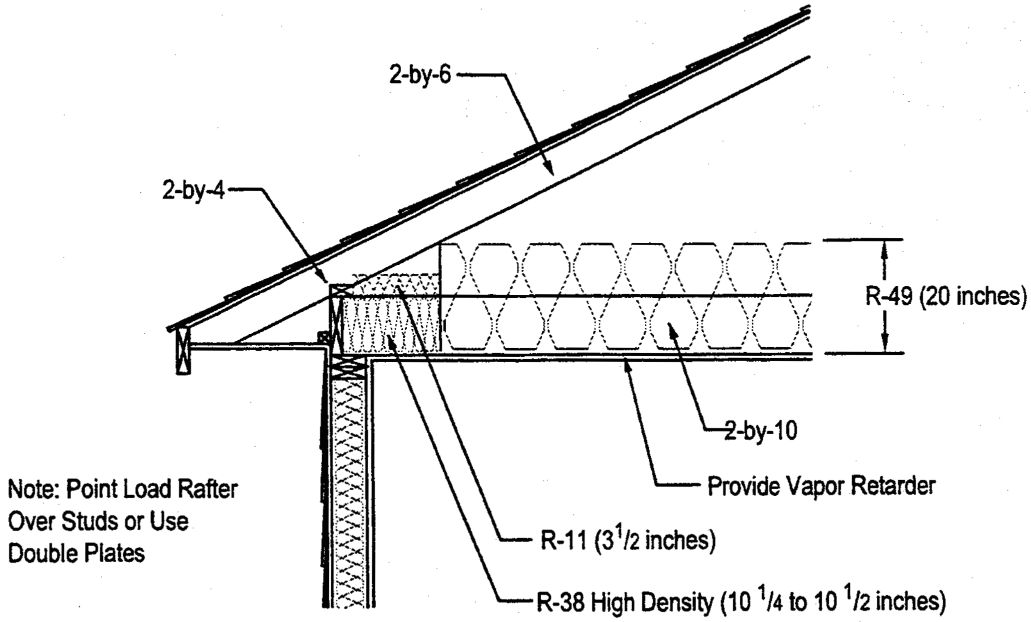


Standard Framing

Advanced Framing

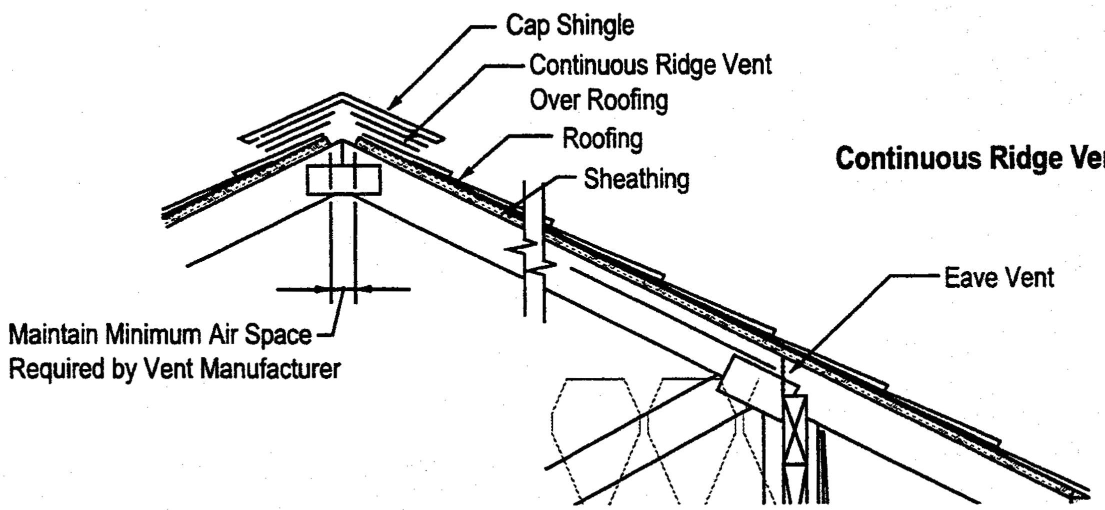






Advanced Framing Using Rafters

(Note: Structural engineering may be required for rafter-to-ceiling joist tie)



Continuous Ridge Vent Over Attic

Windows and Doors

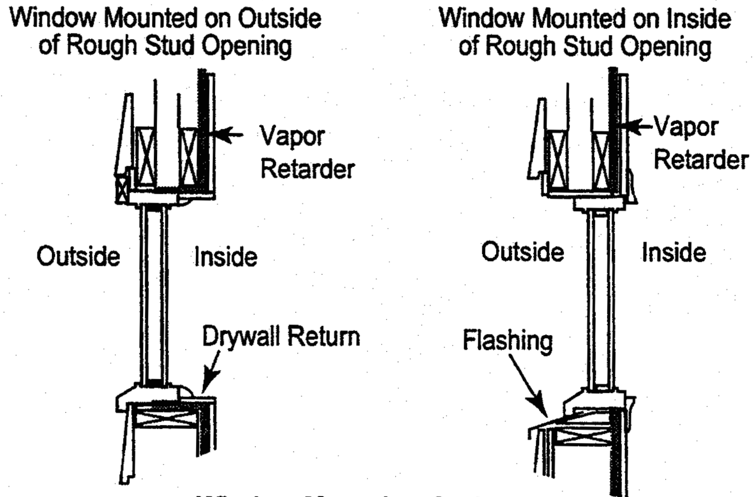
Windows play a huge role in the efficiency of buildings in Alaska. Typically they are the biggest "hole" in the thermal envelope. If following the prescriptive method, windows must have a minimum R-value of 3 (max. U factor of .33) in the Southeast and Southcentral regions and a minimum R-value of 4 (max. U factor .25) in the Interior and Southwest, Northwest, and Arctic Slope regions. In order to meet these high standards, windows will have to have double or triple panes with low-E coatings and be filled with argon or krypton gas. Opening windows must meet air infiltration standards (Appendix A). Windows and doors must be installed to maintain the integrity of the thermal envelope and prevent the flow of heat, air, and moisture between the window or door frame and the rough framing. Limit window area to 12 percent of the heated floor area and face the majority of windows south to capture as much natural lighting as possible and to gain passive solar heat whenever possible. Roof overhangs, awnings, or shades may be necessary to reduce overheating in summer.

Exterior doors should have a minimum R-value of 7 in Southeast and Southcentral regions, R-10 elsewhere, and be fitted with airtight, flexible weather-stripping. Doors should have a weather-stripped adjustable threshold or floor sweep. Door hardware must be high quality for rigorous commercial use, with no plastic parts. Locate doors so that prevailing winds don't rip them off their hinges or block exits with snow drifts.

Installing Windows

The walls of an energy efficient house are generally thicker than those of a conventional house. This presents the choice of installing the window on the inside or outside face. The frames of most windows have the lowest R-value of any part of the thermal envelope. Mounting them on the inside of the wall prevents condensation and frost.

However, inside mounting requires extra care and detailing to construct the deep weatherproof sill. In colder areas, thermal bridging may cause interior condensation. It is much easier to have the window recess on the inside and faced with drywall or wood jamb extensions than to have a deep exterior sill with the resultant flashing requirements. For this reason, the majority of builders install windows on the outside face. The details required for outside window installation are the same as used in conventional building (see graphic below).



Window Mounting Options

Vinyl frame windows differ from wood ones and must be installed differently. Vinyl expands more in temperature changes. In interior Alaska, a window frame can experience temperatures from 50 below to 90 above. Because of expansion and contraction, nailing fins will break and leak. This won't be visible because they are covered by trim and siding.

To allow for expansion and contraction of the window frame, make the rough opening for a vinyl window about ½ inch larger than the window on all sides. Install shims on the sill under each corner and under each mullion or post in the window. Square up the window by shimming the sides, but keep the shims at least eight inches away from the corners. Install mounting clips on the window frame. Put the frame on the sill shims and make sure the window is level and plumb. Check that it is square by measuring across the **inside** of the frame diagonally in both directions (there may be welding burrs on the outside corners). If practical, it is easier to remove the glass and shash from large windows and install the frame first, then put the glass back in.

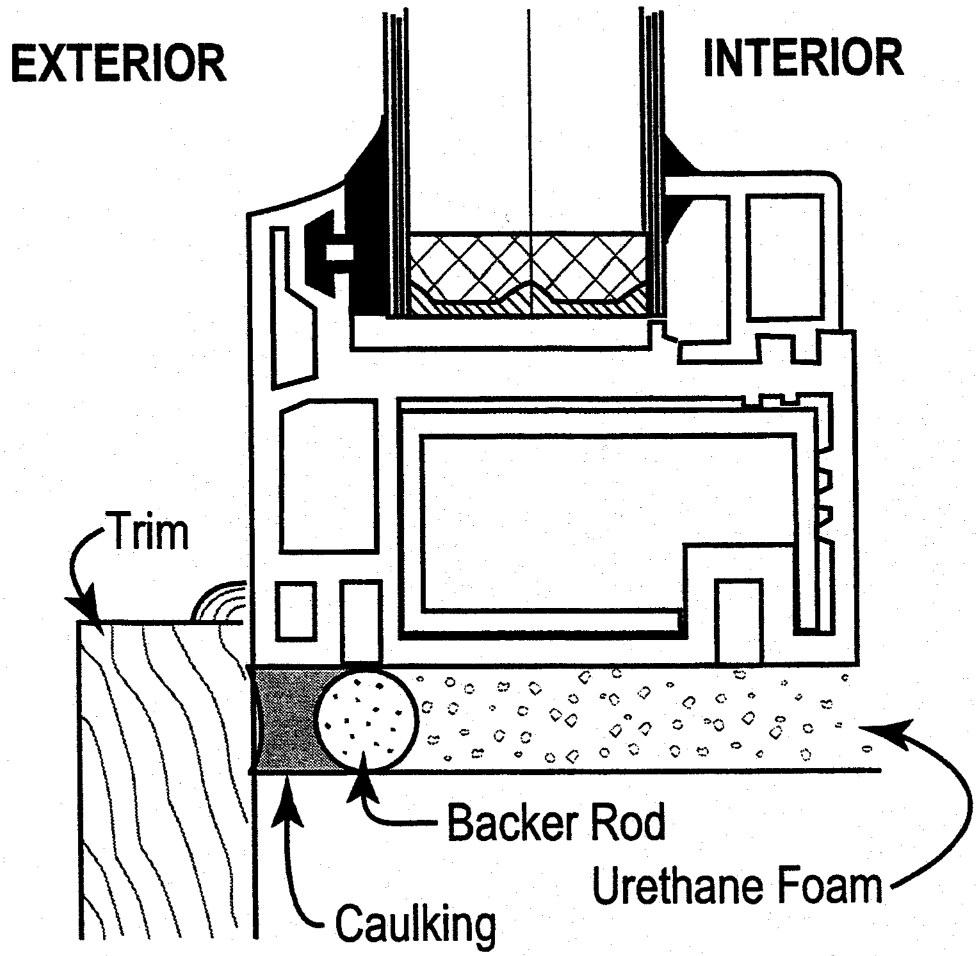
Making the window as energy-efficient as possible requires two separate jobs:

- Insulate the space between the window frame and rough opening.
- Ensure that the air/vapor retarder is continuous and sealed directly to the window frame.

It is important to use the right materials to insulate and seal the window. Use single-part urethane foam to insulate the space between the window and the frame. Make sure it is "low yield" or "nonexpanding," and be careful not to overfill the space and warp or crack the window. Using masking tape on the frame of the window will speed cleanup of any extra foam. Some good foams to use are Hilti, Insta-Seal, and Polycel. Some foams use a dispenser that may not be available in rural Alaska, and some come from a can.

Foam alone is not a good air/vapor retarder. You must also use caulk to seal the window to the wall air/vapor retarder. One vinyl window manufacturer in Alaska recommends Bostik Chem-Calk 900 or Tremco 830, both single-part urethane caulks, or Tremco Spectrum 11 or Tremco 600, both neutral cure silicone caulks. Don't use acid-cure silicone, since it will not stick to bare wood. Make sure the caulk is not out of date and has not been frozen or damaged in storage.

Clean vinyl window frames with denatured alcohol before applying the caulk. The caulked joint should be a two-to-one ratio; for example, 1/2-inch wide and 1/4-inch deep. If a bead of caulk is too thick or is stuck on three sides, it cannot stretch as the window expands and contracts. The joint should be shaped like an hourglass (see drawing below). A closed-cell polyethylene rope (backer rod) helps make the caulk joint the proper size and shape and is a bond breaker so the caulk won't tear.



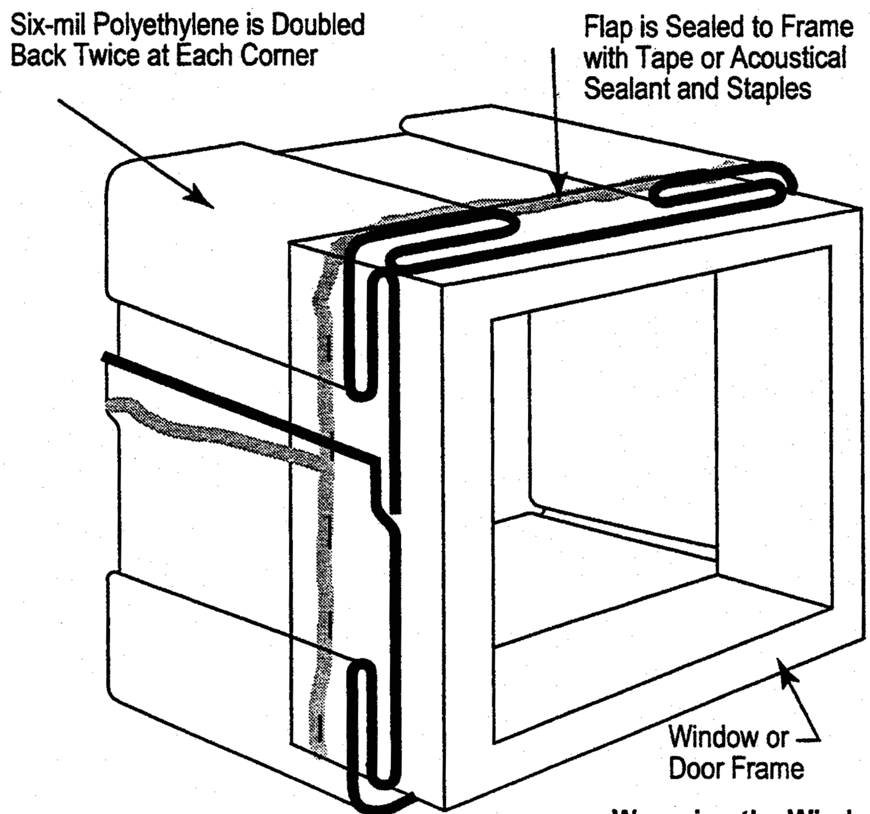
Two methods have been developed for sealing the air/vapor retarder to the window frame:

- Polyethylene wrap—a six-mil polyethylene flap is attached to the window frame. This method is most commonly applied to wood windows.
- Plywood or drywall wrap—the rough opening is lined with **exterior** plywood and the window frame is sealed to the plywood.

Polyethylene Wrap

To install polyethylene wrap:

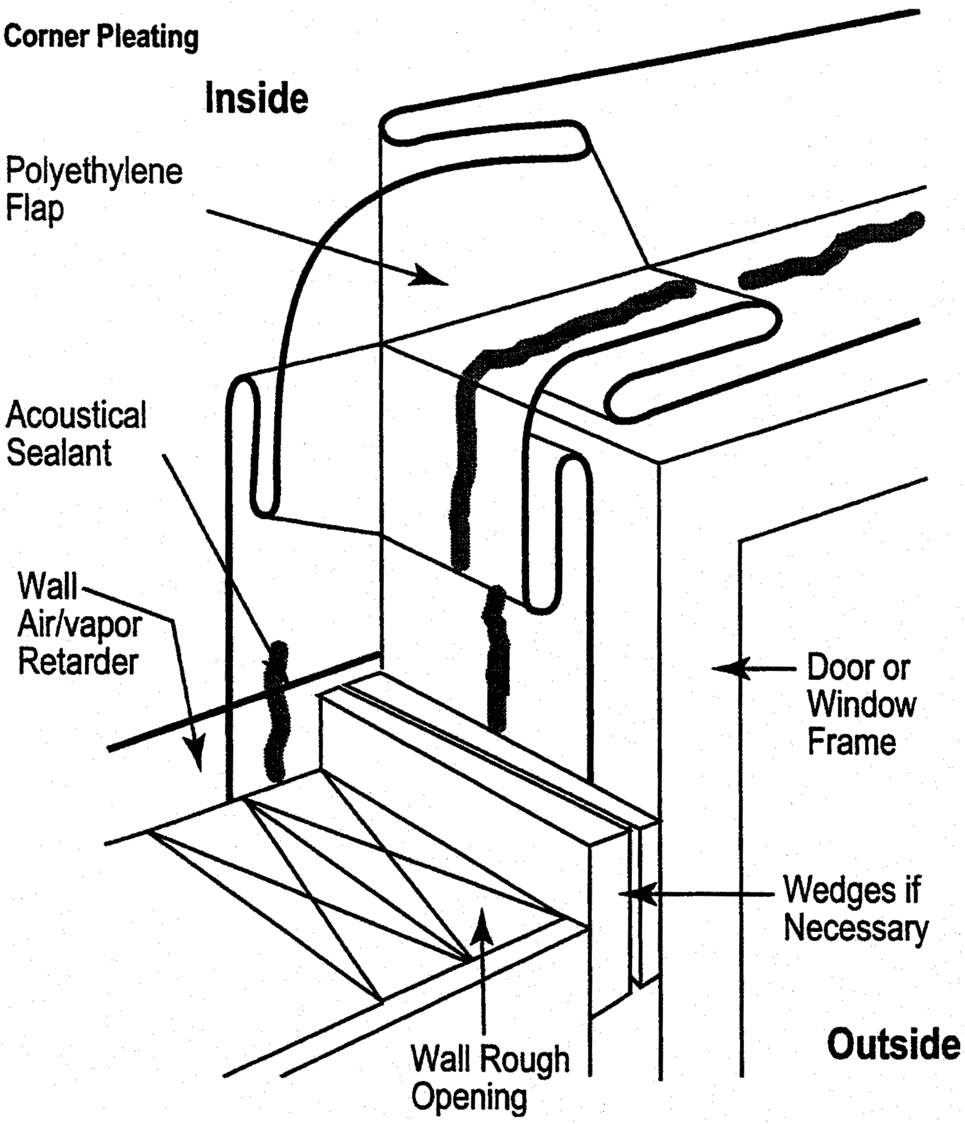
- Cut a 24-inch wide strip of six-mil polyethylene. It should be long enough to go around the window with about 20 inches extra.
- Apply a bead of acoustical sealant to one side of the wood window frame. The bead must be located toward the outside of the window frame to ensure that joints between the window frame and jamb extensions are sealed.
- Lay the polyethylene strip over the caulking bead and staple it to the frame through the caulking bead.



Wrapping the Window Frame

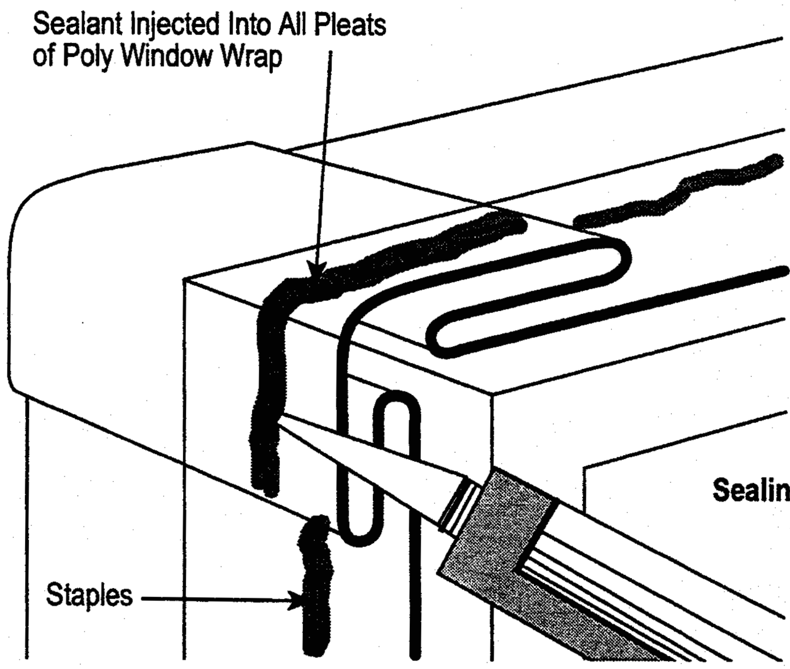
- At the corners place a pleat one inch wide in the polyethylene on both sides of the corner. Staple the pleats to the wood frame and inject acoustical sealant to seal the pleats. The pleats allow the polyethylene flap to fold back at the corners and seal against the wall air/vapor retarder. Continue this process around the frame and join the polyethylene strip to itself with a bead of acoustical sealant.

Corner Pleating



- Place a continuous piece of fiber-reinforced tape on the polyethylene above the bead of the acoustical sealant and staple through the tape, polyethylene, and acoustical sealant into the window frame (on wood frames) at intervals not greater than three inches. This ensures that the polyethylene will stay in place, as staples by themselves do not always have the holding power to keep the polyethylene in place.

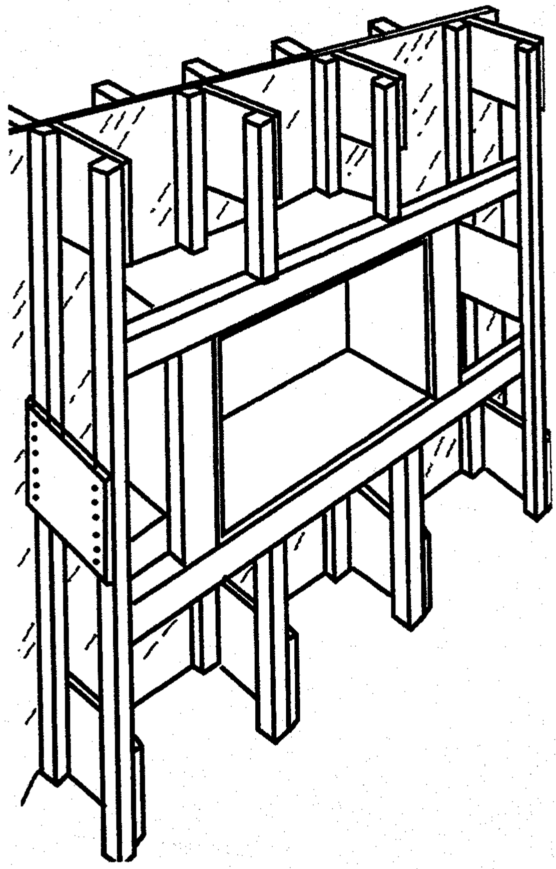
- Insert the window frame in the rough opening and shim in place if necessary. When installing wedges, ensure that they go between the polyethylene flap and the rough opening and not between the polyethylene and the window frame.
- Stuff the space between the window frame and opening with batt insulation, or use backer rods.
- Staple the polyethylene flap to the rough opening.
- After the wall air/vapor retarder is applied, cut out around the window opening. Apply a bead of acoustical sealant between the window flap and wall air/vapor retarder and then staple them together.



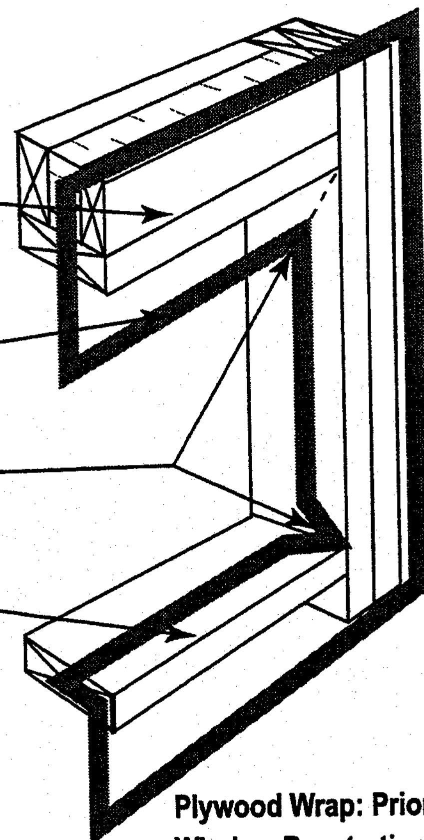
Sealing the Pleats

Plywood Method

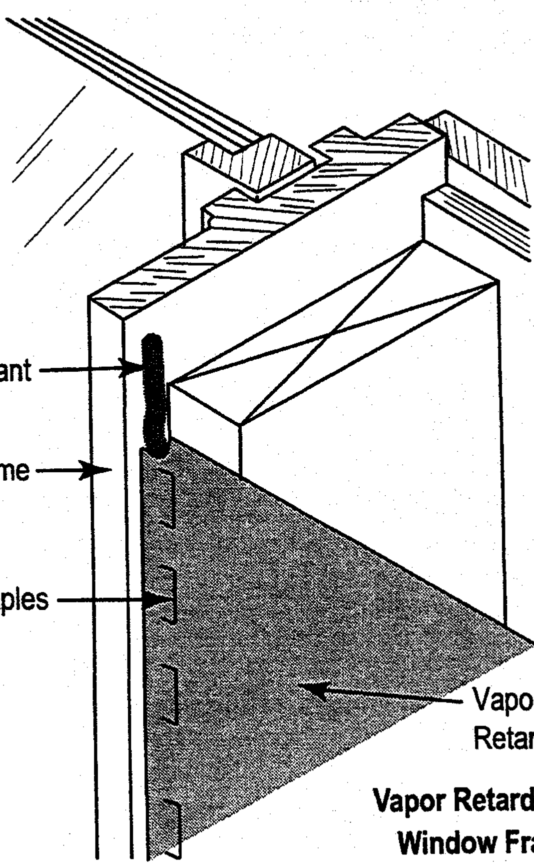
- The rough stud opening is framed to accommodate a ½-inch plywood liner covering the width of the opening. This will mean an increase in both height and width of one inch.
- Seal the air/vapor retarder from the house wall to the plywood liner with either polyethylene or drywall. In both cases, the seal can be to the edge of the plywood facing the room (see figure, next page).
- Nail the plywood liner into place flush with the interior finish and the exterior sheathing. The liner should be caulked to the rough stud on the interior.



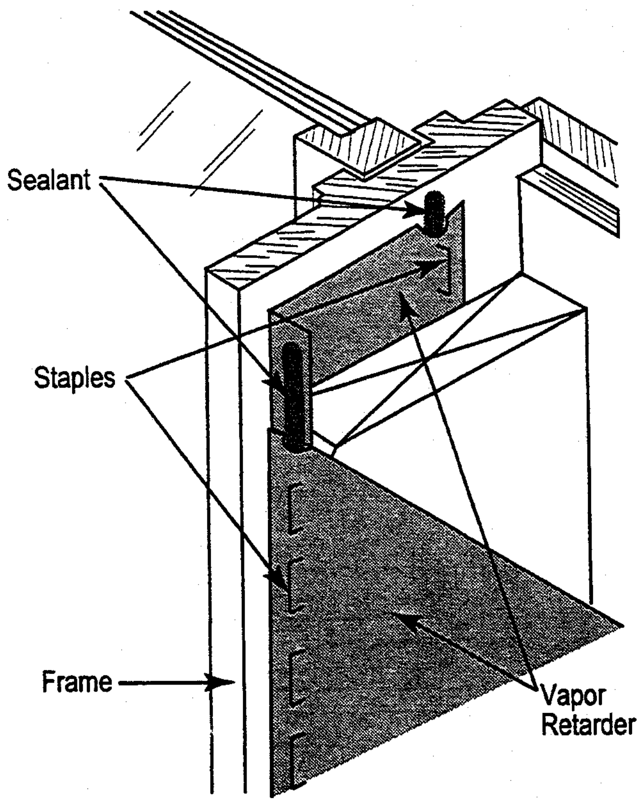
Plywood Frame Around Window in Offset Double Wall



Plywood Wrap: Prior Window Penetration



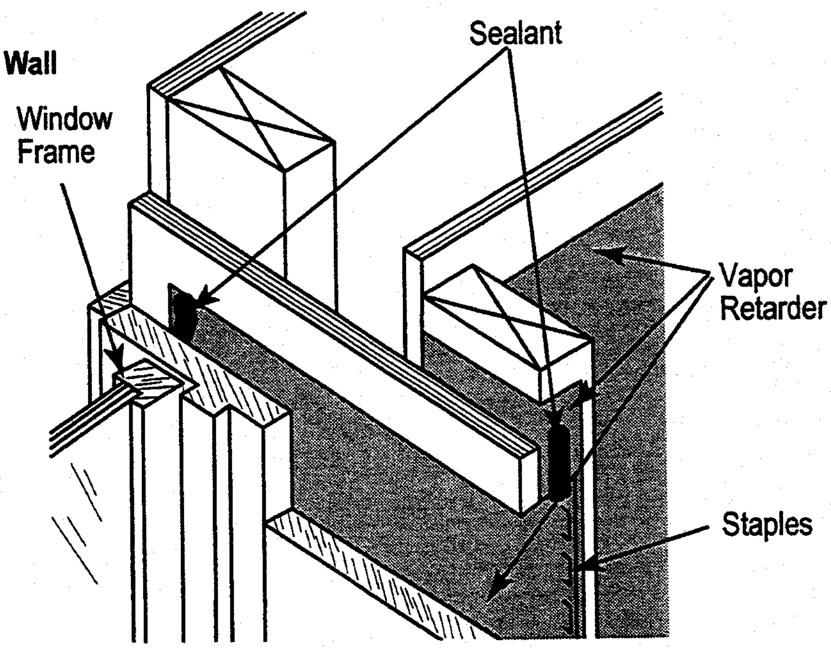
Vapor Retarder Sealed to Window Frame at Edge



Vapor Retarder Sealed in Single Frame Wall

- Install the window into the liner from the inside or the outside, depending on the intended location. If the window is to be located toward the interior of the assembly, install proper flashing on the sill before window installation.
- Insulate and seal the gap between the window and the plywood frame.

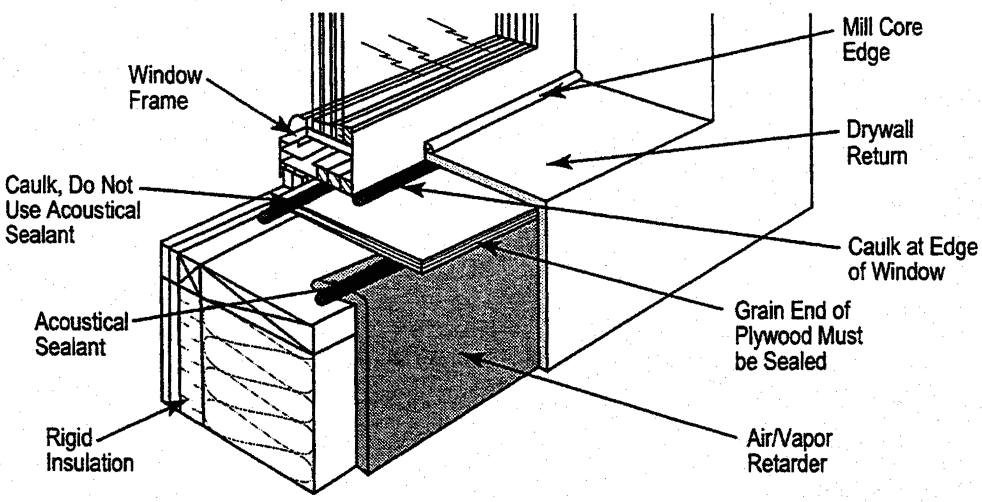
Vapor Retarder Sealed in "Saskatchewan" Type Double Wall



Drywall Method

- After sealing, install drywall over the liner and install the finished sill.
- The rough stud framing and window installation follow conventional practice.
- The drywall interior finish is butted and sealed to the window frame to provide a continuous air retarder.

- Where the window is installed on the outside face of the wall, a drywall return will be required in the rough opening and it should butt onto the face edge of the window frame. Caulk this joint. Using a U-shaped drywall cap called a "mill core edge" to cover the cut edge of the drywall makes caulking this joint a simple matter.
- When the window is installed on the inside face of the wall it may be located so that the face edge of the frame is flush with the face of the drywall. This butt joint may be sealed with tape and covered with trim.



Vapor Retarder Sealed in Single Frame Wall

Energy Efficient Lighting

Providing energy-efficient lighting for community buildings is an important factor in reducing operating costs. Controlling ventilation by using heat recovery ventilation adds the operating cost of an electrical appliance. Reducing the electrical cost of lighting can more than offset the cost of operating the HRV, resulting in a total overall reduction in electrical costs.

Generally speaking, incandescent lamps, or light bulbs, are obsolete. Retrofit lamps called compact fluorescents made to screw into a light bulb socket typically use only 25 percent of the energy used by a standard light bulb. Buying these fluorescents is expensive, but they last for 10,000 or more hours, about 10 times the life span of an ordinary light bulb. The higher the electrical costs in your area, the more important efficient lighting becomes.

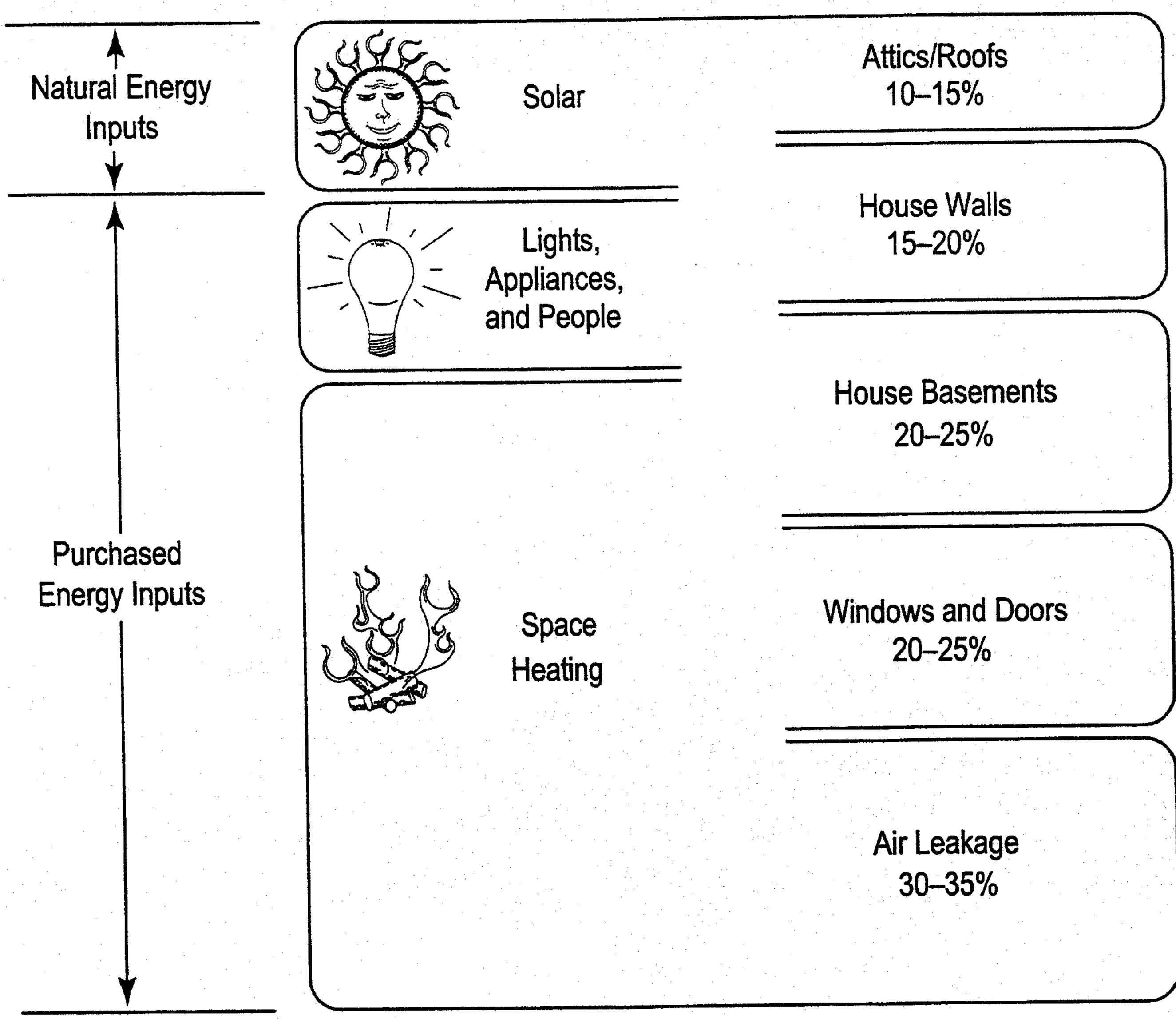
Other lighting options include fluorescent reflector technology and electronic ballasts. Fluorescent reflectors can be retrofitted to existing fluorescent fixtures or purchased new. The reflector acts like a mirror that directs more of the light from the fixture down and to the sides, into the working area. This makes it possible to use half as many smaller fluorescent bulbs while still generating as much usable light.

Ballasts are used to start fluorescent lights. Conventional ballasts use electricity the whole time the lights are on. Electronic ballasts use less electricity than conventional ballasts when starting the lamps and use no electricity after startup. Conventional four-foot long, four tube fluorescent fixtures typically need two conventional ballasts to start the four lamps. Retrofitting four-tube fluorescents into two-tube reflector types reduces the number of ballasts per fixture from two to one. Using reflector type fluorescents and electronic ballasts can provide a 60 percent savings over conventional fluorescents. In a retrofit situation, using the existing fixture, adding the reflector, changing the lamps, and disconnecting one of the conventional ballasts while leaving it in place as a spare can result in a 40 percent reduction in operating costs. This is a less expensive solution than buying all new components, thus making such a retrofit more cost effective.

The most cost effective lighting solution is to plan your building and site orientation to take advantage of daylight. Many areas of Alaska have short daylight hours for part of the year and many cloudy days.

Build Tight and Ventilate Right

A well-sealed outer shell and a properly working mechanical ventilation system are among the key components for any building that is designed and constructed to be healthy, safe, comfortable, and energy-efficient. These two components are essential to each other and to the building system as a whole. When the shell is carefully sealed to reduce drafts, maintain structural durability, and conserve energy, the fresh air exchange rate is reduced below the level needed to maintain good indoor air quality. A mechanical ventilation system must be designed and installed to provide enough air exchange. The ventilation system exhausts stale, moist air from the building and brings in fresh air from outside and distributes it evenly throughout the building. The ventilation system allows for a controlled environment that can be adjusted to meet the variable needs in rural community buildings. All buildings must comply with American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 62-1989.



Energy Flows in Housing

Mechnical Systems

Heating, ventilating, and air conditioning a community building requires integrating these three subsystems into the building as a whole system. For example, if heat recovery ventilation is called for, then the heating system must be correctly sized for a lower design heat load. Because the structure will be airtight, you will be in control of energy use related to air flow. Since energy-efficient lighting, appliances, and motors will be specified, there will be smaller internal heat gains. This will reduce the need for air conditioning.

Heating

Five important issues surround the heating of all buildings: (1) occupant health and safety, (2) building durability, (3) occupant comfort, (4) environmental effects, and (5) affordable and efficient operation.

Health and Safety

Providing a safe, healthy, and secure working environment must take priority, since a building without protection from earthquakes, fire, or high wind cannot adequately serve the community. Poor indoor air quality, such as carbon monoxide buildup or radon gas, is important to consider. The continuous slow input of combustion gas from a leaking or back drafting heating flue can slowly poison the building's occupants with carbon monoxide.

