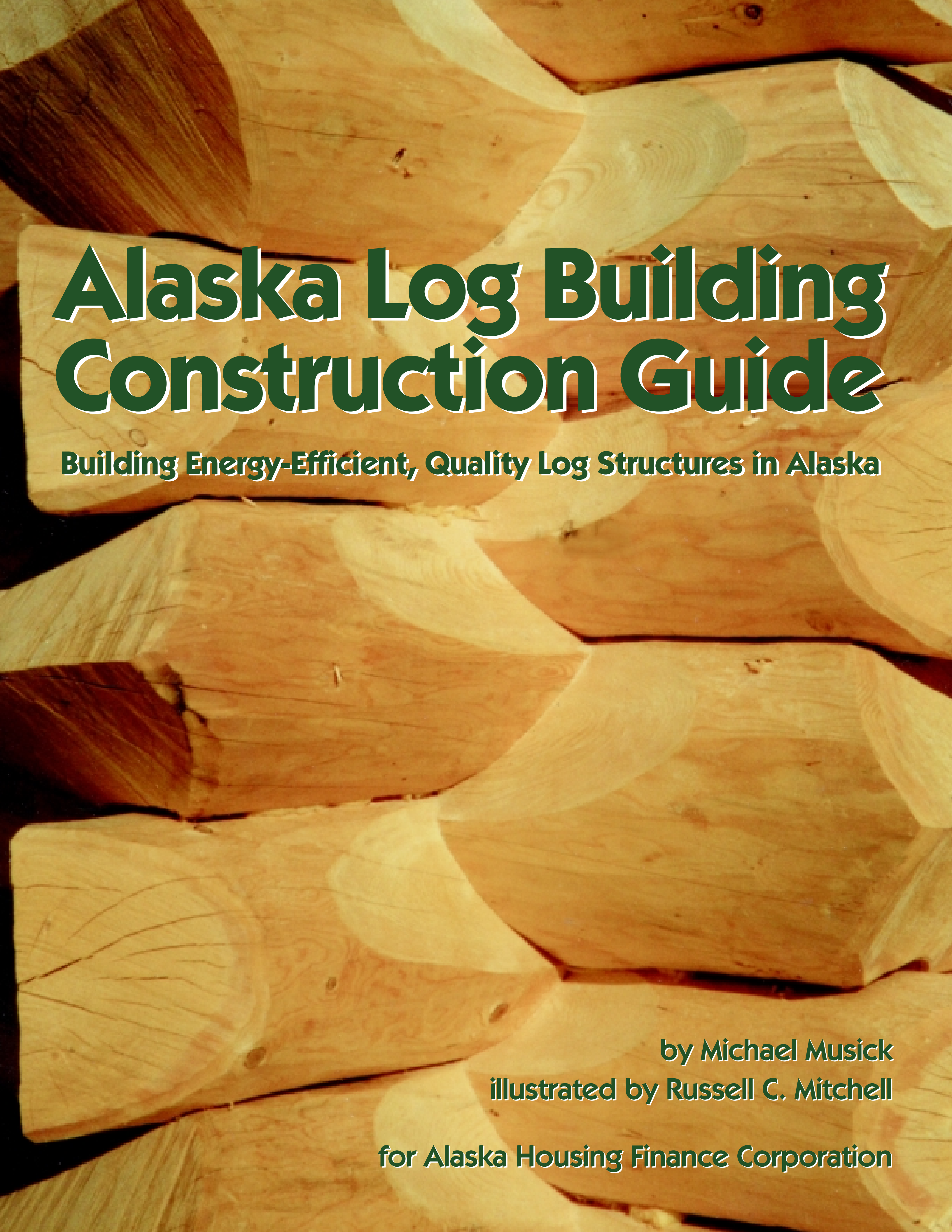

Alaska Log Building Construction Guide

Building Energy-Efficient, Quality Log Structures in Alaska

by Michael Musick
illustrated by Russell C. Mitchell

for Alaska Housing Finance Corporation

Alaska Log Building Construction Guide

by Mike Musick
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for

Alaska Housing Finance Corporation

“

When we build, let us think that we build forever. Let it not be for present delight nor for present use alone. Let it be such work as our descendants will thank us for; and let us think, as we lay stone upon stone, that a time is to come when those stones will be held sacred because our hands have touched them, and that people will say, as they look upon the labor and wrought substance of them, “See! This our parents did for us.”

—John Ruskin

”

Acknowledgements

The authors would like to thank the many people who made this book possible. Please know that your contribution is appreciated, even if we forgot to mention you here. Phil Loudon contributed a lot of time and text to the retrofit chapter. Sandy Jamieson, noted artist and master log builder, provided thoughtful comments and review. Phil Kaluza, energy specialist for Alaska Housing Finance Corporation (AHFC), contributed the sample energy ratings in Appendix C and other information on AkWarm. And particularly, this book would not have been possible without Bob Brean, director of the Research and Rural Development Division; Lucy Carlo, research and rural development specialist; and Mimi Burbage, energy specialist for AHFC. Thanks are due to Dan Fauske, executive director of AHFC, and Judith DeSpain, deputy executive director of AHFC, for their continued support.

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Chapter 1
Introduction

Introduction

The Alaska Log Building Construction Guide is written to help log builders, owner-builders, contractors, architects, engineers, and building manufacturers build log homes that meet the State of Alaska Building Energy Efficiency Standards (BEES) (see Appendix A).

This book contains useful information for anyone interested in building or renovating energy-efficient, quality log structures in Alaska. A number of basic procedures and techniques are described in detail to help even the novice log builder get started building his or her first log project. Building an energy-efficient log home requires the highest level of craftsmanship to meet modern standards of airtightness, indoor air quality, safety, comfort, and durability.

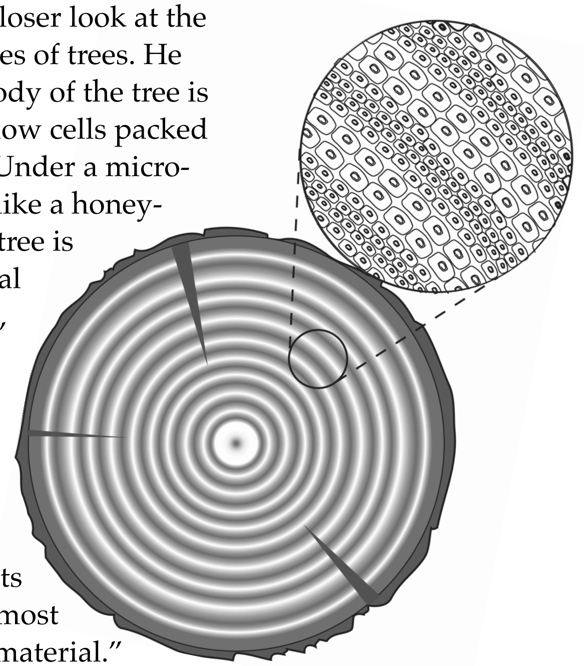
Disclaimer

Alaska Housing Finance Corporation, its agents, and the authors of this book assume no responsibility for the use of information in this book by anyone. All design details, methods of construction, and structural systems should be checked out by a professional to assure compliance with codes and regulations. This book is not intended to supersede either local or national building codes.

Energy-efficient Log Homes

From the south slope of the Brooks Range, which more or less defines the northern limit of the boreal forest, to the rain forests of the southern panhandle, Alaska is blessed with an abundance of trees suitable for building log homes. The romantic image of a log cabin in the woods is slowly being replaced with log homes hand-crafted from massive logs up to two feet in diameter and fitted so tightly that even after several years of settlement and shrinking, you can't easily slide a knife blade between the logs.

In the introduction to the eighth edition of Building With Logs, author and noted Canadian log builder and teacher B. Allan Mackie invites the reader to take a closer look at the physical properties of trees. He notes that "the body of the tree is composed of hollow cells packed tightly together. Under a microscope, they look like a honeycomb. When the tree is felled and the vital fluids have dried, these tiny air pockets seal, becoming an almost perfectly insulated building material. . . The tree as it exists naturally is an almost perfect building material."



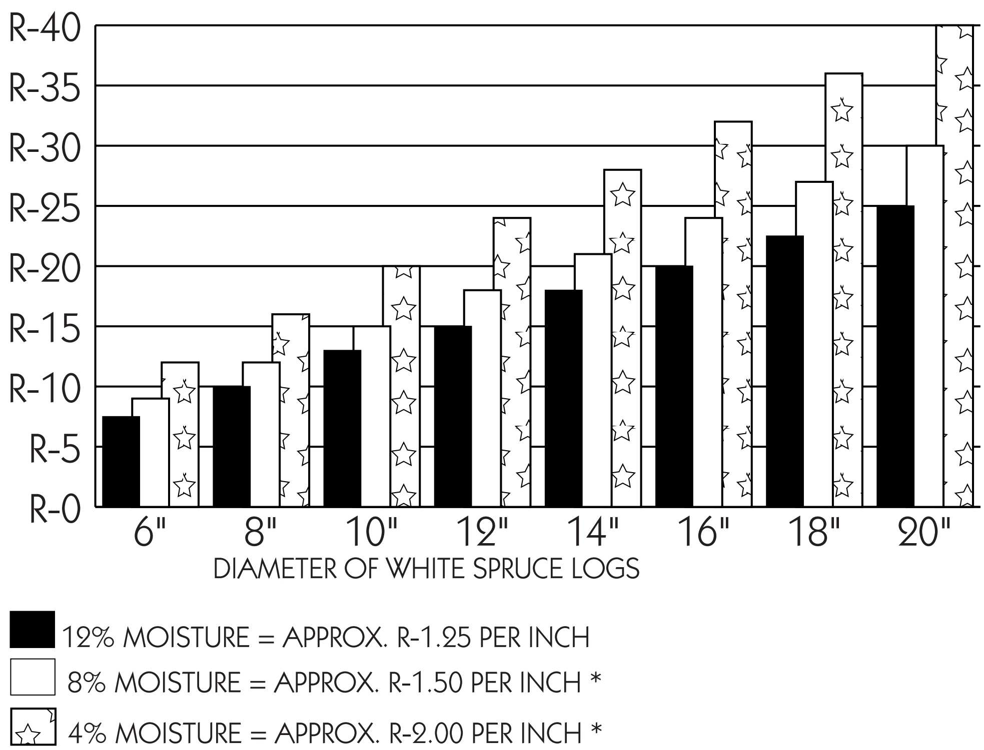
Cross section of a tree in magnification.

Big Logs

In the case of massive logs, R-value, the resistance to heat flow, is not the only property relating to energy use. Logs with a good southern exposure will store heat from the sun during the day and slowly release that heat at night. The cycle repeats until fall when you have to start adding heat from your wood stove or furnace. One or two short, hot firings a day of a good airtight wood stove during the winter heating season will heat a well-built modern log home. The objective is to keep the mass of the logs from cooling to below a thermostat setting for the fossil-fuel-fired furnace or boiler.

As you travel north in Alaska, the trees tend to get smaller and eventually reach a lower limit to the diameter of logs that will meet the prescriptive R-value requirements of State of Alaska Building Energy Efficiency Standards. For example, if the logs average less than 13" in diameter in southeast Alaska, the builder will have to increase the efficiency levels of other components of the building system and use the building budget method of compliance, which requires a HOT-2000 or AkWarm computer energy use calculation, or the energy rated method to comply with BEES (See Appendix A).

AkWarm is an energy analysis software program used by the Alaska Housing Finance Corporation (AHFC) to perform energy ratings on proposed house plans or on old and new houses. Hot 2000 is



* extrapolated from Carlson, *Building a Log House in Alaska* (see Appendix D, References and Bibliography)

an energy analysis software program that was developed for the Canadian R-2000 Program and is also used by the Alaska Craftsman Home Program to qualify a home for meeting their standards of energy efficiency.

Alaska white spruce has a thermal resistance of about R-1.25 per inch at 12% moisture content. Oven dry white spruce has a thermal resistance of 1.47 to 2.04 per inch. Log walls in the interior of Alaska may have a higher R-value because of the extreme dryness of the air during prolonged subzero weather (Carlson, Building a Log House in Alaska—see Appendix D).

AkWarm assigns default R-values for logs that do not exactly match the numbers listed above. The default R-value per inch in AkWarm steadily decreases as the size of the logs increases. AkWarm assumes R-values as in Table 1 below.

Since the moisture content of logs varies, AkWarm does not consider moisture content in assigning these default numbers. If your logs are especially dry, your energy rater might be able to override the default R-values and input slightly higher R-values.

Small Logs

As we noted above, small diameter logs and 6-inch and 8-inch three-sided logs will not comply with the prescriptive standard unless they are furred in (or out) and insulated and vapor barriered like a frame wall. Unless you are just building a simple cabin, 6 or 8-inch three-sided logs usually just end up being very heavy and expensive siding. If you are building a house to meet BEES, three-sided logs may be a poor choice of materials. It might be better to mill the trees into framing materials or post and beam components and log siding or bevel siding.

It is, however, quite possible to use the building budget method or the energy rated method to score enough points to qualify a 6-inch or 8-inch log wall for four-star-plus and five-star ratings. (See Appendix C, Sample Energy Ratings for Log Homes.) This can be accomplished with a thoughtful application of insulation to the foundation or floor and a highly insulated roof, energy efficient windows oriented to the sun, and efficient space heating. The logs must be especially air tight and the ventilation system must comply with section 2.5 of BEES (Appendix A).

Table 1

Log Size	R-value per inch	R-value Assumed by AkW arm
6-inch	R-1.27	R-7.6
8-inch	R-1.23	R-9.85
10-inch	R-1.21	R-12.1
12-inch	R-1.2	R-14.35
14-inch	R-1.19	R-16.6
16-inch	R-1.18	R-18.85
18-inch	R-1.17	R-21.1
20-inch	R-1.17	R-23.35

Chapter 2
Problems and Solutions

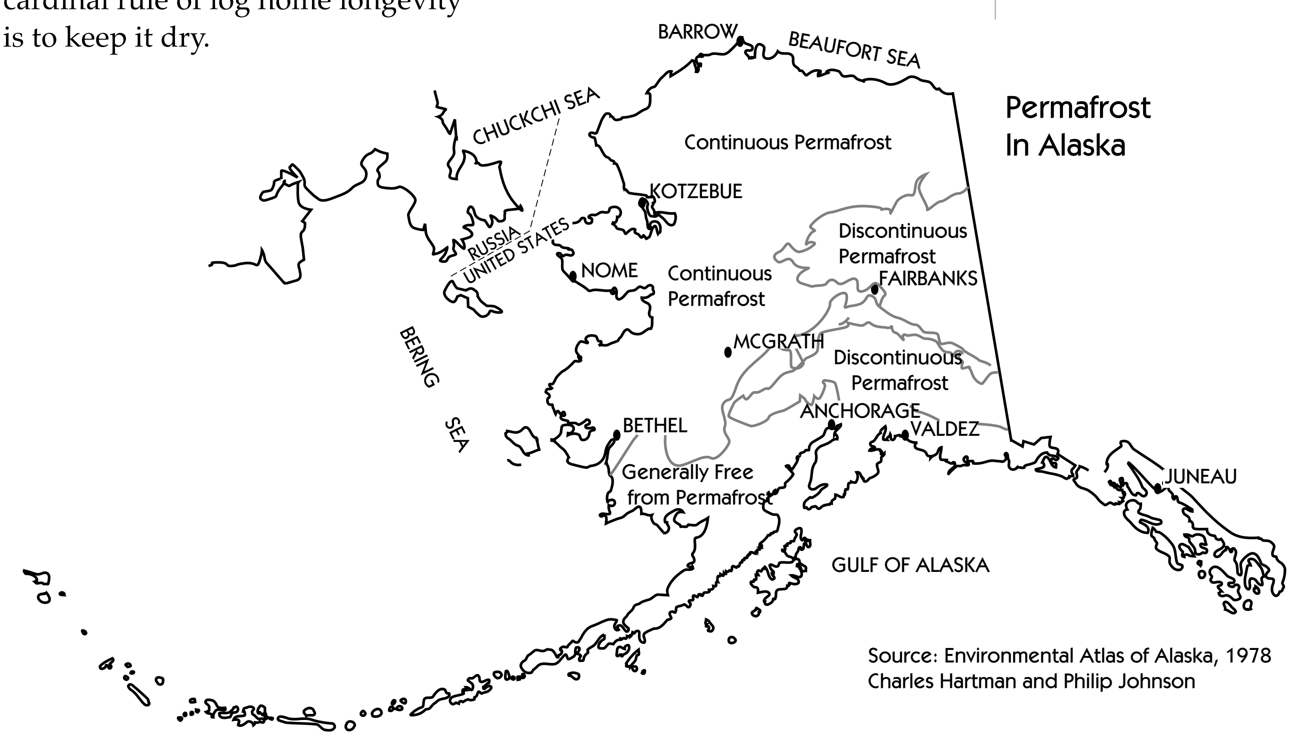
Problems

The first mistake that many log home builders make is building a "permanent" structure on a temporary foundation. When the foundation fails, the house will rapidly self-destruct. Differential settlement caused by melting permafrost, seasonal frost heaving, and flooding is the single most destructive problem in Alaska buildings.

A close second is poor moisture control, which may take only a little longer to destroy a log house through the natural decay process. Damp wood will be attacked by rapidly growing colonies of mold, mildew, and mushrooms, programmed to return the logs to compost on the forest floor. The cardinal rule of log home longevity is to keep it dry.

From the Ground Up

The most important consideration for building a foundation for a log structure is the ground upon which it sits. A log home may be two to four times heavier than a comparable frame house. The heavier and more expensive a structure is, the more important it is to have good soil information upon which to base a foundation design. The best way to determine what kind of ground is under your proposed log home is to core drill test holes under the footprint of the foundation, to at least 40 feet deep if permafrost or mass ice is possible. At the very least, use whatever technology is at hand to dig a hole in the ground. Drive a steel rod or dig a hole with a shovel or a backhoe or a cat.

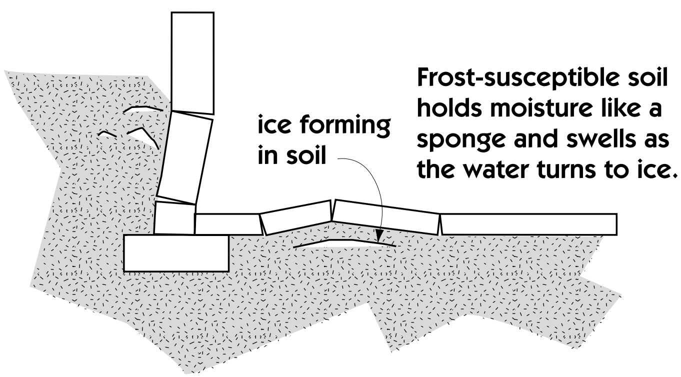


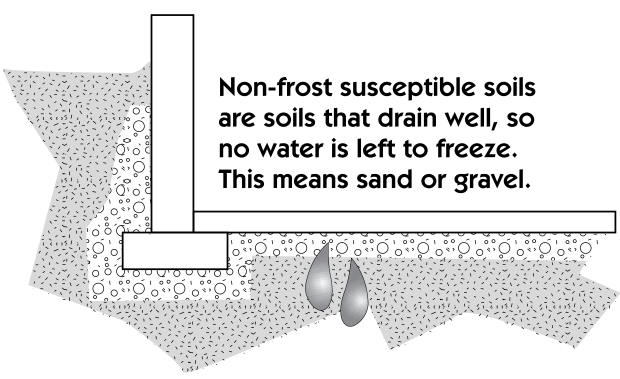
Permafrost In Alaska

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

"The cardinal rule of log home longevity is to keep it dry."

Damage from rot





About half of Alaska is underlain with permafrost. Approximately one quarter of the state must contend with discontinuous permafrost, while the remaining quarter is generally free of permafrost (see map on previous page). The U.S. Natural Resources Conservation Service may be a good source of information on soils in your area.

Good Soils

Good building soils in Alaska are generally non-frost-susceptible (NFS). By this we mean solid rock or free-draining sand and gravels that will not hold water and will not cause frost heaving when the ground temperature is below freezing. If you are building on good soils, just about any structurally sound foundation that complies with local building codes and accepted engineering principles can be used to support a log home.

If you are building in an area where NFS material is not available, you must be especially careful to control the flow of water off the roof with ample roof overhangs and rain gutters or roof troughs. The ground should be sloped away from the foundation in all directions, and surface runoff should be diverted around the site with swales, berms, or ditches or a combination of all three.

Permafrost

If you are building in the half of Alaska with continuous permafrost, you must design a foundation that will maintain the below-freezing temperature of the soil beneath the house. If you are in the transition zone of discontinuous permafrost, you must design and build as if you are building on frozen ground, unless you know no ice is present because you did a core drilling or other research.

Design

Log house design should begin in the woods. You need to know what sort of trees are available. You should know the average mid-log diameters, how long, how straight, how dry, how old, what species.