To avoid back drafting of combustion devices, **you must provide a separate room for the heating plant, with fresh air supply for combustion,** unless it is a Monitor or Toyo-type sealed-combustion space heater. Follow all manufacturer's instructions for installing all mechanical systems.

Durability and Maintenance

The durability of the heating system and how it interacts with the flow of heat, air, and moisture is also critical. Frequent replacement or repair of heating systems, or buildings, is neither efficient nor desirable.

Whatever type of heating system you install, be sure to follow the manufacturer's instructions for regular maintenance. This will prevent many problems in the long run.

Comfort

A building is only comfortable when the interior temperature and humidity are controlled without wide fluctuations. Comfort is a basic requirement of shelter, and a well-designed and installed heating system is a very important part of comfort.

Environmental Impact

Effects on the environment must also be considered, especially in this age of litigation. Frequent fuel handling provides more chances for spills to occur. Responsible, well-informed designers must minimize carbon dioxide contributions to the global environment. The system approach to building will accommodate these environmental considerations and lessen the impact of any community building through proper sizing and design of the heating system.

Affordable and Efficient Operation

If we are successful in providing health and safety, building durability, occupant comfort, and low environmental impact in our building project, then energy-efficient affordable operation is the result.

The community benefits by owning a building requiring very little maintenance and fuel. Appropriately sizing the heating system to the building and producing heat and hot water efficiently make operating such a building affordable. Dollars once sent outside the community to pay for large quantities of heating fuel can now recirculate within the community, creating jobs and providing stability in the local economy. This heating chapter is part of a guideline to self-sufficiency for rural Alaska communities.

Three Types of Efficiencies

When buying a boiler, **steady-state efficiency** is the efficiency measurement claimed by most manufacturers and is almost always higher than seasonal figures.

Annual fuel utilization efficiency, or AFUE, is the second most quoted efficiency. AFUE is a measure of the effectiveness of a system's heat transfer, but it does not consider jacket heat loss or distribution losses or efficiencies of combined domestic water heating and space heating systems.

Seasonal efficiency is an indicator of how efficiently a heating system operates over the entire heating season. Frequent start-up cycles, running, and cooling down—all under different weather conditions—can significantly reduce a system's efficiency. The seasonal efficiency is the truest measure of how efficient any appliance is.

Integrated systems, which combine space heating and domestic hot water production, have the highest efficiencies now available from any oil system. Both the indirect fired and integrated units have longer life expectancies than direct-fired hot water tanks, making them more economical.

Insulating Domestic Hot Water Pipes

There are two reasons for insulating hot water pipes. First, it saves money by reducing pipe heat loss and thus fuel use. Second, it is more convenient since the water in the pipes stays hotter and so hot water is delivered more quickly after a faucet is opened.

Forced-air Distribution

Forced-air systems include a furnace with a fan that circulates heated air through supply ducting to deliver the heated air, and return air ducting to allow cool air to return back to the heater. Gas units without a pilot light are most efficient, and oil-fired units with high static pressure flame-retention head burners are best where gas is not available. The fan that distributes heated air takes more electricity to run than a water circulating pump for a boiler, making forced air more expensive, especially where electric costs are high.

Forced-air systems must be installed to provide a balanced air flow when interior doors are both closed and open. Either install grilles in the doors or have both a supply and return duct to each room.

Sealed-combustion furnaces are becoming more popular because they provide a greater margin of safety against back drafting when the building experiences slight depressurization due to other mechanical devices or wind effects. However, these are currently only available in gas-fired models, and natural gas is not available in most parts of Alaska.

Forced-air ducts must be screwed together, must use smooth metal runs (not flex duct), and must be sealed with mastic, not duct tape. All ducts should be run inside the heated space.

Monitor or Toyo-Type Heaters

Sealed combustion cabinet-type heaters are becoming widely used in rural Alaska. Similar to the "pot burners" of old, these heaters are high-tech models with computer boards and sophisticated set-back controls. These features, combined with sealed-combustion designs, improve heating efficiency and eliminate back drafting problems associated with the earlier pot burners. Units such as the Toyostove and Monitor heaters can be installed in energy-efficient buildings, and multiple units may be used to provide zone control for larger buildings. The heaters come in two sizes, with outputs ranging from around 20,000 to 40,000 Btus.

Number one fuel oil or kerosene is required for these heaters. Most villages have supplies of number one heating oil, but kerosene is rarely used in Alaska. These units support the combustion process with a pipe-within-a-pipe forced venting system that doesn't require a conventional chimney. The unique intake and exhaust design requires that the units be placed against an outside wall and often requires optional extensions for adequate clearance from drifting snow.

While these units are efficient and more affordable than a furnace or a boiler, they have short warranty periods of one to three years and cannot be used to heat domestic hot water. Installation of flue pipe and oil lines must follow accepted airtight procedures for mechanical penetrations through exterior walls. These stoves have problems with fuel contamination, and a good filtering system should be installed at the tank. Always follow the manufacturer's installation instructions and local building codes when installing any heating system.

Boilers

When considering the choice of a forced-air or hydronic (boiler) system, you should also consider domestic hot water. If the building needs to provide a large amount of domestic hot water, as in a cafeteria or day care setting, the advantage obviously goes to the boiler.

Boilers allow zoning to be easily incorporated into the building design. Distribution options for boilers include forced air (through a fan coil or unit heater), radiant floors, perimeter baseboard, or radiators. Hot water run in small-diameter piping will take up less space than forced-air ducting. It is this flexibility in distribution options that often makes hydronic systems more appealing.

It is vital to fill the pipes with a propylene glycol solution so that if the boiler fails or the power goes out, the pipes don't freeze, break, and cause flooding damage. Ethylene glycol, the type used in automobile radiators, should never be used because it is highly toxic.

Solid Fuel Equipment

Heating appliances using solid fuel, usually wood or coal, are available today with efficiencies as high as 85 percent. The most efficient are direct vented, stoker-fired wood pellet units. Wood and coal appliances without automatic features have typical efficiencies of around 60 percent.

Maintenance is the biggest complaint from owners of this equipment. Chimneys need frequent cleaning to be safe from stack fires, and catalytic converters must be replaced every few years with associated high expense. The fuel must be handled twice before being burned, and ashes and clinkers must be removed every few hours or days, depending on the design of the appliance. Buying such a unit is also expensive, especially when you consider the lack of control and automatic operation compared to gas and fuel oil fired appliances.

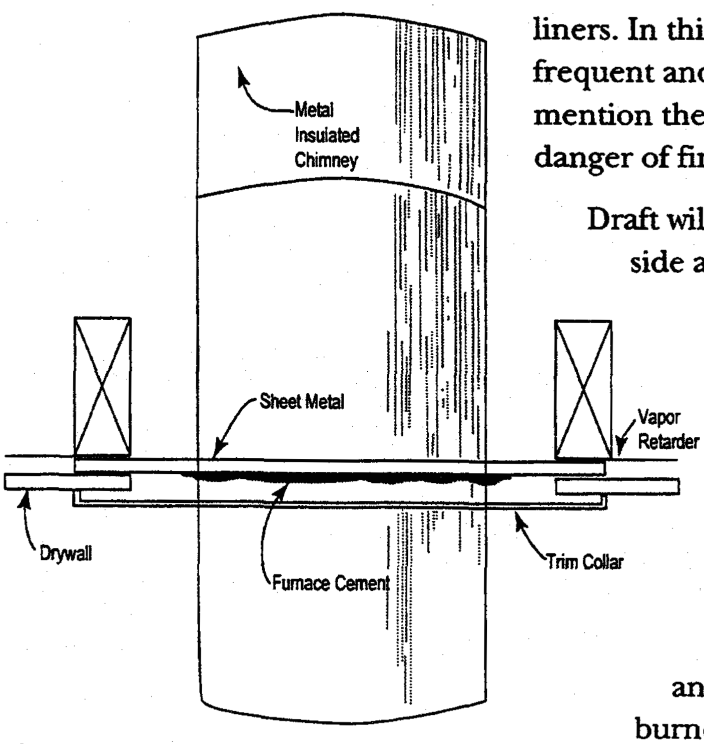
However, the airtight wood stove can be an excellent backup heating source when the local generator fails to operate. All such installations must include outdoor combustion air ducting directly connected to the stove, and only the most airtight models should be considered. The manufacturer's minimum installation specifications should always be followed and exceeded whenever possible, since fire danger is always high in our long winters. See Appendix A (2.3) and Appendix B for more requirements for fireplaces and wood stoves.

Chimneys

Chimney design affects heat loss more than any other single heating system installation option. Not only does heat escape up the chimney, but air leaks around the chimney's penetration through the roof are a major source of heat loss (see Sealing the Chimney Penetration).

If the chimney is allowed to cool before the system starts, it must heat up before the draft is fully established. At start-up, when the draft is lower than normal, reductions in combustion air delivery can be significant, causing lower efficiency until the draft is at or above the minimum. Flue gas will also condense in the cold chimney, resulting in rapid degradation from the acidic condensate. There are many examples of efficient heating systems vented into cold exterior chimneys where the chimneys had to be replaced every two years due to the acid condensate ruining the stainless steel liners. In this case any gain in efficiency is lost in the frequent and expensive chimney replacement, not to mention the inconvenience of replacement and the danger of fire.

Draft will increase as the difference between the inside and outside temperatures becomes greater in the winter. If the draft is too high, too much air is supplied by the burner and the flame temperature drops. If the draft is too low, the flame is starved for air and more smoke is produced. Sealed combustion and isolated combustion appliances are not affected by seasonal draft fluctuations, since their chimneys are not equipped with barometric dampers and combustion air is supplied directly to the burner.



Sealing the Chimney Penetration

The optimum chimney design, one that would overcome most common heat losses, is low mass, short, and well-insulated, without a barometric damper. You must maintain a two-inch minimum clearance between the insulated chimney and any combustible material. Follow manufacturer's instructions for a safe, durable chimney.

Ventilation

Rural community buildings are important to the local people. They provide a variety of functions such as city offices, libraries, health clinics, community gathering places, and jails. The buildings are usually used for several different functions, which means they will require different ventilation rates. It is essential for the health of the occupants and the structural durability of the facility that a central mechanical ventilation system be installed to maintain good indoor air quality and humidity and temperature levels. Community buildings must be constructed with a continuous air and vapor retarder as an integral component of the building's system. Without providing air exchange with the outdoors, indoor air contaminant concentrations will build up.

In addition, the types of materials (paints, sealants, glues, carpet, cleaning aids etc.) that are installed or used can have a significant effect on the indoor air quality. Some building materials are known to outgas, that is, emit gases, long after the manufacturing or application process is done. Chemicals used in cleaning agents are released into the air that we breathe. Reducing the use of materials that release fumes is called source control. Source control is the first step in addressing indoor air quality. If the pollutant is not introduced into the building, then the ventilation system does not have to remove it. Contact the Resource Information Center at Alaska Housing Finance Corporation, phone (800) 478-INFO, or your local Alaska Cooperative Extension agent for more information on product emissions and indoor air quality.

A ventilation system, when properly designed and installed, will provide comfortable and healthy indoor air. An effective ventilation system brings in fresh outside air and distributes it evenly throughout the building. Also, the system removes stale air containing moisture and other pollutants that are produced in the building (see health and humidity chart). The system must be capable of ventilating all primary habitable areas of the building. This excludes mechanical rooms, garages, and storage areas. This section is intended to provide you with the basic information to understand the essentials of ventilation systems for small rural community buildings. It is not intended to be a complete design and installation reference.

Rural Alaska community buildings must comply with ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality." The standard provides outdoor air requirements for various commercial applications. Ventilation air through an exterior door or operable window is not be considered part of a ventilation system and is not included in the required minimum ventilation rate.

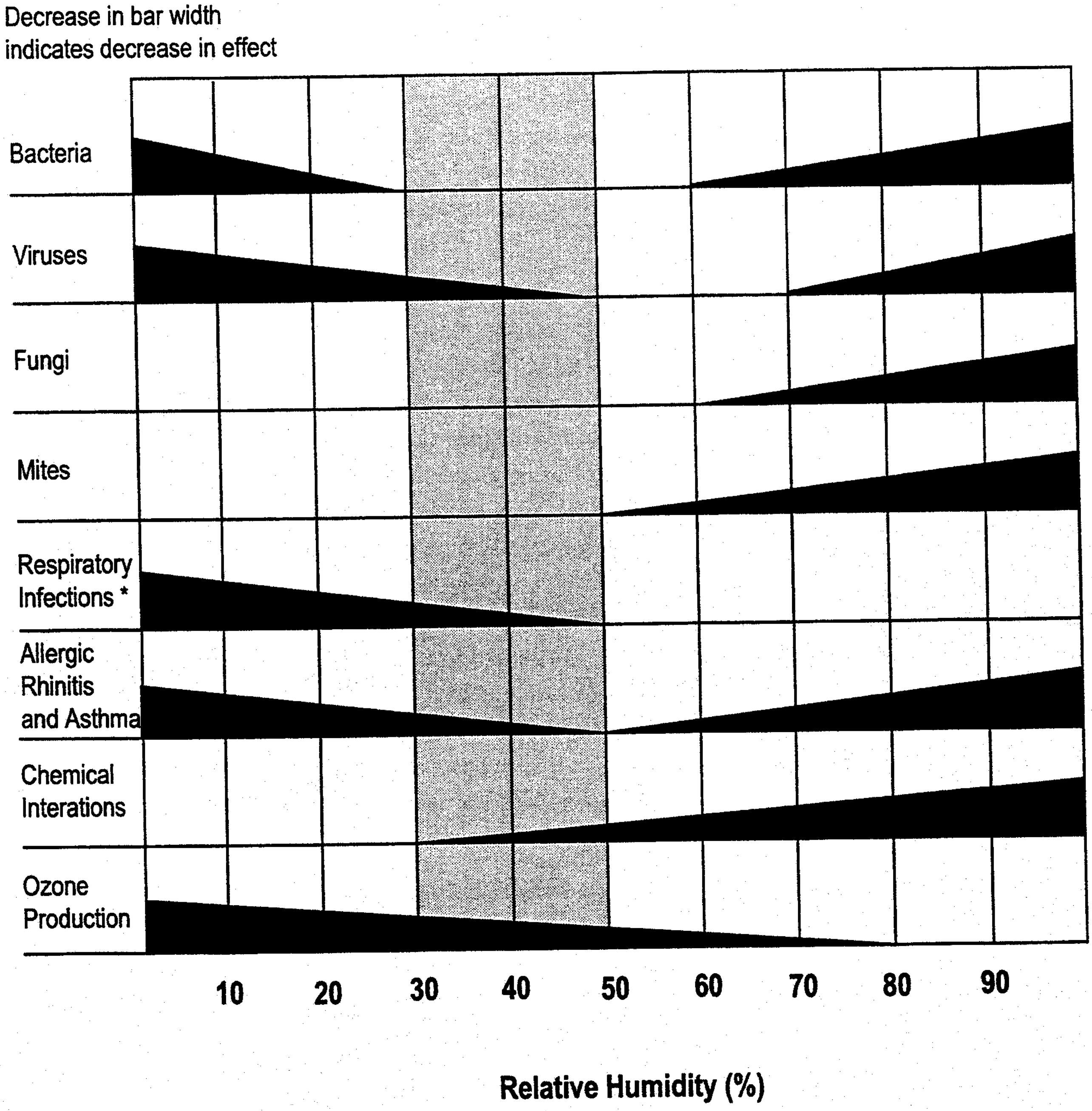
However, there is an inherent difficulty in providing a ventilation system that meets the requirements of ASHRAE 62-1989 and is also appropriate for rural community buildings in Alaska. The ventilation air flow rates based on typical occupancy density factors require ventilation equipment that is not realistic from initial and operational cost standpoints in rural communities. In addition, the complexity and maintenance of the systems essentially ensure that they will not be operated for long. We recommend that you use the anticipated occupancy load, which will result in smaller and less complex systems. Most community buildings are not occupied 24 hours a day, as a house is.

Ventilation System Types

There are three basic methods of mechanically exchanging air across the building envelope: supply only, exhaust only, and a balanced supply and exhaust system. Whichever type of system is selected, the system must be capable of operating continuously when the building is in use and distributing fresh air throughout the occupied areas of the building. The ventilation system must be acceptable to the occupants. If the fresh air is delivered to the building and the occupants feel a draft, the ventilation system will be turned off,which means that the building system fails also. **Do not use a preheat coil to warm incoming air,** because the long-term operating costs will be too high, especially with the high electric costs in rural Alaska.

It is essential that the ventilation system is cost-effective not only to install but to operate. High energy costs in rural Alaska mandate a thorough review of local energy costs and appropriate ventilation strategies. This analysis may be performed using the Hot 2000 program. Note: modeling ventilation rates at one-third of their operating capacity will be necessary, since Hot 2000 assumes a residential setting with 24-hour occupancy. Community buildings are usually occupied eight hours a day, or one-third of the residential occupancy.

Health and Humidity Chart



The proper installation of the ventilation system is an essential aspect of the building's operation. The ventilation system shall be installed and tested by a state-certified ventilation system installer according to the manufacturer's instructions.

Supply-only Systems

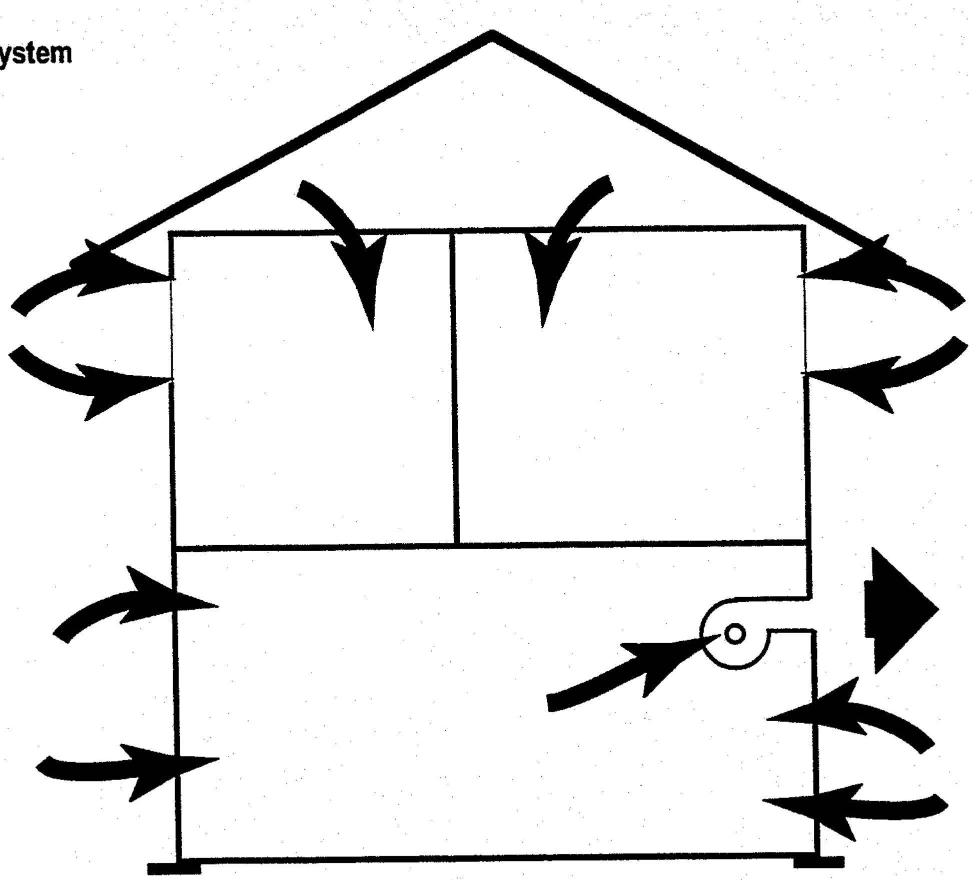
Supply-only systems typically consist of a fan that brings in outdoor air and discharges it in the building. This creates a higher pressure indoors relative to the outdoors. Air flow is always from areas of high pressure to areas of low pressure, so moisture-laden air will be forced out through any gaps or holes in the building shell. When the air reaches its dew point temperature, it will condense into water. Water that condenses inside the building shell will greatly reduce insulation values and cause rot. **A supply-only system is not recommended due to the high potential for moisture damage in the building shell.**

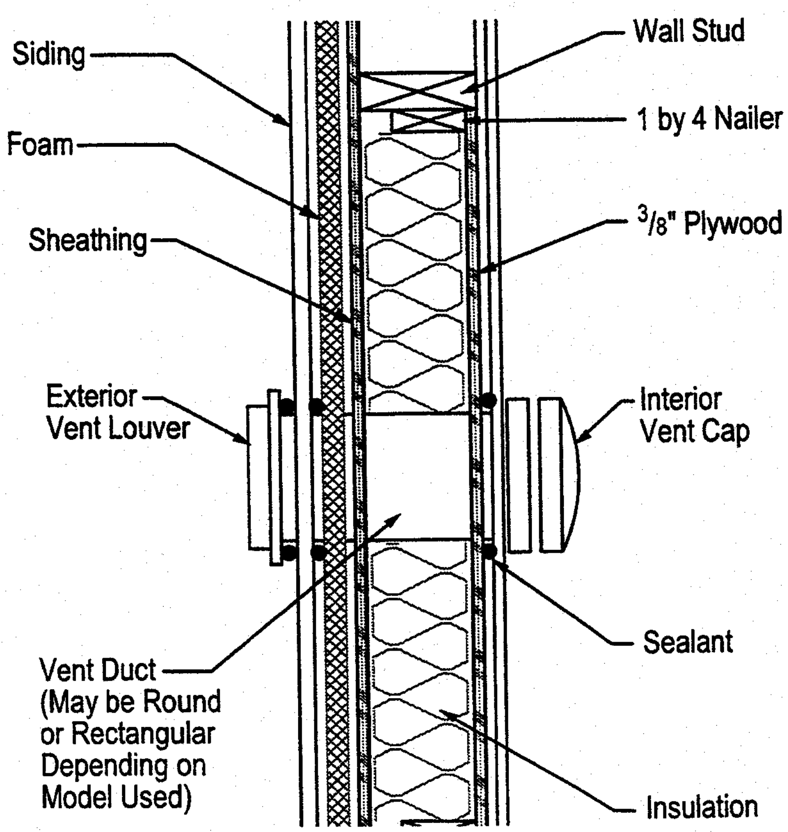
Exhaust-only Systems

An exhaust-only type of system operates by mechanically exhausting air from the building, using a fan. The operation of an exhaust-only ventilation system creates a negative or lower pressure in the building relative to the outside. Outdoor air, which replaces the air being exhausted by the fan, enters the building through intentional fresh air inlets and through any breaks in the building's air retarder. Closable air inlets are installed in each room to allow small amounts of air into the building to replace the air being exhausted by the exhaust fan. The inlets are typically located high on exterior walls or are incorporated into the window frame. This system is inexpensive to install and maintenance is minimal. The air entering the building through the openings will be cold during the winter months and may create discomfort. The inlet openings must be carefully located to reduce this concern. Typical inlet openings might include Fresh 80 or through-the-wall vents.

Caution: prevent back drafting of combustion appliances. With any exhaust-only system there is the possibility that the exhaust fans will create enough negative pressure to draw combustion gases back down the flue of either the space heating or domestic water heating appliances. This is called back drafting. For this reason, only sealed-combustion appliances shall be used if they are located in the occupied zone. Alternately, the combustion appliance room could be air sealed from the building's primary occupied zones, which contain the exhaust fan. Negative pressure developed by the fan then would not effect the combustion appliance room pressure. You must follow the negative pressurization limits for buildings presented in Appendix B. This is a health and safety issue that must be addressed in the design, construction, and final testing of the building.

Exhaust-only Ventilation System





"Fresh 80" Vent Installation

Soil Gases. For buildings with foundations such as crawl spaces, full and daylight basements, and slab foundations, there is a concern that harmful soil gases will be drawn into the building during negative pressurization. These gases include radon where it is found in the soil and various fertilizers and insecticides that may be used around the building.

Balanced Ventilation System

The recommended approach to providing effective ventilation combines balanced exhaust and supply air flow in a single ventilation system. It is then possible to control both the amount of air exhausted from the building and the amount of air supplied to the occupants.

A balanced system provides a neutral pressure in the building relative to the outside. Each room or area would have provision for fresh air supply and stale air exhaust, either directly in the room or indirectly from an adjoining space. This is accomplished with a mechanical ventilation system through an independent system of ducts or integrated with the ductwork and fans of a forced-air heating system. Stale air is generally exhausted from contaminant-generating areas such as kitchens, bathrooms, and workrooms.

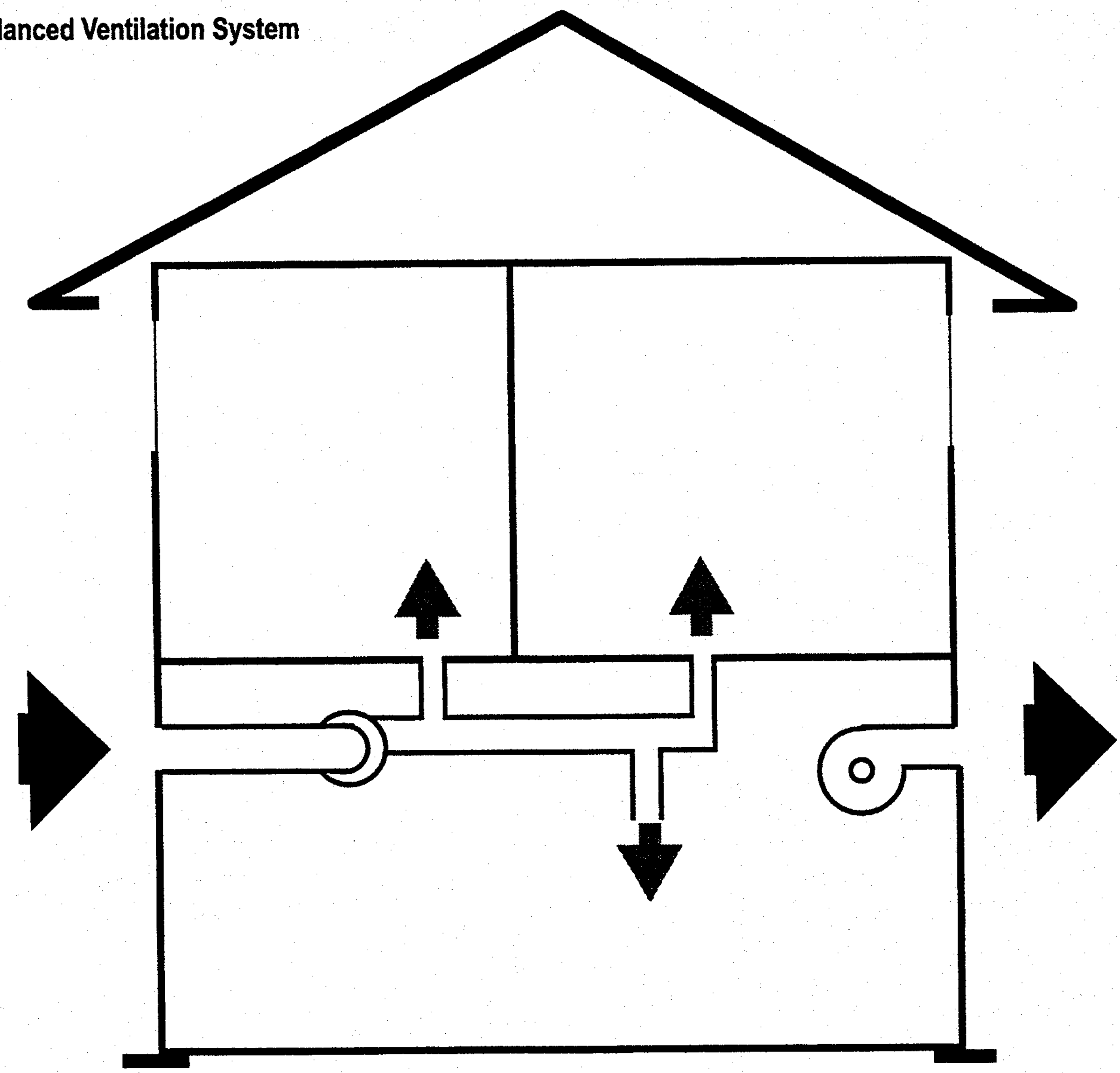
It will be necessary in most regions of the state to preheat or temper the incoming air for comfort reasons. A central balanced system affords the opportunity for exchanging heat from the exhaust air stream to the incoming air stream. The heat transfer provides tempered air to the building. This is called a **heat recovery ventilator, or HRV.** It also allows filtering and treatment of outdoor air prior to entering the building if necessary.

Fans intended for use as the primary ventilator must be capable of continuous operation.

Heat Recovery Ventilators

The balanced ventilation process involves warm indoor air being exhausted outdoors and then being replaced with cold outdoor air that must be heated. Installing a heat recovery ventilator (HRV)—also referred to as an air-to-air heat exchanger—reduces the cost of heating the fresh air by extracting heat from the outgoing air and using it to heat the incoming air.

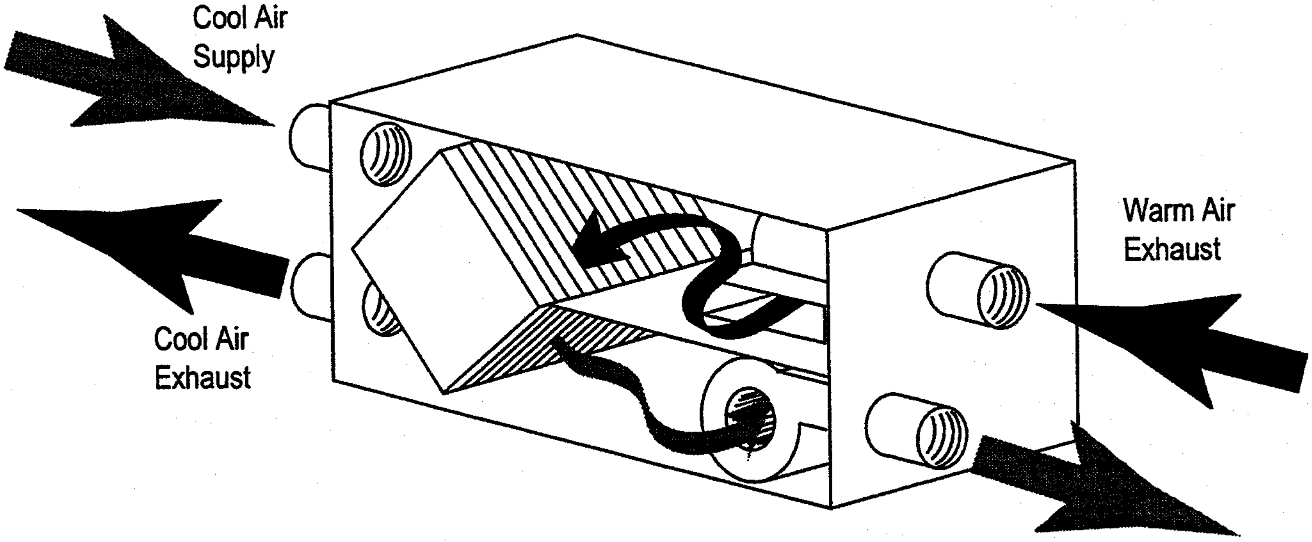
Balanced Ventilation System



The economics of installing an HRV will depend on the cost of energy and the severity of the weather in a particular location. HRVs can reduce the amount of energy needed to preheat ventilation air but usually have higher initial costs than ventilation systems without heat recovery.

In addition to the capital costs of the system, heat recovery ventilation systems require ductwork to bring the exhaust and supply air to one location for the heat exchange process. Since moist, stale indoor air is being cooled through the HRV, the HRV system must also be able to drain humidity that condenses out of the exhaust air and must also provide effective defrosting.

Plate Type Heat Recovery Ventilator (HRV)



Performance Testing and Rating

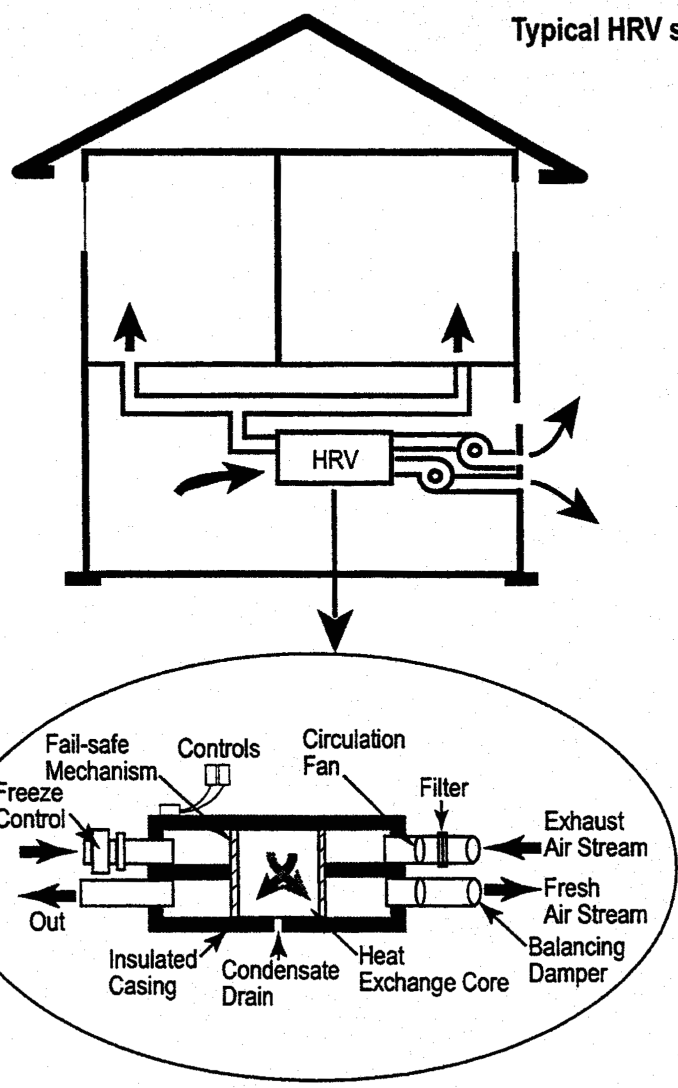
The performance of an HRV is determined by its air handling capabilities and the percentage of heat it can transfer from the exhaust air to the supply air. HRVs must be rated in accordance with CSA-C439, "Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators." These standards describe the test equipment, instrumentation, procedures, and calculations needed to determine air flows and heat recovery efficiency. These tests are carried out at a variety of air flows and two temperatures: 32°F (0°C) and -13°F (-25°C).

The results of these tests are reported on an HRV Design Specification Sheet, which you should request from the supplier of the equipment. A sample specification sheet is shown in Appendix C. The specification sheet is a useful tool, but bear in mind that it should not be the sole basis for selecting an HRV. Cost, warranty, proven reliability, servicing, and suitability of the unit for the climatic zone are some of the other issues that must be considered.

Selecting the Equipment

Before selecting an HRV or fan unit for a ventilation system, determine what air flow is needed to meet the requirements for sufficient air exchange.

Typical HRV system



Locating the Ventilator

In determining the location of the ventilating unit, consider such things as the inlet and outlet locations, noise levels, drainage, power supply, etc.

- The unit should be located in the heated interior, away from noise-sensitive areas. Hang the unit from rubber straps to minimize noise and transmission of vibration through the building.
- It should also be close to an outside wall to minimize insulated duct runs (six feet is suggested, if possible), centrally located to optimize the distribution system, above a drain for condensate disposal, and close to an electrical outlet.
- The unit should also be readily accessible for maintenance.
- Minimize the length and number of fittings required for the distribution ducting.

Locating the Exterior Supply Inlet and Exhaust Outlet

Supply air inlets and exhaust air outlets must be carefully located and installed to avoid contamination and other problems.

Supply Hoods

The fresh air supply from the outside should be the cleanest possible and unobstructed by drifting snow. Don't locate it near sources of bad air such as where vehicles will be idling, or near garbage cans, oil tanks, gas meters or propane tanks, garages, dryer vents, furnace flue vents, corners of the building, or dog yards. Don't locate it in the attic or crawl space. The supply inlet should be at least six feet from the exhaust outlet.

The air inlet should be located where it will not be blocked. Current installation codes specify that the air inlet must be a minimum of 18 in. above the finished grade. Local wind conditions and snow levels should also be considered when locating the hoods. The openings must be screened to keep out birds and rodents. They must be accessible for maintenance and removable for winter operation.

Exhaust Hoods

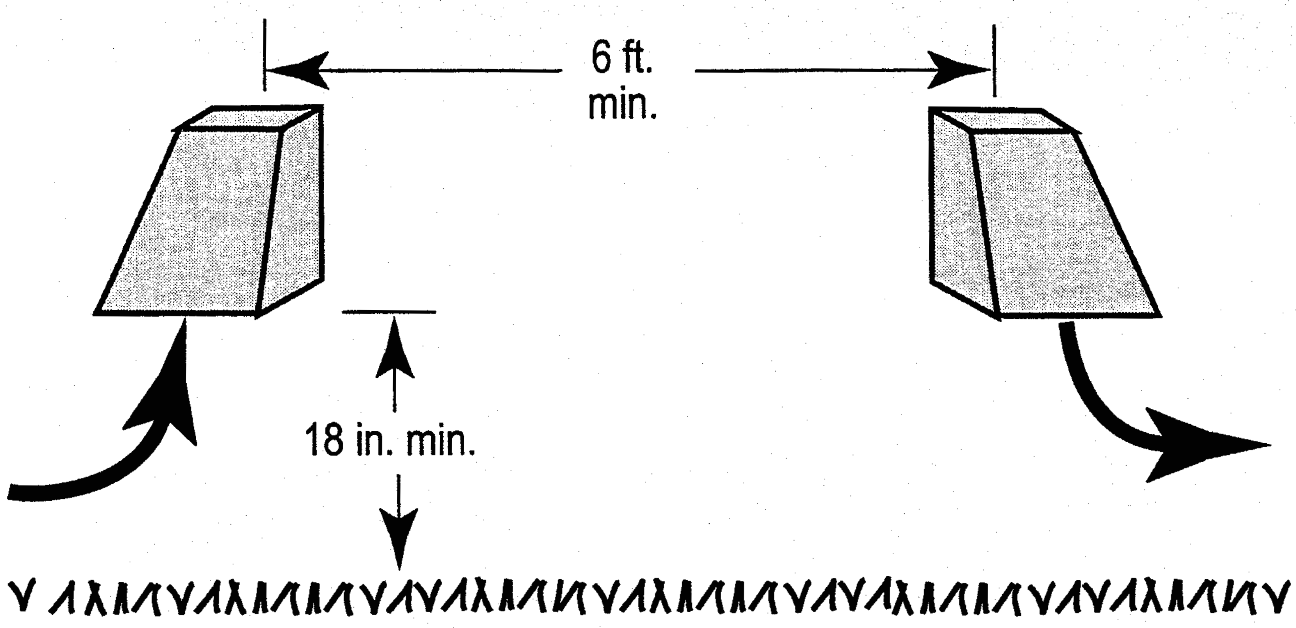
The exhaust outlet should not be located where it could contaminate fresh incoming air, nor in attics or garages or by windows or near walkways where condensation, moisture, or ice could create problems. The exhaust outlet should be a minimum of six feet horizontally from the supply inlet. The bottom of the hood must be a minimum of 18 inches above grade or above expected snow levels.

Fresh Air Distribution

Outdoor supply air can either be distributed through an independent duct system or integrated with, and distributed through, the ductwork of a forced-air heating system.