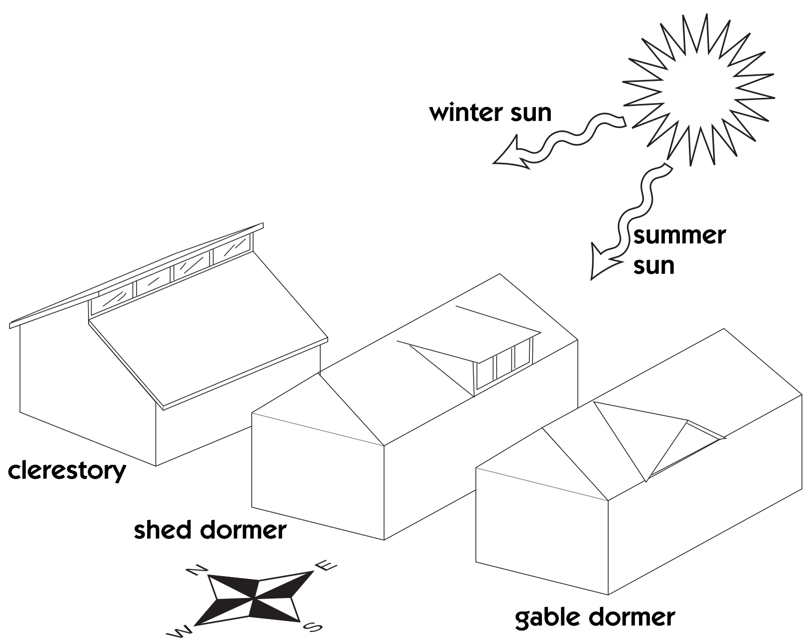
It is equally important to know the building site. When choosing the best location for the house on your property, make a drawing showing the location of the most beautiful natural features on the land. This may be an ancient grove of trees or an interesting rock formation or a meandering trout stream. Whatever it was that made you want to buy this land to build your home on should not be destroyed in the process of building that home. Move back from the stream, avoid getting close to the grove of trees, and don't bulldoze that fascinating rock outcropping.

The house must also work with the slope, solar aspect, vegetation, and other natural and man-made features of the landscape. Face the long side of the house directly at the midwinter sun for natural light and passive solar heat. Don't block the winter sun with evergreen trees. Birch or aspen will shade the house in summer and drop their leaves in the fall, allowing the sun to penetrate deep into the house in the winter.

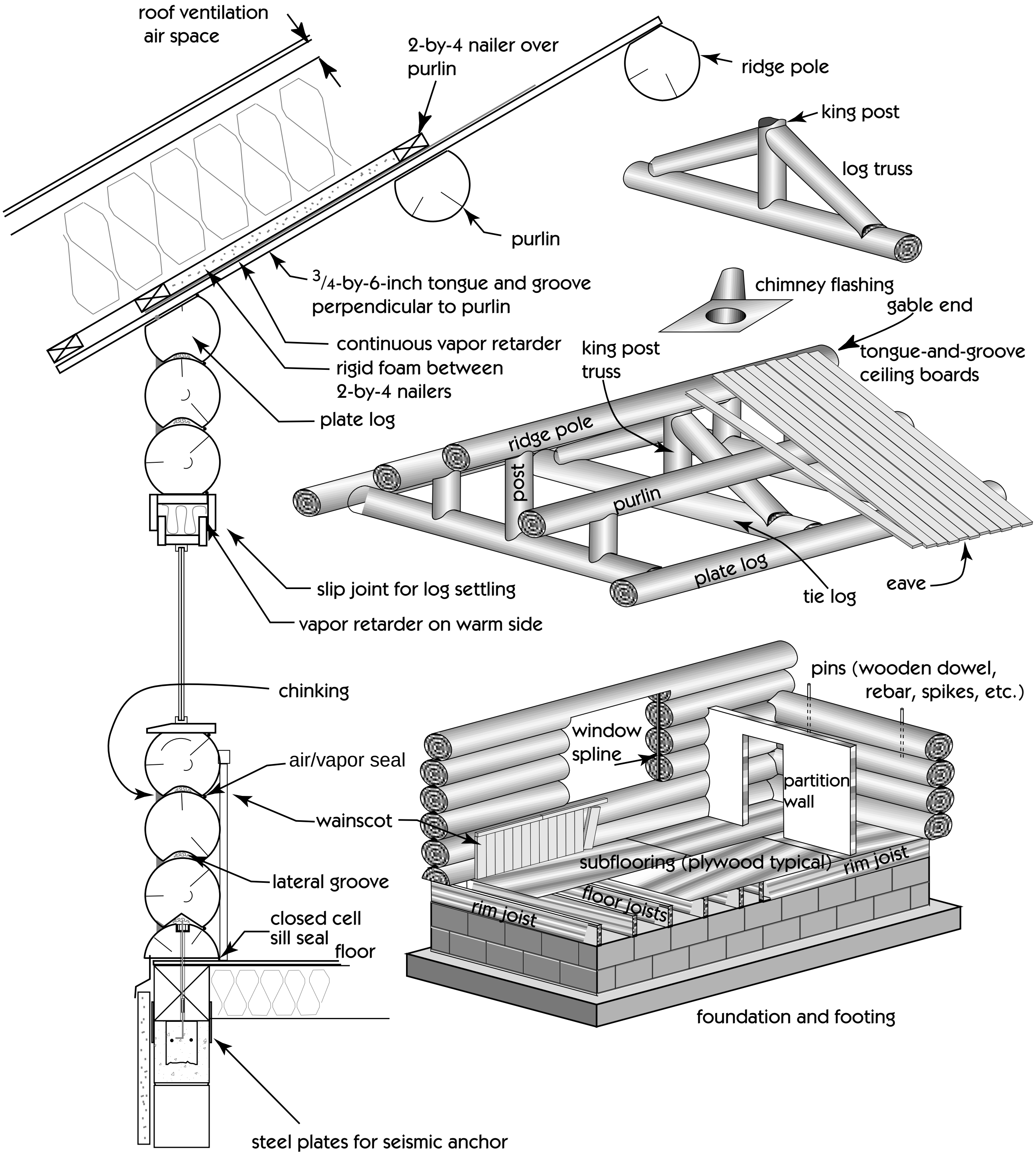
South-facing clerestory or dormer windows are preferable to skylights because of potential glaciering and because a vertical window will catch the low winter sun more directly. Take care to avoid overheating with too much unshaded west-facing glass.

Design the home to fit your needs now and in the future. Think in terms of growing old along with your new log home. Your children may choose to live there with their children. Some log homes in Scandinavia have been lived in continuously by succeeding generations for over five hundred years. Design, construct, and maintain a log home so that it will last at least as long as it took to grow the trees that are used to build it.

> "Think in terms of growing old with your new log home."



Birch or aspen will shade the house in summer and drop their leaves in the fall, allowing the sun to penetrate deep into the house in the winter.



The parts of a log house

Shrinkage

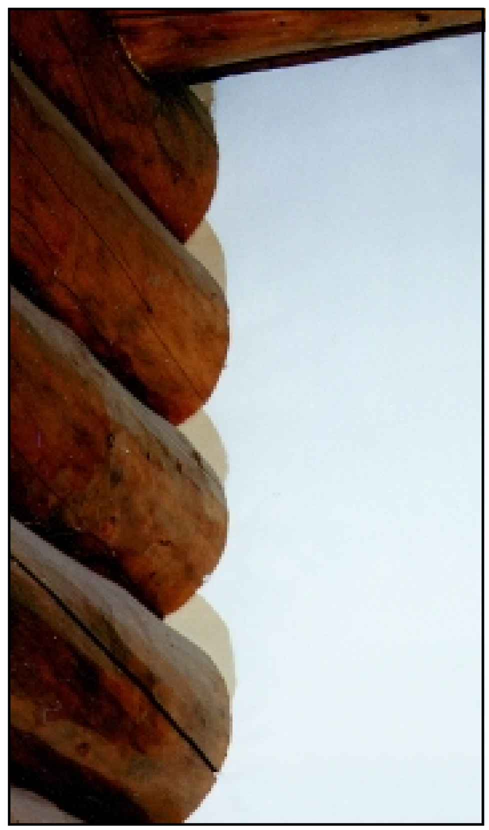
Designing for log construction is not the same as designing for frame construction. You have to allow for settlement of the horizontal wall logs and gable logs of between 1/2 and 3/4 inch per round of logs, depending on species and water content. A green 8-foot-tall log wall may shrink about four to six inches in height, while a 12-foot-high log gable wall may shrink six to eight inches or more. All partitions and walls incorporating vertical posts and stairways must allow for settlement, and log floor systems must account for five or six inches of settlement.

All window and door framing and vertical support posts and interior frame walls must allow the logs to settle down without hanging up and causing gaps to occur between log courses. Air leakage through poorly fit logs is not only one of the greatest sources of heat loss, it is also the major moisture transport mechanism in a leaky house.

Moisture carried by air leaking through cracks between the logs or holes in the ceiling vapor retarder

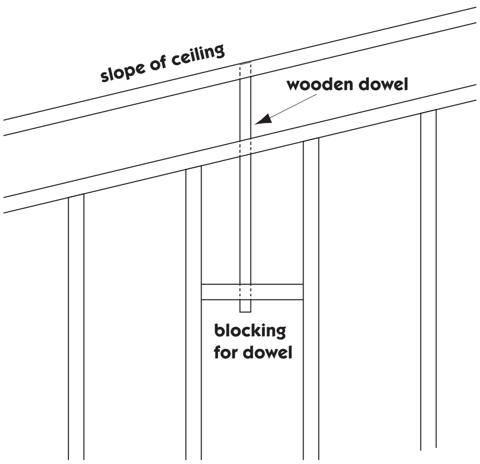
This ridge pole, which rests on a horizontal log gable, shrank and settled more than 6 inches and is now crushing the Sheetrock.

The gap left for settling here is covered with scribe-fit trim.



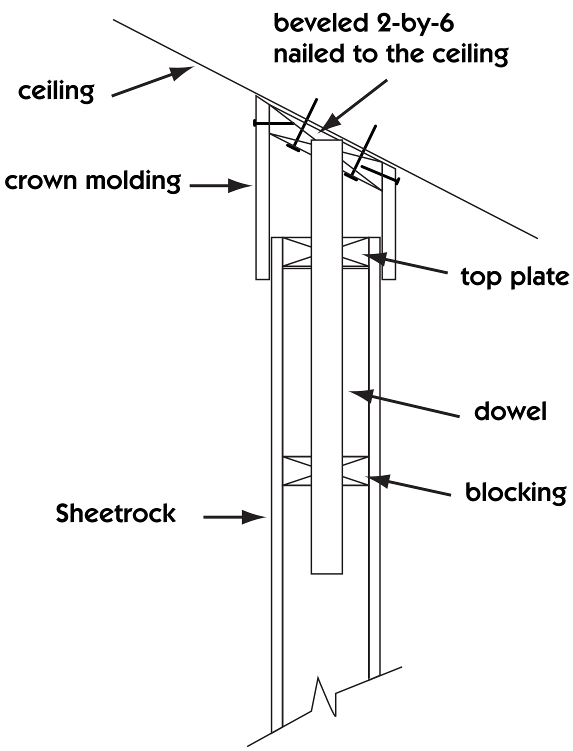
Unpainted Sheetrock exposed as logs settle. The space above the partition, which was more than 6 inches when built, is now 1.5 inches after 12 years of settling.

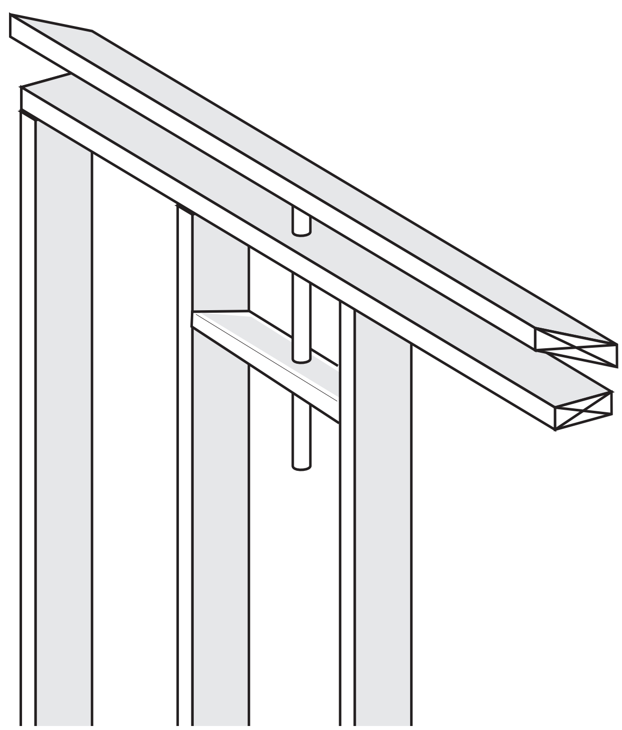
A slip joint for a partition wall that is perpendicular to the ridgepole



A 2-by-4 stud wall partition slip-joint to keep walls straight and allow the ceiling to settle. A wooden dowel is used to align the partition wall with the top plate, which is attached only at the top. The dowel is run down through snug-fitting holes and braced with additional blocking.

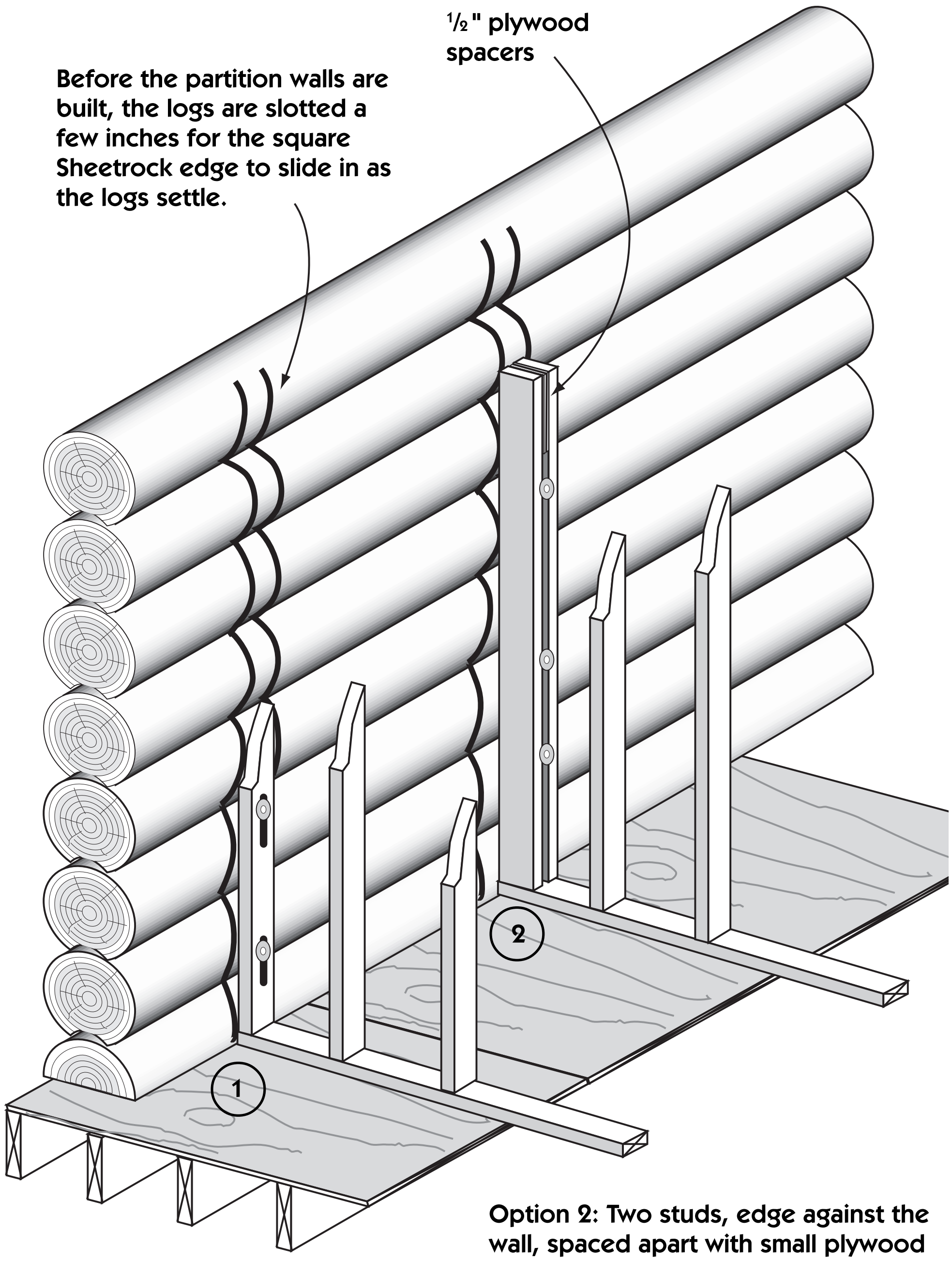
A slip joint for a partition wall that is parallel to the ridgepole





The dowel is only nailed or glued at the top, and slides down through snug- fitting holes in the plate and blocking as the building settles. A 2-by-6 with both sides beveled at ceiling slope and 1 1/2 inches wider than wall frame is nailed or bolted to the ceiling to attach wide crown molding.The crown molding is only nailed at the top and slides down over the Sheetrock.

Two ways to attach frame partitions to log walls and still allow for the settling of the logs

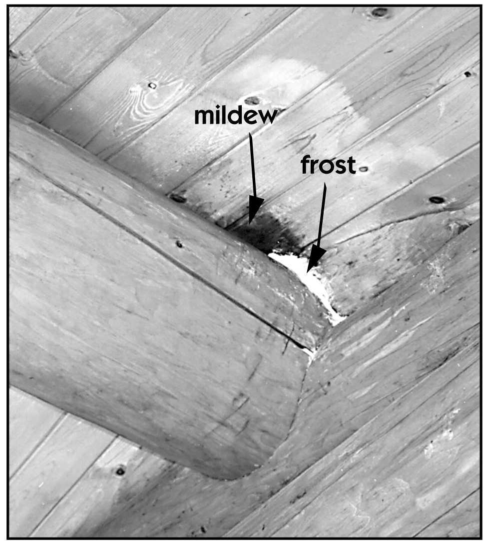


Option 1: A stud laid flat against the wall with bolt run through slots long enough to allow for settling. This method uses less wood.

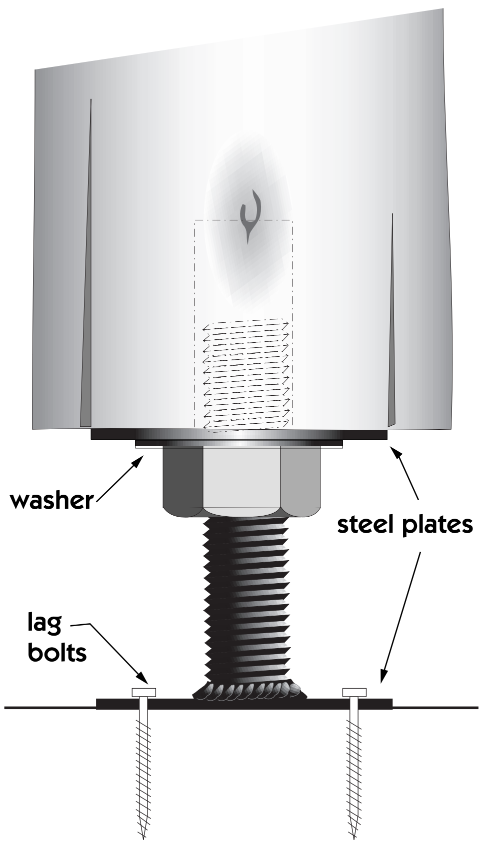
Option 2: Two studs, edge against the wall, spaced apart with small plywood scraps and bolts through the slot to the logs. This method can be faster to build.

will condense into liquid water when it reaches a cool surface. This could lead to rotting logs and glaciers forming on the roof.

In order for a log structure to meet the airtightness requirements of the energy standard, it should be built to the highest possible standards of craftsmanship as outlined in the Log Building Standards of the Canadian and American Log Builders Association (Appendix B).



Frost buildup and mildew at a leak around the ridgepole.

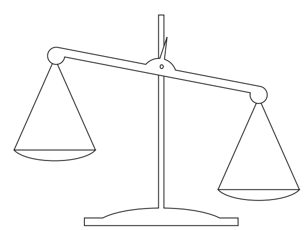


An adjustable vertical support post.

The Building as a System

Log buildings must be designed to work as a system and must control the flow of heat, air, and moisture in and out of the structure. The building system includes the foundation, floor, log walls, windows, doors, ceiling, heating appliance, ventilation system, energy-efficient lighting, the occupants, and the outside environment. A change in any part of the system will affect the performance of the rest of the system.

For example: you build a well-crafted home that is so air tight that the air inside becomes stale and unheathy, and the wood stove won't draw very well. You must ventilate the house, so you put in a powerful exhaust fan. Then the wood stove belches smoke back into the house. Finally, you cut an opening in the wall to provide air for the wood stove. So now you have a system and you are in control of the fresh air in your house.



"A change in any part of the system will affect the performance of the rest of the system."

> "Building your house with an eye toward complying with the Americans with Disabilities Act makes the house easier for you and your visitors to live in, as well as making it easier to eventually sell."

If You Want to Borrow Money

All construction should comply with local building codes and the Uniform Building Code, the Uniform Mechanical Code, the Uniform Plumbing Code, the National Electrical Code, and the State of Alaska Building Energy Efficiency Standards. If you wish to borrow money from the Alaska Housing Finance Corporation and take advantage of their many interest rate reduction programs, or if you want to refinance or sell your home, most loan programs require you to design and build to meet these codes and standards.

Building your house with an eye toward complying with the Americans with Disabilities Act makes the house easier for you and your visitors to live in as well as making it easier to eventually sell. You never know when you might become permanently or temporarily disabled, and it's a lot cheaper to incorporate handicap-accessible features now, when you're building, than to retrofit later. Features like lever handles on doors and faucets make life easier even if you're not disabled.