Independent Systems

This approach is used in buildings that do not have a forced-air distribution system. In winter, the air supplied to each room may be below room temperature. The cooler supply air will behave like cool air supplied by an air conditioning system. The best way to supply cool air to a room is through a high interior wall or intermediate



Location of Exterior Exhaust and Supply Air Hoods

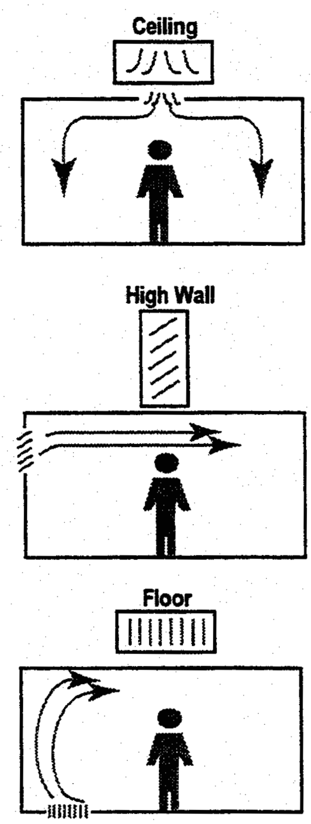
level ceiling diffuser. With this approach the incoming air has time and space to mix with the room air before dropping down to the occupied zone. This also helps to destratify and mix the air in the building (see graphic of grill locations).

Integrated Systems

Combining the ventilation system with a forced-air heating system will eliminate the need for separate supply ducts. The supply air can be delivered to the cold air return of the furnace. The furnace blower must operate continuously, on a lower speed, to distribute the fresh air throughout the building and mix it with the interior air. If the furnace fan is not operated continuously along with the HRV, the fresh air will exit by the nearest available opening and the remainder of the space will not be effectively ventilated. The energy costs to continuously operate the furnace fan should be accounted for in the economic analysis.

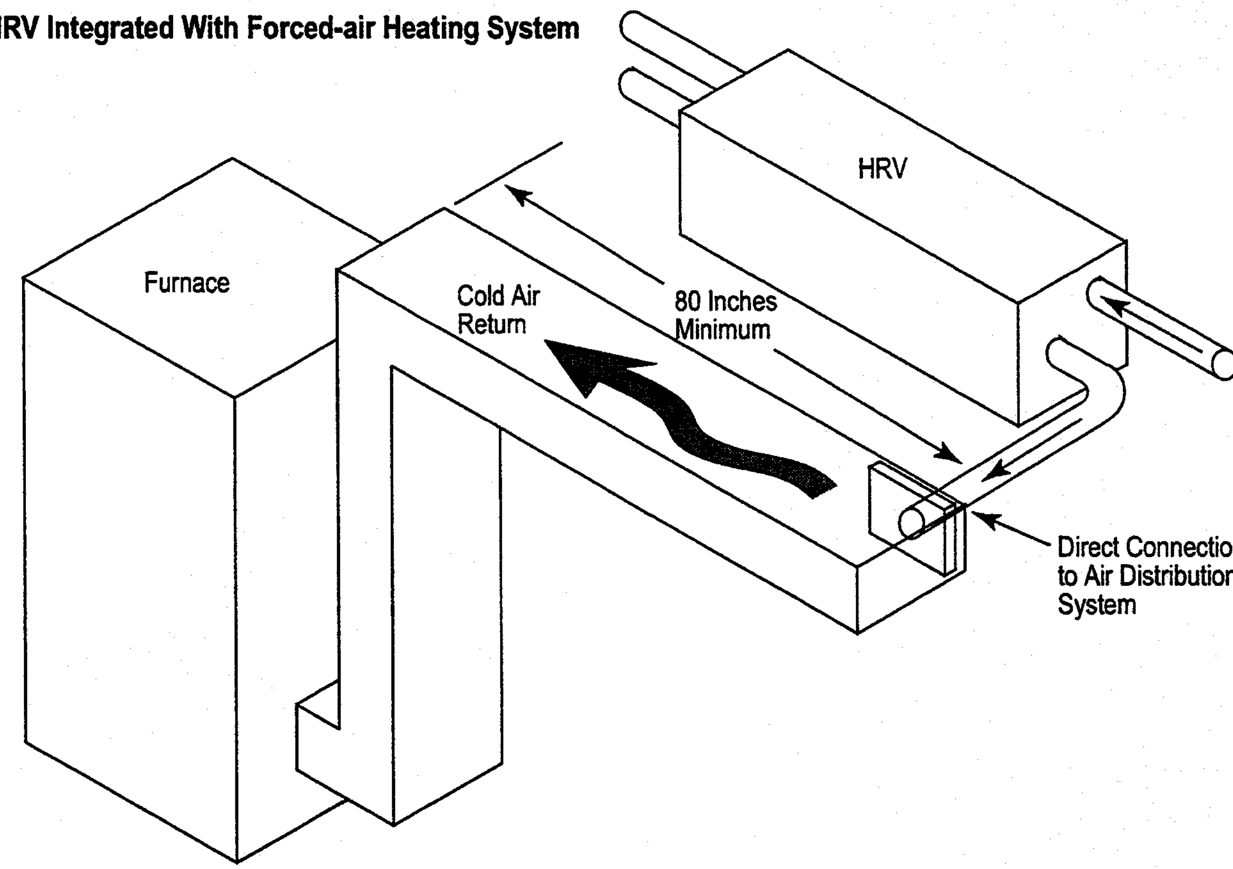
Exhaust Locations

Exhaust air grilles should be located in the rooms where the most water vapor, odors, and contaminants are produced, such as kitchens, bathrooms, and workrooms. Rooms with only exhaust grilles will receive fresh air only indirectly, from other areas of the building. Undercut doors or install transfer grilles to provide adequate air flow to these rooms.



Grille Locations for Fresh Air Distribution

HRV Integrated With Forced-air Heating System



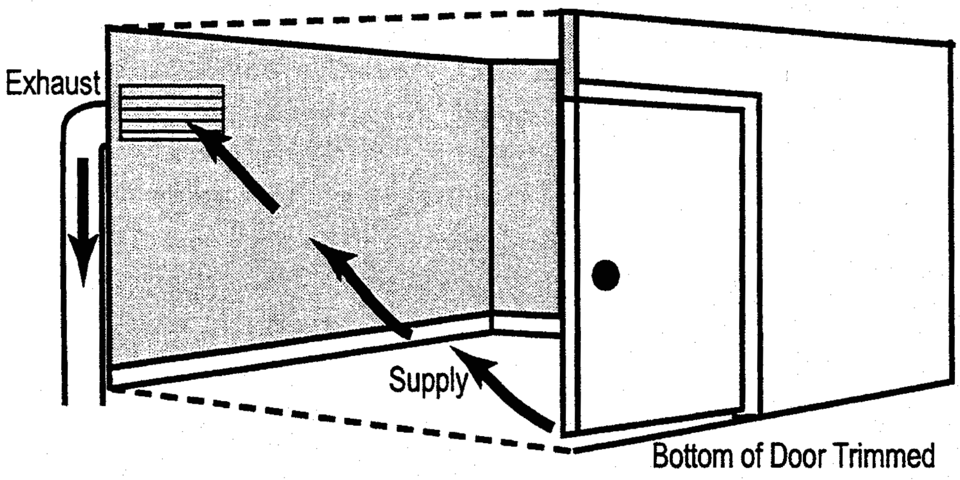
Exhaust grilles in kitchen areas must be located a minimum of four feet horizontally from the stove edge. This will help keep grease from entering the duct system. A separate range hood ducted directly to the outside should be used in addition to the HRV exhaust duct.

Ductwork

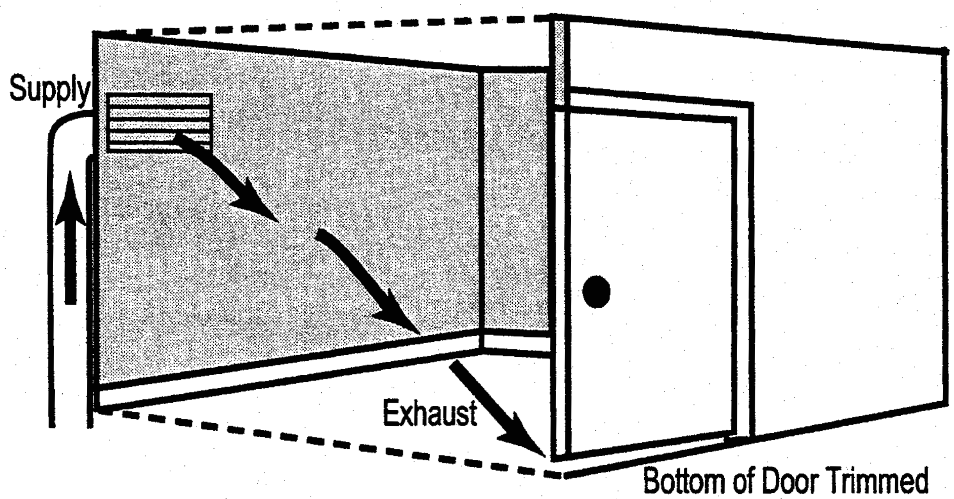
Duct joints, longitudinal seams, and adjustable elbows shall be sealed with a suitable duct mastic to ensure adequate air flows and prevent duct-induced pressure imbalances in the building due to leaky ducts.

Remember that both the incoming air and the outgoing air from an HRV is cold. Both the supply and exhaust ducts must be sealed, insulated, and covered with an air/vapor retarder to prevent condensation from forming on the ducts or in the duct insulation. This is the only place where flexible duct should be used. The air/vapor retarder on the cold side ducts must be effectively sealed to the building air/vapor retarder. Ducts must also be carefully sealed where they penetrate the exterior air/weather retarder, using Tremco acoustical sealant or red contractor's tape.

Typical Installation for Kitchen, Bathroom, or Laundry



Typical Installation for Bedroom, Dining Room, Living/Family Foom



Controls

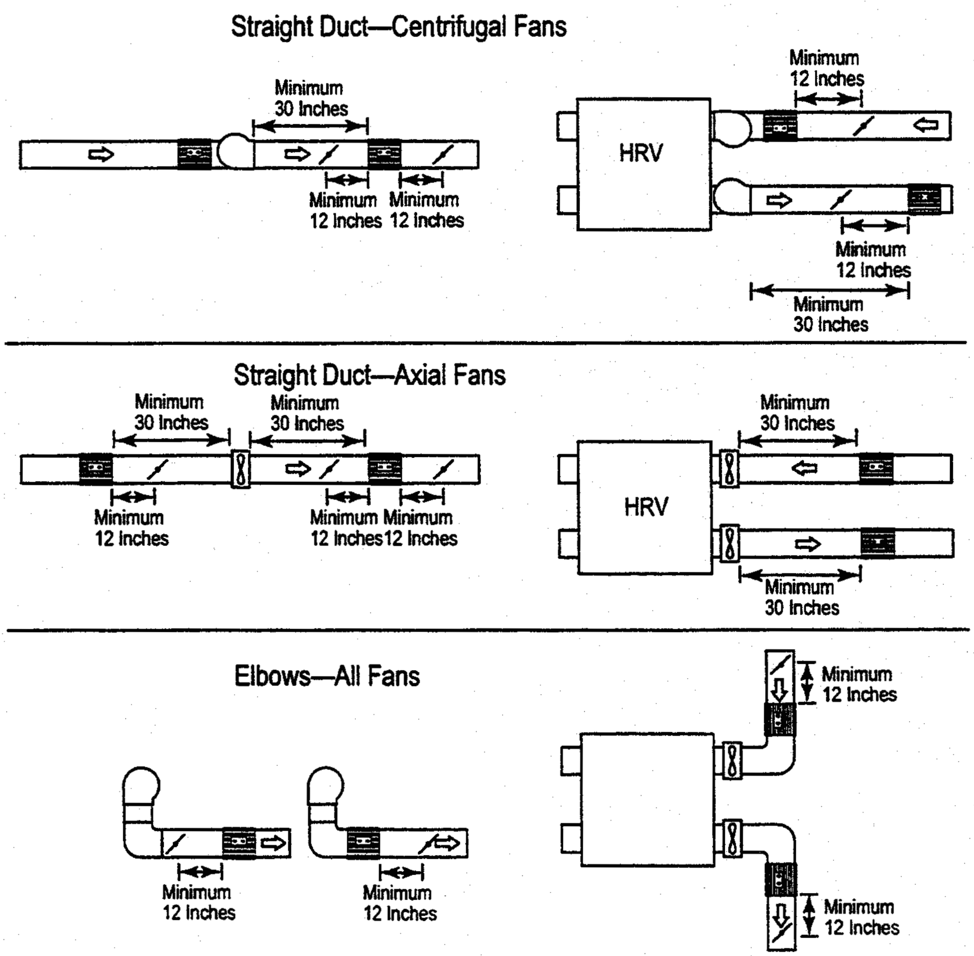
HRV systems are typically designed to operate at two speeds. On low speed, they provide the required base level of ventilation continuously. On high speed, they can handle additional occupant loads and contamination.

High speed can be activated manually by a switch or a timer. Automatic controls include dehumidistats and carbon dioxide or combustion gas sensors. A timer switch is preferable to a standard on/off switch because there is less chance the system will be left on high speed when it is not really necessary.

Air Flow Measuring Stations

Air flow measuring stations should be installed in the warm side supply and exhaust ducts to enable the installer to balance the system. Dampers and flow measuring stations should be located in an accessible location near the ventilation system and in a position that will allow for accurate air flow measurements. The stations should be located so that all the supply and exhaust air is measured. The installing contractor should give the building owner a report that describes the installation, provides air flow measurement results, and ensures that the HRV system meets industry standards. The installer should provide a written air balance report on the ventilation and exhaust air system.

If the ventilation system includes an HRV, the air flow measuring stations should be installed in the warm side ducting. The supply and exhaust air flows are measured and then balanced to provide neutral building pressure. System balancing is performed when the system is operating in the normal continuous ventilation mode.

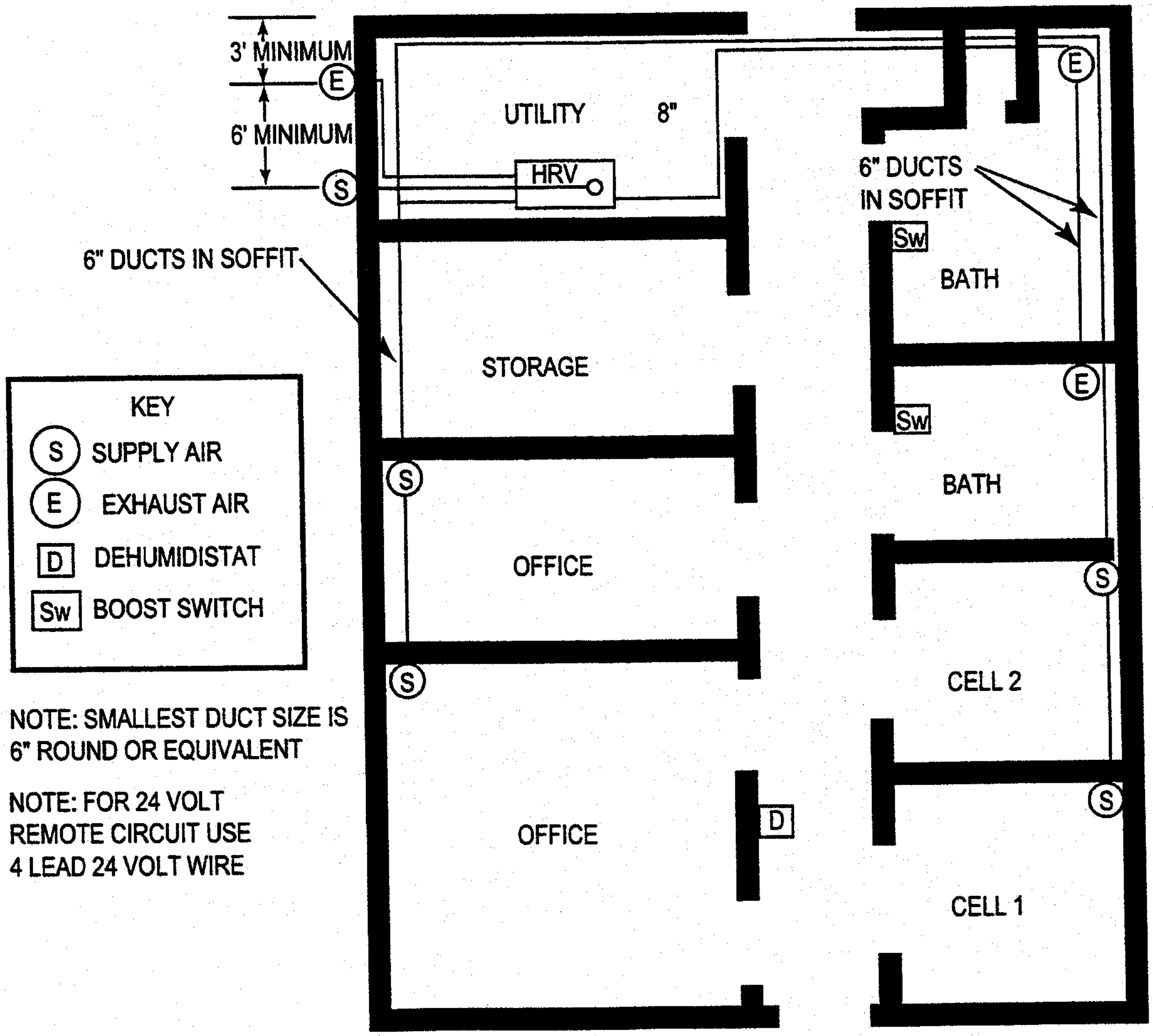


Locations of Airflow Measuring Stations

System Installation

Once the system has been designed, ensure that the certified installer complies with all design and installation requirements, balances the system, and fills out any required installation reports. Any field deviations should be discussed with the designer before modification to ensure a properly operating ventilation system. The ventilation supply must bring in the same amount of fresh air into the building as the exhaust fans are removing, plus or minus 10 percent. The system shall not cause a pressure imbalance greater than that allowed in Appendix B.

A schematic of a sample HRV system installation is shown below. The operation and required maintenance of the ventilation system should be clearly explained to the manager of the building and to the maintenance personnel. Operation manuals and equipment information should be filed for future reference.



VPSO BUILDING

As we have discussed, the ventilation system is an integral part of the building system. If the ventilation system is not operated and maintained properly, the building system will not provide a healthy, safe, durable, and affordable community building.

Water Conservation

Water is such a valuable renewable resource that we must make every effort to conserve it and maintain its purity. Water supply and disposal problems in rural Alaska are a challenge not easily met by conventional southern latitude design. Consider installing a cistern connected to roof drains to provide water for washing or for flushing toilets. Drinking water must meet DEC standards. Consider installing biological waste composting systems and gray water systems along with ultra low flush toilets and low flow shower heads and faucet aerators. Water heaters should be energy efficient and well insulated to reduce standby losses. Insulate all hot water pipes and protect cold water pipes and drains from freezing. Do not put water pipes or drains in outside walls. Plumbing vents may be installed in outside walls if necessary.

The National Energy Policy Act of 1992 requires all new showerheads produced after January 1, 1994, to meet a flow rate of not greater than 2.5 gallons per minute at 80 psi. Furthermore, installing low flow showerheads will save money.

Log Buildings

Many communities in the forested areas of Alaska have an abundance of suitable timber growing near enough to make it cost effective to build log community structures. With a thermal resistance value of approximately R-1 per inch, logs will obviously not meet the minimum prescriptive standards set forth in Table 1 of this manual. Nevertheless, DCRA will consider exceptions to this standard to allow for use of local resources on a case-by-case basis.

In the case of massive logs, R-value is not the only property relating to energy use. Logs act as a heat storage medium, so that once heated, they do not require a great deal of additional heat energy to maintain a comfortable indoor environment. This assumes that the log structure is built to the highest possible standards of craftsmanship with strict attention to the 10 basic rules of building science introduced in the first part of this text. Hot 2000 analysis and air tightness testing will be required.

First and foremost, as with any successful building, the envelope must be made airtight to resist the flows of heat, air, and moisture.

With logs, this can be accomplished with the use of gaskets or backer rod, flexible chinking materials such as Permachink or equivalent, and tight-fitting log work. Seal the cracks between logs on or near the inside surface to prevent moisture-laden air from reaching the dew point and condensing between logs, causing accelerated self-destruction. In high wind areas you should seal both inside and outside the logs. Fiberglass chinking or fiberglass sill seal is not an acceptable airtightening material for use between logs.

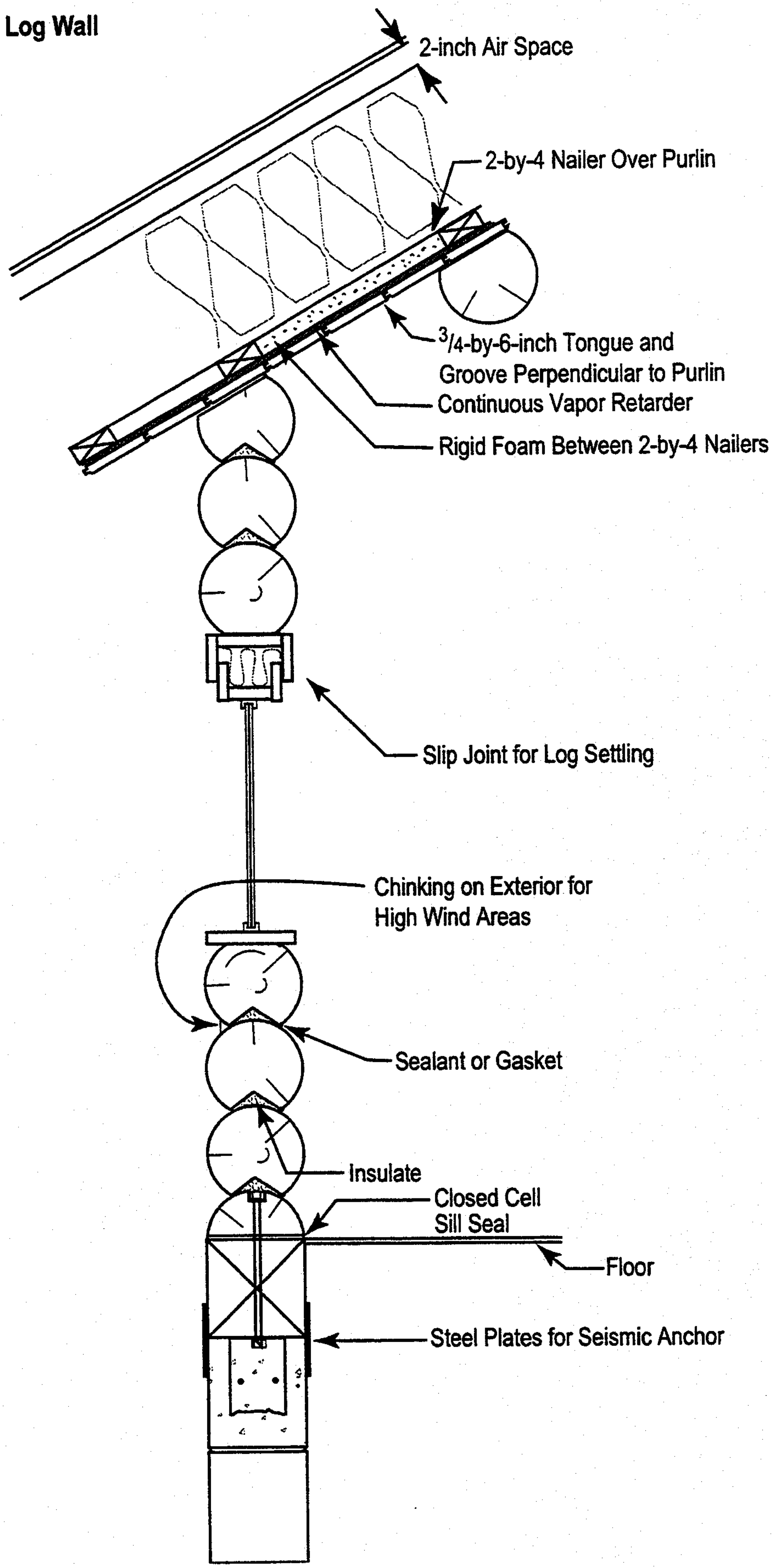
Log buildings are somewhat more forgiving than a typical frame or masonry structure in an earthquake because of the inherent flexibility of the connections between logs. The bottom round of log structures must be securely attached with long anchor bolts poured into the foundation wall. Log structures on post and pad or piling foundations must be through-bolted to support beams that are securely attached to the post or piling. Each succeeding course should be fastened to the course below with wooden pegs or dowels or with threaded rod or even rebar. Three-sided logs are often nailed together with countersunk 12-inch spikes. Door and window cutouts should be notched to accept wood or steel splines or both to keep the log wall aligned as it settles and shrinks about ½ to ¾ inch per foot, depending on the water content of the wood.

Typically, heat loss through walls accounts for only 15 to 20 percent of the overall energy use of a building. As such, once you have done the very best you can do relative to the airtightness of a log structure, you must then focus on the other 80 percent of the building system that remains. Super-insulated floors and roofs with airtight vapor retarder systems and airtight connections to the log walls must be part of the overall strategy.

Windows and doors must be of the highest quality available and must be fitted to the log walls with airtight, flexible gaskets or chinking material. The four-to-six-inch settlement space that must be provided above windows and doors should be insulated and fitted with an airtight vapor retarder that will remain effective while the logs shrink and settle over the years. Trim boards and door and window frames and splines must allow the logs to settle without disturbing their airtightness systems or the airtightness between the logs. As with frame structures, orient the majority of the windows south to take advantage of all available light and passive solar heat.

Two excellent books on building with logs are noted in the bibliography. Also see Appendix D, *Log Building Standards.*

Log Wall


2-inch Air Space
2-by-4 Nailer Over Purlin
3/4-by-6-inch Tongue and Groove Perpendicular to Purlin
Continuous Vapor Retarder
Rigid Foam Between 2-by-4 Nailers
Slip Joint for Log Settling
Chinking on Exterior for High Wind Areas
Sealant or Gasket
Insulate
Closed Cell Sill Seal
Floor
Steel Plates for Seismic Anchor

Foam Panel Construction

Foam panel construction is an attractive alternative to "stick-building" a structure on site. Panels up to 40 by 10 feet can be barged to the building location, but the usual wall panels are four by eight feet. Floor and roof panels are sized according to span requirements and available lifting equipment in the field. R-values range from a low of about R-13 for a 3 ½-inch thick panel insulated with expanded polystyrene to more than R-60 for a 10-inch thick panel filled with urethane foam.

Foam panels are manufactured by several companies, and each has its own proprietary glues and foam insulation, resulting in different structural and insulating properties. Some panels are structural in the sense that they do not require additional framing to carry design loads. Other panels are nonstructural and are meant for sheathing post-and-beam or similar structures.

Each panel company has a system of joining panels that must be sealed with caulk, glue, or gaskets. Of the 15 or so panel structures blower-door tested by the authors, only one did not have some air leakage between panels. This one super-tight panel structure had a continuous six-mil air/vapor retarder, and the walls were strapped with two-by-threes to provide a chase for electrical wiring on the warm side of the vapor retarder. Another foam panel house tested, which had the electrical wiring run in chase-ways provided by the manufacturer, had considerable air leakage through all of the outside wall electrical outlets. The wires were run up through the rim joist space, which was not sealed tightly to the exterior.

Most panel manufacturers do not require a separate air/vapor retarder, since the foam and sheathing used in their products are resistant to moisture damage. However, we recommend that you install an airtight six-mil polyethylene vapor retarder on the warm side of the panels to keep all moisture out of the exterior walls and ceiling. Water freezing between panel joints could lead to premature failure of the structure.

One of the problems with closed floor systems like foam panels is there is no room to easily run plumbing, heating, ventilation, and electrical systems. Some designers have gotten around this by installing nonstructural joists on top of the foam panel floor system to provide space for utilities and for additional insulation if necessary. Put an insulated arctic chase or insulated corrugated pipe beneath the floor to protect incoming water and outgoing waste water.

Project Management

Project management is more effective if you use three planning and control tools: **policies, procedures**, and **budgets**. Policies are general rules and are not specific or detailed but rather are guidelines for action. Procedures are more specific and follow patterns for continuity and flow. Budgets divide the funding into expected costs. Budgets support the project goals and measure the money. All policies, procedures, and budgets should be considered dynamic and should be changed as needs change.

Every job should start by establishing a "Job Policy and Procedures Manual." The manual should be a loose-leaf, three-ring format that permits flexibility in managing, reviewing, and updating material. The manual helps everyone learn and understand the rules because they are written down, and it explains how and where the paper flows through the job. Rules and routines help establish the discipline necessary to a smooth operation. The manual establishes a foundation for authority and responsibility. This is important: defining authority among the workers clearly distributes responsibility.

Defining Responsibility

Managing personnel, or workers, is as important as managing materials. According to some estimates, 90 percent of all cost overruns are related to labor expenses. Thus, it is important to determine the skill level and experience of the workers. First, draw up an organizational chart on paper, or a chain of command, explaining who reports to whom and what the job descriptions are. Don't hesitate to explain what you expect from the workers you lead. Outline goals and objectives of the job. Provide clear controls and commands. Indicate any limits of authority. State which worker directly reports to whom and who will supervise or who will be supervised.

Summarize the job responsibilities in a job title and description, stating the main contribution of the job. Write that summary down for the policies and procedures manual. Describe the key tasks to be performed and the key results to be expected. When the work starts, give the workers an opportunity to perform. Then, review each worker's performance. Let the workers know how they are doing. Continue to test, evaluate, and take corrective action on the workers' capabilities. As work progresses, any changes to the workers' job responsibilities or job descriptions—and there most likely will be some—should be written down.

Projecting a Timeline

Develop a project start-up timeline and determine what workers will be needed to meet the production timeline. Write this down. Provide guidance or training where needed. Training a crew is a sound investment. Call an expert in the field you want training in. Today in Alaska, there are experts in building who will provide on-site training in the latest techniques for construction. Training takes planning and time and costs money, but there is a payoff. Remember, too: encourage a pleasant work atmosphere.

Create and manage a schedule that coordinates the specific jobs that cover the scope of work. Like the policies, procedures, and budgets, a schedule must be flexible, especially in Alaska where the extreme environment—climate, distances, methods of transportation, natural obstacles, to name a few—can lay waste to the best of planning. Always have a back-up plan, just in case your first expectations fall through.

Scheduling for construction plans, material lists, purchasing and delivery of materials, and startup, buildup, and shutdown of labor crews test the basic plan of action. Work backwards. If you want something done by a certain date, what actions must precede that date to accomplish the plan? For example, to meet the first barge that leaves on May 20, the materials must be on the dock the day the dock opens. The dock opens on May 1, and to get the materials ordered and shipped to the dock takes three weeks after the order is made. To make the order will take a selection of bids from vendors who will need two weeks to draw up bids on a material list. Materials lists may take up to three weeks if other work is going on as well. So to make the first barge, the plan of action had better schedule for up to 11 weeks to get the job done.

Keep Accurate Records

Keep accurate records and specialized reports, especially those required by government and financial institutions. Keep accurate payroll, inventory, and invoice records. Document, document, document. Maintain a record-keeping system that complies with local, state, and federal laws, regulations, and inspection procedures. Use a file cabinet or a file box to keep and protect these documents. Give each file folder a general title at first, such as "Payroll" or "Reports," and get more specific as the job progresses, such as "First Quarter Payroll" or "Monthly State Required Reports." Understand the purpose for each document and have a summary of the deadlines and due dates for paperwork and reports and a schedule for making payments. You should also review and monitor your procedures to avoid unnecessary or inappropriate administration.

Many projects that are funded totally or in part by federal or state funds must be in compliance with the requirements of governing regulations. Know the regulations of the programs that fund the project. Read them, understand them, and have them available to refer to if necessary. Pay particular attention to the contractors that are hired and the construction materials and methods they use.

Develop, or have someone help develop, high-quality work specifications that include the scope of work to be done. The schedule for completion must be clearly defined. The work write-up must meet required building standards. Know what the standards are before starting construction. Make sure your plans meet the standards. The methods for choosing vendors or services most likely must use open and free competition and lead to cost-effective purchasing. Conflicts of interest, gratuities, or favors must be avoided. They may be against the law.

Understand that all public jobs fall under labor laws and safety laws. The use of a worker's time and overtime, the payment of workers' compensation, unemployment, social security, and other mandatory payments, taxes, or deductions must be observed. Protection of workers' health and welfare is important and mandatory. Workers should have regular safety meetings, there should be a hazardous situation handbook on site, and every worker should know how to handle an emergency and what to do in case of fire. We suggest that you understand the more common labor and safety laws, perhaps through your own research or by asking those experienced in such matters, before the governing agencies visit your job site. Have hazardous materials data safety sheets on hand for all potentially hazardous materials used on site, such as paints, solvents, caulks and sealants, etc.

The success or failure of a project is connected to decision-making ability. Basic concepts, principles, and procedures are essential and must be applied to the everyday operation. Managing a project requires objectives and processing information. To analyze a situation, the project manager must uncover all information and options and gather the facts. Write them down. Carefully consider any difficulties that might be encountered and how those difficulties might be overcome. Then decide on a plan of action.

After a decision is made and a plan of action drawn up, the information must be communicated. The more comprehensive the plan, the more methods of communication are necessary, such as oral, written, individual meetings, and group meetings. Be sure to, at the least, write it down.

Problems and Pitfalls

Pitfalls are everywhere in construction. Pitfalls to the decision-making process include dealing only with symptoms and not causes, dealing with persons who "know it all" and who will block the investigation of the process, dealing with the limits of time that may demand a quick fix rather than a permanent and positive solution, and dealing with the attitude that the situation is someone else's responsibility. Most pitfalls are of human origin. The environment is no obstacle at all compared to a human with a conviction to undermine a project or authority. Some, if not most, pitfalls can be avoided by having clear, written objectives and rules that you can point to as policy or procedure. Control of a situation and knowing what the procedure is will help alleviate pitfalls. There are never any guarantees, this is for certain, but having guidance will help.

Technical Advisor

One form of guidance available is the project technical advisor. A technical advisor may be required in your project budget. The technical advisor is there to ensure that the community gets the most out of its grant dollars, has a successful project, and ends up with a facilty with a long life and low maintenance and operating costs. The technical advisor will help you make informed decisions about construction of the building. He or she can provide the following services:

- Teach village government and construction personel what makes a quality building.
- Review building plans to optimize the design for conditions in the region.
- Review building components and mechanical systems for quality, design, and performance standards.
- Help develop material lists, reasonable budgets, and labor cost projections.
- Conduct on-site labor training and workshops.
- Negotiate with vendors.
- Help with permitting and other compliance tasks.

- Provide expert advice on construction, systems, and materials.
- Solve problems and oversee the project to completion.
- Make a final inspection to make sure the project meets necessary standards.

Construction Sequencing

There are a few critical construction details that require a change in the way subcontractors do their jobs. With the exception of open crawl spaces, foundations are part of the thermal envelope and must provide for continuity of the vapor retarder and insulation. In some buildings, for example, rigid insulation and polyethylene are installed before any concrete is poured. If a concrete slab is being poured in an area known to have high levels of radon, a subslab ventilation system should be installed first. Extreme care must be taken to protect the vapor retarder from being penetrated by screed pins or with reinforcing mesh or rebar. One good way to accomplish this is to place the polyethylene down first, followed by a layer of rigid foam. Some concrete contractors have modified their screed pins by welding on a six-inch by six-inch plate that supports the pin on top of the polyethylene or foam to avoid puncturing the radon/moisture retarder.

Subfloors above unheated crawl spaces or in buildings constructed on pilings should be airtight with all joints in the sheathing sealed with waterproof adhesive. The underside of insulation should be protected from wind intrusion with a weather retarder house wrap of spun-bonded polyolefin or polyester or microperforated polyethelyne (Tyvek, Barricade, Typar, or other brands). Where beams support the floor joist system, house-wrap tabs should be placed over the beams and later integrated into the building weather retarder to provide continuous coverage. The underside of the insulation and the house wrap should also be protected from physical damage with plywood attached to the underside of the floor joists.

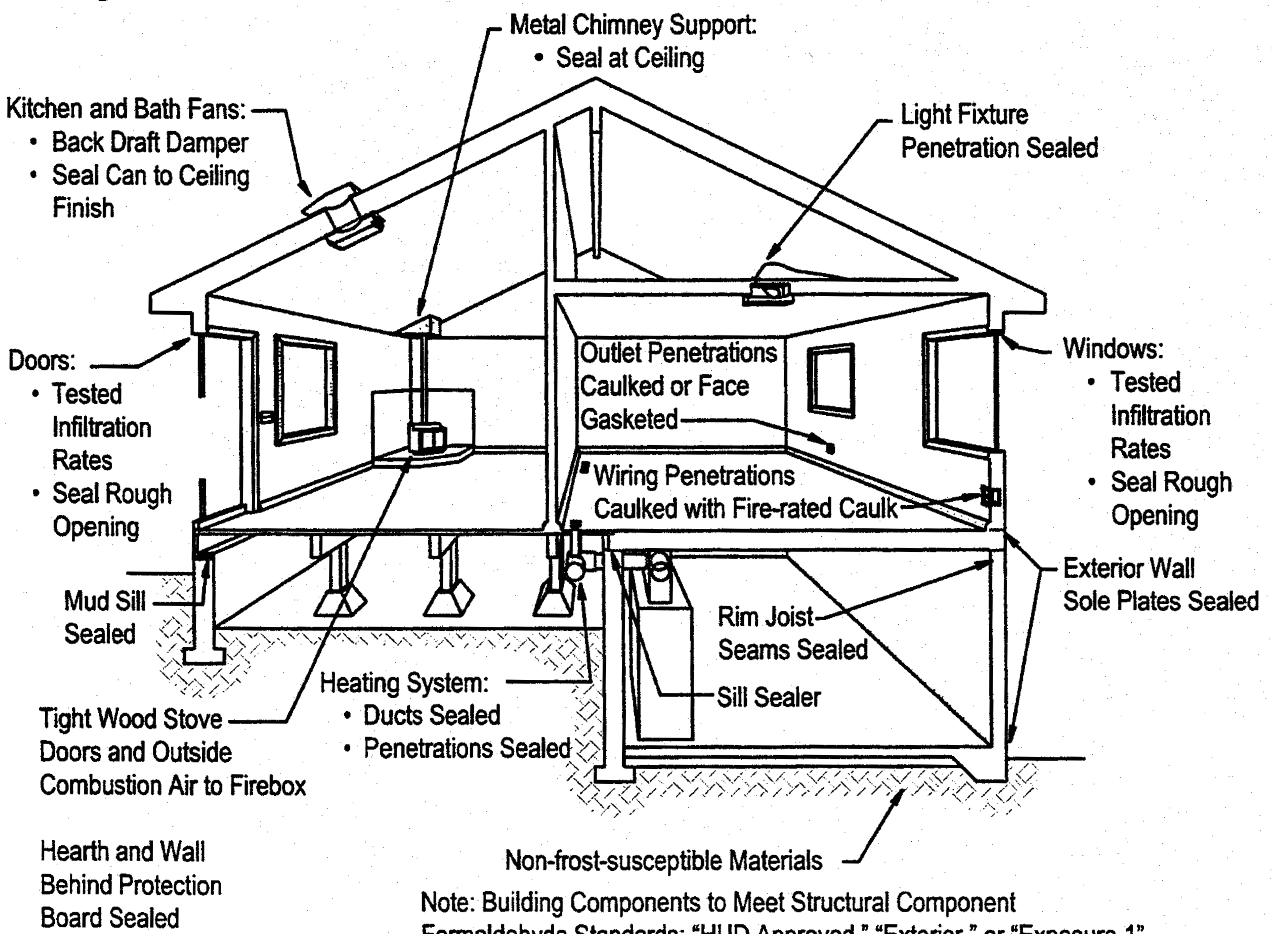
Bottom plates of exterior walls should be caulked or gasketed. The framing contractor must be sure that all exterior wall corners and partition intersections are fully insulated and maintain the vapor retarder system. The framers should install insulation and polyethylene behind stair framing, tub enclosures, and other areas that will be very difficult or impossible to get to later. Plumbers must be sure that water pipes are installed on the warm side of the vapor retarder and that all penetrations pass through solid backing so that an EPDM gasket can be installed and caulked to the vapor retarder to minimize the flow of heat, air, and moisture into attics or crawl spaces. Electricians should install the distribution panel on an interior partition. This results in only one hole through the thermal envelope and will not compromise the exterior wall insulation. All switch boxes, wall outlet boxes, and ceiling light boxes must provide for continuity of the vapor retarder.