Top Ten Building Science Rules

1. **Heat flows from hot to cold.**
2. **Heat does not rise—warm air rises.**
3. **Heat is transfered by conduction, convection, and radiation.**
4. **Heat flow through insulation is slowed by 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.**

Chapter 3
Meeting the State of Alaska's Building Energy Efficiency Standards

Statewide Regions

For the purpose of creating statewide building energy efficiency standards, Alaska is divided into five geographic and climatic areas (see map below) with minimum standards for each region.

This chapter explains the different ways to meet these standards. The standards themselves are found in Appendix A.

The traditional sod homes of the north and west coasts were constructed of driftwood, whale bones, and sod. These structures often had a below-grade entry tunnel, with an animal skin door to regulate the flow of ventilation air through a hole in the roof. These structures were often heated with a seal or whale oil lamp and body heat.

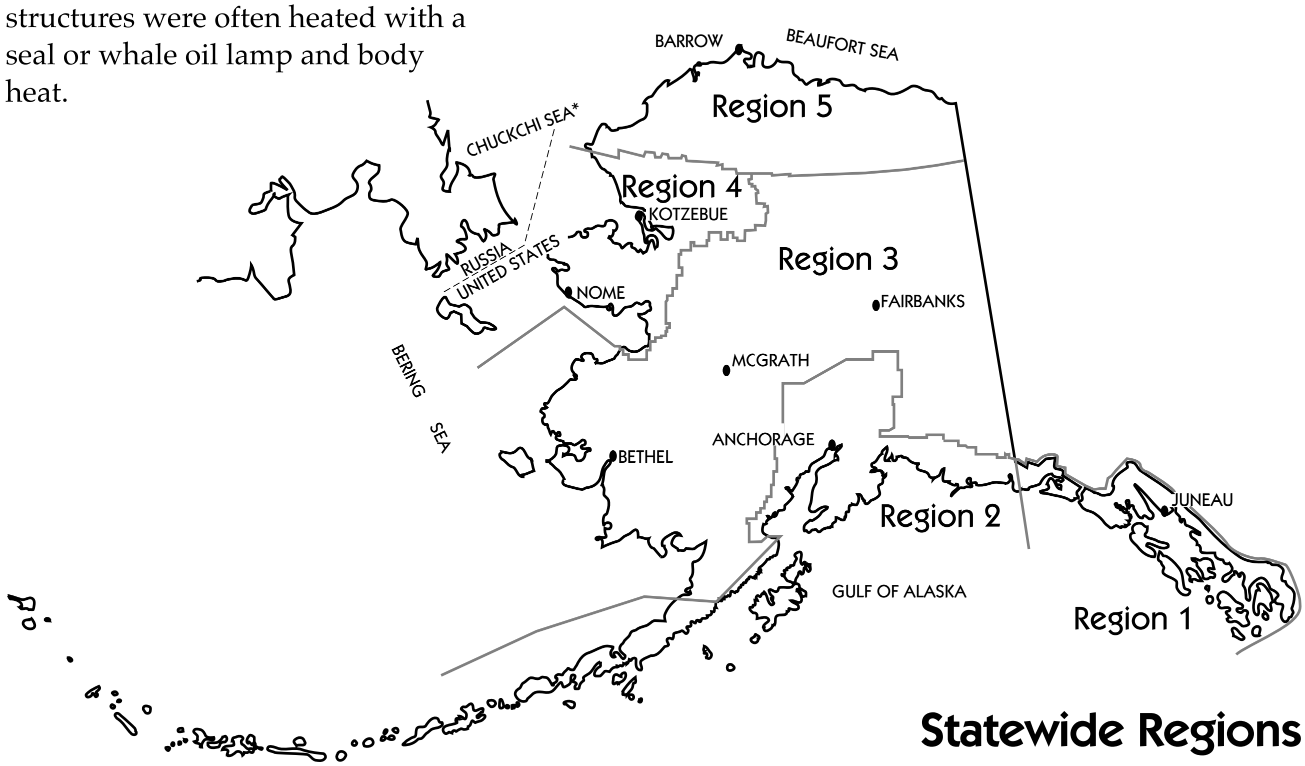
The Arctic Slope does not have any suitable trees from which to build log homes. Therefore, this manual will not include a discussion of building with logs in Region 5, the North Slope.

Four Ways to Comply With the Building Energy Efficiency Standard

There are four methods of compliance with the State of Alaska Building Energy Efficiency Standard:

1. The prescriptive method
2. The performance method
3. The building budget method
4. The energy rating method

All of the methods require minimum standards of balanced



Statewide Regions

mechanical ventilation. (See BEES Ventilation Requirements in Appendix A.)

1. Prescriptive Method

The prescriptive method requires minimum R-values for the ceiling, floor, and walls including windows and doors (Table 2). This method requires the least amount of calculation. You just have to meet or exceed the R-value requirements for all of these building components, comply with all the statewide mandatory measures outlined in chapter two of BEES, and meet the ventilation requirements. However, meeting the R-value requirements for an above-ground wall will be difficult with smaller logs.

2. Building Budget Method

The building budget method sets limits on the total amount of space heating energy used by a building. Your house is allowed to lose only a calculated amount of heat per square foot per hour. This requires a computer energy use analysis using either the HOT-2000 or AkWarm software programs. These software programs are available through AHFC.

3. Performance Method

The performance method allows the trade-off of insulation requirements between elements of a particular thermal envelope assembly, such as increasing wall insulation values to

Table 2
Prescriptive Standards

		Thermal Envelope R-value Requirements							
Region	Heating Fuel	Ceiling	Above-Grade Wall	Floor	Below-Grade Wall	Slab Floor: Basement	Slab Floor: On Grade	Window	Door*
Region 1 Southeast	All Fuels	R-38	R-21	R-30	R-15	R-10	R-15	R-3	R-2.5, 7
Region 2G Southcentral	Natural Gas	R-38	R-18	R-19	R-10	R-10	R-10	R-3	R-2.5, 7
Region 2A Southcentral, Aleutian Kodiak	All Fuels Other Than Natural Gas	R-38	R-25	R-30	R-15	R-10	R-15	R-3	R-2.5, 7
Region 3 Interior & Southwest	All Fuels	R-38	R-25	R-38	R-19	R-10	R-15	R-3	R-7
Region 4 Northwest	All Fuels	R-38	R-30	R-38	R-19	R-10	R-15	R-3	R-7
Region 5 Arctic Slope	All Fuels	R-52	R-35	R-43	N/A	N/A	N/A	R-3	R-7

* Not more than one exterior door in a residential building in Region 1 or 2 may have an R-value less than 7 but not less than 2.5.

make up for north-facing windows. You are not allowed to trade off insulation values with different thermal envelope assemblies. In other words, you could not use this compliance method to reach a heat loss target by increasing the R-value of the roof insulation to make up for low wall or floor insulation values. Therefore you cannot use the performance method to make up for the lack of R-value in a log wall.

4. Energy Rated Method

The energy rated method requires that the building shall achieve at least four-star plus (83 points) on an energy rating performed by a trained and certified energy rater. This is the method most often used by builders to comply with BEES. An energy rater records the R-values of all the elements of the thermal envelope and notes the efficiency of the heating appliances, lighting, solar aspect, and other energy use considerations.

The most crucial aspect of the energy rating for the log builder is the blower door test, which uses a powerful fan to depressurize your house and accurately measure the air loss from leakage. This test also helps a builder find those leaks. Several tight log homes have qualified for a four-star plus energy rating, and a few log homes have made a five-star rating, scoring 88 points on an energy rating. A new log home in Fairbanks was recently rated five-star plus.

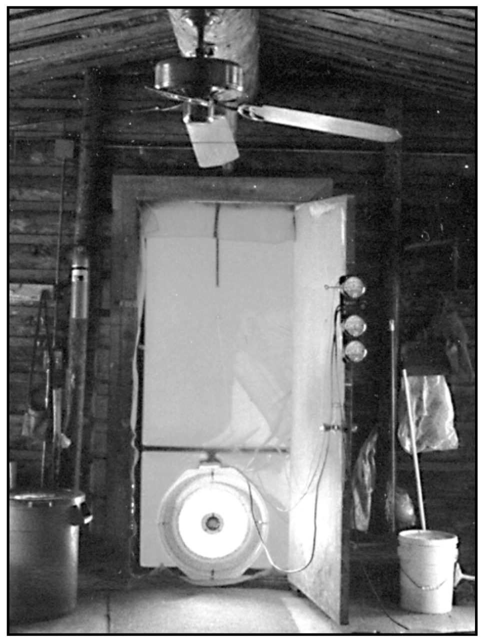


photo by Phil Loudon

Using a blower door to test the airtightness of a log home in Arctic Village.

Chapter 4
Building the Log House

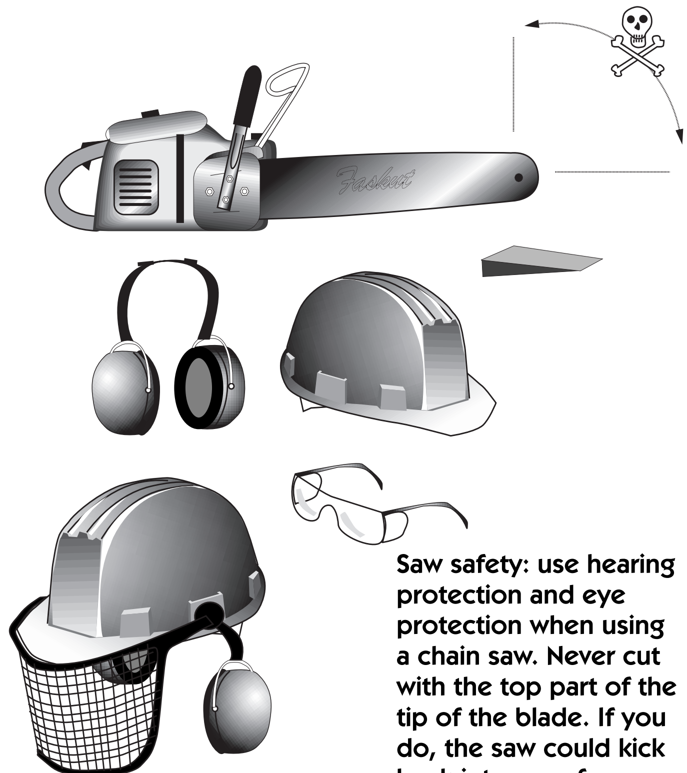
In the Woods

Trees are a renewable resource if logged on a sustainable time schedule of a hundred or more years between harvests. The way to ensure a perpetual source of house logs is selective logging.

House logs are best cut in winter, when the sap is down and the logs can be skidded over the snow with minimum damage to the logs and the environment. Bark beetles are dormant in winter, and a long winter drying season may dry the logs enough to keep the beetle population down in the spring. Bark beetles will not invade dry logs.