Some builders complete the entire shell, including insulation, vapor retarder, and ceiling drywall, before installing interior partitions. In Alaska where it is always a race to get heat in a building as quickly as possible, this actually makes sense. This will call for close coordination between all subcontractors since it means that they may have to come back twice.

Vapor Retarder Installation

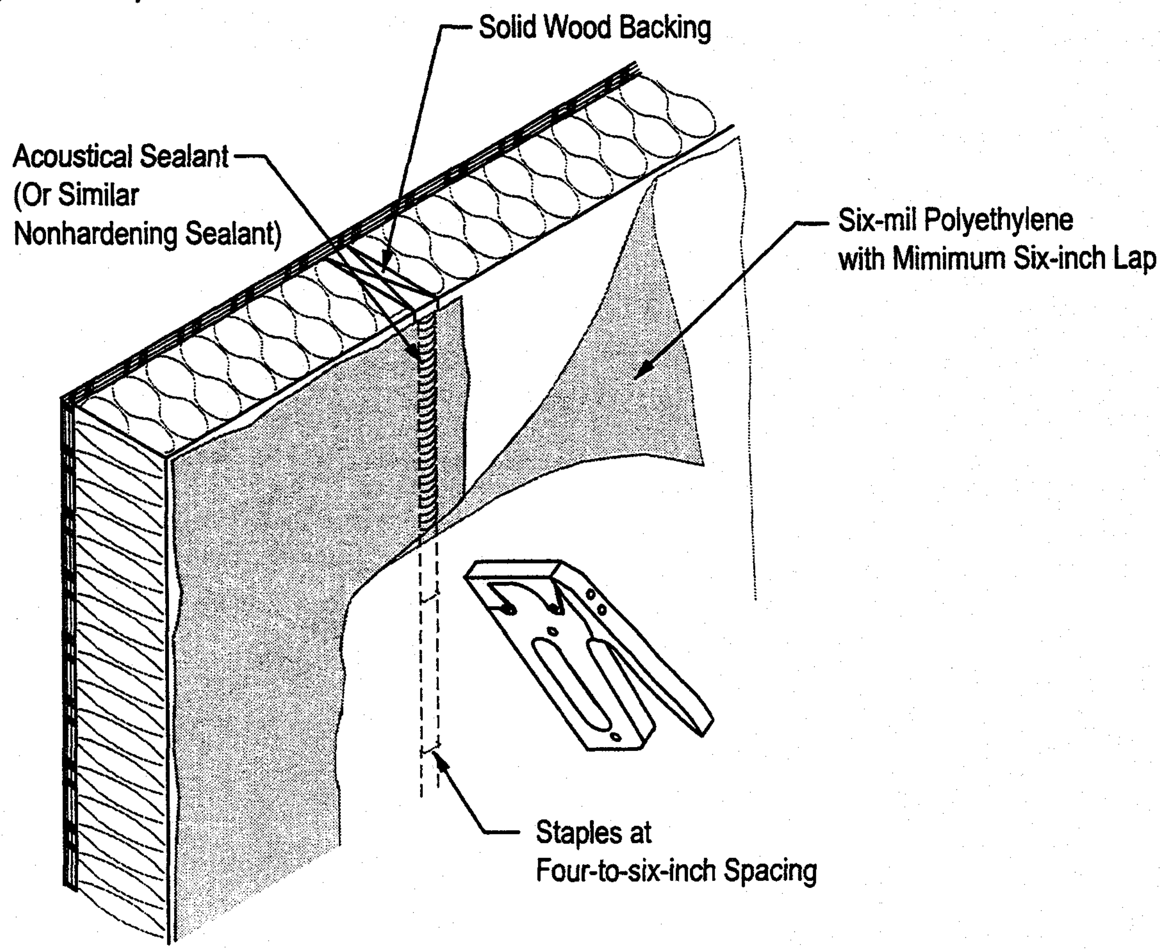
Installing a nearly airtight minimum six-mil polyethylene or cross-laminated vapor retarder (such as Visqueen, Ruffco, or Tutuff) is critical to the long-term success of a building. The most effective way to accomplish this is to plan ahead to provide for a continuous

Air Leakage Control: Places to Seal



Note: Building Components to Meet Structural Component Formaldehyde Standards: "HUD Approved," "Exterior," or "Exposure 1" vapor retarder system. This means that strips of polyethylene must be in place over the top plates of interior partitions and behind partition wall junctions with the outside wall. Once the roof is on and all of the wiring and insulation are finished in a single-stud frame wall, it is time to install the vapor retarder in as large as possible sheets to reduce the need for lapping and sealing. Wall vapor retarder materials should be a few inches taller and longer than the wall so that even if the installation is not perfectly straight it can still be sealed to the floor and to the ceiling polyethylene, with the plates providing solid backing at top and bottom and the drywall nailer or last stud in a partition wall providing solid backing for the ends. The large sheets of polyethylene should be tacked in place with as few staples as possible, stopping just short of lapping another sheet of polyethylene. Now and only now should you take out the caulk gun to apply a continuous bead of acoustical sealant to the junction of the bottom plate and the floor and to the partition polyethylene tabs.

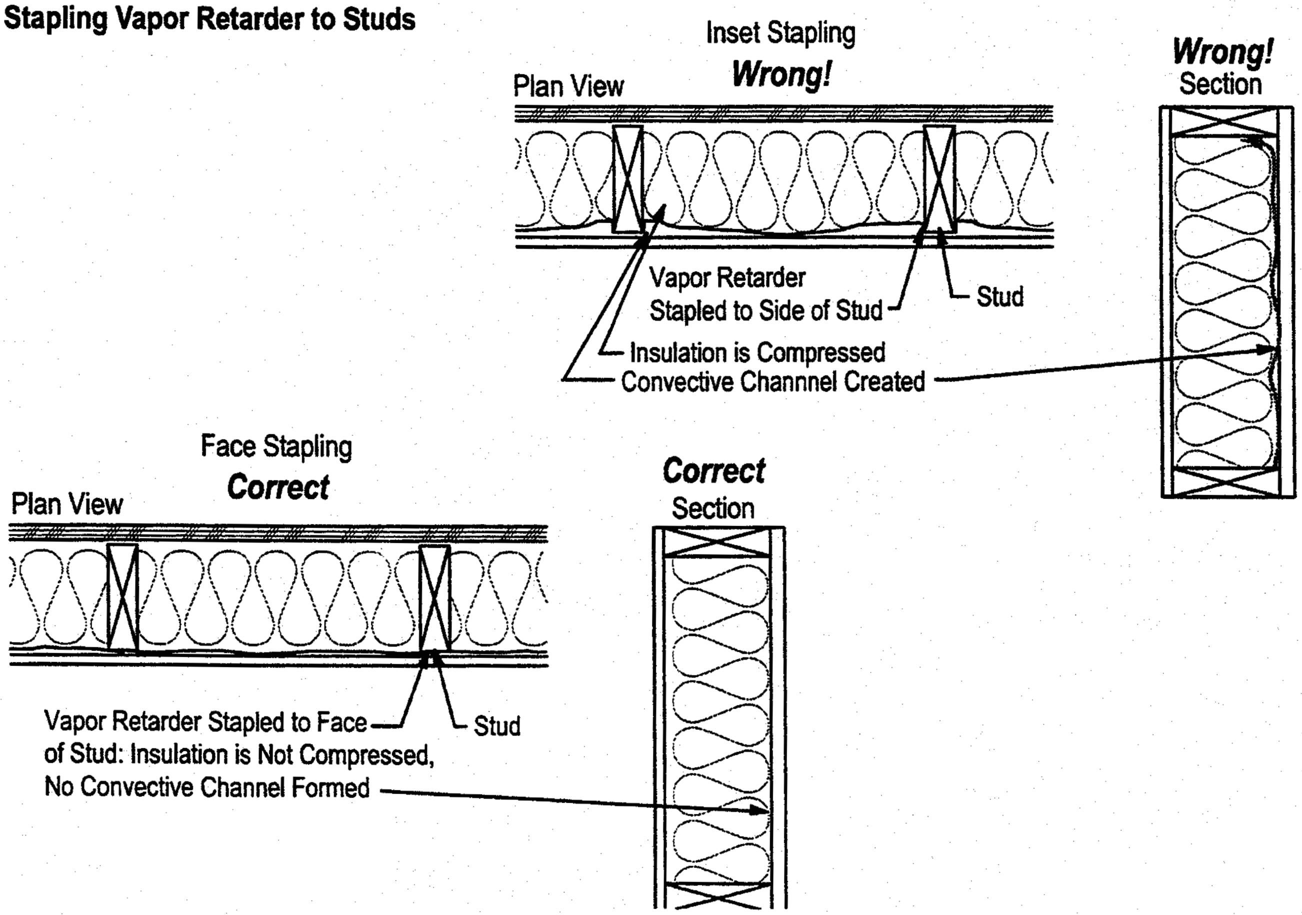
Installing the Air/Vapor Retarder

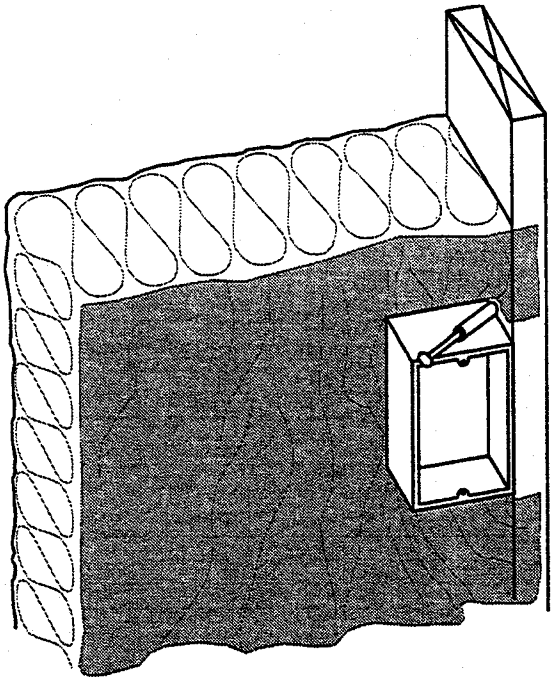


Now that we have the wall vapor retarder sealed on two ends and the bottom, it is time to put down the caulk guns and install the ceiling polyethylene. Once again, staple sparingly and stop just short of where you have to join the ceiling polyethylene to the wall polyethylene. Now take out the caulk gun and apply a continuous bead of acoustical sealant to the wall polyethylene, at least an inch down from the top so that when the wall drywall is installed it will compress the joint to provide an airtight seal. All vapor retarder lap joints must be made over solid backing so that a positive compression joint can be accomplished. Lap joints made without solid backing will come apart during the first wind storm or the first time someone slams a door in a tight structure. The sequencing of detailing the vapor retarder system will vary depending on the wall system used. For example, furred wall systems and double-stud walls require very few penetrations and are easier to make airtight than a single-stud wall.

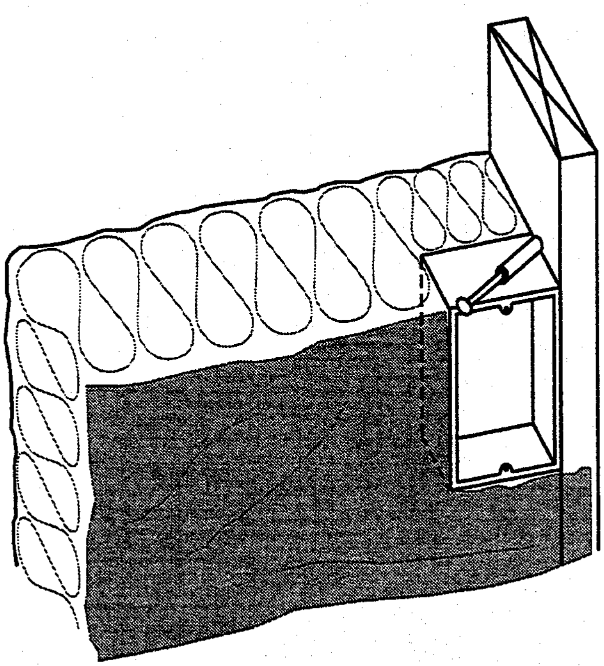
An exterior weather retarder such as Tyvek or Typar or Barricade is a modern substitute for tarpaper on walls. It is especially appropriate in high wind areas.

Stapling Vapor Retarder to Studs



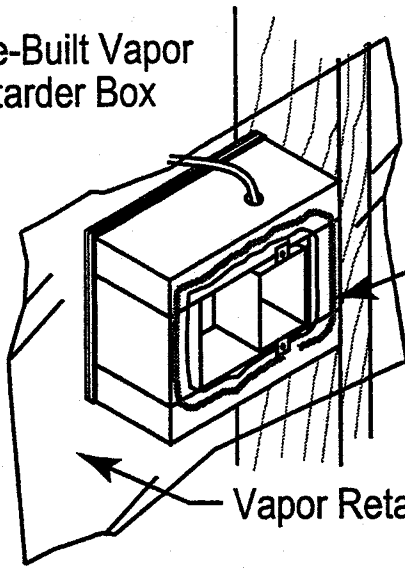


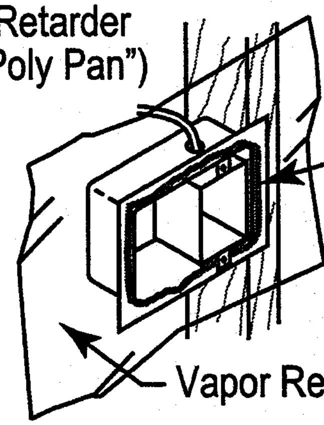
WRONG!
Insulation is Smashed
Behind the Junction Box

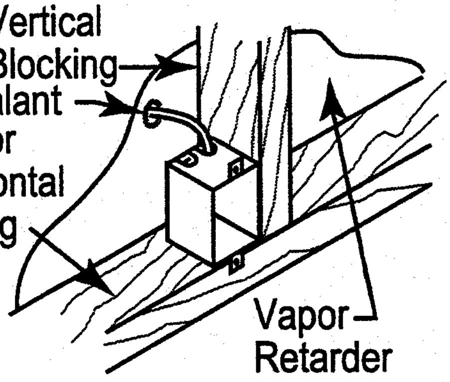


CORRECT
Insulation Carefully Cut to Fit Behind
Junction Box and Snugly at Sides

Installing Insulation Around Electrical Boxes

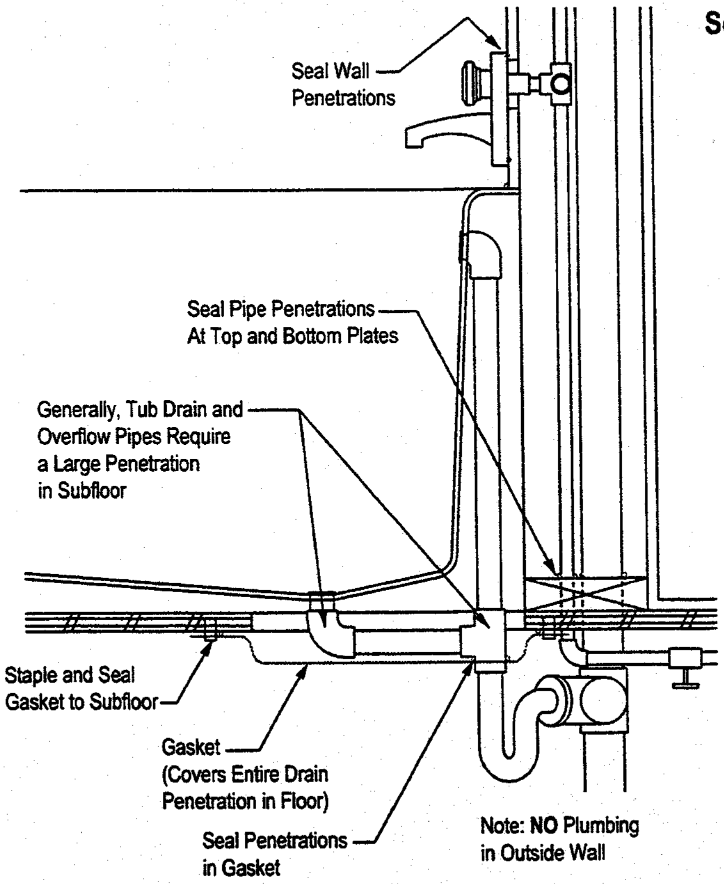




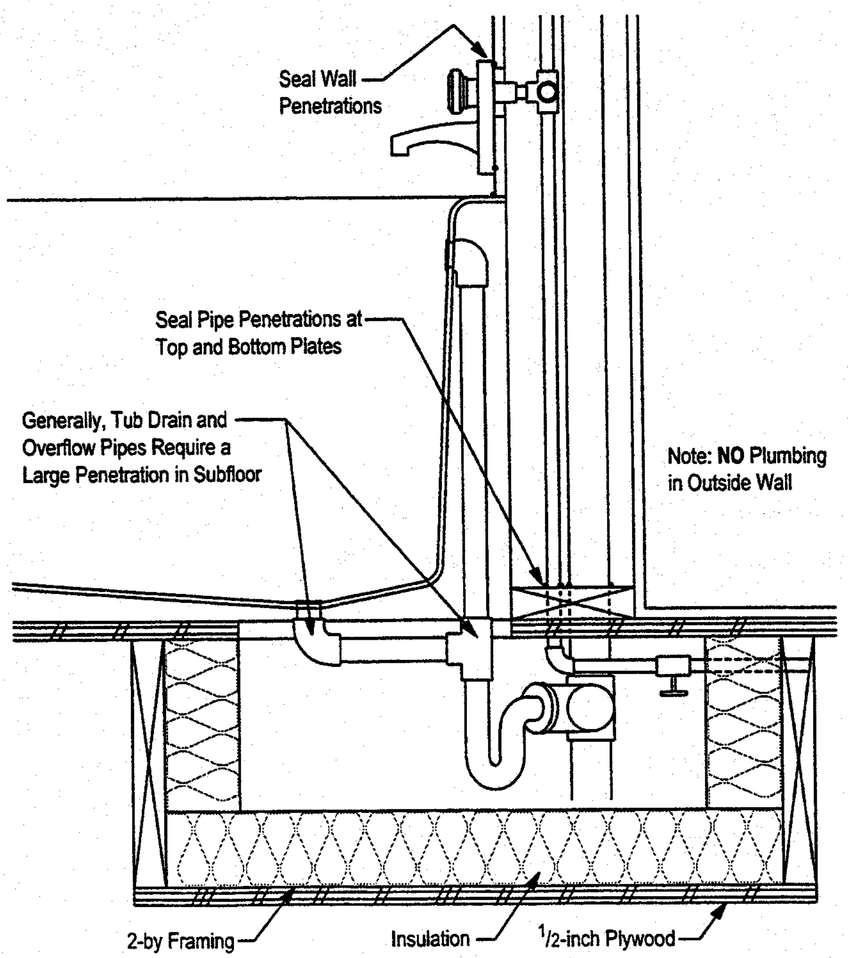


Sealing Electrical Penetrations

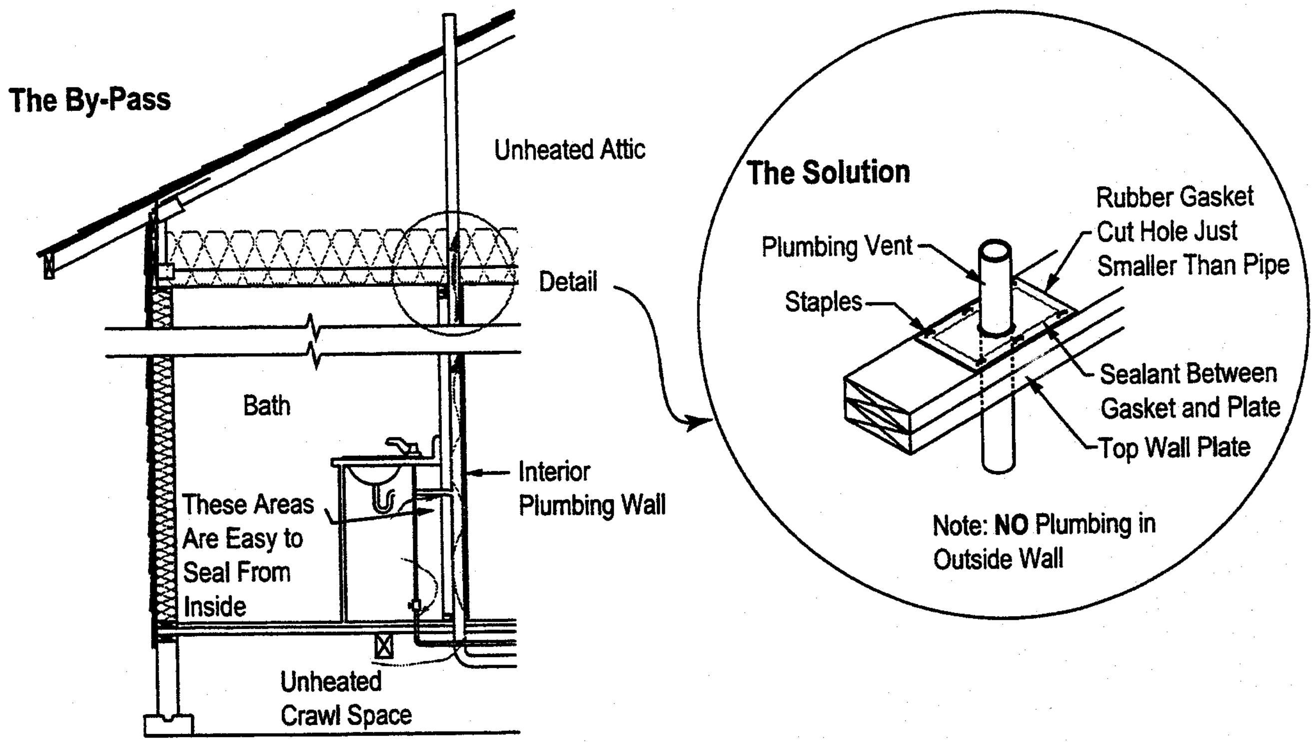
Sealing Plumbing Penetrations in the Floor



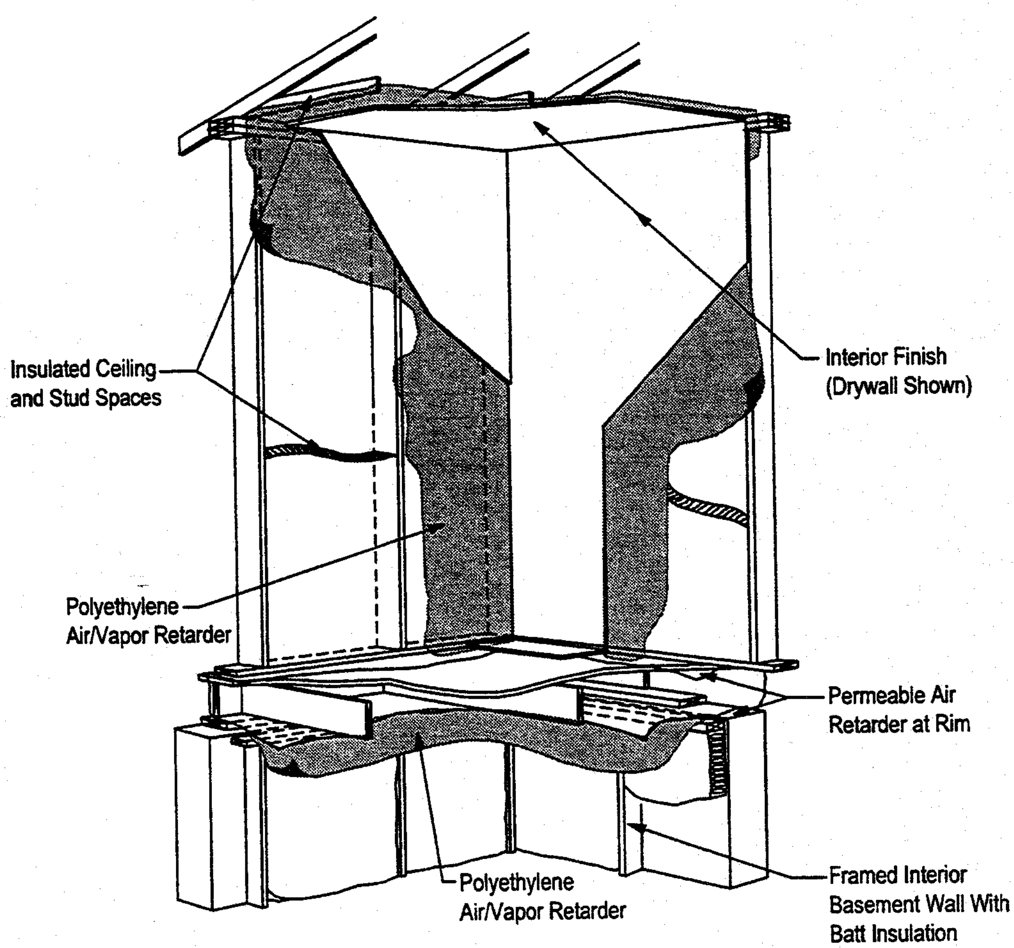
Sealing Plumbing Penetrations Over a Crawl Space



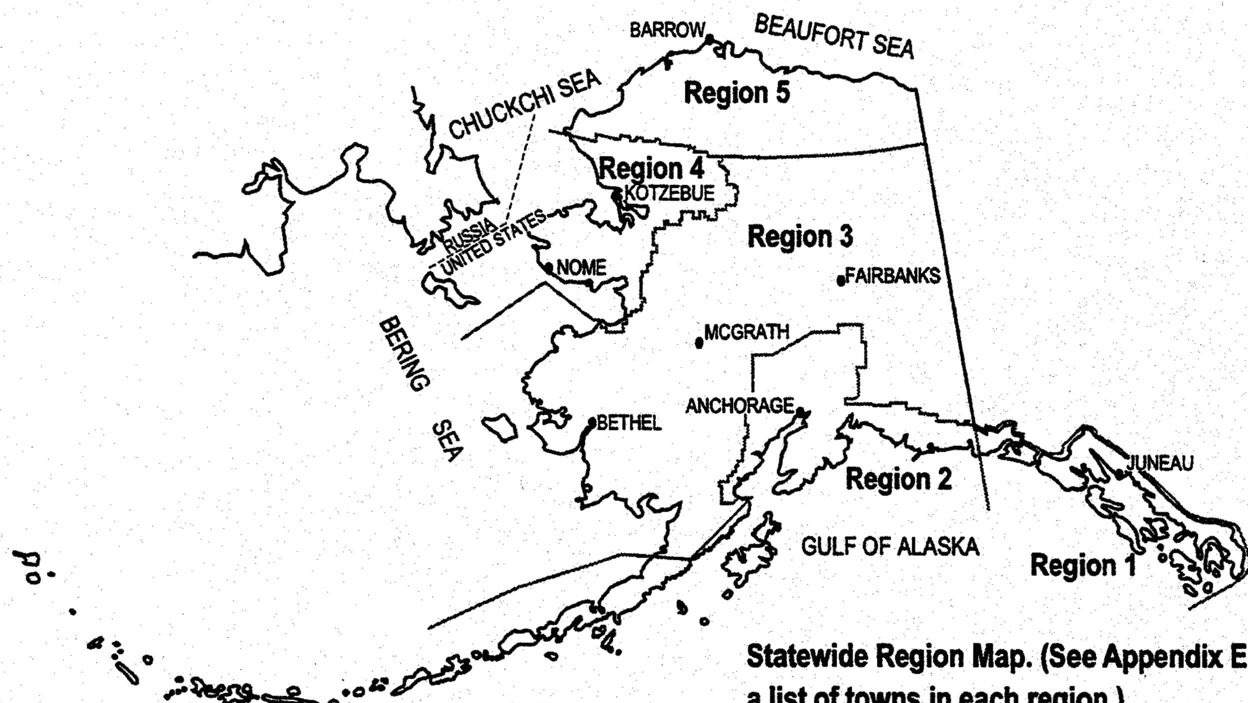
Sealing the Plumbing Bypass



Detailing the Air/Vapor Retarder



Part III
Regional Considerations



Statewide Region Map. (See Appendix E for a list of towns in each region.)

In Part III we will describe how to build the various foundation, floor, wall, and ceiling systems required to meet the prescriptive R-values for each region. We will examine the climatic, geographic, and demographic conditions of each region and relate these factors to the design considerations specific to each region. There are many ways to meet the prescriptive standard R-values found in Table 1 (page 8) or to comply with the results of a Hot 2000 energy analysis. It is not the authors' intent to select any "best" method of achieving these prescriptive standards. We only intend to provide several examples, illustrating the flexibility available to designers and builders.

Region 1: Southeast Alaska

Southeast Alaska stretches from the Lynn Canal near Prince Rupert, British Columbia, on the south to Yakutat Bay on the north. Southeastern Alaska is often called the Scandinavia of North America because of its thousands of miles of coastline with majestic snow-capped mountains plunging into world-class fjords, many of which are filled with ice by active glaciers calving into the sea. This is a maritime climatic zone, home to some of the world's richest fisheries and some of the last remaining old-growth rainforests in the world. It is also one of the most difficult areas in the world to build a durable, comfortable, healthy building.

Weather in this region is tempered by warm ocean currents, so that relative to the rest of Alaska, winters are warm but summers are cool. Southeast Alaska is noted for its nearly year-round rainfall and persistent surface winds. The heating degree days range from about 7,000 in Ketchikan to about 9,500 in Yakutat. These are the same conditions that Norwegian builders have faced for centuries, and they have developed ways to build successfully in this type of climate. (See the bibliography for several publications by the Norwegian Building Research Institute.)

Control of Underground Water

Many communities in Southeastern Alaska are built on a narrow, sloping bench of alluvial soils of sand and gravels washed down from the coastal mountains. They are flanked by the sea on one side and tall mountains on the other. A nearly constant stream of water may flow beneath the surface through a prospective building site. This water flow must be diverted. This can often be accomplished by digging a trench upstream from the proposed foundation and lining it with a heavy duty, UV stabilized, watertight geotextile membrane to divert water around the building foundation.

Prescriptive R-Values for Southeast Alaska

Juneau was used as a baseline to develop the prescriptive standards for the Southeast region. If following the prescriptive method, the minimum thermal envelope insulation values are R-38 in the ceiling; R-21 for above-grade walls; R-20 for below-grade walls; R-30 in an unheated crawl space floor; R-10 for a slab; R-3 for windows; and R-7 for doors. These R-values are based on heat recovery ventilation (HRV) operating eight hours a day. Add 10 percent to all component R-values if a non-HRV type of ventilation is used. Measured air leakage maximum is 1.5 air changes per hour at 50 Pascals (1.5 ACH 50). You must also comply with all mandatory measures described in Appendix A.

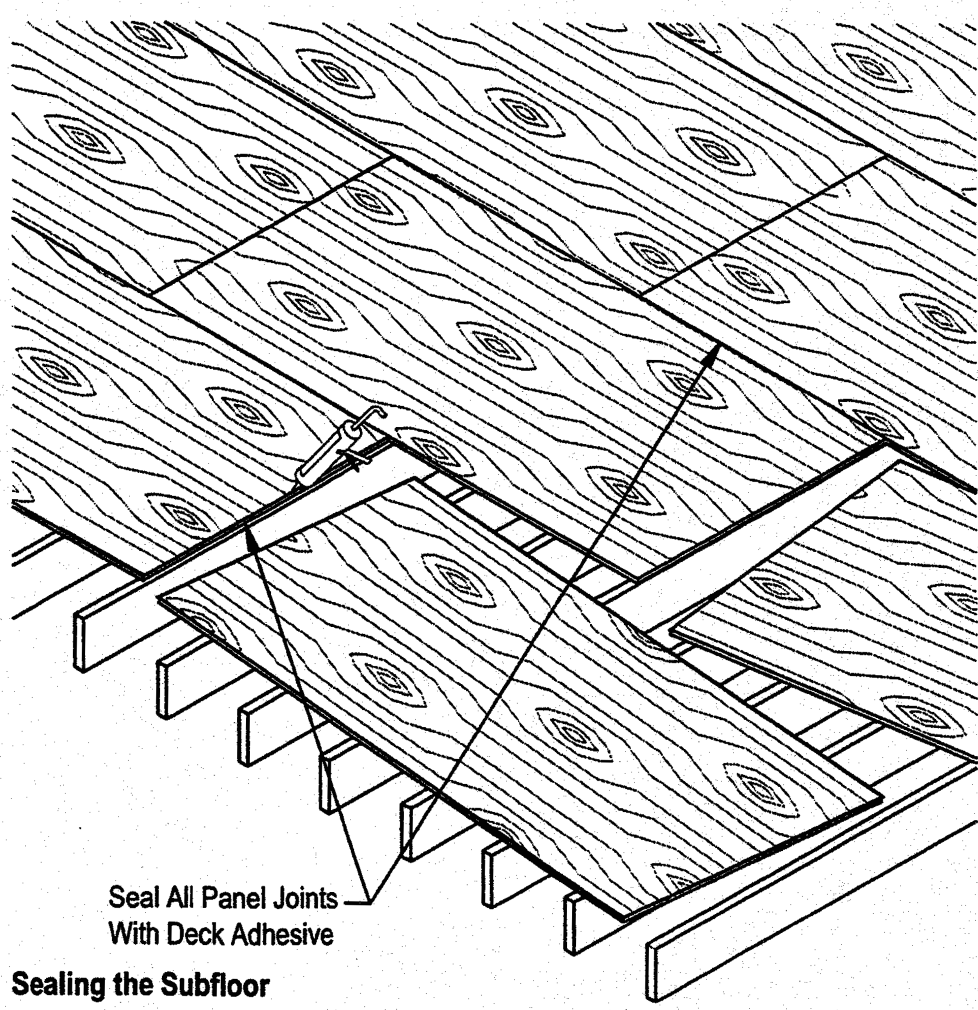
Foundations, if heated, must be thought of as part of the thermal envelope. If soil conditions permit, a heated crawl space or a full basement may be constructed to meet the standard. A simple way to meet the standard for Southeast Alaska with a concrete foundation is to insulate the exterior and under the slab with two inches of high density extruded foam and fur in the basement wall or crawl space wall and insulate with fiberglass. One could also insulate the exterior of the foundation with four inches of extruded foam. Various foam forming systems are on the market that eliminate the need for plywood forms and result in a poured concrete foundation insulated to about R-20. In areas where urethane foam is available, this product can be used on the exterior of foundations, but it must be protected from water damage with a waterproof coating. All foam products must be protected from exposure to sunlight. Most foam insulation cannot be exposed in a crawl space or in any living space and must be covered with a fire safing product. There are some exceptions to this, so check with your code official before deciding what system of insulation to use.

All closed crawl spaces or basements require a continuous vapor retarder on the surface of the ground to serve as a barrier to moisture migration from the soil. Most building codes require passive ventilation of crawl spaces with screened openings of prescribed net free area located near the corners of the foundation. Research shows that this does not make sense if the crawl space is heated, since the space will be airtight and watertight. Mechanical ventilation of closed crawl spaces through a heat recovery ventilator is being done very effectively in all areas of Alaska.

Concrete is not a cost-effective building material in much of Alaska due to high transportation costs of materials and distance from ready-mix operations. If the design calls for a heated crawl space or full basement, a pressure-treated wood foundation may be the foundation of choice. The key to a successful pressure-treated wood foundation is to keep the soil surrounding the foundation dry or above freezing or both. This type of foundation is most effective when constructed upon and backfilled with non-frost-susceptible materials: in other words, relatively clean sand and gravel that does not contain significant amounts of silt or expansive clay particles. The floor systems at grade and on top of the foundation walls must be in place to resist lateral loads before backfilling. Remember that all closed foundations must have a continuous ground cover of six-mil polyethylene sealed at all laps. Do not try to meet the pressure-treated wood manufacturer's bare minimum requirements for stud sizing or on-center placement or maximum backfill height. Most such standards do not account for the active freeze-thaw cycle that foundations in Alaska experience. Build it strong.

R-30 Floors

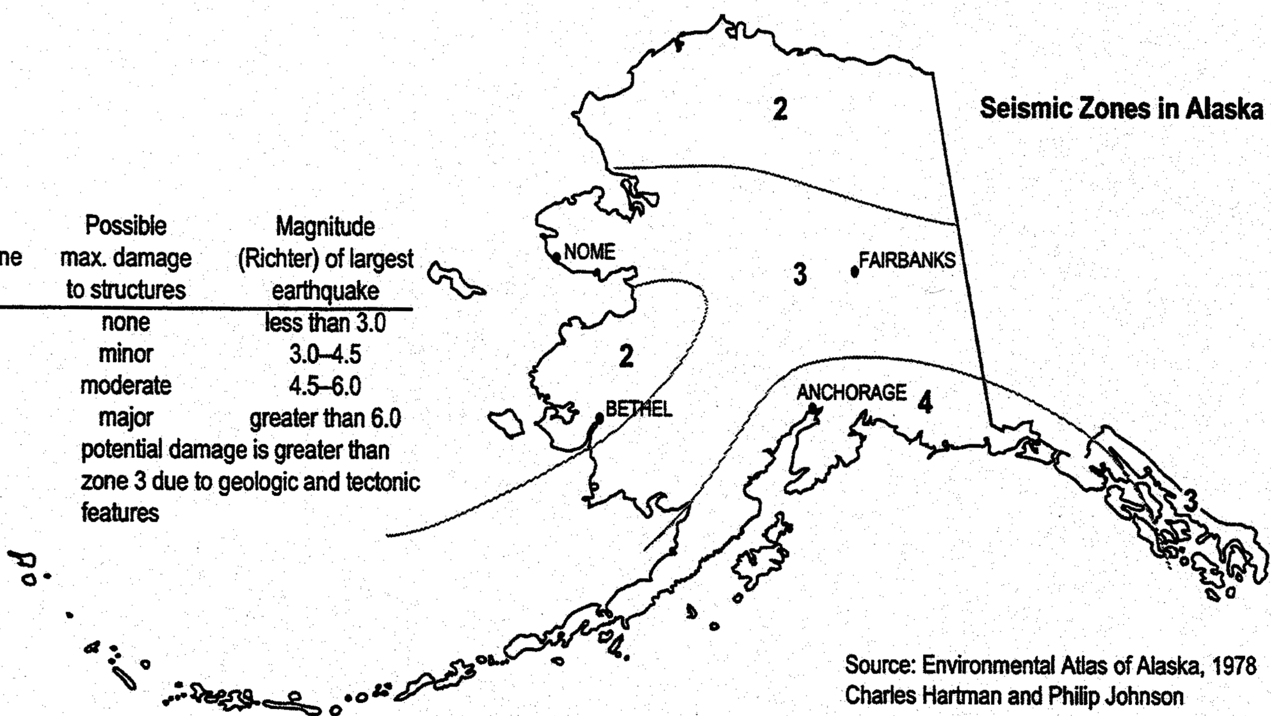
In Southeastern Alaska, open crawl spaces are common and the foundation will usually not be insulated. In this case, the floor must be insulated to a minimum of R-30 if following the prescriptive method of compliance. This can be easily accomplished using 2-by-10 floor joists or 9 1/2-inch engineered plywood I-joists such as TJIs or BCIs. The underside of the floor joists should be covered with a weather retarder house wrap of Typar, Tyvek, Barricade, or equivalent. This house wrap should extend up the outside of the rim joist where it can be overlapped by the wall weather retarder. All seams, laps, and penetrations in the house wrap must be sealed with a compatible tape designed for use with these products. This will keep wind from intruding into the floor system and carrying away heat and lowering effective R-values. It will also prevent drafts on the floor and provide the occupants with a comfortable, draft-free



Sealing the Subfloor

environment. The topside of the joists should be fitted with a minimum $^3/_4$-inch exterior-grade tongue-and-groove subfloor plywood glued and screwed to the floor joists and sealed on all edges with waterproof adhesive. The underside of the joists should be covered with plywood to prevent physical damage by animals or high winds. If access to the underside of the floor system is limited, the builder can glue tight-fitting rips of plywood on top of the bottom flanges of plywood I-beam floor joists. Butt joints between these plywood panels should be air sealed with compatible tape to prevent air intrusion but allow water vapor to escape. R-30 insulation can then be placed from above if weather permits or if the roof is dried in. Alternatively, foam core panels are available that meet the R-value requirements for floors.

Seismic Zones in Alaska



Zone	Possible max. damage to structures	Magnitude (Richter) of largest earthquake
0	none	less than 3.0
1	minor	3.0–4.5
2	moderate	4.5–6.0
3	major	greater than 6.0
4	potential damage is greater than zone 3 due to geologic and tectonic features	

Source: Environmental Atlas of Alaska, 1978
Charles Hartman and Philip Johnson

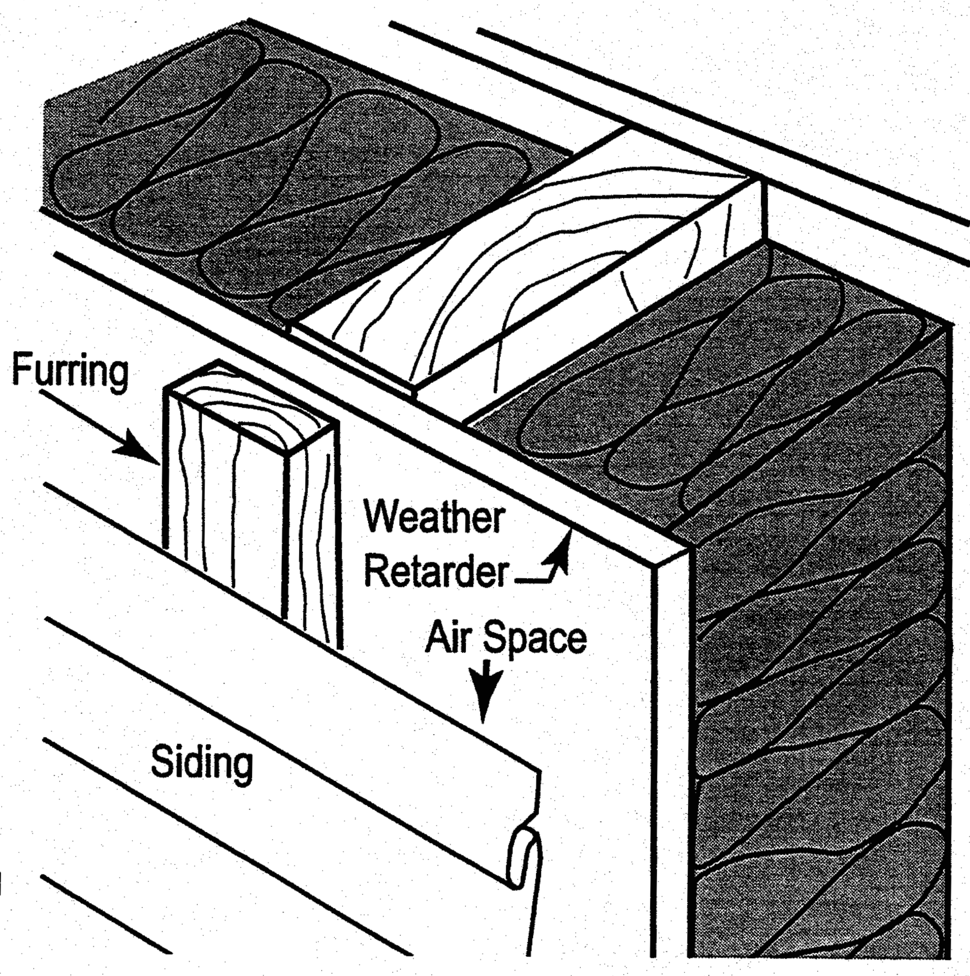
Seismic, Snow, and Wind Loads

Southeast Alaska is in Seismic Zone 3 (see seismic zones map), which means that it is subject to major earthquakes greater than 6.0 on the Richter scale. Floors must be anchored securely to the foundation with a system of metal straps or bolts and brackets or at the very least thoughtful application of plywood sheathing and nailing patterns. The seismic and wind shear system must continue through the wall framing from floor to floor right up to the roof framing to form a unified structure capable of withstanding earthquakes and hurricane-force winds (refer to local building codes).

Remember to consider roof snow loads when designing foundations, walls, and roofs for wind loads and for earthquake loads. Snow loads in this region range from 30 pounds per square foot in Ketchikan, Sitka, Petersburg, and Juneau to 80 pounds in Haines and Yakutat. Check with your local building official and weather service office for wind and snow load design criteria.

Exterior Ventilated Cladding

The construction of insulated walls exposed to the ravages of wind and rain is a fairly new science relative to the length of time mankind has been living in these conditions. It is only since the cost of energy has made insulation a good investment that Norwegian engineers have begun to solve the wet wall insulation syndrome. They do this by making the structure absolutely airtight on the inside, with an exterior ventilated cladding system that allows the wall to dry rapidly. A contractor in Juneau has adopted this strategy and is wrapping the exterior of the wall framing with house wrap and furring out the framing with 3/4 x 2-inch pressure-treated plywood strips, over which he nails either horizontal siding or T1-11 sheathing. The bottom openings are screened to allow drainage and the top is sealed to prevent convection currents.



Norwegian-style Ventilated Cladding System

R-21 Walls

One of the easiest ways to comply with the R-21 wall insulation requirement of the prescriptive standard is to frame the building with 2-by-6 studs at 24 inches on center and insulate the wall cavity with relatively low cost cellulose or high-density fiberglass R-21 insulation. Spraying a 2-by-4 stud cavity with urethane foam with an aged R-value of about six per inch will easily meet the minimum R-value requirements, but since urethane is not a vapor retarder you will have to install polyethylene on the inside face of the studs, as you will with the other systems mentioned in this manual. A new foam product on the market called Icynene Insealation has an R-value of about 3.6 per inch, which results in about R-21 in a 2-by-6 wall. Icynene does not contain CFCs, which are known to contribute to the greenhouse effect and resultant global warming.

Another promising new insulation system is called BIBS, or Blown In Blanket System, which consists of blowing chopped fiberglass or cellulose along with an adhesive binder into the stud cavity. The wall is first sheathed with exterior siding, and the inside face of the studs are fitted with a lightweight netting that holds the material in place. This material results in about R-21 in a 2-by-6 wall, which will meet the prescriptive standard. The main feature of the Blown In Blanket System is that it completely fills the stud bays around wiring and plumbing, resulting in a very tight insulation blanket. The BIB system requires a separate vapor retarder. There have been some problems related to moisture in the adhesive not drying before the vapor retarder was installed. To avoid trapping moisture in the wall cavity, some insulation contractors are using the BIB system without the adhesive. Some insulation contractors are only using the adhesive in the top few inches of ceiling insulation to keep it from blowing away in high wind areas and to minimize convection currents within the blown-in insulation.

Foam core panels may also be used to meet the standard. Whatever wall system you choose to meet the standard, it must be airtight on the inside and must breathe to the outside yet remain impervious to wind-blown rain and snow.

R-38 Ceiling

The most effective way to insulate a truss-type roof system is with blown insulation, since this process allows for complete coverage over and around truss components. If fiberglass batts are used, plan to install two layers of R-19 insulation with the first layer tucked in between the bottom chords of the trusses and the second layer installed at right angles to the trusses. The batts should be cut to fit tightly around the truss webs and snugged up tight to one another to provide a continuous thermal blanket over the ceiling. Do not use a single 12-inch batt as this often results in no insulation at all over the bottom chords and serious heat leaks around the truss webs. Energy heel trusses should be used to allow room for full depth of insulation over the walls and to provide a minimum of two inches of air space above the insulation for ventilation. Install insulation baffles at the eaves to direct outside ventilation air up and over the insulation. Baffles prevent wind intrusion into the insulation. An R-38 rafter-type roof can be constructed using 2-by-12s or 11 7/8-inch engineered plywood I-beam rafters. If a cold roof is desired, the 12-inch rafters must be furred out to accommodate at least 1 1/2 inches of ventilation air over the insulation. Foam core panels are available, and if they are sealed properly between panels and at the walls, they will make an excellent hot roof. If a cold roof is required, then the foam core panels must be strapped with 2x material to provide for air flow under the roofing.

Region 2: Southcentral

Southcentral Alaska forms an arc bounded on the north by the south slope of the Alaska Range and stretches from Yakutat on the east to the tip of the Aleutian archipelago.

While most of this region is in the maritime climatic zone and transition climate zone, it also includes areas of continental climate in the center of the Kenai Peninsula and the northern reaches near the Alaska Range (see map p. 8). This region is somewhat cooler than Southeast, with heating degree days ranging from about 9,500 on the south to about 12,000 in the north. Southcentral Alaska is one of the most active earthquake regions in the world, with a seismic zone 4 designation. This means that there is a possibility of a major earthquake greater than 8 on the Richter scale.

Rain, sleet, and snow driven by 100-knot winds must be designed for in exposed coastal areas or exposed uplands. A National Weather Service map shows snow depths of 800 inches (66.7 feet) a year in an arc from Valdez to Yakutat. Roofs must be designed for snow loads of 100 pounds in Valdez and Cordova. Roof snow load design for Anchorage, Kodiak, and the Kenai Peninsula is 40 pounds. The Aleutians call for only 30 pound live load because high winds keep roofs clear of snow. Keep in mind that local building codes may vary from meteorological data. Check with local building officials and local weather service offices to be sure what wind and snow load design criteria to use.

Prescriptive R-Values for Southcentral Alaska

Anchorage, with 11,000 heating degree days, was used to develop the prescriptive standards for Southcentral region. If following the prescriptive method, the minimum insulation values are R-40 in the ceiling, R-25 in the above-grade wall, R-20 in a below-grade wall, R-38 in the crawl space floor, R-20 for the slab; R-3 windows, and R-7 doors. This is based on heat recovery ventilation (HRV) eight hours a day. Add 10 percent to R-values if non-heat recovery ventilation is used. Measured air leakage maximum is 1.5 air changes per hour at 50 Pascals (1.5 ACH 50). In addition, you must comply with all mandatory measures in Appendix A.

R-25 Walls

One of the easiest ways to comply with the R-25 wall insulation requirement of the prescriptive standard is to frame the building with 2-by-6 studs on 24-inch centers. Insulate the wall cavity with relatively low-cost cellulose or fiberglass insulation and add rigid foam insulation to either the inside or outside of the framing. This technique has an added value beyond just increasing the R-value of the wall, since it also eliminates the direct conduction of heat through all of the framing members. Adding one inch of foil-faced polyisocyanurate insulation such as R-Max or Thermax on the inside and taping all the joints with vapor retarder tape will enable the builder to meet the minimum R-value requirements and airtightness requirements at the same time. A polyethylene vapor retarder would not be necessary since aluminum foil is a perfect air/vapor retarder. Other types of foam products can be used on the inside, but they will require a vapor retarder. The wall could also be furred in or out and insulated with fiberglass batts or with rigid foam. Pay careful attention to placing the vapor retarder near the warm side of the insulation system to avoid moisture condensation within the wall. Put no more than one third of the insulation on the inside of the vapor retarder.

Spraying the 2-by-6 stud cavity with urethane foam with an aged R-value of about six per inch will easily meet the minimum R-value requirements, but since urethane is not a vapor retarder, you will have to install polyethylene on the inside face of the studs. The BIB system and Icynene foam system will require a vapor retarder and additional insulation to obtain an R-value of 25 in a 2-by-6 wall; however, they will meet the prescriptive standard in a 2-by-8 wall. Foam core panels will also meet the standard if they are airtight and vapor-tight on the inside.

R-38 Floors

Floors insulated to R-38 can most easily be constructed with 2-by-12 floor joists or 11 7/8 plywood I-beam joists and 12 inches of fiberglass insulation. If plywood I-beams are used as joists, carefully cut insulation to fit tightly around the irregular profile of the I-beam, eliminating voids in the insulation. Densely packed cellulose insulation in 12-inch joists will also meet the standard. Smaller joists can be used with higher R-value urethane foam insulation or with a layer of rigid foam applied to the underside of the floor joists. Rigid foam can also be installed between plywood I-beam joists and supported by the bottom flange, with fiberglass or cellulose installed from above. Foam core panels are available that meet the standard for R-38 floors.

R- 40 Ceiling

An R-40 ceiling requires about 13 inches of fiberglass insulation. Since the mandatory measures in Appendix A require that no less than 80 percent of the minimum ceiling R-value can be installed over the wall, this means that the raised heel truss height over the wall can be no less than 10 inches for a hot roof and no less than 12 inches for a ventilated roof. The truss engineer must know these details in order to design a truss that will comply with the standard if you plan to use fiberglass insulation. If only substandard trusses (formerly considered standard) without a raised heel over the wall are available, then a two-foot-wide band of higher R-value foam insulation can be used along the bearing walls to obtain the minimum required insulation level.

Region 3: Interior and Southwest

The Interior and Southwest region is larger in land mass than regions 1, 2, 4, and 5 combined. The Interior is more varied in climate and geography than any of the other regions. The Interior region is bounded on the north by the Brooks Range and on the south by the Alaska Range and forms a huge basin for most of the major rivers in Alaska, including the Porcupine, Koyukuk, Yukon, Tanana, Kuskokwim, and all but the southern portion of the Copper River. Most of the flatlands consist of permanently frozen bogs, with the exception of some well-drained sand and gravel soils along rivers which cut through bedrock on their way to the sea. The central Interior is technically a desert, with only about 10 to 20 inches annual precipitation, yet the countryside is dotted with bogs, ponds, and lakes because permafrost just below the surface prevents drainage. This has profound implications on water supplies and sewage waste disposal as well as foundations. A thorough knowledge of the soils where you plan to build is critical to the durability of the building.

The Interior is a study in extremes. For example, the city of Ft. Yukon, located just north of the Arctic Circle, has recorded a summertime high of 100 degrees F and a winter low of -75 degrees F, with about 15,000 annual heating degree days. Heating degree days in Region 3 range from just over 8,000 at St. Paul and St. George in the Pribilofs to about 17,000 in Arctic Village. Design wind loads vary from 70 pounds per square foot at Cape Newenham to 20 pounds per square foot at Cape Romanof. Refer to local building officials and local weather service offices for accurate design criteria.

Prescriptive R-values for Interior and Southwest

The authors selected McGrath (14,500 heating degree days) as the location to develop prescriptive R-values for the Interior region. McGrath is geographically near the center of the region and has about average heating requirements for the Interior. If you are building in an area with fewer heating degree days, it would be especially cost effective to use Hot 2000 6.02g energy analysis software to optimize insulation R-values.

If following the prescriptive method, the minimum thermal envelope R-values for Region 3 are R-50 in the ceiling, R-30 in above-grade and below-grade walls, R-40 in exposed crawl space floors, R-25 under slabs, R-4 windows, and R-10 doors. This is based upon heat recovery ventilation eight hours a day. Add 10 percent to these R-values if non-heat-recovery ventilation is used. Maximum tested air leakage is 1.5 air changes per hour at 50 Pascals. Comply with all mandatory measures in Appendix A.

Permafrost

The choice of foundations for community buildings in Interior and Southwest Alaska is as varied as its geology, geography, and climate. Most of this region is underlain with discontinuous permafrost. The annual mean temperature of the soil is just barely below freezing, so any disturbance to the temperature balance can result in catastrophic structural failure of a building. Permafrost is often absent from south slopes and from free-draining sand and gravels left by rivers or glaciers. Permafrost is usually found on north-facing slopes and beneath thick layers of vegetation and peat in the valleys. While vegetation is commonly used as an indicator of whether or not permafrost is present, there is only one kind of tree that will guarantee the absence of ice: a palm tree. The only way to be sure is to test (see permafrost map on page 16).

R-30 Below-Grade Foundation Wall and R-25 Slab

If soil conditions are suitable for a conventional crawl space foundation or full basement and if you are following the prescriptive method of compliance with the standard, then you must insulate the below-grade wall to R-30 and the slab to R-25. This can most easily be accomplished by insulating outside the foundation wall with four inches of high-density extruded foam insulation for an R-value of 20, then adding fiberglass insulation to the inside walls in a full basement or crawl space wall or a code-approved foam insulation system on the inside of the crawl space wall. An R-25 slab will require five inches of high-density rigid foam. Be sure to place a below-grade foundation wall or slab on non-frost-susceptible soil.

Permafrost Foundations

If ice-rich soils cannot be avoided, the best strategy will be to preserve the permafrost by disconnecting the building from the ground. This is commonly accomplished by building on pilings with a heavily insulated floor three or four feet off the ground to allow the free flow of cold air to carry away any heat from the building. A new type of foundation known as a space frame (see drawing on page 17) that relies on a combination of triangles of structural tubing joined by hubs into a rigid foundation system may be a cost-effective alternative to piling foundations. The manufacturer claims that this type of foundation will eliminate differential settlement. If borne out in practice, this will solve the problem of rapid self-destruction from foundation failure all too common in piling and post and pad foundations.

R-40 Crawl Space Floor

An R-40 floor can be constructed of 11 7/8-inch engineered plywood I-joists or 2-by-12 joists with plywood sheathing under the joists and cellulose insulation blown in the floor cavity to a density of at least two pounds per cubic foot. If a blower machine is not available, it is possible to hand pack the floor joist cavity to sufficient density to meet the standard.

Foam core panels are available that meet the prescriptive standard for Region 3. One of the problems with foam core panels is providing space to easily run utilities such as plumbing, heating, and ventilation. Some designers have gotten around this limitation by installing nonstructural joists on top of the foam core panels to provide space for utilities on the warm side of the insulation. Others have designed insulated utilidors under the floor. You must also build an insulated chase or utilidor for incoming water and outgoing waste water.

R-30 Walls

Single-stud walls insulated to R-30 are easily constructed with 2-by-6 studs 24 inches on center and insulated with high-density fiberglass batt insulation, Blown In Blanket, blown in cellulose, or Icynene Insealation, all of which provide an insulation of about R-21. The rest of the R-value can be made up with rigid foam insulation placed on the inside or the outside. If urethane foam is available, it can be sprayed into the stud cavity to easily meet the standard. Only taped foil-faced rigid insulation will not require an air/vapor retarder on the warm side of the wall. Foam core panels will also comply with the standard. Beyond about R-30, the high cost of foam insulation makes a double-stud wall insulated with fiberglass batts cost effective.

R-50 Ceiling

An R-50 ceiling is most easily constructed using an energy-heel truss with about 16 inches of fiberglass or cellulose insulation. Allow for at least 80 percent of the required depth of insulation over the bearing walls. You must also provide for about two inches of air space over the insulation if building a cold roof. Baffles should be installed at the eaves to prevent air intrusion into the insulation and to provide an open channel for ventilation over the insulation.

Region 4: Northwest

The Northwest region is a combination of the land within the boundaries of the Northwest Arctic Borough and the NANA Regional Corporation and the boundaries of the Bering Straits Native Corporation. The northernmost boundary more or less follows the south slope of the Brooks Range. Most of this region is underlain with continuous permafrost that is maintained by below-freezing mean annual temperatures. The coastal areas are in the transitional climatic zone with a mean annual temperature between 25 and 35 degrees F, while the inland areas are in the continental zone with a mean annual temperature range from 15 to 25 degrees F. Snowfall ranges from 100 inches in the headwaters of the Noatak and Kobuk Rivers and inland to about 50 inches along the coast.

The Northwest region is in seismic zones 2 and 3, which means that there is a probability of structural damage from moderate earthquakes of magnitude 4.5 to 6.0 on the Richter scale to the south of Norton Bay and a probability of major structural damage in the northern half of the region, with earthquakes greater than 6.0 on the Richter scale. Wind load and snow load are about 30 pounds per square foot in the coastal regions, with an increase in snow load as you move inland and increase in elevation. Check with local building officials and local weather service offices for snow load and wind load and seismic design criteria.

Prescriptive R-values for Northwest

The authors chose the city of Kotzebue (16,000 heating degree days) as a location to develop prescriptive R-values for the Northwest region. Although somewhat colder on an annual basis than the Interior, the Northwest does not have its extreme high temperatures or extreme low temperatures. Kotzebue rarely gets below -50 or above 80 degrees F. Heating degree days in Region 4 range from about 14,000 in Unalakleet to 17,000 in Kivalina.

If you are following the prescriptive method, insulation values for the Northwest region are R-55 in the ceiling, R-30 in above-grade walls (below-grade walls and slabs will be considered in Region 4 only in special cases based upon sound geotechnical engineering principles), R-40 in the floor, R-4 windows, and R-10 doors. This is based on heat recovery ventilation eight hours a day. Add 10 percent to the R-values if non-heat-recovery ventilation is used. Measured air leakage must be less than 1.5 air changes per hour at 50 Pascals. You must comply with all mandatory measures outlined in Appendix A.

R-40 Floors and R-30 Walls

Most foundations in this region will be piling, post and pad, or space frame to reduce the risk of melting the permafrost that underlies most of northern Alaska. As such, elevated insulated floors above open crawl spaces insulated to R-40 will be the norm. These floor and wall systems can be constructed using any one of the systems described for Region 3. Foundations of community buildings that are on permafrost soils must be engineered to prevent differential settlement.

R-55 Ceilings

Check with local building code officials before even beginning to design the roof system for community buildings in the Northwest region. In Kotzebue, for example, the building official requires a tightly sealed hot roof design *only*. Buildings in sheltered inland areas such as Ambler or Shungnak will have deep snow piled up on their roofs and will be best served with well designed and constructed cold roofs. An R-55 ceiling will require about 18 inches of fiberglass or cellulose insulation in a 14-inch high-heel truss system. Insulation baffles must be installed at the eaves in a cold roof system to keep blown-in insulation out of the eaves and to prevent blocking the ventilation space over the insulation. Only a urethane-filled foam core panel can reach the prescriptive standard for this region. Expanded polystyrene (EPS) foam panels are usually built to fit standard framing materials. An 11 1/4-inch EPS-filled panel will only have about an R-45 insulation value.

Region 5: Arctic Slope

The Arctic Slope region includes all of the lands within the North Slope Borough plus the far southeastern sector around Arctic Village, bounded on the south by the 68th parallel. The south boundary of Region 5 runs east and west through the heart of the Brooks range. The Arctic climatic zone is characterized by long, dark, cold winters punctuated by a very short, cool summer. This is truly the land of the midnight sun, with continuous sunlight at Point Barrow from May 10 to August 2. In winter there is continuous darkness or twilight from November 18 until the sun makes its next appearance for a few minutes on January 24. The coast is subject to strong winds, which diminish further inland. The Arctic Ocean opens only briefly in late summer to allow delivery of construction materials by barges.

Permafrost

Almost the entire Arctic Slope region is underlain with deep, continuous permafrost maintained by a mean annual temperature range of 10 degrees to 20 degrees F. Most buildings are constructed on pilings, which can only be drilled and set before breakup to prevent water from filling the holes. In summer, ground water will seep into the drill holes and begin thawing the permafrost, causing the hole to collapse before a piling can be installed. In some coastal areas the depth of the permafrost is limited by salt water intrusion from the Arctic Ocean. If you drill too deeply you will punch through the frozen strata and have no bearing to support the piling. Again, you must know what is beneath the surface before you design the foundation. The new space frame foundation system may be a good alternative to pilings, since it does not have seasonal limitations. All community buildings that are built on permafrost soils must be engineered to prevent differential settlement.

Prescriptive R-values for Arctic Slope

Point Barrow, with 20,000 heating degree days, was selected by the authors to develop minimum insulation values for the prescriptive standard. If following the prescriptive method, the minimum thermal envelope values for the Arctic Slope region are R-60 in the ceiling, R-40 in above-grade walls (below-grade walls and slabs in Region 5 will be considered only in special cases based upon sound geotechnical engineering principles), R-50 in a crawl space floor, R-4 windows, and R-10 doors. These R-values are based on using heat recovery insulation eight hours a day. If non-heat-recovery ventilation is used, add 10 percent to the prescriptive R-values. A measured maximum air leakage of 1.5 air changes per hour at 50 Pascals is required. You must also comply with all of the mandatory measures in Appendix A.

R-50 Floors

An R-50 floor will require about 16 inches of fiberglass or cellulose. Deeper floor joists will be necessary to meet the prescriptive standard for this region. Engineered plywood I-joists up to 24 inches deep can be purchased from most large building supply stores. Parallel chord floor trusses are also easily obtained. The advantage of these kinds of floor systems is that they allow room for running utilities within the joist spaces on the warm side of the insulation. If plywood I-beams are used as joists, carefully cut insulation to fit tightly around the irregular profile of the I-beam, eliminating voids.

Expanded polystyrene foam core panels will not quite meet the standard; however, urethane-filled panels can easily. One of the problems with closed floor systems like foam panels is there is no room to easily run plumbing, heating, ventilation, and electrical systems. Some designers have gotten around this by installing nonstructural joists on top of the foam panel floor system to provide space for utilities and for additional insulation if necessary. Put an insulated arctic chase or insulated corrugated pipe beneath the floor to protect incoming water and outgoing waste water.

R-40 Walls

R-40 walls can be constructed using a single-wall stud system insulated with fiberglass batts and rigid foam applied to the exterior or interior of the studs. This can be expensive in both labor and materials. A double-stud wall insulated with fiberglass batts vertically between the studs and horizontally between the walls can reach insulation values of up to R-60, with the only extra cost being the price of the thicker fiberglass batts. A double 2-by-4 stud wall with five-inch space between walls and insulated with R-11 fiberglass in both stud walls and R-19 in between the walls will meet the R-40 prescriptive standard for this region. Another good system to reach higher R-values is to fur in a foam panel wall system with horizontal strapping or vertical metal or wood studs to provide space for utilities on the warm side of the vapor retarder. This space can be insulated, provided the vapor retarder remains above the dew point temperature. This should be the case as long as no more than one-fifth of the total R-value is on the warm side of the vapor retarder.

R-60 Ceilings

R-60 ceilings can be most easily constructed using energy heel trusses filled with 18 inches of blown fiberglass or cellulose. Foam core panels can also be used, but since the maximum depth of most expanded polystyrene panels only provides an insulation value of slightly over R-40, you will have to add furring either above or below to provide space for additional insulation. Urethane-filled panels framed with 2-by-12s will meet the required R-60 insulation value.

Glossary

Above-grade Wall is any portion of a thermal envelope wall more than 12 inches above an adjacent finished grade (ground).

Air Infiltration is an uncontrolled flow of air through a hole, opening, crack, or crevice in a thermal envelope caused by pressure effects of wind or the effect of differences in indoor and outdoor air density.

Air Retarder is a material carefully installed as part of the building envelope to minimize the passage of air into and out of the building.

Approved is approval by an Alaska Housing Finance Corporation or building official of a material or type of construction as the result of an investigation or test by them, or by reason of an accepted principle or test by a recognized authority or technical or scientific organization.

Back Draft is the reverse flow of chimney gases into the building through the barometric damper, draft hood, or burner unit. This can be caused by chimney blockage or by a negative pressure in the building that is too high for the chimney to draw.

Below-grade Wall is any portion of a wall below ground that extends no more than 12 inches above an adjacent finished grade.

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

Ceiling is a group of members that define the boundaries of a space and has a slope of 60 degrees or less from the horizontal plane.

Conditioned Space is a room or other enclosed space that is intentionally or unintentionally heated to a temperature of 50 degrees F or higher. A bedroom, living room, or kitchen is an example of a conditioned space.

Design Heat Loss expresses the total predicted heat loss from the building over the heating season for a particular building design in a particular climate.

Dew Point is the temperature at which the air is at 100 percent relative humidity. Consequently, if the air comes in contact with a surface that is colder than this temperature, condensation will form on the surface.

Door Area is an opening (other than a window) in a wall, including the framing and sash, used by people to enter and exit a building.

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

EPDM stands for ethylene propylene diene monomer, a synthetic rubber gasket material.

Frost Heaving is the movement of soils caused by the phenomenon known as ice lensing or ice segregation. Water is drawn from the unfrozen soil to the freezing zone where it attaches to form layers of ice, forcing soil particles apart and causing the soil to heave.

Glazing is a transparent or translucent material in an exterior envelope that lets in natural light, including a window, skylight, sliding glass door, glass brick wall, or the glass portion of a door.

Gross Wall Thermal Envelope Area is the sum of all wall thermal envelope areas, including opaque wall areas, window areas, and door areas. It is measured from the subfloor elevation for an above-grade wall or from the top of the footing for a below-grade wall up to the junction point with a roof or ceiling structural member.

Heat Recovery is the process of extracting heat that would otherwise be wasted. For example, heat recovery in buildings generally refers to the extraction of heat from exhaust air.

Heating Degree Days (HDD) is a cumulative measure of the duration and magnitude of the need for heating in a building. It is used in estimating fuel consumption. For any one day, when the mean temperature is less than 65 degrees Fahrenheit, there are as many heating degree days as degrees Fahrenheit difference in temperature between the mean temperature for the day and 65 degrees Fahrenheit.

Hot 2000 is a computer-based energy use analysis program developed by Canada for use in the R-2000 building program.

Pascal is a unit of measure of pressure. Building airtightness tests are typically conducted with a pressure difference of 50 Pascals between the inside and the outside. Fifty Pascals is the equivalent of the pressure of .2 inches of water at 55 degrees F, or roughly equal to a 20-mile-per-hour wind.

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

Semiconditioned Space is a room or other enclosed space that is heated directly or indirectly by the presence of a component of a heating system or by thermal transmission from an adjoining conditioned space. A crawl space, attached garage, mechanical room, or basement is an example of a semiconditioned space.

Skylight Area is an opening in a roof surface that is glazed with a transparent or translucent material, including the frame.

Slab on Grade is horizontally placed concrete in direct or indirect (as when placed over rigid insulation) contact with the ground and used as a thermal envelope floor.

Thermal Envelope is an assembly of a building that is exposed to conditioned or semiconditioned space on one side and the outdoor environment on the other.

Thermal Transmission is the quantity of heat flowing from one space to another through an intermediary element, such as insulation, due to all mechanisms, in unit time, under the conditions prevailing at that time; expressed as Btu per hour.

Unconditioned Space is a room or other enclosed space which is not intentionally heated and experiences temperatures of 50 degrees F or less.

U-value is the coefficient of heat transmission from an interior air film to an exterior air film. 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-hr-°F. U-value applies to the heat flow path through a single or combination of materials that comprise a building section. U-values can **not** be added to give a total U-value for an assembly.

Vapor Retarder is a material that impedes transmission of water vapor from one side to the other under specific conditions. Some vapor retarder materials and the way they are applied also function to impede the flow of air from one side to the other.

Wall is a group of members that define the boundaries of a building or space and that have a slope of 60 degrees or greater from the horizontal plane.

Weather Retarder is the exterior protective material that keeps out wind and rain.

Window Area is an opening (other than a door) in a wall surface that is glazed with a transparent or translucent material, including the framing or sash.

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For access to these books and a host of other energy-efficient construction related publications, call the Alaska Housing Finance Corporation Resource Information Center, (800) 478-INFO, fax (907) 561-6063.

Appendix A
Alaska Building Energy Efficiency Standard

Mandatory Design Measures

Amended slightly; original by Stuart Brooks

Energy efficiency involves insulating the thermal envelope, installing the vapor retarder carefully, providing proper ventilation, installing high-efficiency heating appliances, caulking, sealing, and weather stripping, and applying many other measures that together make a complete, unified system.

2.1 Insulation

Thermal insulation is the primary material that resists the flow of heat out of a heated building. There are many kinds of insulation. Specific application, ability to resist heat flow, flame spread, smoke developed, and other factors vary for each. Insulation installation shall be as recommended by the manufacturer and approved by local building codes.

The following requirements govern the use of a thermal insulation material:

a. A recessed light fixture may be installed in an insulated cavity, provided the fixture is labeled for such installation by an appropriate agency such as Underwriters Laboratory. A fixture shall not break the continuity of a vapor retarder.

b. An insulation material shall not be installed within two inches of a concrete or masonry chimney unless the insulation is designated as noncombustible and approved for such installation by the insulation manufacturer and local building codes.

c. Clearance around a gas flue vent or metal chimney shall comply with provisions of the appropriate ICBO codes.

d. A noncombustible material shall be installed to permanently maintain required clearances of thermal insulation from a heat source.

e. A pipe, wire, electric box, or other object in an insulated cavity shall have insulation shaped and installed around the object rather than compressed behind it or shifted out of place because of it.

f. An insulation material shall not be installed in any manner that obstructs an opening required for attic ventilation.

g. If eave baffles are necessary to maintain required attic ventilation, they shall be wood, metal, moisture-resistant cardboard, or other such material that can be fixed, is rigid, weather resistant, and noncollapsible. A baffle shall provide a minimum clear air space of 1.5 inches above the baffle the full width between roof rafters. An eave baffle itself or solid backing shall shield the face of the insulation to prevent wind from blowing through an eave vent directly into the insulation. Do not extend an impermeable baffle, such as plastic-coated cardboard, the full length of the ceiling. This creates a double vapor retarder problem. See Section 2.8 for more information on permeability requirements of outer envelope materials.

h. Loose fill insulation in ceilings that slope more than 2.5 inches in 12 inches requires a glue binder, netting, or other means recommended by the insulation manufacturer to prevent any settling or slumping of the insulation over time.

i. Loose fill insulation shall meet or exceed the insulation manufacturer's recommended installed density to achieve a required R-value.

j. A corner of an exterior wall or a juncture where an interior wall meets an exterior wall shall be fully and properly insulated.

k. A standard raised-heel truss design shall maintain the required insulation level all the way to the outer line of the building envelope.

l. A drop chord truss design, where the top of the insulation is above the level of the envelope wall top plate, shall extend the insulation all the way to the outside of the envelope wall.

m. Some roof insulation designs create "warm roof" conditions. Warm roofs can result in condensation and ice dam problems. Designers and builders should know the difference between warm roofs and cold roofs and the appropriate application of each.

2.2 Vapor Retarder

The following requirements govern a vapor retarder:

a. A continuous vapor retarder shall be installed throughout a building's thermal envelope, including rim joist areas between floors, except as permitted in paragraph h.

b. A vapor retarder shall be installed at a point between the room interior surface and the theoretical winter dew point within each envelope assembly. The dew point shall be determined using 70 degrees F and 40 percent relative humidity for interior conditions and outside temperature of January average minimum (30-year average) for the building location. See the *Building Energy Efficiency Standard Workbook* for weather data or use other recognized weather data sources.

c. A vapor retarder shall have a dry cup perm rating of 0.6 or less.

d. Different vapor retarder materials may be used throughout a structure, provided the joint between them is sealed, gasketed, or overlapped to provide for continuous coverage as required above. For example, a ceiling and wall vapor retarder may be polyethylene while a floor vapor retarder may be exterior grade plywood with joints caulked.

e. All penetrations, punctures, or tears of a vapor retarder shall be carefully sealed. Sealing can be done with acoustical sealant, gaskets, polyethylene tape, or other products made especially for sealing a vapor retarder. Select a proper sealing material for the intended application. For example, latex, oil-based, or silicone caulks lose their sealing ability over time and should not be used to seal a vapor retarder. In most situations, acoustical sealant has proven to be effective. Sealing over solid backing is recommended.

f. Where seams in polyethylene vapor retarders are parallel to framing members, they shall be overlapped a minimum of one framing member. Where seams face an air space or do not occur over solid backing, such as a seam perpendicular to framing members, they shall be sealed with vapor retarder tape. Where seams are sandwiched between rigid materials, such as between framing and gypsum wallboard, they do not need to be sealed (although it is recommended). Duct tape shall **not** be used for any sealing.

g. A polyethylene vapor retarder shall not be drawn tightly across framing members before fastening. Slack in the polyethylene shall be provided to allow for expansion, contraction, and movement of structural members.

h. A vapor retarder is not required for a crawl space wall.

i. A vapor retarder of minimum six mil (0.006 inches) thick polyethylene or approved equal shall be laid over the ground within a crawl space. A vapor retarder shall be overlapped 12 inches minimum at all joints and shall extend up the crawl space wall a minimum of 12 inches. It is recommended that the vapor retarder be protected from punctures or tears by covering it with a two-inch layer of concrete or sand.

2.3 Airtightness

Cracks, joints, and openings in a building's thermal envelope can be the cause of as much as 40 to 50 percent of a building's total heat loss. This standard contains a number of measures to minimize uncontrolled air movement through a thermal envelope. Controlling random air movement and providing controlled ventilation is the best way to reduce air leakage and heating costs, reduce the infiltration of radon, protect the building structure, and provide needed fresh air.

Blower Door Testing. Air tightening may be accomplished in any manner provided total air changes per hour (ACH) for a building does not exceed 1.5 ACH at 50 Pascals when tested in accordance with the ASTM (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103) E779-87 "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization" or the Canadian CAN/CGSB-149.10-M86 "Standard for Determination of Airtightness of Buildings by the Fan Depressurization Method."

2.4 Fireplaces and Wood Stoves

A fireplace or wood stove shall be installed with the following:

a. A tight-fitting, closable metal or glass door covering the entire opening of the firebox;

b. A means to use outside air for combustion, as per manufacturer's design specifications, and equipped with a readily accessible, operable, and tight-fitting damper;

c. For a fireplace, a tight-fitting flue damper with a readily accessible manual control.

Exception: gas-burning fireplaces shall have a minimum position stop on the damper as specified by the fireplace manufacturer and the appropriate ICBO codes.

2.5 Ventilation Requirements

The airtightness requirements in this standard substantially reduce air leakage through a building's thermal envelope. This provides the opportunity to introduce controlled ventilation into a building, resulting in health, comfort, and energy efficiency benefits. Airtightness, controlled ventilation, and regular maintenance all work hand in hand to achieve good indoor air quality. A heat recovery ventilator is not required, but is highly recommended.

Ventilation requirements shall be met by using one of the two options listed below and by meeting the requirements of subsection **2.5.3 Mandatory Measures for Ventilation, Options I and II.**

2.5.1 Ventilation Option I

The current ASHRAE (the American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329) Standard 62, "Ventilation for Acceptable Indoor Air Quality" shall be used to determine ventilation requirements for a building.

2.5.2 *Ventilation Option II*

This ventilation option applies only to a residential building. These requirements deal only with normally encountered levels of household pollutants. Further, this option assumes outdoor air is suitable for ventilation. Specific pollutants and their acceptable levels for adequate indoor air quality are provided in ASHRAE Standard 62. Additionally, the ventilation air called for below does not provide for the combustion or dilution air requirements of a combustion appliance. For Ventilation Option II, all requirements under subsection **2.5.4 Additional Mandatory Measures for Ventilation Option II** shall be met.

Ventilation Rate. A ventilation system shall have the capacity to provide ventilation air (air supplied to and exhausted from) *the greater of:*

a. 0.30 air changes per hour (ACH), based on the volume of conditioned space within a building (this assumes 0.05 ACH is provided by natural air leakage);

or

b. The ventilation air rate for a building as determined by using the procedures for room count.

Table 2.3 Minimum Ventilation Air Requirements, cfm

Space	Base Flow Rate	Continuous Exhaust	Intermittent Exhaust
Category A Rooms: Supply			
Master Bedroom	20		
Other Bedrooms	10		
Living Room	10		
Dining Room	10		
Family Room	10		
Recreation/Hobby Room*	10		
Nonpartitioned Basement	20		
Other Habitable Rooms	10		
Category B Rooms: Exhaust			
Kitchen	10	25	100
Bathroom	10	20	50
Laundry Room*	10		
Utility/Work Room* (not mechanical room)	10		

* these rooms may generate excessive indoor air pollutants and may require additional exhaust capability.