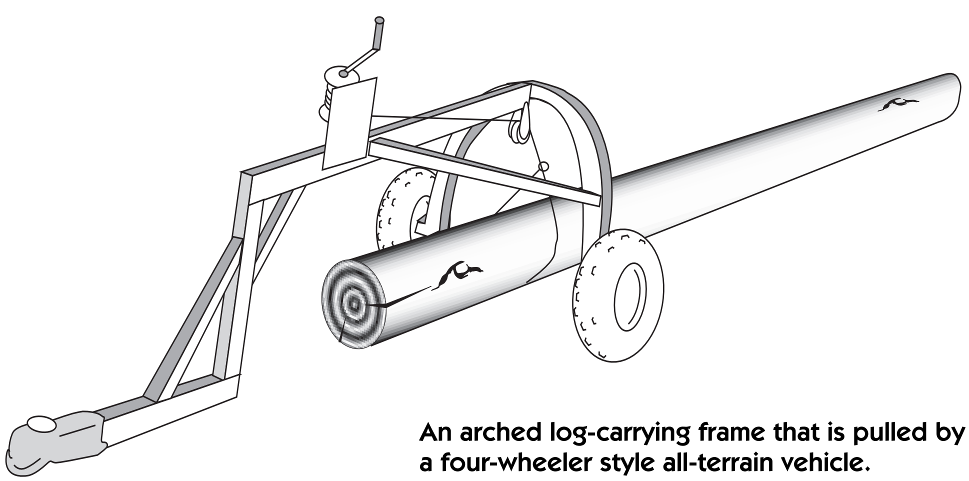
Choose trees that are of the length and diameter that will suit your needs. Think in terms of cutting a matched set of logs with the same mid-point diameter.

Leave the remaining trees undamaged by traveling lightly on the land as you skid the logs out of the forest. The trees left behind will benefit from having more light and space to grow in.



Saw safety: use hearing protection and eye protection when using a chain saw. Never cut with the top part of the tip of the blade. If you do, the saw could kick back into your face.

A modern equivalent to horse-logging is a four wheeler fitted with an arched log-carrying frame equipped with a 2,000-pound capacity electric winch powered by the 12-volt battery system of the off-road vehicle (see drawing below).



An arched log-carrying frame that is pulled by a four-wheeler style all-terrain vehicle.

Sawmill Island

(As told by Robert Charlie, director of the Cultural Heritage and Education Institute.)

Sawmill Island is located directly across from Old Minto, which is about 30 miles downriver from Nenana. Old Minto was originally settled in 1912 by a group of Athabascans from the Minto Flats area. Today, Old Minto is the site of a cultural heritage camp. One of the reasons that Chief Charlie originally settled in Old Minto in 1912 was the abundance of timber found at Old Minto and across the river on Sawmill Island. Sawmill Island is about 1.7 miles long. The timber served many purposes, but it was primarily used for fuel by the community members and later for contracts with the United States government.

In the early 1920s, Robert Charlie's uncle, Arthur Wright, who was one of the first Native ministers for the Episcopal Church in Alaska, used timbers from Sawmill Island to build Old Minto's first school. The two-story structure was about 60 by 80 feet. Arthur Wright had a small portable sawmill located on the island. Also built of timbers from Sawmill Island was the Episcopal Church that stills stands today. The Cultural Heritage and Education Institute is working to preserve it as a historical site.

Years ago, there were four or five winter trails to the island that led to dry timber areas. Everyone in the village used the island to get wood. Also, you could walk into the woods in the summer, and pick gallons of cranberries.

During World War II, the federal government was busy building Galena Air Force Base. About that time, Robert Charlie's dad was the first contractor with the Alaska Railroad (federal government) to sign for cord wood. The first year he signed for 50 cords of wood, the second year for 100 cords of wood, and the third year for 150 cords. Most of that wood came from Sawmill Island.

Later on, Robert's dad signed a contract with the federal government to produce 1,000 cords of wood. People from his village produced the 1,000 cords of wood. Robert's brothers and dad cut about 360 cords. People would stack the cords along the river and the steamboats would use them to power the boats up and down the Tanana and Yukon rivers. During the war, the federal government leased steamers from Canada and had another three steamers that traveled these rivers, hauling materials to the Galena base.

Today, Neil Charlie's allotment is partly located on Sawmill Island. Robert Charlie says that his family used to have their fish camp on the island. He remembers as a child seeing old slabs of wood and sawdust where Wright had his portable sawmill.

Whether you are clearing your own land or logging a timber sale, keep waste to a minimum. Maximize the use of local wood products whenever possible. Birch makes good cabinet building material and flooring or window and door trim. Aspen and poplar or spruce make good paneling, wainscoting, and trim. Douglas fir, hemlock, and white spruce can be made into framing lumber or timbers for post and beam construction.

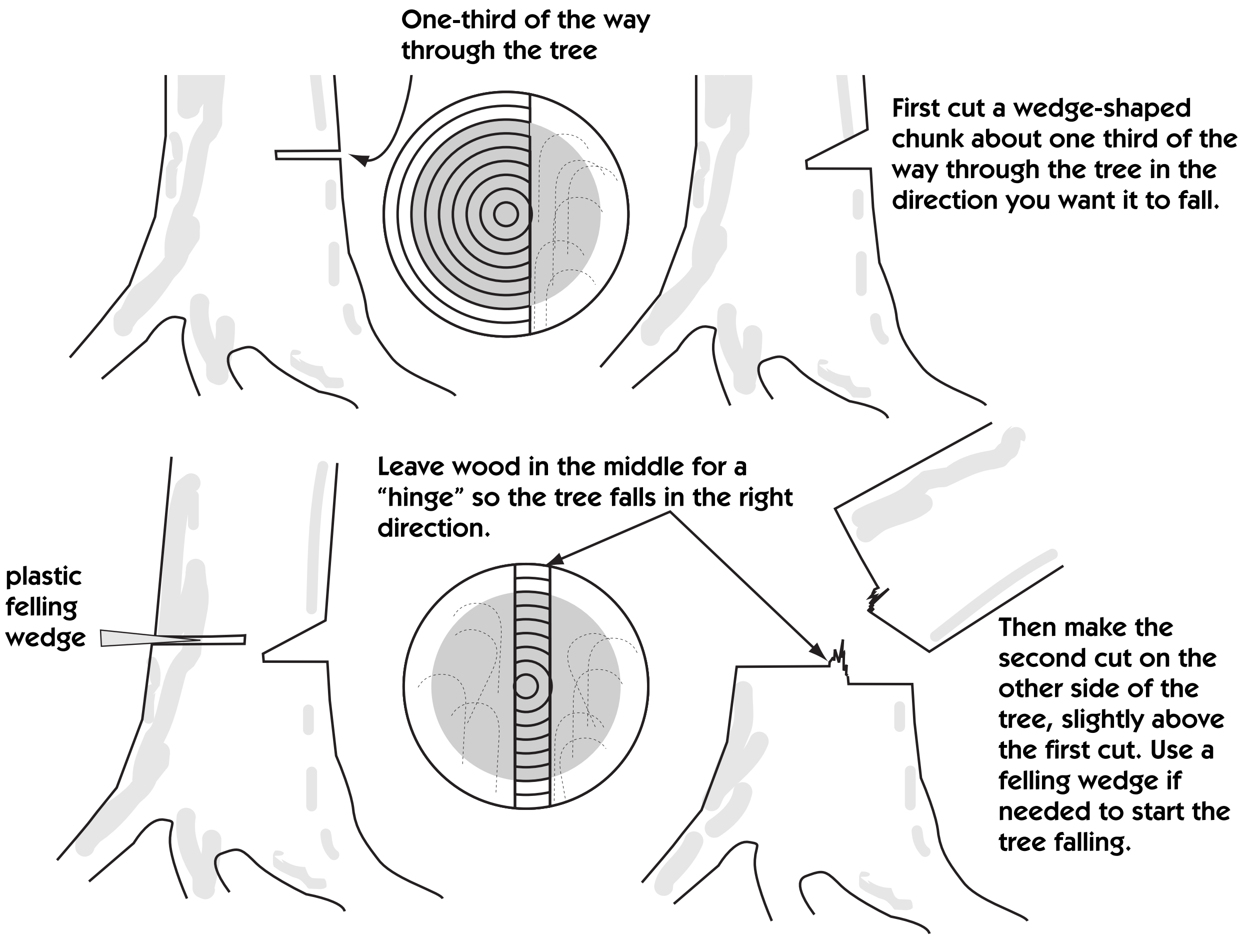
White spruce trees are likely to be the logs of choice for building in interior or southcentral Alaska. Large, straight aspen or white poplar can also be used. In southern Alaska, yellow cedar and western red cedar, Sitka spruce, Douglas fir, and western hemlock all are excellent log building materials if they are straight and of the size required for your building. Alaska yellow cedar is very strong and very durable and suitable for cabinetry and furniture, power poles and pilings, decking, bridges, and housing.

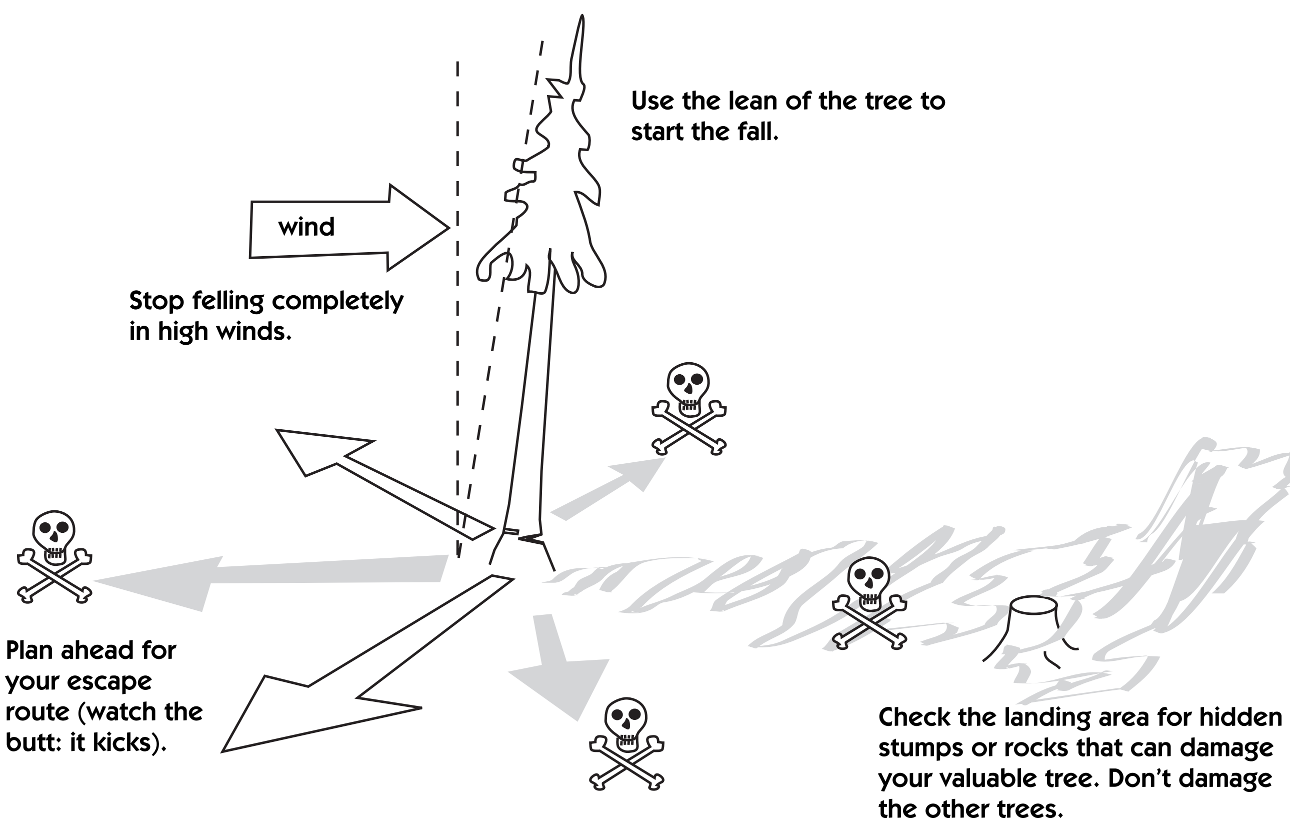
Don't peel too far ahead of the actual placement of the logs on the wall, since the bark protects the wood from mechanical damage, mold, and mildew.

Weathering

Logs may have to be treated with a dilute solution of mildewcide after peeling to keep them from turning green or black with mold. Some builders prefer to use a solution of borate crystals dissolved in water and sprayed on the logs to retard mold growth. Borate is less toxic to the environment and to the log workers than some other chemicals used to protect logs from mold.

Safe tree felling





After a couple of years lying around with the bark on, logs will start to rot and may become bark beetle habitat. At this point, it may be best to peel the logs and treat them with a water-repellent wood preservative to keep them sound until you can begin to build.

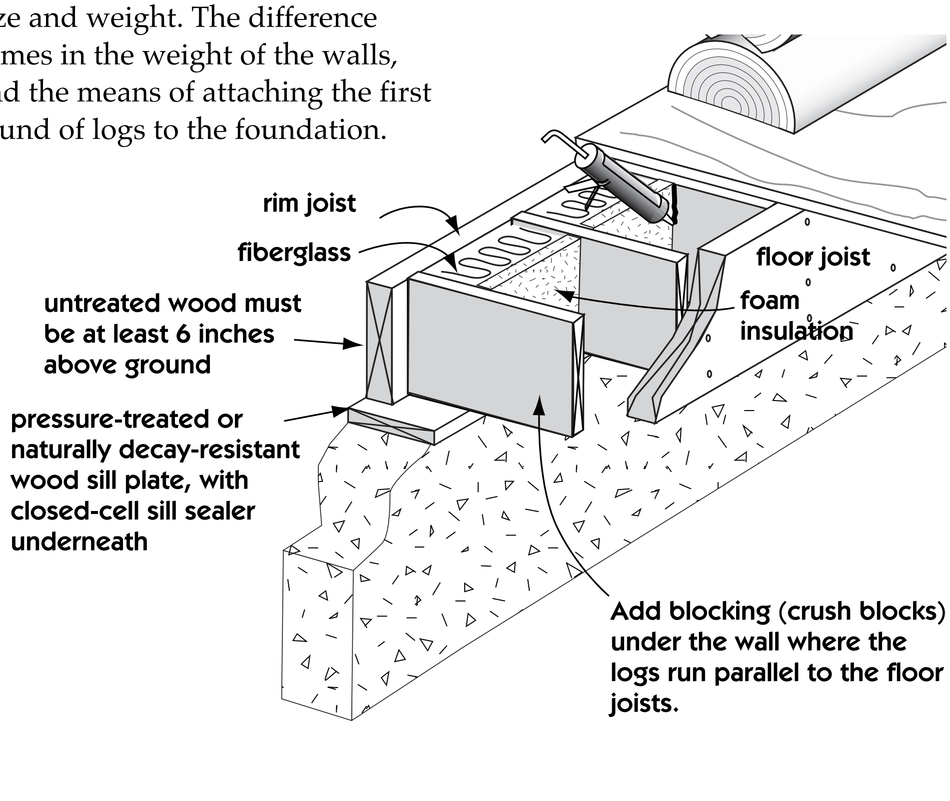
Spring is the worst time to fell and peel a log. However, if you must use wet, green logs, place them on the wall as soon as possible so that they take a set in line with the shape of the building.

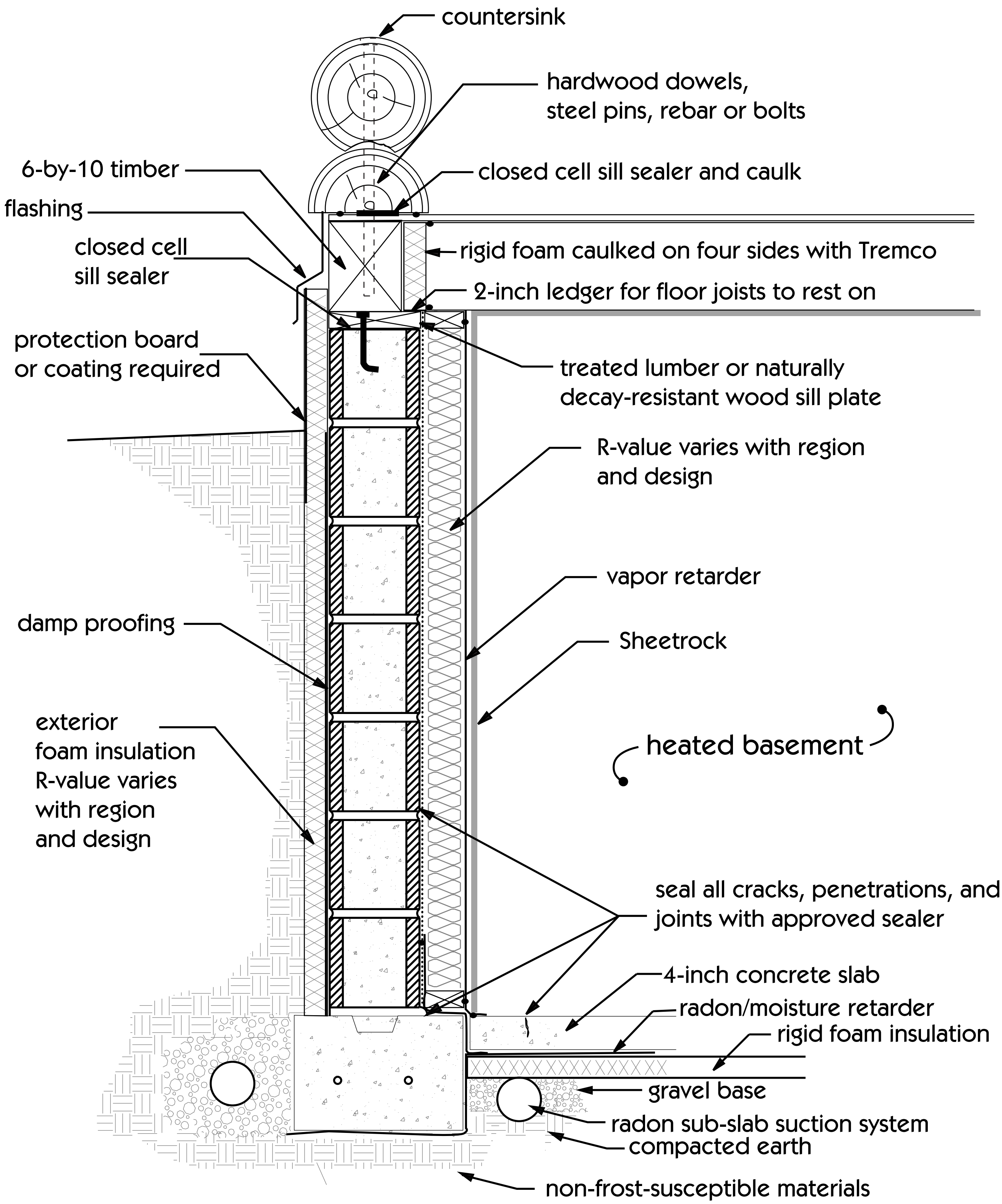
If the logs begin to turn green with mold, wash them with a solution of household bleach and detergent, rinse thoroughly, and allow to dry completely. Protect them with a water-repellent wood preservative and allow them to season before applying the final finish.

The Foundation

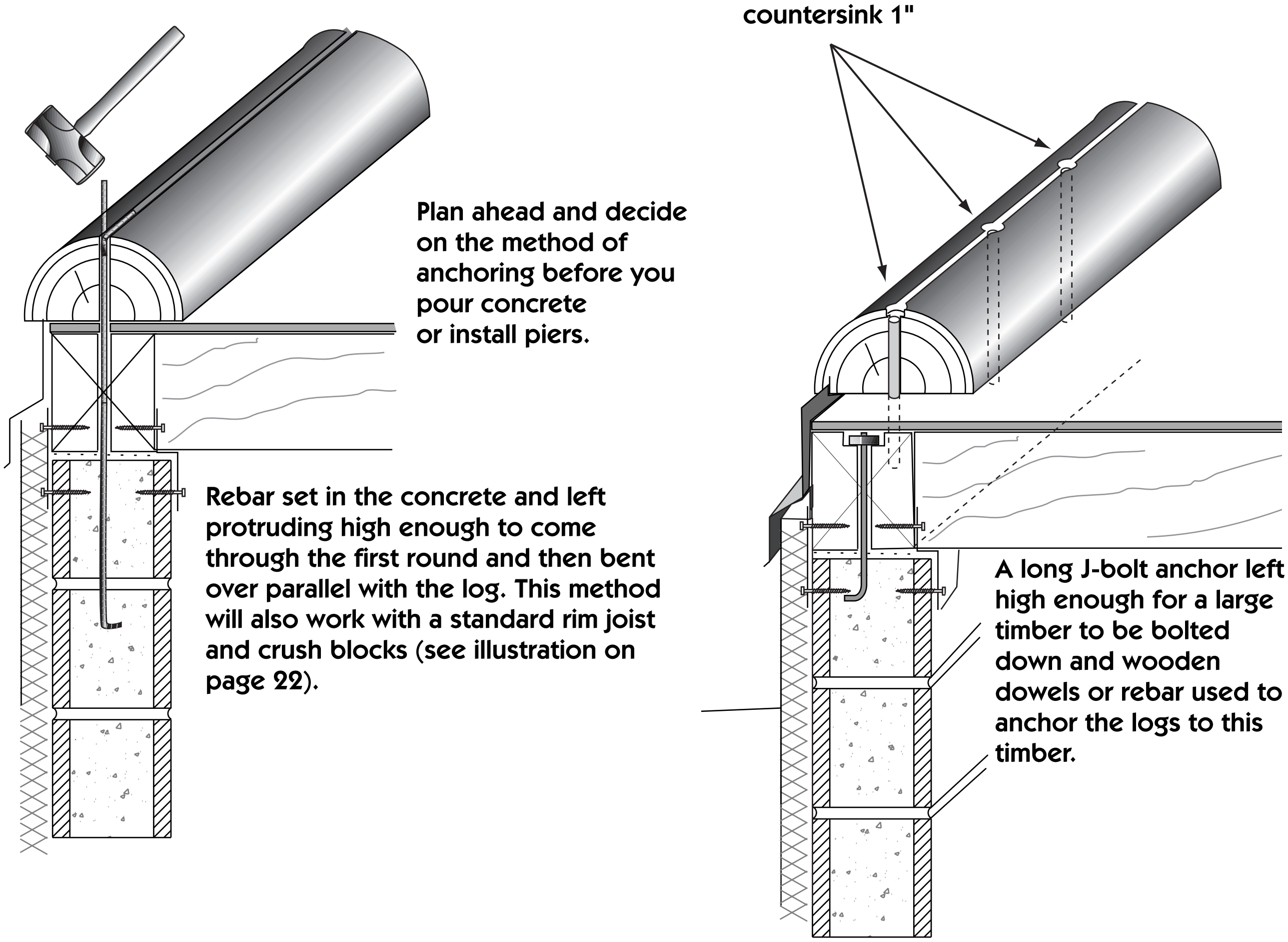
As we noted earlier, the configuration of a foundation for a log house is the same as a good foundation for any structure of comparable size and weight. The difference comes in the weight of the walls, and the means of attaching the first round of logs to the foundation.