Procedures for using Table 2.3:

1. Add the base flow cubic feet per minute (cfm) rate for each room in the building.
2. Add the continuous exhaust flow rate for each room in the building.
3. Total ventilation air flow shall be the larger of total base flow cfm or the total continuous exhaust flow cfm. This is the minimum supply and exhaust air that shall be provided.
4. If the total continuous exhaust cfm is larger than the total base flow cfm, then supply air shall be increased to match the exhaust cfm flow rate, or part of the exhaust requirement may be accomplished by intermittent exhaust. If a space chosen for intermittent exhaust is a bathroom or kitchen, the minimum intermittent flow rate listed for the room shall be met. Intermittent exhaust air shall be transported direct to the outdoors. Total continuous ventilation air flow shall still be the larger of the remaining continuous exhaust air flow or the base air flow.
5. The ventilation air requirement for a combined room such as living/dining or kitchen/dining may be determined as if each were an individual room.
6. Ventilation air to a Category B room called for in the base flow rate column can be provided indirectly from a Category A room through continuous exhaust from a Category B room.
7. Ventilation system design shall account for any air flow loss as a result of design specifics or installation effects. A minimum air flow rate specified above shall be verifiable after installation is complete. Caution: research studies show that low to medium quality ventilation equipment and duct systems generally result in actual air flow rates only 30 to 50 percent of an equipment's rated ventilation capacity. It is recommended that high quality ventilation equipment with a 2.0 sone rating and permanent split capacitor motor be used.

2.5.3 Mandatory Measures for Ventilation Options I and II

a. Ventilation air through an exterior door or operable window shall not be considered as part of a ventilation system design and shall not be included in proving compliance with a required minimum ventilation rate. Opening windows and doors do **not** count.

b. Estimated natural ventilation provided by leaks through a building's thermal envelope may be included as part of a ventilation system design. The natural ventilation flow rate, however, shall be confirmed after construction is complete by one of the blower door test methods specified in Section 2.3, Airtightness. The air flow rate shall be stated in terms of cfm and shall be derived using the Lawrence Berkeley Laboratories (LBL) methodology. Modification of this methodology is not allowed. The test shall be conducted by a person trained and certificated to do such work. The accuracy of airflow measurement for blower door equipment shall be accurate within plus or minus 10 percent of the actual measured flow rate. Pressure measurement apparatus shall be accurate to within plus or minus two Pascals. If the tested natural ventilation rate is less than estimated during design, the ventilation system shall be upgraded so that the total minimum ventilation air requirement is met.

2.5.4 Additional Mandatory Measures for Ventilation Option II

a. If using a central ventilating appliance, the supply and exhaust air flows shall be balanced within plus or minus 10 percent of each other. A means to permanently assure flow rates within the balancing tolerance shall be provided.

b. A ventilation system shall be designed and installed to uniformly mix and circulate supply air throughout an occupied zone. Supply air shall be introduced into a room in a manner that does not create human discomfort and is not potentially damaging to the building.

c. There shall be adequate air circulation into and out of a room at all times. A door or transom louver, undercut door, wall transfer fan, return grille or other means shall be used.

d. Exhaust air shall not be recirculated except that cross flow leakage from the exhaust to the supply air stream of a heat recovery ventilator (HRV, formerly referred to as air-to-air-heat exchanger) shall be limited to no more than five percent.

e. A back draft or automatic damper shall be used to provide positive closure of a dedicated exhaust duct during a standby period.

f. A clothes dryer or kitchen range hood exhaust duct shall lead directly to the outdoors and shall not be connected to a ventilation system.

g. A ventilation system's supply and exhaust vents on the exterior of a building shall be separated a minimum of six feet horizontally and shall be at least 18 inches above an adjacent finished grade. A vent location shall also be placed a minimum of 10 feet horizontally away from a known pollutant source (such as car exhaust fumes). Care shall be taken to locate a vent where wind or snow accumulation does not adversely affect the ventilation system's performance. Coordinate location requirements with the appropriate ICBO codes and local site conditions.

h. An exterior exhaust vent shall not be located where the exhaust air rises into an attic vent.

i. A duct transporting ventilation air shall be sealed at all joints. Wrapping with duct tape alone is not adequate. A duct transporting ventilation air of 60 degrees F or greater through any unconditioned space shall be insulated to a minimum of R-6 and wrapped with a vapor retarder of 0.06 perms or less.

j. A ventilation air duct shall use a smooth-walled material such as galvanized steel or lined fiberglass (rigid or semirigid) as much as possible. When necessary to use flexible ducting, it shall be supported along its full length with no sags and no bends greater than 90 degrees.

k. A mechanical ventilation appliance shall be equipped with one or more automatic controls. Some examples are a timer, dehumidistat, or sensor. A control shall also have a manual override option.

l. A ventilation system may be designed to shut completely off during daily periods when a building is not occupied. A manual shutoff capability shall be provided for extended periods of nonoccupancy.

m. Where the operation of a ventilation system includes a period when no supply air is provided (such as defrost cycles for heat recovery ventilators), the system shall be designed so that the total time of no supply air does not exceed one hour within any two hour period.

n. A builder shall provide written operation and maintenance instructions to the building owner for the ventilation system.

o. A combustion appliance such as a furnace, boiler, wood stove, or fireplace shall be provided with sufficient combustion and venting air as required by the appliance manufacturer. This requirement is in addition to ventilation air requirements given above.

p. A ventilation appliance shall not be located in a space that is difficult or inconvenient to access such as a crawl space or attic if the appliance requires maintenance on a monthly or more frequent basis.

2.5.5 Air Pressure Limitations

Controlling interior air pressures within acceptable positive and negative tolerances is critical to occupant safety, building longevity, and building performance. Positive pressure can force moist indoor air into the thermal envelope. This moisture can condense, freeze, and build up over the winter. Ice buildup degrades insulation performance and encourages mold and mildew growth, and ice expansion damages the building. Thawing during the summer causes water damage and wood rot. This damage often goes unchecked for several years because it occurs mostly within the thermal envelope, out of sight. Negative pressure can cause back drafting of heating and cooking appliances. Back draft exhaust fumes contain a number of gases dangerous to human health such as carbon monoxide and nitrogen oxides. Carbon monoxide causes headaches, drowsiness, shortness of breath, blurred vision, and dizziness. High concentrations lead to death. Nitric oxide produces toxic effects similar to carbon monoxide and additionally irritates the eyes, nose, and throat. Nitrogen dioxide causes lung damage.

2.6 Windows, Doors, and Skylights

Windows, doors, and skylights affect heat loss more than any other element of a building's thermal envelope. For example, windows can account for as much as 25 percent of the total envelope conductive heat loss, although they generally account for only three to five percent of the total envelope area. A common double-glazed window loses 10 times more heat per square foot than a 2-by-6 insulated wall.

The following requirements apply to a window, door, or skylight:

a. A product performance claim referencing a test conducted after December 31, 1994 shall be acceptable only if testing was performed using the protocols specified by the National Fenestration Rating Council (NFRC, 962 Wayne Avenue, Suite 750, Silver Springs, MD 20910). Such a test shall be conducted by an independent laboratory certified by NFRC to perform such a test. The test report shall include a statement that the test was performed in accordance with NFRC protocols.

   1. Standard test size for residential windows shall be:

Window Type	Width by Height (inches)
Horizontal Sliding	60 by 36
All Other	36 by 48

   2. A window test sample shall be of a production line closest to the model size stated above.

b. A sample used for testing shall be a production line unit representative of a unit commonly manufactured. No adjustment shall be made to a unit to prepare it for testing other than would ordinarily be made in the field by a builder.

c. A manufacturer's literature is **not** an acceptable substitution for a laboratory test report. A report will be available for public inspection to allow consumers to verify performance claims.

d. A hollow core wood door or a single-glazed window or skylight in the thermal envelope is not allowed.

e. A metal frame for a window, skylight, or threshold shall have a continuous thermal break between inside and outside metal surfaces.

f. Air infiltration shall be limited to the following maximums:

   1. **Operable Window:**

      casement: 0.10 cubic feet per minute per linear foot of operable sash crack;
      awning/projecting: 0.15 cubic feet per minute per linear foot of operable sash crack;
      sliding/double hung: 0.20 cubic feet per minute per linear foot of operable sash crack;

fixed: 0.10 cubic feet per minute per square foot of window;
all other: 0.15 cubic feet per minute per linear foot of operable sash crack.

2. **Swinging Door:** 0.10 cubic feet per minute per linear foot of door perimeter;
3. **Sliding Door:** 0.05 cubic feet per minute per square foot of door.

2.7 Crawl Space Vents

A crawl space vent shall be equipped with a mechanism allowing tight closure when necessary.

Exception: Combustion air shall be provided at all times to an appliance that draws crawl space air for combustion.

2.8 Permeability of Outer Envelope Materials

Water vapor penetrating through a vapor retarder must be able to pass on through a building's thermal envelope material to the outdoors. Water vapor that does not pass through to the outdoors condenses 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 can damage insulation and a building's structure.

Permeability of building materials on the exterior side of a vapor retarder determines how easily vapor within a thermal envelope assembly migrates to the outdoors. These materials shall therefore have a dry cup perm rating of five or more.

Exception: A panelized foam core building product; insulation board product such as urethane, polyisocyanurate, or expanded polystyrene; or plywood siding product is exempted. If using an insulation board product on the exterior, do not tape joints between boards.

2.9 Attached Garages

A wall, ceiling, or floor of a conditioned space adjoining a garage shall have insulation and a vapor retarder installed in the same manner as required for other thermal envelope assemblies. For this purpose, a garage shall be considered an unconditioned space.

2.10 Conservation of Hot Water

Hot water is usually the second most demanding use of energy in a building. In a highly insulated building, hot water can be *the* most demanding use of energy. Efficient use of hot water, therefore, can lower a building's energy costs significantly.

The following mandatory measures are required:

a. A shower head shall be equipped with a flow control device that limits water flow to a maximum of 2.5 gallons per minute.

Exception: A flow control device is not required where water turbidity or the distribution pressure at an outlet may render it unusable.

b. A toilet shall be plumbed to use the least amount of heated water necessary to prevent condensation on the tank or bowl. Alternatively, an insulated toilet tank may be used to prevent condensation. Note: continuous ventilation of the bathroom should minimize condensation.

c. A domestic hot water tank installed in an unconditioned space shall have the tank top and side surfaces insulated to at least R-16 for an electric water heater or storage tank or R-10 for a fuel-burning water heater or storage tank. Insulation may be an integral part of or wrapped around the outside of a water heater or storage tank. In no case shall the combined internal and external insulation total be less than required. Externally wrapped insulation shall not cover the control panel nor interfere with a relief or drain valve, drain pipe, incoming or outgoing plumbing line, or air flow requirement. Clearance to a flue gas vent shall be as specified in the appropriate ICBO code.

Exception: A water heater with no storage tank is exempt from the above insulation requirements.

d. A hot-water pipe coming out of a water heater shall be insulated with at least R-4 insulation for the first three feet of pipe closest to the water heater. It is not necessary, however, to penetrate a wall or ceiling with the pipe insulation to maintain the three-foot requirement. Check ICBO codes for required clearances to a flue gas vent.

e. To minimize conductive heat loss, an electric water heater shall not be placed in direct contact with a concrete floor. A platform shall be constructed to provide a minimum clearance of 10 inches from the concrete floor to the bottom of the heater, or R-10 insulation between the floor and the bottom of the heater shall be installed.

f. A water heater shall have a thermostat capable of varying the heater's temperature setting. At time of installation a thermostat shall be set to 120 degrees F. A builder shall instruct the building owner about the ability to vary the temperature setting.

g. A water heater shall be equipped with a heat trap, check valve, or other mechanism on both inlet and outlet pipes to prevent convective water movement.

2.11 Plumbing

A hydronic or domestic hot-water pipe located outside of a conditioned space and not intentionally used to heat the space or, if within three inches of a cold-water pipe, shall be insulated to a minimum R-4.

2.12 Heating Air Ducts

A heating air duct shall be sealed against air leakage at all joints and seams by using caulking, sealant, or other appropriate material. Wrapping with duct tape alone is not adequate.

A duct transporting air of 60 degrees F or more through an unconditioned space shall be insulated to a minimum R-6 and wrapped with a vapor retarder of 0.06 or less perm rating.

2.13 Heating Systems

Poorly or improperly functioning heating equipment can easily increase heating costs by 25 percent. Savings gained from better equipment, properly installed and maintained for maximum efficiency, can more than offset the extra cost of that equipment.

The following requirements govern a heating system:

a. A heating appliance shall be installed, tested, and adjusted per the manufacturer's recommendations before being turned over to a building owner.

b. Adequate combustion air shall be provided to an appliance for proper operation at all times.

c. A chimney or exhaust gas vent system shall be installed per the manufacturer's recommendations for proper operation, maintenance, and safety to eliminate condensation or back drafting problems.

d. A heating appliance and its related components shall meet or exceed the manufacturer's federal requirements for energy-efficiency performance current at the time of installation.

Appendix B
Energy Efficiency Standard Air Pressure Limitations

Excessive positive or negative air pressure within a building can adversely affect the performance of heating and ventilating equipment, the health and comfort of occupants, and the durability of the structure. The following guidelines, therefore, set pressure limits.

Pressure Increase Limits

Positive pressure in a building can force moist interior air into a ceiling, wall, or floor, causing condensation, frost, mold, and wood rot problems. There is also a possibility that the combustion efficiency of some fuel-burning appliances may be adversely affected by excessive pressure.

Therefore, a ventilation system shall be designed so that if operated in a continuous mode the sum of all flows through supply air devices shall not exceed the sum of all flows through exhaust air devices by more than 0.014 cfm/sq. ft. of interior surface of the building thermal envelope.

Pressure Decrease Limits

In order to avoid dangerous combustion appliance back drafting, depressurization within a building caused by a mechanical exhaust device is limited as follows:

- For a building using a Category I fuel-burning appliance, the reference exhaust air flow shall not decrease the pressure in the building relative to the outside by more than five Pascals of pressure.
- For a building using a Category II appliance, the reference exhaust air flow shall not decrease the pressure in the building relative to the outside by more than either 10

Pascals of pressure or the value for which the appliance has been certified by an accredited agency.

- For a building using a Category III appliance, the reference exhaust air flow shall not decrease the pressure in the building relative to the outside by more than either 20 Pascals of pressure or the value for which the appliance has been certified by an accredited agency.
- If no fuel-burning appliance is installed in a building, the reference exhaust air flow shall not contribute to decreasing the pressure in the building relative to the outside by more than 20 Pascals of pressure.

Reference Exhaust Air Flow

In defining the reference exhaust air flow, all powered exhaust appliances that contribute to the net exhaust are considered, with the exception of a fuel-fired heating appliance. Net exhaust means exhaust air flow in excess of supply air flow. Some appliances, such as heat recovery ventilators, have both supply and exhaust air flow through the appliance. To obtain the reference exhaust air flow:

Add the net exhaust air flow of the ventilation system, the clothes dryer (or 160 cfm if one is not yet installed), and the two additional installed mechanical exhaust devices providing the largest net exhaust air flow (for example, this could be a downdraft cooktop vent and a central vacuum).

Category I Fuel-burning Appliance

This appliance takes combustion air and chimney draft dilution air from within a building; is installed with a draft hood, draft regulator, or other means of allowing for regulation of dilution air; and depends upon natural draft to vent products of combustion to the outdoors. For example, such an appliance includes a fireplace, wood stove, natural draft furnace, boiler, water heater, or gas range. This type of combustion appliance is the most sensitive to back drafting.

Category II Fuel-burning Appliance

This appliance takes combustion air from a building but has a sealed, gas-tight, corrosion-resistant flue without any openings through which combustion gases can back draft into the building. Such an appliance includes a forced draft or induced draft heater.

Category III Fuel-burning Appliance

This appliance takes combustion air directly from outside through a connection sealed from the atmosphere in the building and has a sealed, gas-tight, corrosion-resistant flue without any openings through which combustion gases can back draft into the building. This type of appliance is the least sensitive to back drafting.

Make-up Air and Pressure Relief Vents

A make-up air or pressure relief vent may need to be provided to keep a building pressure within the limits given in Pressure Increase Limits and Pressure Decrease Limits above. The table below may be used to size an air vent. A design may require this vent to function for both make-up air and pressure relief. An air vent shall be placed where cold incoming air does not make the occupants uncomfortable. An example of how to determine indoor pressures and how to size a make-up or relief air vent is included in the Alaska Craftsman Home Building Manual (2nd ed.).

Maximum Passive Air Flow Met by Relief or Make-up Air Vents

Vent Diameter (Inches)	ELA * (in.^{2})	Air Flow Met by Vent (cfm) ** Pressure Difference 5 Pa (.02" WG)	10 Pa (.04" WG)	20 Pa (.08" WG)
3	7	8	10	19
4	13	16	23	38
5	20	31	46	67
6	28	53	74	114
7	38	85	106	169
8	50	116	159	254
9	64	169	233	318
10	79	212	296	445

* ELA means equivalent leakage area

** Calculated flow rates for passive make-up or relief air vents assuming an equivalent length of 66 feet. If more airflow is needed than shown, use two or more vents spaced throughout the building.

Appendix C Reading the HRV Design Specification Sheet

You can use the HRV Design Specification Sheets to compare the performance and efficiencies of different HRVs and to determine what units can satisfy the base ventilation requirements of a given building. From the heat recovery efficiency you can estimate the anticipated energy savings from a properly installed and operated unit relative to a system providing the same air change without heat recovery. Remember that the air flow performance of an HRV is more important than the heat recovery efficiency. A high heat recovery efficiency is of little value if the HRV cannot satisfy the base ventilation requirements.

To determine whether a particular unit will satisfy the ventilation requirements of a given building, compare the air flow performance, the efficiency, and installation details with other HRVs:

- Determine the airflow needed through the unit to meet ventilation requirements. Find this number in the "Net Supply Air Flow" column, then look to the left and find the external static pressure (ESP) available at this flow. This is a measure of how much duct resistance the unit can overcome at a given air flow. If the external static pressure available at the required flow is greater than 100 Pa (0.4 in. of water), or if you know or suspect that the duct resistance will be higher than normal, select a more powerful unit and consult with a duct designer.
- When comparing the energy performance of different units, look at their sensible recovery efficiency. This figure provides the basis for an overall comparison that integrates fan power, defrost, and other factors. Efficiencies are given at various flows and at two test temperatures, 32 degrees F (0 degrees C) and -13 degrees F (-25 degrees C). Find the air flows that match the continuous flow rate required by the building, then determine the sensible recovery efficiency. The higher the number, the better.

Selecting an HRV

Many different products are available. The selection of an HRV system should be based on the following:

- The ability of the equipment to meet the ventilation requirements for the dwelling, both continuously and intermittently.
- The heat recovery efficiency of the HRV and the local fuel costs.
- The availability of equipment suitable for the climate and trained service people and installers in your area.
- The defrost mechanism of the equipment, specifically whether it can depressurize the building and affect make-up air requirements.
- The installed cost of the equipment.

HRVs tested to the Ortech standard will have a Home Ventilating Institute (HVI) certified rating and label. Additionally, HVI provides the actual certification for Ortech HRV design specification tests and sheets.

HRV SPECIFICATION SHEET

Testing Agency: ______________________ Model: ______________________
Date Tested: ______________________ Serial Number: ______________________
Manufacturer: ______________________ Options Installed: ______________________
Address: ______________________

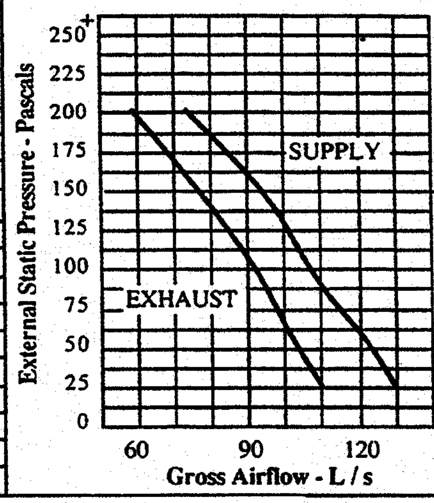
Telephone: ______________________ Electrical Requirements: 120 Volts 2.05 Amps

VENTILATION PERFORMANCE

Maximum Continuous Rated Airflows:
55 L/s @ -25 C
73 L/s @ 0 C

Lowest Temperature Unit Tested To: -25 C
Low Temperature Ventilation Reduction During -25 C Test: 5 %
Maximum Unbalanced Airflow During -25 C Test: 49 L/s
Exhaust Air Transfer Ratio: 0.03

External Static Pressure		Net Supply Air Flow		Gross Air Flow			
				Supply		Exhaust	
Pa	in. W.G.	L/s	cfm	L/s	cfm	L/s	cfm
25	.1	126	267	130	275	111	235
50	.2	120	254	124	263	104	220
75	.3	112	237	115	244	99	210
100	.4	105	223	108	229	92	195
150	.6	93	197	96	203	77	163
200	.8	71	150	73	155	57	121



ENERGY PERFORMANCE

		Supply Temperature		Net Airflow		Supply / Exhaust Flow Ratio	Average Power (Watts)	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
		°C	°F	L/s	cfm					
HEATING	i	0	32	35	74	1	124	86	102	.08
	ii	0	32	53	112	1	138	83	93	.07
	iii	0	32	73	155	1	206	82	92	.05
	iv	0	32	55	117	1	142	83***	—	—
	v	-25	-13	53	112	.96	144	59	77	.03
	vi	-25	-13	55	117	—	144	58***		
COOLING	vii	35	95	72	153	.99	210	26 **		
	viii	35	95	51	108	.99	140	26 **		

***Description of Defrost:**Defrost was activated by a temperature sensitive switch in the cold supply side of the HRV (-5 C setpoint). During defrost both fans would remain running and a damper simultaneously blocks the cold supply inlet and opens a port to bring ambient (indoor) air through the supply side of the HRV. During defrost the HRV continues to exhaust air. Defrosting was controlled by a timer. The unit operates for 31 minutes then defrosts for 6 minutes.

** Indicates Total Recovery Efficiency, not Sensible Recovery Efficiency.
+ 250 Pascals = 1" of Water: 0.47 L/s = 1 cfm.
*** Calculated for R2000 Home Program Rating Purposes.

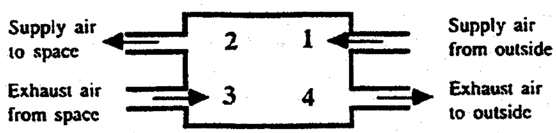
Comments from Test Agency: The rated airflows are for continuous operation . Higher airflows may be achieved during intermittent operation, however defrost ability was not tested for these conditions. All efficiency tests were done at intermediate fan speed settings.

ORF Reference Report: EEE/ESC-88-74

Testing was performed in general accordance with CAN/CSA - C439 - 88, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators and was conducted in accordance with normal professional standards. Neither the Ontario Research Foundation nor their employees shall be responsible for any loss or damage resulting directly or indirectly from any default, error or omission. Specification Sheet format revised September, 1988.

EXPLANATION OF HRV SPECIFICATION SHEET

A heat recovery ventilator provides controlled ventilation while preventing undue loss of heat. The supply side of the device brings fresh air into the home, while the exhaust side vents stale air to the outside. Heat is transferred from the warmer to the cooler air as the two streams flow past one another in the core of the unit. Points 1 through 4 on the diagram refer to air from outside to equipment (1), air from equipment to space (2), air from space to equipment (3), and air from equipment to outside (4) respectively.



The HRV Design Specification Sheet shows test results and values calculated from test data. The unit tested was supplied by the manufacturer or Canadian distributor, who claims that it is representative of models offered for sale at the date of testing. The model number is the distributor's designation of the unit tested. The tests determined ventilation performance; percentage of exhaust air carried over into the supply air; the capability of the ventilator to recover heat from one air stream and transfer it to the other under varying conditions; and performance during cold weather (referred to as "the 72-Hour Cold Weather Test").

All air flow data are corrected to standard conditions of air density of 1.201 kg/m3 (0.075 lb/cu.ft.). In order to make precise calculations, please refer to CAN / CSA - C439 - 88, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators. **It is important to recognize that for comparison of equipment, only data at equivalent supply temperature and net air flow should be used.**
For an explanation of the terms used, refer to the list below.

PERFORMANCE SUMMARY

Maximum Continuous Rated Airflow
Maximum continuous net outdoor airflow selected by manufacturer for testing and rating of the unit at the temperature shown.

Airflow Range for Multispeed Units
Airflow achieved by setting unit at Maximum Rated Airflow, then using unit controls to reduce flow. Fixed speed units will have individual rating points. Variable speed units will have a range of flows shown.

Exhaust Air Transfer Ratio
Ratio of the quantity of exhaust air found in the air supply to the total air supply flow. This ratio can be expressed as a percentage if multiplied by 100.

$$\text{Exhaust Air Transfer Ratio} = 1 - \left(\frac{\text{Net Supply Air Flow}}{\text{Gross Supply Air Flow}} \right)$$

Low Temperature Ventilation Reduction
The percentage reduction in net outdoor air flow rate at the end of the 72-Hour Cold Weather Test, compared with operation at 22 C conditions. The final flow rate is taken as the average from the last 12 hours of the test.

Max. Unbalanced Airflow During Low Temperature Test
This represents the depressurization potential during normal operation (including defrost). Short term transients caused by dampers moving are not considered, nor is depressurization caused by equipment or component failure, or blockage.

Lowest Temperature Unit Tested to
The supply temperature at which the 72 hour test was carried out.

VENTILATION PERFORMANCE

External Static Pressure
The total differential measured between Points 1 and 2 (supply) or Points 3 and 4 (exhaust).

Net Supply Air Flow
The gross supply air flow minus cross-leakage (EATR). This is the actual amount of outside air supplied by the unit and is used only for sizing the equipment for the required ventilation rate.

Gross Exhaust and Supply Airflows
The measured volume of air at Points 2 and 3 which may contain recirculation air from cross-leakage (EATR). These values are used only for selecting ductwork.

ENERGY PERFORMANCE

Values are listed for various test points of supply (outside air) temperature, and corresponding air flow points are selected according to specific pressure or Net Supply Air Flow. The number of test points listed depends upon the manufacturer.

Supply Temperature
This column shows (i) steady state tests at 0 C (32 F) at maximum rated air flow and at other test points selected by the manufacturer; (ii) the 72-Hour Cold Weather Test, carried out at temperature shown at maximum rated air flow (All values are taken as the average over the last 12 hours of the test).

Net Air Flow
Average net maximum air flow during test period adjusted for cross - leakage (EATR).

Average Power (kilowatts)
The average power consumption (watts) during the specific test for fans and controls. See also Description of Defrost.

Sensible Recovery Efficiency (SRE)
The sensible energy recovered minus the supply fan energy and preheat coil energy, divided by the sensible energy exhausted plus the exhaust fan energy, corrected for cross - leakage (EATR). This value is used to determine and compare HRV heat recovery performance.

Apparent Sensible Effectiveness (ASE)
The measured temperature rise of the supply air stream divided by the temperature difference at Points 1 and 3 and multiplied by the mass flow rate of the supply divided by the minimum of the mass flow rate of the supply or exhaust streams. This value is used principally to predict final delivered air temperature at a given flow rate.

Total Recovery Efficiency (TRE)
The total energy recovered minus the supply fan energy and the preheat coil energy, divided by the total energy exhausted plus the exhaust fan energy, corrected for cross-leakage (EATR). It is used principally to predict and compare performance for cooling applications.

Net Moisture Transfer (NMT)
Moisture recovered divided by moisture exhausted and corrected for the effect of cross leakage. NMT=0 indicates that moisture was not transferred (other than that associated with cross leakage from the exhaust to the supply air). NMT=1 would indicate complete transfer of moisture at test conditions.

Description of Defrost
Describes defrost operating system. For units with an electric defrost system, the electrical energy required during cold weather operation over and above the normal operating requirements for fans and controls is also described.

Appendix D
Log Building Standards

1995 Log Building Standards
for Residential, Handcrafted, Interlocking, Scribe-fit Construction

American Log Builders Association

The association, founded in 1974, is a world-wide organization devoted to furthering the craft of log construction. Registered as a nonprofit society in the United States, the ALBA writes and distributes educational material on log construction to individuals, institutions, and industry. The organization is dedicated to the advancement of log builders and to the promotion of the highest standards of their trade.

It is the responsibility of every builder to understand and to conform to the best practices of the trade. These are minimum standards for residential, handcrafted, interlocking, scribe-fit log construction. They are revised by the Building Standards Committee of the ALBA. Changes to this edition were made in January 1995.

The ALBA has endeavored to prepare this publication based on the best information available to the ALBA. While it is believed to be accurate, this information should not be used or relied upon for any specific application without competent professional examination and verification of its accuracy, suitability, and applicability. The publication of the material herein is not intended as a representation or warranty on the part of the American Log Builders Association, its affiliates, or any person named herein that this information is suitable for any general or particular use or of freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability arising from such use.

These standards are founded on performance principles that allow the use of new materials and new construction systems. Anyone may propose amendments to these standards. These standards are not intended to prevent the use of any material or method of construction not specifically prescribed by these standards, provided the proposed action is satisfactory and complies with the intent of the provisions of these standards and that the material, method, or work offered is, for the purposes intended, at least the equivalent of that prescribed in these standards in suitability, strength, effectiveness, fire resistance, durability, safety, and sanitation.

For further information, or additional copies of these standards, please contact:

American Log Builders Association
7928 Lynwood Dr.
Ferndale, WA 98248, USA

Standards

Preface

1. In these standards the word "shall" means mandatory, and the word "may" means discretionary.
2. The 1995 Log Building Standards are comprised of both the **standards** and the **commentary**.

Section 1 Foundations

Shall conform to applicable building codes and accepted engineering practice.

Section 2 Log Walls

2.A. Log Specifications

2.A.1. The minimum diameter of wall logs shall be 20 centimeters (8 inches).

2.A.2. Green or dry logs may be used for construction.

2.A.3. Logs shall have all bark removed and **shall be of sound wood.**

2.A.4. Spiral Grain

The following restrictions apply to the use of green logs. (Refer to Table 2.A for definitions of spiral grain categories):

a. Left-hand severe spiral grain logs shall be used as wall logs only as cut-in-half sill logs.

b. Left-hand moderate spiral grain logs shall be used only as continuous logs (not cut through for door, window, or other openings), not used for splicing (see Section 2.G), and shall be used only in the lowest one-third (1/3) of the vertical height of the wall.

Commentary

Section 1 Foundations

Like all buildings the foundation of a log building must be of sufficient design to support safely the loads imposed as determined from the character of the soil. In addition to the loads imposed by gravity, the foundation is important in connecting the building to the ground as it resists wind or seismic forces and accelerations. Therefore the connection between the building and the foundation must also be capable of resisting the sliding, uplift, and overturning associated with local wind and seismic conditions.

Section 2 Log Walls

2.A. Log Specifications

2.A.1. Logs smaller than 20 centimeters (8 inches) in diameter are unsuited to residential construction.

2.A.2. For the purposes of this standard, "dry" means moisture content equal to or less than 19 percent, and "green" means moisture content greater than 19 percent. Dry and green logs have different requirements for preventing sap stain and have different shrinkage and structural properties that must be appropriately accounted for in design and construction.

2.A.3. Leaving the bark on logs promotes insect attack and makes scribe fitting difficult. Eventually, the bark will fall off by itself, although by that time the wood has usually been degraded by fungus or insects or both.

2.A.4. Spiral grain is the condition in which the alignment of wood fibers is at an oblique angle to the long axis of the log. Spiral grain is expressed as the slope of the direction of fiber alignment to the length of the log—this slope is shown in Figure 2.A.

Standards

c. Right-hand severe spiral grain logs shall be used only as continuous logs (not cut through for door, window, or other openings), not used for splicing (see Section 2.G), and shall be used only in the lower one-quarter (1/4) of the height of the wall.

d. Right-hand moderate spiral grain logs may be used as a wall log at any location in the building, except they shall not be used as a plate log.

e. Straight grain logs may be used in any location.

f. Plate logs shall be straight grain only, see also Section 2.I.4.

Table 2.A

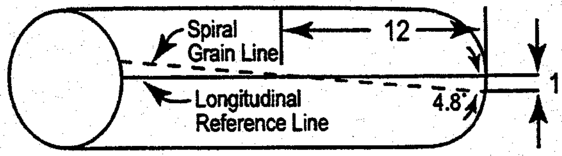
	Right	Left
straight	less than 1:24 less than 2.4°	less than 1:35 less than 1.6°
moderate	1:24 to 1:12 2.4 to 4.8°	1:35 to 1:24 1.6 to 2.4°
severe	greater than 1:12 greater than 4.8°	greater than 1:24 greater than 2.4°

Commentary

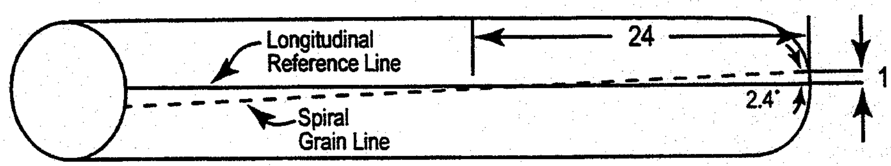
To determine fiber alignment, examine the log for surface checks caused by drying—surface checks are parallel to fiber alignment. Another option is to use a sharply pointed timber-scribe instrument designed for detecting spiral grain.

To determine whether a log has left hand or right-hand spiral grain, place your hand on the log, fingers pointing down the length of the log. You can stand at either end of the log. If the grain spirals around the trunk like a barber pole in the direction your thumb is pointing, then the tree has left-hand spiral grain. If the grain spirals in the direction your little finger is pointing, then the tree has right-hand spiral grain.

Scientific studies have shown that left-hand spiral grain logs undergo more severe distortions during drying than right-hand spiral grain logs, and this is one reason why greater restrictions are placed on the use of left-hand spiral logs (Table 2.A). Also, left-hand spiral grain logs are considerably weaker in bending and deflect more than straight-grain or right-hand spiral grain logs, although this is more critical in using logs as structural elements (joists, rafters, and timber members for example), than as wall logs.



Example of Right-hand 1:12 Spiral



Example of Left-hand 1:24 Spiral

Figure 2.A

Standards

2.B. Log Walls

Shall be constructed of logs laid in horizontal courses, scribe-fit one to another, with interlocking notches at the corners.

2.C. Sill Logs

2.C.1. Shall be not less than 20 centimeters (8 inches) in diameter.

2.C.2. Shall be flattened on their bottom side for their entire length to a width of not less than 10.2 centimeters (4 inches).

2.C.3. Shall not be in direct contact with masonry.

2.C.4. **Shall be set on a vapor, weather, and air barrier.**

2.C.5. **Shall have a drip cut or flashing that directs water away from the underside of the sill log.**

2.C.6. **Shall be anchored to resist applicable wind and seismic loads.**

2.C.7. Shall be a minimum of 30.5 centimeters (12 inches) above grade.

2.D. Long Grooves

2.D.1. Logs in walls shall have a continuous scribe-fit long groove along the length of each log. A long groove is required wherever a log wall separates unheated from heated space, or heated space from the exterior of the building.

2.D.2. **Long grooves shall be self-draining or shall be gasketed, and in all cases shall restrict water, air, and insect infiltration.**

2.D.3. The minimum width of the long groove shall be 6.3 centimeters (2.5 inches) and this minimum

Commentary

2.B. Log Walls

These standards do not apply to walls constructed of vertical logs or logs that are not fully scribe-fit to one another or to manufactured log home kits. For more on notches see Section 4.

2.C. Sill logs are the bottom logs of the building, the first logs above the foundation in each wall.

2.C.1. See also the log specifications in Section 2.A.

2.C.2. A continuous sawn flat provides bearing area and stability for sill logs.

2.C.3. Untreated wood should not be in direct contact with masonry because of the likelihood of decay.

2.C.4. Caulks, sealants, and gaskets can provide vapor, air, and water barriers.

2.C.5. To avoid decay, it is important that rainwater be directed away from under the sill logs.

2.C.6. The amount and kind of anchoring depends upon local conditions and codes. In areas of extreme wind and seismic load conditions, continuous through-bolting the full height of the log wall to the foundation can be an effective technique.

2.C.7. Sill logs can be prone to decay if they are too close to grade and rainwater and soil splashes on them.

2.D. Long Grooves

Also known as "lateral," lateral groove," "cope," "Swedish cope," and "long notch." The long groove is a notch cut into a log to fit two logs together along their length and between intersecting corner notches.

2.D.1. The long groove must be continuous between notches, or openings, such as for doors. Other styles of log construction do not have a long groove, or have a groove that is not continuous—the gaps between logs are then filled with a chinking material. Scribe-fit log work, in contrast, has a continuous

Standards

width shall extend for no more than 30.5 centimeters (12 inches) in continuous length. At all times, however, the long groove shall conceal and protect through-bolts, pins, dowels, kerfs, electrical holes, and the like, and **shall be wide enough to restrict weather and insect infiltration.**

2.D.4. The maximum width of the long groove shall be three-eighths (3/8) of the log diameter at each point along the log. In cases of extremely irregular log contours, the width may be increased to one-half (1/2) of the log diameter, but this increased allowance shall extend for no more than 46 centimeters (18 inches) in continuous length.

2.D.5. The long groove may have the following cross-sectional profiles: rectangular, shallow cove, "W" shaped, or double scribed.

2.D.6. The depth to which the groove is cut shall be less than one-quarter (1/4) the diameter of the log (see also Section 2.J.2).

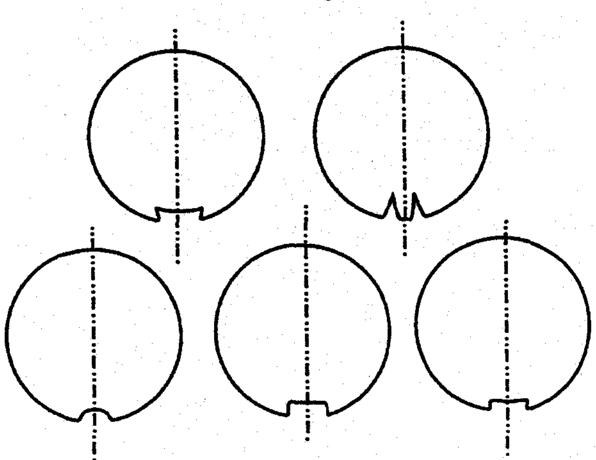


Figure 2.D

Commentary

long groove, and no chinking is required because there are no gaps to fill. The interior edges of the long groove are often sealed with a gasket material, and its interior is commonly insulated.

2.D.2. *Some profiles are not self-draining, that is, they could trap water and so promote decay. Such long grooves shall be gasketed to restrict water from getting into the groove. Being visibly tight is not sufficient to restrict air or water infiltration.*

2.D.3. *Narrow long grooves are difficult to seal from the weather. The groove must always be wide enough to restrict weather infiltration into kerfs, electrical holes, and the like.*

2.D.4. *Wide long grooves remove so much wood that the log is unduly weakened and may check only on the bottom of the log, which is not desired. (See also Section 2.J.)*

2.D.5. *There are many shapes, or cross-sectional profiles, for long grooves. Figure 2.D illustrates some of these. Desired traits are: sharp and strong edges along the scribe line; a reasonable minimum amount of wood removed from the groove so that the groove touches the log below only along its scribed edges with no internal "hang-ups"; and a reasonable assurance that the log will check on its top (that is, in the kerf) as it dries. (See Section 2.J for more on kerfs.)*

2.D.6. *Deep long grooves are not necessary and can weaken a log. Note that at least one-half of the diameter of the log must remain intact after both the kerf and long groove are cut (Section 2.J.2).*

Standards

2.E. Log Extensions

2.E.1. The maximum length of log extensions shall be based on weather protection criteria described in Section 7.0.

2.E.2. The minimum length of log extensions shall be 23 centimeters (9 inches) measured from the edge of the notch to the end of the log overhang. This standard applies to both interior and exterior log extensions. Dovetail corner notches are exempt from this requirement.

2.E.3. Exterior log extensions shall not have a tight fit to the log extensions below. See Figure 3.B.3.

2.E.4. Where a log extension acts as a support for a structural member, this extension and the structurally supporting logs below the weight-bearing extension shall be exempt from the requirement in 2.E.3 (see also Section 7.J).

Commentary

2.E. Log Extensions

Also known as "flyways" or "log overhangs," are the short part of the log that extends past a notched corner.

2.E.1. Overly long log extensions can be prone to decay unless adequately protected by roof overhangs.

2.E.2. Overly short log extensions can be prone to having wood split off, severely weakening the notch and the corner. Interior log extensions are those that project inside a building, and exterior log extensions extend towards the outside of a building. The stability of a dovetail corner does not depend upon log extensions and is not susceptible to having wood split off and so is exempt from any minimum length requirement.

2.E.3. The end grain of exterior log extensions can take on moisture seasonally, shrinking or swelling more than the rest of the log. If the long grooves of extensions fit tightly, then during periods of high moisture the tight fit of the long grooves along the rest of the log could be compromised. This has, in fact, been observed—tight long grooves in the log extensions and gaps in the grooves everywhere else.

Since log extensions are not kerfed (Section 2.J.7), it is probable that log extensions will check on their bottoms—from their long grooves towards the center of the log. When logs check in this location, internal hang-ups are common. To avoid this, the grooves of exterior log extensions should have enough wood removed to avoid hang-ups after checking and slumping. See Figure 3.B.3.

2.E.4. Where roof overhangs, outriggers, or balconies are supported by log extensions, it may be necessary to have two or even three log extensions fit tightly

Standards

2.F. Distance Between Corners

2.F.1. When using logs with a diameter less than 30.5 centimeters (12 inches), the distance between intersecting log walls with corner notches shall be no more than 7.3 meters (24 feet). When using logs with a minimum diameter of 30.5 centimeters (12 inches), the distance between corner notches shall be no more than 9.75 meters (32 feet). Log walls with spans in excess of these distances shall have reinforcement such as wood keys, dowels, smooth-shaft steel, through-bolts, lag screws, steel bar, or log stub walls. All such reinforcement shall allow for settling (see Section 6).

2.F.2. Log walls with openings cut for doors, windows, and passageways may require additional bracing. The loads on a log wall, and the openings cut into a log wall, will affect its structural performance and may require structural analysis.

2.G. Joining Logs Lengthwise

2.G.1. The spliced logs within a course shall be secured to each other **with bolts or other fasteners and to adjoining courses of logs above and below with steel pins, wooden dowels, lag bolts, or through-bolts in such a manner as to preserve the structural integrity of the wall.**

2.G.2. When more than half of the logs in a corner are spliced, then engineering analysis shall be required.

Commentary

so as to gain the structural strength needed to support the cantilevered load put on these logs.

2.F. Distance Between Corners

2.F.1. Log walls gain lateral stability from corner notches at stub walls and intersecting log walls, and this is the reason for limiting the distance between notched corners—to ensure lateral stability of the wall. Larger logs are laterally more stable than small logs and so are allowed a longer maximum distance between notches.

2.F.2. Openings cut into a log wall, especially numerous, tall, or wide openings, reduce the lateral stability of the wall. Some stability is gained by door and window framing (see Section 5), but in most cases other steps must be taken to stabilize the wall, especially when the wall is supporting the load of floors or roofs.

2.G. Joining Logs Lengthwise

2.G.1. Some walls are straight and too long to be spanned with single logs, and so logs are joined end-to-end. A better design may be to step a long wall in or out to add corner notches and allow the use of wall-length logs, thereby eliminating end-to-end splices. End-to-end butt splicing of wall logs is an acceptable practice, however, so long as steps are taken to maintain the strength and stability of the walls and corners and the spliced joint is completely covered from view.

2.G.3. The completed wall must appear to be made of only continuous, full-length logs. No exposed splices or joints are allowed. All joints and splices must be completely covered by corner notches or stub wall notches.

Standards

2.G.3. The notch and long groove shall at all times completely hide a splice and its fasteners and help protect splices against weather and insect infiltration.

2.H. Header Logs

2.H.1. A header log shall have no more than half of its vertical height removed at the location of openings, unless it is covered by at least one more log. In all cases, the header log shall be adequate for structural requirements.

2.H.2. Openings in header logs shall be cut so as to completely cover door and window head jamb and exterior trim in order to restrict water infiltration.

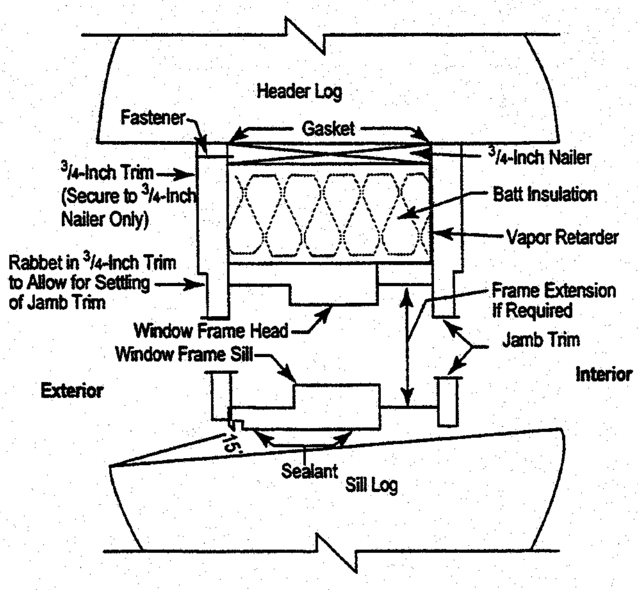


Figure 2.H

2.I. Plate Logs

2.I.1. Wall plate logs shall be notched, drifted, pegged, lag-bolted, or through-bolted to the log below to prevent movement caused by drying stress and roof thrust. **Wall**

Commentary

2.H. Header logs are logs at the head, or top, of window and door openings cut into log walls.

2.H.1. A header log has a level sawn cut facing the opening, to which settling boards may be attached. These cuts should not remove more than half the vertical diameter of the header log at this point unless the strength of the wall is sufficient to support the roof and floor loads placed upon it.

2.H.2. Figure 2.H illustrates one way to install settling boards and avoid water infiltration.

2.I. Plate logs are the top logs on each wall. The roof framing rests on the plate logs.

2.I.1. Wall plate logs are prone to twisting and shifting and need extra steps to keep them in place. Square notches and lock notches can provide restraint, as can any number of methods using bolts, threaded rod, and pegs.

Roof uplift caused by wind, for example, can be counteracted by locking together the top rounds of each wall. Smooth pins such as dowels, smooth shaft steel, and wooden pegs are not sufficient for preventing uplift, and this is why lag bolts and through-bolts are specifically mentioned.

2.I.2. A study of Minnesota log homes found the intersection of roof framing and the plate log to be the source of considerable air infiltration. Special steps are required to make this area weather tight. Permanently sealing the vapor barrier to the plate log is an accepted method of reducing air infiltration and retarding the migration of water vapor. Stapling the vapor retarder to the plate log is, by itself, not sufficient.

Standards

plate logs shall be attached with lag or through-bolts to one or more rounds of logs below the plate log so as to resist the uplift forces associated with local wind and seismic conditions.

2.I.2. Where conventional framing meets a plate log, this intersection shall have an expandable gasket to accommodate anticipated shrinkage of the log plate and **to restrict weather and insect infiltration.**

2.I.3. **The ceiling vapor retarder, where required by local code, shall be permanently sealed to the plate log with caulk or sealant.**

2.I.4. Plate logs shall be straight grained wood (see Section 2.A.4.f).

2.J. Kerfing

2.J.1. When building with green logs, a longitudinal kerf shall be cut on the top of each wall log.

2.J.2. The depth of the kerf shall be at least one quarter ($^1/_4$) of the diameter of the log, and shall be no deeper than one-third ($^1/_3$) the diameter. In no case shall more than one-half ($^1/_2$) the diameter of the log be removed by the kerf and long groove combined.

Commentary

2.J. Kerfing

2.J.1. The kerf is usually, though not always, a cut made with a chain saw. Logs are known to check, or crack, in those places where wood has been removed closest to the pith, or center, of the log. Kerfing is therefore an effective way to control the location of checks as green logs dry. Because dry logs already have seasoning checks, kerfing will not change the location of checks, so kerfing is not required for dry logs.

2.J.2. The kerf must be deep enough to promote checking. Note that even those long groove profiles that do not require kerfing (like the double cut) are nevertheless required to be the depth of at least one quarter of the diameter of the log at every point along the top of the log. (See also Section 2.D.5.) After a log has both the kerf and the long groove cut, there must still be at least one-half of the diameter of the log remaining uncut. Removing more than half the diameter of the log for kerf and groove combined would weaken the log and so should be avoided.

The amount of wood removed by the kerf (or special long groove profile) must be between $^1/_4$ and $^1/_3$ of the log diameter (Section 2.D.6). When the kerf is $^1/_4$ of the diameter of the log deep, then the groove must be less than $^1/_4$ of the log diameter deep ($^1/_4$ plus $^1/_4$ equals $^1/_2$). When the kerf is $^1/_3$ of the log diameter deep, then the groove must be less than $^1/_6$ of the log diameter deep ($^1/_6$ plus $^1/_3$ equals $^1/_2$).

2.J.3. Because kerfs are not self-draining, that is, they can catch rainwater and hold it, kerfs must always be protected by being fully covered by the groove of the log above (also see Section 2.D.3). In practical terms, this means that kerfs are never visible in a completed wall.

Standards

2.J.3. Kerfs shall at all times be protected from weather by being fully covered by the long groove of the log above.

2.J.4. The kerf shall be continuous except that it shall not extend to within 30.5 centimeters (12 inches) of all notches, and kerfs need not extend into openings in log walls where they would be seen.

2.J.5. No kerf shall be required when the long-groove profile encourages checking on the top of wall logs.

2.J.6. No kerf shall be required on the top of the half-log sill logs.

2.J.7. No kerf shall be cut in exterior log extensions.

2.K. Log Wall–Frame Wall Intersections

2.K.1. Log walls shall be cut as little as necessary when joined to non-log partition walls.

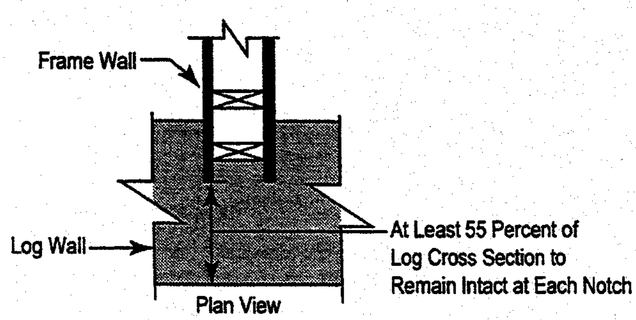


Figure 2.K.1

Commentary

2.J.4. The kerf should run the full length of the top of every log, except it should not be cut too closely to notches. In the case of openings or passageways cut in log walls that are not covered by jambs or doors, the kerf would be unsightly—and in these areas the kerf need not extend all the way to the opening.

2.J.5. Some long-groove profiles encourage checking without kerfing. For example, the long-groove known as double-cut or double-scribed (see Section 2.D.5), removes a V-shaped section from the top of every log. Long-groove profiles that promote checking on top of wall logs do not require a kerf, but they must comply with Section 2.J.2.

2.J.6. Half logs do not usually check, and so do not require a kerf.

2.J.7. No kerf should be cut on any log extensions outside the building because this upward-facing cut could catch and hold moisture from rain and promote decay. The long grooves of exterior log extensions shall not be tight-fitting (Section 2.E.3), and so do not protect the kerf from water. This is why log extensions should not be kerfed.

2.K. Log Wall–Frame Wall Intersections

It is common for some interior, non-bearing partition walls to be conventionally framed with studs. This section describes how stud walls and other non-log walls should be attached to log walls.

2.K.1. It is common for a plumb groove, dado, or rabbet to be cut in the log wall and the first stud of the frame wall to be attached to the log wall in this groove. One problem is that to have the frame wall completely seal against the log wall, the groove must be cut as deep as the narrowest long groove, and this is often close to the midpoint of the log wall. One way to avoid removing too much wood from the log wall and unduly weakening it is shown in Fig. 2.K.1.

Standards

2.K.2. Where wood is removed at the intersection of a log wall and frame wall, the log wall shall have 55 percent or more of its cross-sectional area remain intact and uncut. See Figure 2.K.2 below.

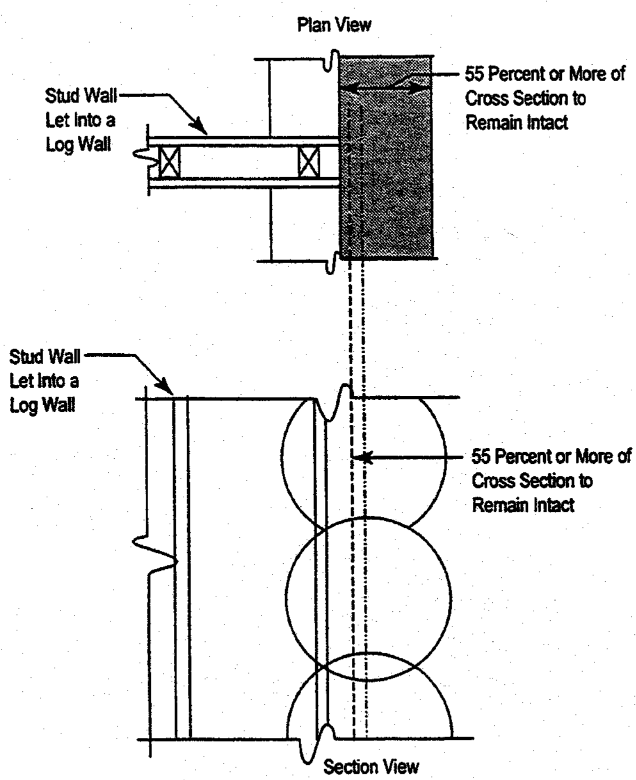


Figure 2.K.2

2.K.3. Where frame partition walls are notched into opposite sides of a log wall there shall be a minimum of 122 centimeters (4 feet) between the end of one notch and the beginning of the next notch on the opposite side of the log wall, or, if closer than 122 centimeters (4 feet), a minimum of one-third (1/3) of the wall cross-sectional area shall remain intact and uncut.

Commentary

2.K.2. Enough wood must be left in the log wall that it is not weakened by the dado. The dado must leave 55 percent or more of the cross-sectional area at this intersection uncut, Figure 2.K.1.

2.K.3. Where two frame walls are closer than 122 centimeters (4 feet) to each other; and on opposite sides of a log wall, the cross section of the log wall, after both dados are cut, must have at least one third of the wall area remain uncut, Figure 2.K.3. Note, also, that Section 2.K.1 still applies—each single cut shall leave 55 percent or more of the cross sectional area at each intersection uncut and intact. See Figure 2.K.3.

2.K.4. Cutting past the center of a log wall weakens it and should be avoided.

2.K.5. The first stud attached to the log wall must be fastened in such a way as to allow the log wall to shrink and settle. One common method is for lag screws to be attached to the logs through vertical slots cut in the stud, not just round holes. The lag screw and washer should be attached near the top of the slot and allowed to slide down the slot as the log wall behind shrinks in height.

The frame wall must also allow a second floor, or the first floor ceiling, to lose elevation as the log walls shrink in height. (See Section 6 for more on settling.)

Standards

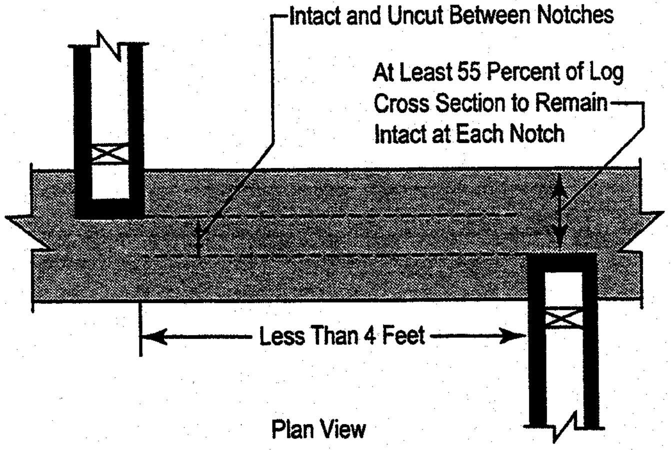


Figure 2.K.3

2.K.4. In no case shall cuts go past the centerline or midpoint of the log wall.

2.K.5. Log wall–frame wall intersections must allow for unrestricted settling of the log wall (see also Section 6).

2.L. Height of Log Walls

Log walls taller than two stories, or 6.1 meters (20 feet) in height shall require engineering analysis.

2.M. Bearing Walls

Bearing walls shall be designed and constructed to structurally accommodate horizontal and vertical forces that are anticipated to act upon the building.

2.N. **Preservation of Log Walls**

Where necessary, steps should be taken to restrict the growth of mildew and fungus on logs while the building is under construction.

Commentary

2.L. Tall log walls should be closely examined for stability.

2.M. Bearing Walls

Bearing walls can be exterior or interior log walls. Roof and floor loads are the most common loads to design for, but uplift and lateral loads from winds and seismic activity may have to be considered as well.

2.N. Preservation of Log Walls

Green logs, in particular, are prone to attack by mold, mildew, and fungus during construction. Dry wood will not decay, and so good roof protection is very effective in prolonging the life of log walls. During construction, and until roof protection is complete, it may be advisable to use sap stain and mold preventative chemicals or processes. Additionally, the use of a sealant on all exposed end grain during log storage, construction, and after all work is completed will slow the loss of moisture and reduce checking.

Standards

Section 3 Notches

3.A. Self-Draining and **Weather-Restricting Notching**

All forms of interlocking notches and joinery shall be self-draining and **shall restrict weather and insect infiltration.** Shrink-fit and compression-fit notches are recognized as achieving these goals.

3.B. Notching Standards

3.B.1. Notches shall have a concave profile across the notch not less than 15 millimeters (9/16 of an inch) and not more than 35 millimeters (1 3/8 inches).

3.B.2. Notches shall be clean in appearance and have no ragged edges.

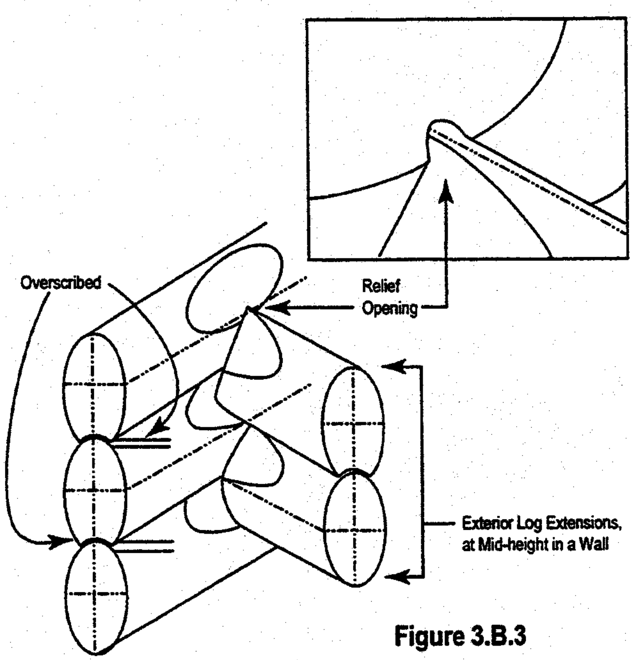


Figure 3.B.3

Commentary

Section 3 Notches

3.A. Self-draining means that notch surfaces slope in a way that restricts water from going into areas where it can be held, promoting decay. Interlocking means that notches will tend to be stable when exposed to stresses and loads that the corner can reasonably be anticipated to experience. Shrink-fit and compression-fit notches are designed to remain tight fitting as the wall logs shrink in size as they dry. (Note that a round notch that is designed to function as a compression-fit notch meets this criteria.)

3.B. Notching Standards

3.B.1. When a straight edge is held across a notch so that it is approximately perpendicular to the long axis of the log and so that the straight edge touches the scribed edges of the notch, then the straight edge should not touch the inside of the notch at any place. In fact, the gap between the straight edge and the inside of the notch should be between 15 millimeters and 35 millimeters. This means that the notch, when in place over the log below, should touch the log below only on its scribed edges, and should touch at no other place. (If it touches on some inside place, it causes a "hang up.") The concave area created by scooping out the notch in this way not only prevents internal hang-ups, but also can be used to place materials that will prevent air infiltration through the notch (gaskets and insulation, for example)—an important consideration in all climates.

3.B.2. The scribed edge of notches should be sharp, strong, and cleanly cut. The edges should not crush or permanently deform under the load they support. Ragged wood fibers indicate weak notch edges or a notch cut past the scribe line.

Standards

3.B.3. To maintain tight notches with green logs the following apply:

a. Space shall be left at the top of the notch to allow for compression.

b. Sapwood from the sides of the log should be removed to create a saddle scarf. These saddle scarfs shall be smoothly finished.

3.B.4. The amount of log to remain uncut at a notch shall not be less than one-third ($^1/_3$) the original diameter of the log, or not less than one-third ($^1/_3$) of the original cross-sectional area.

3.B.5. All forms of dovetail notches are exempt from the requirements of Section 3.6.

3.C. Blind Notches

A blind notch shall resist the separation of the two log members it joins, or shall have mechanical fasteners that resist separation.

Commentary

3.B.3. There are techniques that help keep notches tight as green logs season and dry. One technique is to remove wood at the top of a notch to allow the notch to compress onto the log below as it dries. The extra wood removed from the top of a notch creates a gap that should be nearly invisible when the corner is assembled, that is, the gap should be covered by the notch of the next log. Figure 3.B.3.

Cutting saddles, or saddle scarfs, is another technique that helps. Saddle scarfs should not be simply chain sawed off, but should be finished to a smoother surface. See Figure 3.B.3.

3.B.4. After a notch has been cut, there shall be no less than one third of the log's original cross-sectional area or diameter at the notch remaining uncut. Removing more than two-thirds of the log area or diameter by notching weakens a log, sometimes even to the point where the log extensions may break off. Good log selection avoids the problem of notches that remove more than two-thirds the diameter of the log at the notch.

3.B.5. Dovetail notches are unlike most other notches, and are not required to follow the standards of Section 3.B.

3.C. Blind Notches

A blind notch is a log joint in which one log does not cross over or beyond the other log. Because one log does not continue past or over, it can be prone to separating from the log it is joined to. To resist separation, the following methods are recommended:

1. *A dovetail or half-dovetail on the blind notch to interlock with the intersecting log.*
2. *Hidden dowels that accommodate settling.*
3. *Hidden metal straps, fasteners, or bolts to join the intersecting log walls together.*

Standards

Section 4 Joists and Beams

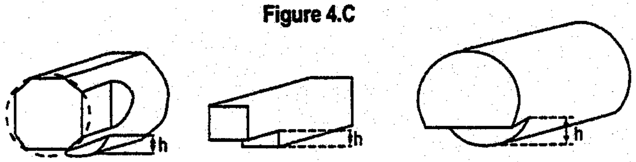
4.A. Joists and beams, if dimensional material, shall conform to applicable building codes.

4.B. Joists and beams, if log or timber, shall conform to the following standards:

- 4.B.1. Shall have straight grain or shall be right-hand spiral grain with spiral no more than 1:12, and **shall be of sound wood.** (See Section 2.A.4 for more on spiral grain.)
- 4.B.2. **Shall be designed to resist all loads according to applicable building codes and accepted engineering practice.**

4.C. Where log or timber beams are notched at an end, on the bottom face, the depth of the notch shall not exceed one-quarter ($^1/_4$) of the beam depth at the location of the notch, or less if calculations so indicate.

Figure 4.C



4.D. Where log or timber joists are supported by a log wall, the wall logs shall be notched to receive the joists in such a way as to prevent failure in the supporting log wall.

Commentary

Section 4 Joists and Beams

4.A. Dimensional joists and beams (including rafters, purlins, ridges, and the like) shall conform to local applicable building codes for dimensions, load, and span.

4.B. Log joists and beams, including sawn timber members, shall be sized to adequately support the leads they carry.

- *4.B.1. Studies have shown that left-hand spiral grain logs and timbers are significantly weaker than straight and right-hand grain members, but it is not yet known precisely how much weaker. Therefore, left-hand grain is not allowed for these members unless it can be shown that it is structurally adequate.*

  Straight-grain and right-hand spiral grain up to a slope of 1:12 is allowed.
- *4.B.2. At all times, log and timber beams and joists must be designed and installed to adequately resist the loads they will experience. Joists and beams with excessive deflection can cause uncomfortable, and in some cases unsafe, springiness in floors and roofs. Long spans are prone to excessive deflection, and in some cases a deflection limit of $^1/_{360}$ of the span may not be sufficient.* ***It is prudent to consult with an engineer familiar with wood structures for assistance in the design of complex load carrying systems.***

4.C. Where joists and beams are notched at their ends (for example, to be supported by a log wall), no more than one-quarter ($^1/_4$) of the height of the beam shall be removed from the bottom of the beam. Less than one quarter ($^1/_4$) shall be removed if engineering calculations require. See Figure 4.C.

4.D. It is also important to not remove so much wood from a log wall that is supporting a beam or joist that the log wall itself is unreasonably or unsafely weakened. One example would be a joist above a door or window opening. See Figure 4.D.

Standards

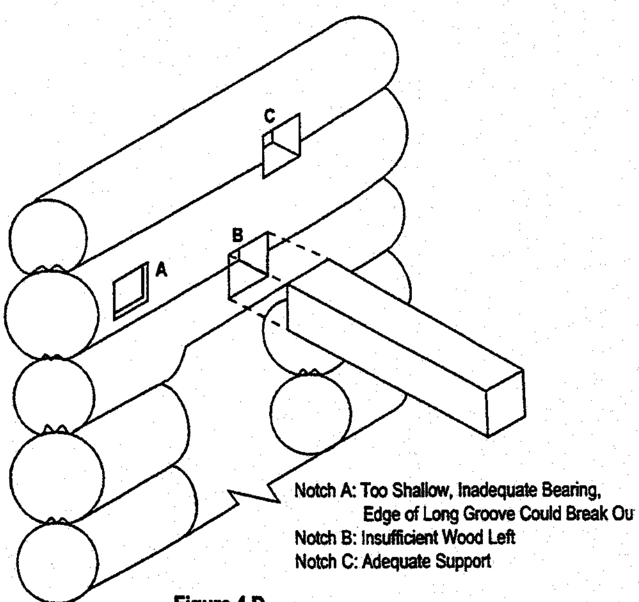


Figure 4.D

4.E. The distance, after settling is complete, from the bottom of ceiling joists and beams to the finished floor shall conform to applicable building codes.

4.F. **Where a beam or joist passes through a wall to support additional floor areas or other loads, the beam or joist shall be notched in such a way that the structural integrity of both the beam and the supporting wall are maintained.**

4.G. **Where an interior beam extends through a wall to the exterior it shall be protected from the weather so that its structural integrity is maintained. The intersection of the beam and wall shall be constructed to restrict weather and insect infiltration.** See also Sections 7.F and 7.G.

Commentary

4.E. Joists and beams (whether log, timber, or dimensional material) that are supported by log walls will get closer to the floor as the logs dry and shrink and the log wall gets shorter in elevation. Many local building codes specify the minimum height from the floor to joists and beams above. The height of joists and beams off the floor must conform to local building codes, if any, after settling is complete. (See Section 6.A for more on calculating settling allowances.)

4.F. One common log building design has floor joists cantliever through an exterior log wall to support a balcony or roof load outside the building. It is not uncommon for the stresses that this type of beam must withstand to be at a maximum where the beam passes through the log wall. It is therefore important that all such cantilevered beams not be substantially weakened due to notching at this location. A square notch is one way to help protect the strength of the beam; Figure 4.F. Square notching does remove more wood from the log wall than other notches, and so it is important to ensure that the wall is not weakened past its ability to support the loads placed upon it.

4.G. Cantilevered log beams that extend outside the building (even if they are only notched through the wall and have relatively short

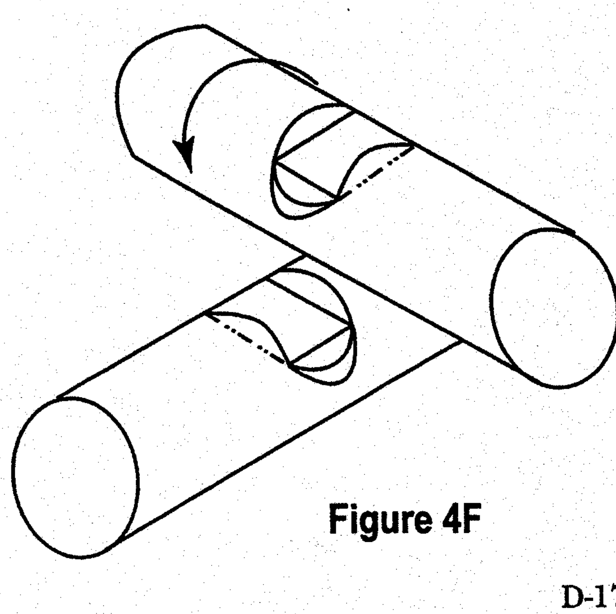


Figure 4F

Standards

4.H. Log joists and beams shall be flattened on top to a minimum of 2.5 centimeters (1 inch) where they support flooring or framing.

Section 5 Window and Door Openings

5.A. Settling space shall be provided for all doors and windows placed in walls constructed of horizontal logs.

5.B. **The settling space for windows and doors shall be covered by a cladding or trim to restrict weather and insect infiltration.** In order to not restrict settling and to avoid damage to windows or doors, this covering shall not be attached to both the log wall and to the window or door frame until all settling is completed.

5.C. Trim at jambs shall not restrict settling.

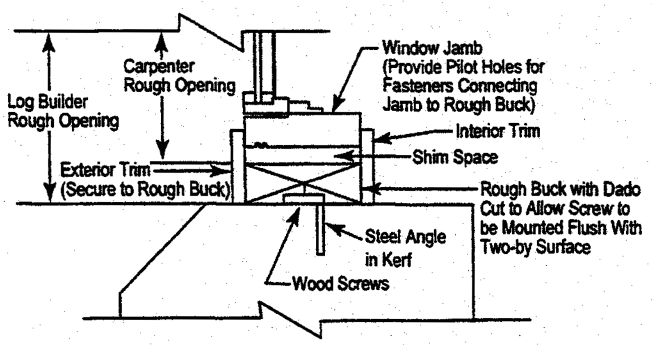


Figure 5.D.1

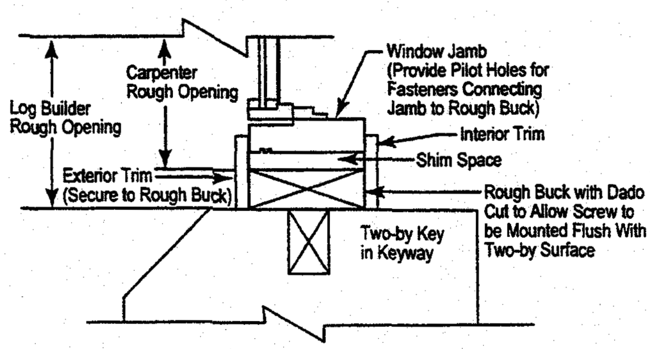


Figure 5.D.2

Commentary

log extensions) need protection against decay. Metal flashings, waterproof membranes, and wide roof overhangs are recommended. The top of any deck supported by logs ***or other structural members must slope so that water will drain in a manner that protects the house from damage.*** *This type of care is advised because of the susceptibility of unprotected log ends to decay and the great difficulty and expense in repairing or replacing such logs once degradation occurs.*

Section 5 Window and Door Openings

5.A. Openings cut in log walls become shorter over time as the logs dry to an in-service condition. The settling space must not have any materials in it that do not allow for the space to become vertically shorter over time. (See also Section 6 for more about shrinkage and settling.)

5.B. Settling spaces are typically covered by settling boards, which are pieces of trim that are wide enough to span the settling space. The settling boards can be attached to the log or to the window or door framing, but not to both. Attaching the settling board to both would not allow for the settling space to get smaller over time, and would either cause the logs to hang up or the windows or doors to deform.

5.C. The sides of doors and window trim must allow for logs to settle unhindered. This means that the jamb trim on the sides of doors and windows cannot be attached to the log wall. Side trim can be attached to the window or door and to bucks. See Section 5.D below.

5.D. Openings in log walls for door and windows need special framing to install the jambs of doors or windows, and this framing is usually called a "buck." The bucks must allow for logs to shrink and settle—typically this means that the height of the bucks is less

Standards

5.D. Both sides of each opening shall be keyed vertically to withstand lateral loads and in such a way as to allow unrestricted settling.

5.E. All exterior sills shall be beveled to allow water to drain to the outside face of the log wall.

5.F. The position of openings in walls constructed of horizontal logs shall conform to the following:

5.F.1. The distance from the side of window and door openings to the centerline of an intersecting log wall shall be a minimum of 25.4 centimeters (10 inches) plus one half the average log diameter.

5.F.2. Wall sections between openings shall be a minimum of 92 centimeters (36 inches) long or shall be provided with support in addition to the required keyways (see Section 5.D).

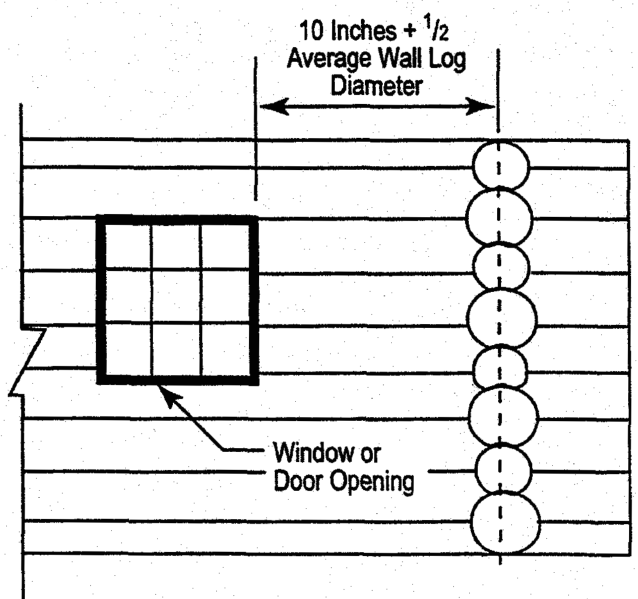


Figure 5.F

Commentary

than the height of the log opening, and the difference in these heights is equal to or greater than the settling allowance. (See Section 6.A for help calculating settling allowances.) The bucks are usually attached to keys of wood or angle iron that are let into the log ends of openings. Keys are required because they laterally stabilize the log wall at openings: they restrict logs from moving horizontally while still allowing logs to move vertically. See Figure 5.D.

5.E. Where a log acts as an exposed exterior window or door sill, it must shed water and slope so that it drains away from the window or door.

5.F. Window and Door Location

5.F.1. It is undesirable to have door and window openings cut too close to intersecting log wall and stub wall notches. The notched log is weakened and may split off if it is too short. (This situation is comparable to log extensions that are required to be a certain minimum length; see Section 2.E.2.) Therefore, window and door openings shall be cut no closer to the center line of an intersecting log wall or log stub wall than 25.4 centimeters (10 inches) plus half the average log diameter; see Figure 5.F.

5.F.2. Sections of log shorter than 92 centimeters (36 inches) are prone to split and are also unstable (since they do not contain a log corner), especially if they support loads such as those of a second floor or roof. Therefore, it is best if the sections of log wall between doors, between windows, and between a door and a window be longer than 92 centimeters (36 inches). Sections of log wall can be shorter than this minimum if there is sufficient additional support used, but the keys required by Section 5.D do not qualify as additional support.

Standards

Section 6 Settling

6.A. Settling Allowance

6.A.1. The minimum allowance for settling when using green logs is 6 percent (3/4 inch per foot of log wall height).

6.A.2. The settling allowance for dry logs may be up to 6 percent, but may be less than this, depending upon the moisture content of the logs.

6.B. Adequate provisions shall be made for settling at all openings, load-bearing posts, chimneys, fireplaces, interior frame partition walls, electrical entrance boxes and conduits, plumbing vents and drains, second-story water and gas pipes, staircases, downspouts, heating and air conditioning ducts, and all other non-settling portions of the building.

6.C. The log contractor shall provide information to the general contractor to help guide subcontractors in the use of techniques applicable to their trade to deal with the unique characteristics of log construction and specifically how each trade should accommodate for settling.

6.D. All caulking and weather sealing must account for the change in diameter and shape of the logs as they dry.

Commentary

Section 6 Settling

6.A. Settling is the term that describes the loss of log wall height over time. The principal causes of settling are: (1) shrinkage of log diameter as logs dry to an in-service condition (also known as equilibrium moisture content, or EMC) and (2) compression of wood fibers under the load of the building. A third component is slumping, which occurs if logs check only in the long groove. Slumping is nearly eliminated by kerfing, which is one reason why kerfing is required; see Section 2.J.

6.A.1. Green logs (defined in Section 2.A.2 as logs with greater than 19 percent moisture content) must be allowed to settle 6 percent (60 millimeters per meter, or 3/4 inch per foot) of wall height. Note that logs cannot be expected to shrink to equilibrium moisture content or completely settle by air-drying alone, but must be expected to complete settling only after a period of up to five years as part of a heated building. The process of reaching equilibrium moisture content depends on a number of variables, including wood species, log diameter, initial moisture content, interior temperature, and humidity and climate.

In general, logs do not shrink much in length, and so only the loss of diameter must be considered for settling. With extremely long logs, however, it is advisable to investigate the loss of length as they dry.

6.A.2. Dry logs (defined in Section 2.A.2 as logs with moisture content equal to or less than 19 percent) may settle nearly as much as green logs. In part, this is because of the nature of the definitions of dry and green—19 percent MC is a "dry" log and 20 percent MC is a

Commentary

"green" log, but these two logs will obviously differ very little in the amount they actually shrink in diameter as they approach EMC.

It must be assumed that log walls made of dry logs will settle. Further, it should be assumed that logs stored outside, not covered by a roof, are not at EMC and will shrink. The amount of shrinkage depends upon the difference between the actual moisture content of the logs (as determined by a moisture meter, for example) and the final in-service EMC.

Settling allowance for dry logs may be reduced from the required 6 percent, and the amount of the reduction allowed is proportional to the moisture content of the logs. Note, however, that even if the initial moisture content of the logs is equal to EMC, and the logs are not expected to shrink, the logs will still compress somewhat, and there must be a settling allowance for this compression.

6.B. Everything that is attached to a log wall must accommodate settling. Also, settling problems must be investigated even between two non-log items. For example, there is settling to accommodate between a second floor framed of 2-by-10s and a plumbing vent stack. Neither is log, but the floor framing is attached to and supported by log walls and will settle. The plumbing vent stack is anchored to non-settling members in the basement or crawl space and does not settle.

Another example is the settling between a roof framed of 2-by-12s and a chimney. Again, neither is made of logs, but because the roof rafters are supported by log walls, this means that the rafters will get closer to the ground as the log walls settle. Therefore, roof framing must not be attached to a chimney unless special steps are taken to accommodate settling. The list in Section 6.B is far from exhaustive. Every non-log, non-settling part of a building must be examined to see if there needs to be an accommodation for settling.

6.C. The log builder or contractor knows the special techniques involved in completing a log house and should share this knowledge with the general contractor so that the subcontractors are properly educated about settling and other potential problems.

6.D. Where caulks, sealants, gaskets, and the like are used in contact with logs, these joints must be designed to accommodate shrinkage of the logs without having the joint fail. Trim boards that are scribe fit to logs shall allow for settling.

Standards

Section 7 Roofs and Roof Support Systems

7.A. If constructed of dimensional material, shall conform to applicable building codes.

7.B. If constructed of log or timber, roof systems shall conform to the following standards:

7.B.1. Shall be constructed only of straight grain or moderately right-hand spiral grain material (see Section 2.A.4 for definitions of spiral grain).

7.B.2. **Shall be designed to resist loads according to applicable building codes and accepted engineering practice.**

7.B.3. **Where beams are notched at an end, on their bottom face, the depth of the notch shall not exceed one-quarter (1/4) the beam depth at the location of the notch,** or less if calculations so indicate.

7.C. The distance from the bottom of roof beams to the finished floor must conform to applicable building codes after settling is complete.

7.D. Roof overhang shall help protect log walls from the weather associated with the site of the building. Figure 7.D illustrates how to calculate the minimum roof overhang.

Commentary

Section 7 Roofs and Roof Support Systems

7.B. Log roof systems include, but are not limited to, log posts and purlins, ridge poles, log trusses, and log common rafters. In Section 7, "log" also means "timber."

7.B.1. Severely spiral grained logs are significantly weaker in bending strength and shall be avoided. Left-hand spiral grain logs are significantly weaker than right-hand spiral grain of equal angle. (See Section 2.A.4 for more on spiral grain.)

7.B.2. All log roof members shall be designed to sufficiently resist all expected loads.

7.B.3. Notches cut into, and any wood removed from, a log beam will weaken the beam. One example of this is at the ends of a log beam, where no more than one-quarter (1/4) of the depth of the beam, and less if calculations so indicate, shall be removed for a notch. (Figure 4.C.) It is best to consult an engineer who is familiar with wood structures for help designing log roof systems and especially for complex roof systems.

7.C. Consider the original height of the beam, the involved settling height, and the settling allowance (6 percent for green logs) to calculate the height of roof beams after settling is complete.

7.D. Roofs for log homes shall protect log beams and log walls from degradation caused by the weather. One good way to accomplish this is to use wide roof overhangs. The effectiveness of roof overhangs also depends upon the height of the wall and the height of the roof drip edge. Figure 7.D shows how the amount of roof overhang shall be calculated.

Standards

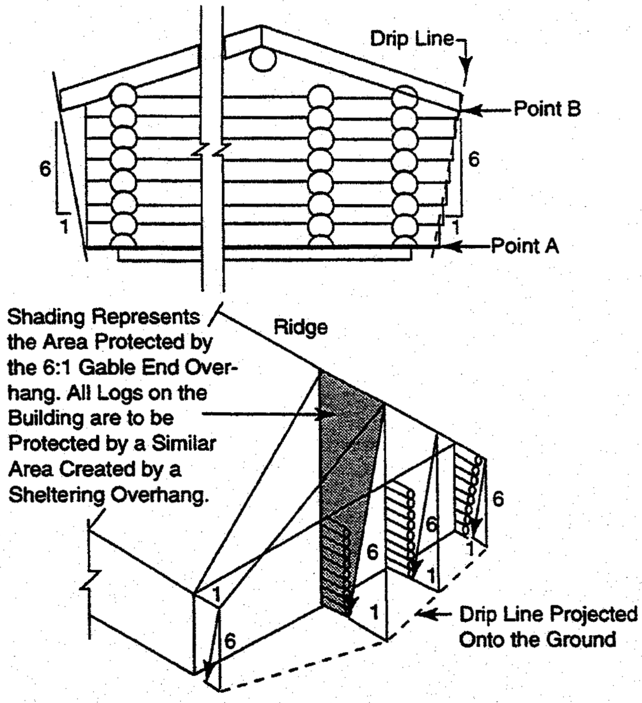


Figure 7.D

7.E. **The roof shall protect all roof stuctural members from the weather associated with the site of the building.**

7.F. Log roof beams shall be flattened on top to a minimum width of 38 centimeters (1 ½ inches) where they support lumber or finish materials.

7.G. Where log structural members pass through exterior frame walls, they shall be notched slightly to receive interior and exterior wall coverings. Expandable gaskets shall be installed to restrict weather and insect infiltration. Roof members shall be designed to meet structural requirements even after such notching.

7.H. Flashing and an expandable gasket shall be used where conventionally framed gable end walls meet a plate log.

Commentary

Notes for Figure 7.D:

The criteria set forth in Figure 7.D is a minimum. This approach to calculating roof overhang is independent of roof pitch and wall height and relies on a ratio (6:1) to define the relationship between the roof overhang and the logs to be protected. If, for example, the distance that the end of a sill log projects beyond the notch (point A) is known, then the drip line defined by the roof overhang can be calculated by projecting a line from point A up and out from the building at the 6-to-1 ratio as illustrated, until this line intersects the bottom of the roof plane (bottom of the rafters), then measure out horizontally here (point B) to find the minimum roof overhang distance.

Or, if the roof overhang is known, then the maximum projection of log ends beyond the notch can be calculated by reversing the process and beginning at point B. A reference line is then constructed down and inward toward the building at the 6-to-1 ratio until it intersects the plane of the bottom logs (usually the first floor), then measure out horizontally to point A to find the maximum allowed length of log extensions. Also check that the log extensions are not shorter than required in Section 2.E.2. Note that the allowed length of log extensions increases as you go higher on the building. That is, log extensions may corbel out at the 6-to-1 ratio, if desired, though they are not required to do so. At all points around a building, this 6-to-1 reference line should be used, and no log or log end should project beyond this reference line.

7.E. Log roof beams that extend to the outside of a building need protection from the weather. Purlins, ridge poles, and posts must not extend outside the drip line of the roof unless special steps are taken, for example wrapping the log end with a durable metal flashing. Preservative chemicals by themselves are insufficient.

Standards

7.I. Roof structures shall be designed and constructed to resist the uplift loads associated with local wind and seismic events.

7.J. **Where roof structures are supported on outriggers, which are in turn supported on log extensions, the extension log carrying the outrigger shall be supported by additional log extensions (a minimum of two extensions below the extension carrying the outrigger) in such a way as to support all loads from the outrigger in a manner other than by cantilever action, unless the log extension carrying the outrigger is designed and constructed as a structural cantilever.** (See also Section 2.E.4.)

Section 8 Electrical

Shall comply with applicable codes, with accommodations where necessary for prewiring and wall settling allowance. (See also Section 6.B.)

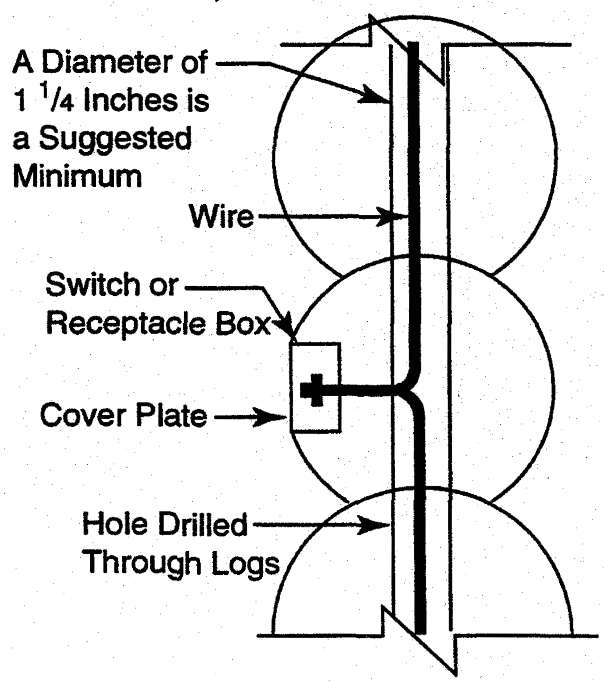


Figure 8

Commentary

7.F. It is impractical to attach framing lumber or finish materials to the irregular, waney round of a log. Therefore, round log roof beams shall be flattened to a width of 1 ½ inches or more where they support other materials.

7.G. It is common to extend log roof beams, like purlins and ridge poles, outside over posts to support roof overhangs. This can be a difficult spot to seal from weather infiltration as the log roof beams shrink in diameter. Gaskets help, as do shallow notches to house the sheathing and inside finished wall materials. Make sure that the roof beams are still sufficiently strong even after notching and removing wood.

7.H. The plate log of gable end log walls is flattened on top, often to receive conventional stud framing. It is important that the flat sawn on the plate log does not hold or wick water. A metal flashing is an effective way to direct water away from this intersection.

7.J. Log outriggers are roof plates outside of, and parallel to, log eave walls. Do not use just one log extension (log flyway) to support the outrigger unless it can be shown that one extension is sufficiently stiff and strong. In any case, no matter how the outrigger is supported, its means of support must be sufficient (see Section 2.E for more on log extensions).

Section 8 Electrical

Common practice is to predrill vertical holes in the log wall, from long groove to long groove, so that the holes are completely hidden from view and no electrical wiring is exposed inside or out (a diameter of 32 mm or 1 ¼ inches is often used as a minimum). Do not use conduit in a log wall. Do not attach conduit to a log wall without allowing for settling.

Outlets and switch boxes are usually mortised into a log so that the cover plate is even with the surface of the log, or, more commonly, flush with a portion of the log that has been flattened for this purpose; see Figure 8.

Standards

Section 9 Plumbing

9.A. To comply with applicable codes, with settling considerations. See also Section 6.

9.B. A plumbing run shall travel through a log wall only perpendicular to the long axis of the logs and shall be level or nearly level.

Commentary

Section 9 Plumbing

9.A. Investigate carefully the need for settling allowances in all plumbing for log homes. It is usually preferable to run plumbing in frame walls vertically without horizontal offsets, though offsets are possible if settling considerations are carefully made. Supply pipes to a second floor can allow for settling by incorporating a loop that opens as the second floor loses elevation. Waste and vent pipes can have a slip joint. *See Figure 9, next page.*

9.B. It is usually not advisable to run plumbing waste, vent, or supply pipes through or within log walls. If they must, however, pipes can run perpendicular and level through a log wall. A pipe that runs vertically up through a log wall or a pipe that runs horizontally within a log wall (for example, lying in a long groove) can never again be serviced without cutting the log wall apart—a drastic event that is difficult to repair.

Because supply lines are known to age, fill with scale, and sometimes to leak, and because the venting of sewer gases is a matter of health and safety, it is best to not locate plumbing in log walls.

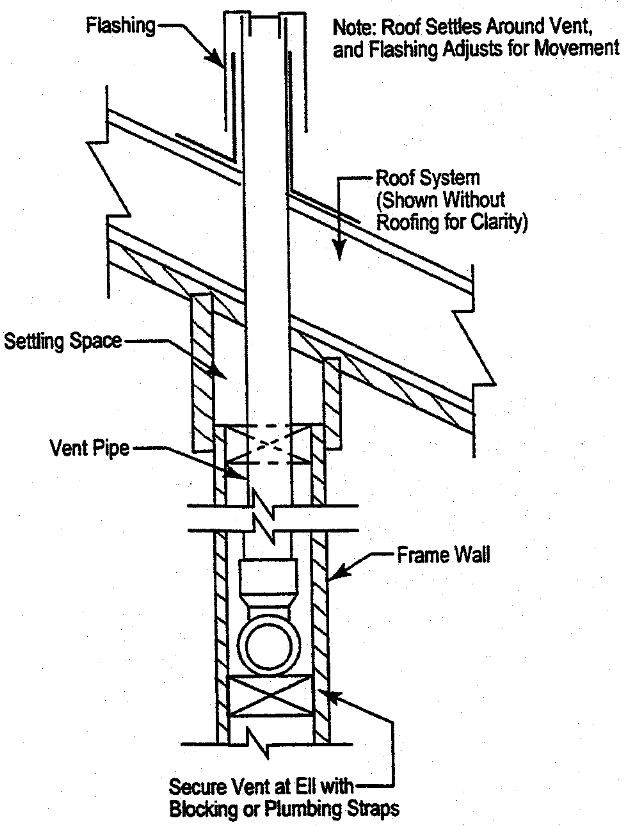


Figure 9.A

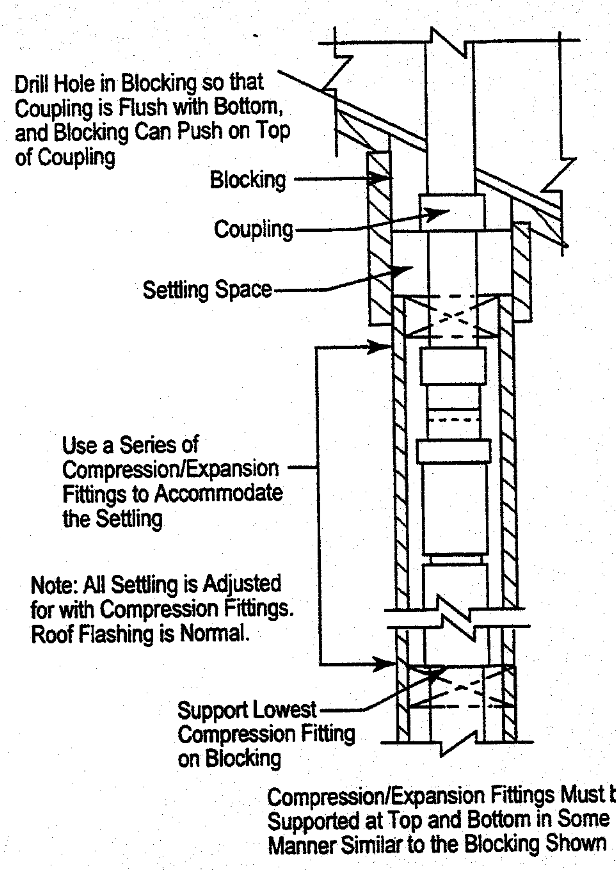


Figure 9.B

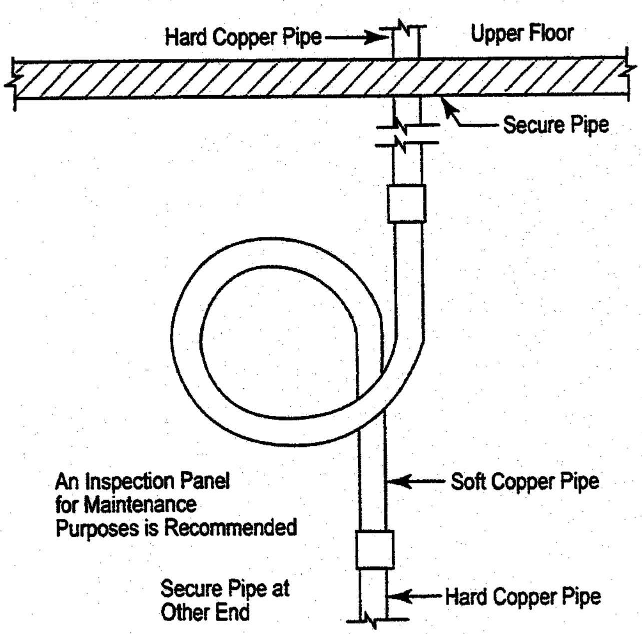


Figure 9.C

Using a Combination of Hard and Soft Copper Pipe to Allow for Settling in Water Supply Lines

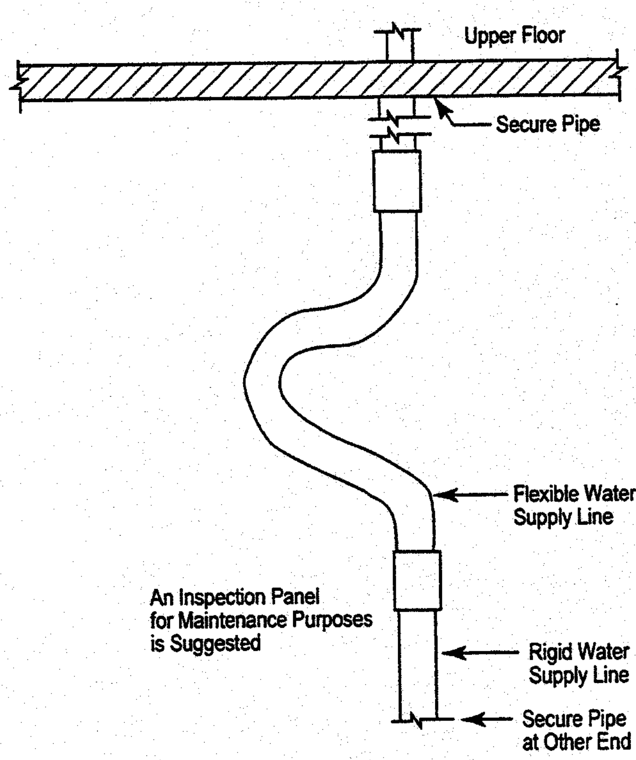


Figure 9.D

Using a Combination of Flexible Water Supply Line and Rigid Pipe to Allow for the Needed Settling

Standards

Section 10 Fireplaces and Chimneys

10.A. Shall conform to applicable codes.

10.B. No combustible materials, including log walls, shall be closer than 2 inches to a masonry chimney.

10.C. Flashing to conform to applicable codes, and to accommodate settling. See also Section 6.

10.D. No portion of the building shall come into contact with a masonry column unless the assembly is specifically designed to accommodate structural and settling considerations.

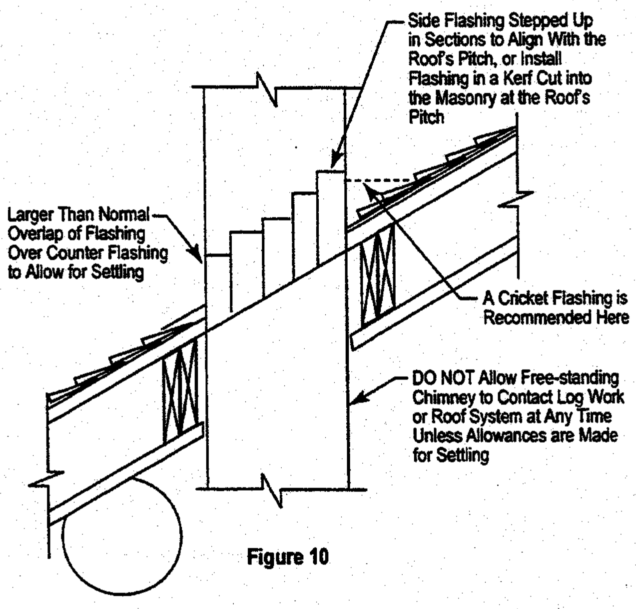


Figure 10

Commentary

Section 10 Fireplaces and Chimneys

10.C. The flashings used where a chimney goes through the roof must accommodate settling and protect against water and weather penetration at all times, including after the building has fully settled. The roof, when supported by log walls, will lose elevation while the chimney will remain the same height. This effect requires that chimneys be flashed and counterflashed (see Figure 10). Further, the flashing must be tall enough, and must have sufficient overlap when the logs are green, so that even after all settling is complete the counterflashing still overlaps the flashing at least 5.1 centimeters (2 inches), or more if local building codes require or the situation dictates.

Note: Because such tall areas of flashing can be exposed (12 inches high is not uncommon), it is recommended that flashing material be thicker than normal to protect the flashing from degradation. Remember that the flashing and counterflashing cannot be attached to each other in any way (solder, rivets, etc.) because they must freely slide vertically past each other to allow settling.

10.D. This refers especially to a common practice in stick frame buildings—supporting roof or floor beams on the masonry column of the chimney. This must not be done in a log home unless special measures are taken to allow for settling.

It is desirable to position masonry columns during the design process so that they avoid areas in floors and roofs that require structural members. For example, position the chimney so that it avoids the ridge pole.

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Appendix E
Index of Regions

For your convenience, the following communities have been grouped according to the regions shown on the Statewide Regional Index Map (page 69).

Region 1: Southeast

Angoon
Annette
Annex Creek
Auke Bay
Baranof
Beaver Falls
Bell Island
Alder
Canyon Island
Chenega
Chickagof
Coffman Cove
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
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
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
Kachemak
Kaguyak
Karluk
Kasilof
Kenai
King Cove
Knik
Kodiak
Kulis ANGB
Larsen Bay
Latouche
Mat. Ag. Exp.
Middleton Island
Moose Pass
Mountain Village
Naptowne
Nelson Lagoon
Nikiski Terminal
Ninilchik
Nikolski
Old Harbor
Ouzinkie
Palmer
Perryville
Petersville
Pillar Mountain
Portage
Port Graham
Port Heiden
Port Lions
Port Moller
Portlock
Rabbit Creek
Salamatof
Sanak
Sand Point
Sawmill
Seldovia
Seward
Shemya
Skwentna
Soldotna
Squaw Harbor
Starisky Creek
Sterling
Summit
Susitna
Sutton
Talkeetna
Tatitlek
Tehneta Pass
Thompson Pass
Trappers Creek Camp
Tyonek
Unalaska
Unga Island
Valdez
Wasilla
Whittier
Willow
Women's Bay
Yakataga Bay

Region 3: Interior, Southwest

Akiachak
Akiak
Alakanuk
Aleknagik
Allakaket
Anderson
Aniak
Anvik
Atmautluak
Aurora
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 Creek
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
Kohkanok
Koliganek
Kongiganak
Kotlik
Koyukuk
Kwethluk
Kwigillingok
Lake Minchumina
Lime Village
Livengood
Lower Kalskag
Lower Tonsina
Manley Hot Springs
Manokotak
Marshall
Ma 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
Pitka's Point
Platinum
Port Alsworth
Quinhagak
Rampart
Red Devil
Richardson
Russian Mission
Ruby
Saint George
Saint Mary's
Saint Matthew
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
Ugashik
Upper Kalskag
Usibelli
Unkumiute
Venetie
Wiseman

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 F Climate Data for Alaska Cities

Climate Data for Communities in the AKWarm Library Database

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Adak	ADAK	9,046	40.4	23	12.7	20
Akhiok	KODIAK	9,102	39.8	13		
Akiachak	BETHEL	13,213	29.0	-39	13	25
Akiak	BETHEL	13,105	29.1	-39	13	22
Akutan	COLD BAY	8,554	41.3	9	16.7	5
Alakanuk	BETHEL	13,339				
Alatna	BETTLES	16,625	19.5	-45	6.3	600
Aleknagik	KING SALMON	11,751			9	
Allakaket	BETTLES	16,625	19.5	-45	7.9	600
Ambler	BETTLES	15,675	22.1	-45	9	135
Anaktuvuk Pass	BETTLES	18,873			6.9	
Anchor Point	HOMER	10,115	37.2	-2	6.3	10
Anchorage	ANCHORAGE	10,816	35.3	-18	7	114
Anderson	FAIRBANKS					
Angoon	JUNEAU	8,450	42.2	1	10.6	10
Aniak	BETHEL	13,356	28.2	-39	6.5	80
Anvik	MCGRATH	13,462	28.7	-39	6.5	325
Arctic Village	BETTLES	17,356		-43	9	2,250
Atka	COLD BAY	9,054	40.3	23	11.9	40
Atmautluak	BETHEL	13,106	29.1	-39	13	17

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Atqasuk	BARROW	20,370	9.3	-41	12	65
Attu	ADAK	9,490		22	11	60
Auke Bay	JUNEAU	8,461	41.6	1	8.3	40
Barrow	BARROW	20,370	9	-41	12	31
Beaver	BETTLES	15,788	21.6	-47	6.3	365
Bethel	BETHEL	13,334	28.3	-39	13	125
Bettles	BETTLES	15,959	21.2	-45	6.7	644
Big Lake	WASILLA	11,796	32.4		4.6	180
Birch Creek	BIRCH CREEK	16,326	20.5	-57	7.9	450
Boundary	FAIRBANKS	15,412	22.3			
Brevig Mission	NOME	14,138	26.0	-28	11	25
Buckland	KOTZEBUE	16,462	19.9	-40	9.8	30
Candle	KOTZEBUE	16,462	20.5		9.8	20
Cantwell	FAIRBANKS	13,893	26.7		9.8	2,150
Central	FAIRBANKS	16,315	20.0		9	870
Chalkyitsik	FAIRBANKS		19.4	-57	7.9	560
Chandalar Lake	BETTLES	17,241	17.3		7.9	1,900
Chefornak	BETHEL	12,990	29.2			
Chena Hot	FAIRBANKS	15,381	22.6		5.2	1,200
Chenega	YAKUTAT	9,350	39.6	7	4.8	10
Chevak	BETHEL	13,339				
Chickaloon	WASILLA	11,790	32.7		9.8	930
Chicken	FAIRBANKS	14,891	24.5			
Chignik	COLD BAY	9,612	38.4		11.5	30
Chignik Lake	COLD BAY	9,612	38.4		11.5	50
Chiniak	KODIAK	8,539	41.3	13	10	
Chistochina	GULKANA	13,534	27.7			
Chitina	GULKANA	13,200	29.4		9	570
Chuathbaluk	MCGRATH	13,356		-39	6.5	300
Chugiak	ANCHORAGE					
Circle	FAIRBANKS	16,349	20.5			
Circle Hot	FAIRBANKS	15,763	22.0		9	940
Clam Gulch	HOMER	11,375	33.5	-21	7.1	
Clark's Point	KING SALMON	11,306	34.1		9	10
Clear	FAIRBANKS	14,375	25.2	-47	5.8	580
Coffman Cove	JUNEAU	8,104	42.6			

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Cold Bay	COLD BAY	9,877	37.9	9	16.9	100
Coldfoot	BETTLES	16,589	19.4			
Cooper Landing	HOMER	10,527	35.9			
Copper Center	GULKANA	14,101				
Cordova	YAKUTAT	9,004	40.6	-2	4.8	40
Craig	KETCHIKAN	7,487	44.9		9	10
Crooked Creek	MCGRATH	13,552	28.3		3.8	130
Deering	KOTZEBUE	16,462	20.5		9.8	15
Delta Junction	FAIRBANKS	13,549	27.6	-43	11.5	1,268
Denali Nat'l	MCGRATH	14,152			9.8	
Dillingham	KING SALMON	11,306	34.1		9	80
Diomede	KOTZEBUE	15,939	21.2			
Dot Lake	FAIRBANKS	14,829	24.2		9.8	1,100
Douglas	JUNEAU	8,075			8.3	
Dry Creek	FAIRBANKS	14,829	24.2		9.8	
Dutch Harbor	COLD BAY	9,197		16	11.9	
Eagle	FAIRBANKS	14,891	24.5			
Eagle River	ANCHORAGE					
Eek	BETHEL	11,548	33.1			
Egegik	KING SALMON	11,836	32.4		11.5	100
Ekwok	KING SALMON	11,306	34.1		9	130
Elfin Cove	JUNEAU	8,140	42.5			
Elim	NOME	13,943	26.8		9.8	130
Emmonak	BETHEL	13,467	28.8			
English Bay	HOMER	10,136	37.0		9	
Ester	FAIRBANKS					
Evansville	BETTLES	15,788	21.6	-43	6.3	
Eyak	YAKUTAT	9,778	38.0		9.8	
Fairbanks	FAIRBANKS	14,274	25.9	-47	5.4	436
False Pass	COLD BAY	9,733	38.1	9	17	20
Fort Yukon	FAIRBANKS	16,326	20.5	-57	7.9	443
Gakona	GULKANA	13,534	27.7		6.5	1,460
Galena	MCGRATH	14,847	24.1	-46	5	120
Gambell	NOME	14,572	25.1		13.3	30
Girdwood	ANCHORAGE	10,336	36.4	-18	9.8	50
Glenallen	GULKANA	14,067	26.2		6.5	1,456

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Golovin	NOME	13,943	26.8		9.8	25
Goodnews Bay	BETHEL	12,107	31.8			
Grayling	MCGRATH					
Gulkana	GULKANA	14,004	26.5	-40	6.8	1,572
Gustavus	JUNEAU	8,858	40.9		6.7	36
Haines	JUNEAU	8,505	41.5		8.5	31
Halibut Cove	HOMER	10,349			6.3	20
Healy	FAIRBANKS	12,582	30.1		9.8	1,490
Hollis	KETCHIKAN	7,802	44.3		9	20
Holy Cross	BETHEL	13,462	28.7		6.5	150
Homer	HOMER	10,349	37	-2	7.6	89
Hoonah	JUNEAU				9.8	30
Hooper Bay	BETHEL					
Hope	ANCHORAGE	10,100	37.1	-18	7.1	20
Houston	WASILLA	10,810				
Hughes	BETTLES	14,942	23.7			
Huslia	BETTLES	14,942	23.7			
Hydaburg	KETCHIKAN				9.8	30
Hyder	KETCHIKAN	7,165	45.9		10.6	
Igiugig	KING SALMON	11,306	34.1		9	110
Iliamna	KING SALMON	11,130	34.2	-19	9.6	190
Indian	ANCHORAGE	10,604	35.7	-18	7	100
Ivanof Bay	KING SALMON	9,612	38.4		11.5	
Jakolof Bay	HOMER	10,349				
Juneau, Airport	JUNEAU	9,105	40	1	8.3	20
Juneau, City of	JUNEAU	8,021	42.8	1	8.3	30
Kake	KETCHIKAN	8,527			11.5	10
Kaktovik	BARROW	20,370	9.8			
Kalifonsky	HOMER	11,395	33.5		7.1	20
Kaltag	NOME					
Karluk	KODIAK	8,539	41.3	13	10	137
Kasaan	KETCHIKAN	7,802	44.3		9	10
Kasigluk	BETHEL	13,106	29.1	-39	13	40
Kasilof	HOMER	11,337	34.1		7.1	60
Kenai	HOMER	11,395	33.5		7.1	86
Kenny Lake	GULKANA	14,036	26.3			

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Ketchikan	KETCHIKAN	7,084	45.9	17	10.6	50
Kiana	KOTZEBUE	15,675	22.1	-45	9	150
King Cove	COLD BAY	9,733	38.1	9	17	148
King Salmon	KING SALMON	11,716	32.8	-22	10.8	49
Kipnuk	BETHEL	12,990	29.2			
Kivalina	KOTZEBUE	16,758	18.8		9.8	10
Klawock	KETCHIKAN				9.8	12
Klukwan	YAKUTAT	10,476	36.3		9.8	
Kobuk	BETTLES	15,716	21.6			
Kodiak	KODIAK	8,837	40.7	13	10.8	112
Kokhanok	KING SALMON	11,610	33.0			
Koliganek	KING SALMON	11,306	34.1		9	240
Kongiganak	BETHEL	11,306	34.1		9	25
Kotlik	NOME	13,467	28.8			
Kotzebue	KOTZEBUE	16,032	20.9	-37	13	20
Koyuk	NOME	13,943	26.8		11.5	130
Koyukuk	NOME					
Kwethluk	BETHEL	13,106	29.1	-39	13	28
Kwigillingok	BETHEL	12,990	29.2			
Larsen Bay	KODIAK	9,065	39.9		10.6	20
Levelock	KING SALMON	11,306	34.1		9	60
Lime Village	MCGRATH	13,339	28.3			
Lower Kalskag	BETHEL	13,382	28.1		5	50
Manley Hot	FAIRBANKS	14,593	24.6		5.2	275
Manokotak	KING SALMON	11,306	34.1		9	107
Marshall	BETHEL	12,785	29.7		9.8	90
McCarthy	GULKANA	13,053	29.0		9	1,400
McGrath	MCGRATH	14,574	25	-47	4.8	344
Mekoryok	BETHEL	13,575	27.9		13.8	46
Mentasta Lake	GULKANA	15,400	22.6	-54	9	
Metlakatla	KETCHIKAN	7,000	45.6		10	10
Meyers Chuck	KETCHIKAN	7,165	45.9		10.6	10
Minchumina	FAIRBANKS	13,858	27.0			
Minto	FAIRBANKS	15,528	22.2			
Moose Pass	HOMER	11,126	34.4		9	485
Mtn. Village	BETHEL	13,448	27.8			

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Naknek	KING SALMON			-12	10.6	50
Napaimute	BETHEL	13,356	28.2	-39	6.5	200
Napakiak	BETHEL	13,106	29.1	-39	13	20
Napaskiak	BETHEL	13,106	29.1	-39	13	24
Nelson Lagoon	COLD BAY	8,865	40.5		12.5	13
Nenana	FAIRBANKS	14,539	25.5		5.8	358
New Stuyahok	KING SALMON	11,306	34.1		9	125
Newhalen	KING SALMON	11,130	34.2		9.6	190
Newtok	BETHEL	13,048	28.9			
Nightmute	BETHEL	13,048	28.9			
Nikiski	HOMER	10,899	34.9			
Nikolaevsk	HOMER	11,155	34.3	-24	7.1	75
Nikolai	MCGRATH	15,214	23.1		4.8	430
Nikolski	COLD BAY	9,555		21	15.2	73
Ninilchik	HOMER	11,155	34.3	-24	7.1	100
Noatak	KOTZEBUE	16,758	18.8		9.8	60
Nome	NOME	14,371	25.5	-27	10.7	13
Nondalton	KING SALMON	11,130	34.2		9.6	250
Noorvik	KOTZEBUE	15,675	22.1	-45	9	70
North Pole	FAIRBANKS	15,403			5.2	
Northway	FAIRBANKS	15,763	21.7	-53	3.8	1,713
Nuiqsut	BARROW	20,370	9.3	-41	12	50
Nulato	NOME					
Nunapitchuk	BETHEL	13,106	29.1	-39	13	12
Old Harbor	KODIAK	8,614		13	11.5	20
Oscarville	BETHEL	13,106	29.1	-39	13	10
Ouzinkie	KODIAK	8,539	41.3	13	10	55
Palmer	WASILLA	10,868	35.0	-18	9	225
Paxson	GULKANA	14,182	25.8	-25	9.8	2,750
Pedro Bay	KING SALMON	11,130	34.2		9.6	45
Pelican	JUNEAU	8,529	41.7		9.8	22
Perryville	COLD BAY	9,612	38.4		11.5	25
Petersburg	KETCHIKAN	8,134	42.7		5.4	115
Pilot Point	KING SALMON	10,415	37.0	-6	14.6	50
Pilot Station	BETHEL					
Pitkas Point	BETHEL	12,785	29.7			

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Platinum	KING SALMON	12,107	31.8			
Point Baker	KETCHIKAN					
Point Hope	KOTZEBUE	16,501			12.3	10
Point Lay	BARROW	19,109		-37	12.7	10
Port Alexander	KETCHIKAN	7,513	44.1			
Port Alsworth	KING SALMON	11,206	34.0		9	260
Port Graham	HOMER	10,136	37.0		9	93
Port Heiden	KING SALMON	10,415	36.2	-6	15	92
Port Lions	KODIAK	8,539	41.3	13	10	52
Port Protection	KETCHIKAN					
Quinhagak	KING SALMON	12,107	31.8			
Rampart	FAIRBANKS	15,528	22.2			
Red Devil	MCGRATH	13,339	28.3			
Ruby	MCGRATH	13,858	27.1			
Russian Mission	BETHEL	13,382	28.1		6.5	50
Saint George	ST. PAUL	10,242		4	15	100
Saint Mary's	BETHEL	12,785	29.7		9.8	25
Saint Michael	NOME	14,272	25.9		9.8	30
Saint Paul	ST. PAUL	11,178	34.3	4	17.7	22
Salcha	FAIRBANKS					
Sand Point	COLD BAY	8,865	40.5		12.5	22
Savoonga	NOME	14,971	23.6		18	53
Saxman	KETCHIKAN	7,165	45.9			
Scammon Bay	BETHEL	13,048	28.9			
Selawik	KOTZEBUE	16,827	18.6	-37		
Seldovia	HOMER	10,136	37.0		9	30
Seward	HOMER	9,188	39.5	7	4.8	35
Shageluk	MCGRATH	13,462	28.7		6.5	70
Shaktoolik	NOME	13,919				
Sheldon Point	BETHEL	13,467	28.8			
Shemya	ADAK	9,555	38.6	24	19.6	122
Shishmaref	KOTZEBUE	15,790			13.5	20
Shungnak	BETTLES	15,586			9	140
Sitka	JUNEAU	8,011	43.4	17	6.3	67
Skagway	YAKUTAT	8,666	41.0		11.5	30
Skwentna	TALKEETNA	11,873	32.4		2.9	153

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Slana	GULKANA					
Sleetmute	MCGRATH	13,339	28.3			
Soldotna	HOMER	11,775	32.6	-24	7.1	90
South Naknek	KING SALMON	11,772	32.5		10.6	50
Stebbins	NOME	14,272	25.9	-34	9.8	26
Sterling	HOMER	12,006	31.9	-23	7.1	250
Stevens Village	FAIRBANKS	15,528	22.2			
Stony River	MCGRATH	12,633				
Sutton	WASILLA	10,451	36.1	-18		
Takotna	MCGRATH	14,424	25.3	-47	4.8	825
Talkeetna	TALKEETNA	11,804	32.6	-25	4.6	345
Tanacross	FAIRBANKS	15,479	23.0	-54	9	1,550
Tanana	FAIRBANKS	15,024	24.0	-48	5.2	232
Tatitlek	YAKUTAT	9,778	38.0		9.8	25
Tazlina	GULKANA	14,067	26.2		6.5	
Teller	NOME	15,142	24.1	-27	9.8	10
Tenakee Springs	JUNEAU	8,180	42.4		9.8	20
Tetlin	GULKANA	15,400	22.6		9	
Thorne Bay	KETCHIKAN	7,802	44.3		9	10
Togiak	KING SALMON	11,306	34.1		9	12
Tok	GULKANA	15,400	22.6	-54	9	1,630
Toksook Bay	BETHEL	12,990	29.2			
Tonsina	GULKANA	13,928	26.6			
Trapper Creek	TALKEETNA	11,863	32.5		4.6	500
Tuluksak	BETHEL	13,106	29.1	-39	13	30
Tuntutuliak	BETHEL	13,106	29.1	-39	13	16
Tununak	BETHEL	13,106	29.1	-39	13	17
Twin Hills	KING SALMON	11,306	34.1		9	25
Tyonek	ANCHORAGE	9,742	38.1			
Ugashik	KING SALMON	10,415	36.2	-6	14.6	25
Unalakleet	NOME	13,919	26.9	-34	12.7	18
Unalaska	COLD BAY	9,014	40.6	16	11.9	20
Upper Kalskag	BETHEL	13,356	28.2	-39	6.5	49
Valdez	YAKUTAT	9,711	38.3	-2	9.8	37
Venetie	BETTLES	16,465	19.6			
Wainwright	BARROW	19,824	10.9	-41	10.6	30

Name	Weather City	Degree Days	Avg. Dry Bulb Temp.	Design Temp	Wind Speed	Elevation
Wales	KOTZEBUE	15,939	21.2		17.5	9
Ward Cove	KETCHIKAN	7,165	45.9		10.6	
Wasilla	WASILLA	10,810	35.8	-18	6.7	50
White Mtn.	NOME	13,578	27.8		9.8	50
Whittier	YAKUTAT	9,348	39.2	5	10.6	60
Willow	TALKEETNA	12,332	31.1		4.6	600
Wiseman	BETTLES					
Wrangell	KETCHIKAN	7,968	43.4		10.6	40
Yakutat	YAKUTAT	9,605	38.9	5	7.4	28

Alaska community weather information is from the "Alaska Climate Summaries," 2nd Edition, 1989, by Arctic Environmental Information and Data Center, University of Alaska, Anchorage. If the annual average temperature listed in the table conflicted with the heating degree days data listed, the heating degree days value was ignored. When AKWarm uses weather data, it first looks for annual average dry bulb temperature; if that value is missing it will search for heating degree days, and if that value is missing it will use the values given for the weather city that is associated with that community. The weather city is also used for obtaining solar data.

Fuel costs are from the "Fuel Price Tracking Survey," produced by the University of Alaska Anchorage Institute of Social and Economic Research, for October 1993, and from independent calls made by AHFC Rural Housing staff in regional offices in August 1994. AKWarm allows for operator input of fuel costs for those areas and fuels where they are not listed.