There is an ongoing debate of whether to place the first logs directly on top of the treated foundation sill plate or on top of a timber of the same height as the floor joists. If you use a timber for a rim joist, it is a relatively easy matter to attach the first round of logs, using whatever pinning system you use for the rest of the log wall. Some log builders prefer to build on top of the plywood subfloor, which has been framed to the outside of the sill plate. In either case, the logs or timbers must be securely attached to the foundation with long anchor bolts or with coupling nuts connecting all-thread rods to the anchor bolts. Some builders extend $^{1}/_{2}$-inch rebar 18 inches to 2 feet out of the foundation, drill the log accordingly, and bend the rebar tightly against the first logs with a sledge hammer. If the logs sit on top of a floor, additional blocking should be installed where the joists are parallel to the lay of the logs.



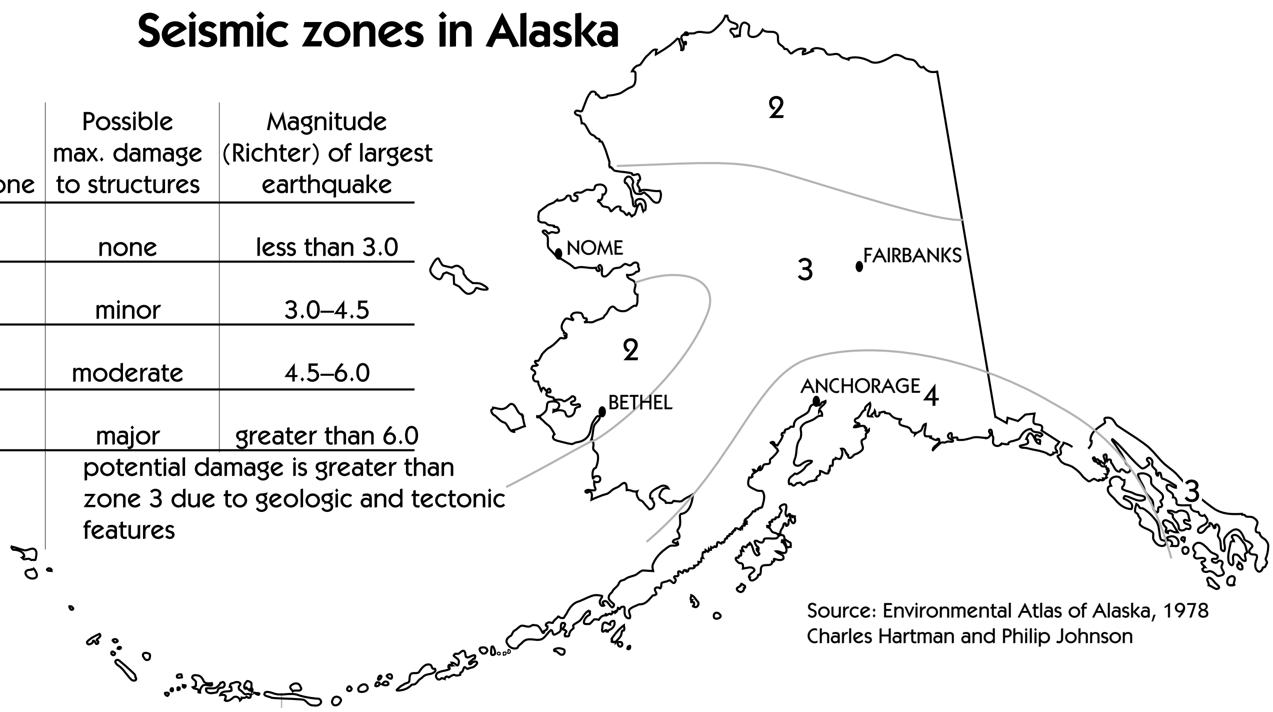

countersink
hardwood dowels,
steel pins, rebar or bolts
6-by-10 timber
closed cell sill sealer and caulk
flashing
closed cell
sill sealer
rigid foam caulked on four sides with Tremco
2-inch ledger for floor joists to rest on
protection board
or coating required
treated lumber or naturally
decay-resistant wood sill plate
R-value varies with region
and design
vapor retarder
damp proofing
Sheetrock
exterior
foam insulation
R-value varies
with region
and design
heated basement
seal all cracks, penetrations, and
joints with approved sealer
4-inch concrete slab
radon/moisture retarder
rigid foam insulation
gravel base
radon sub-slab suction system
compacted earth
non-frost-susceptible materials

Options for attaching the half log to the foundation



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	

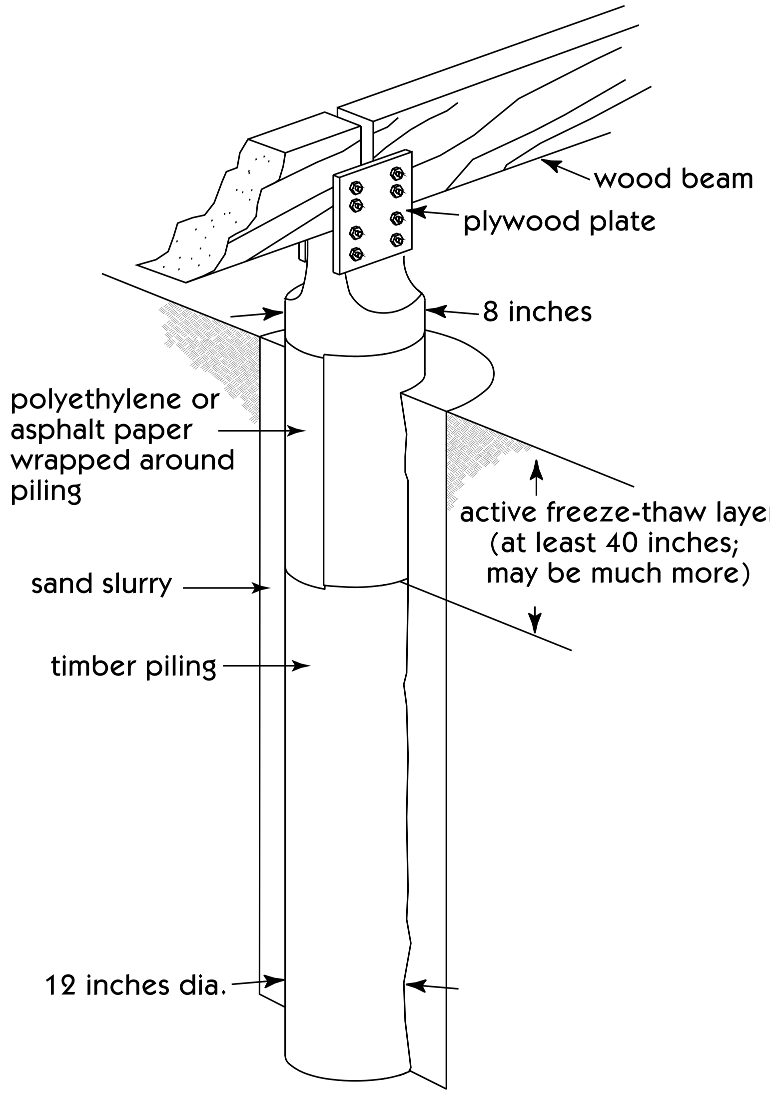


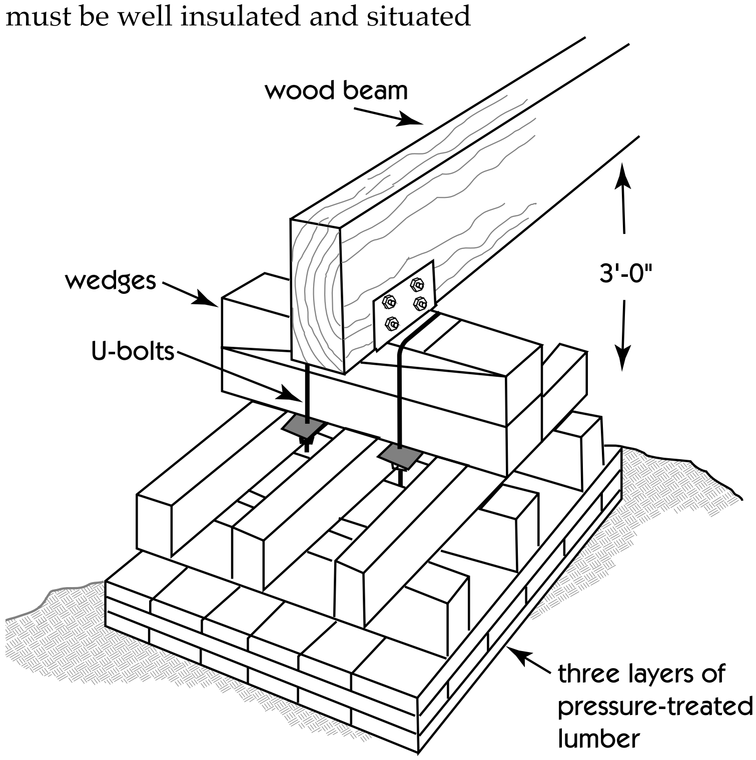
Source: Environmental Atlas of Alaska, 1978
Charles Hartman and Philip Johnson

Most of the engineered plywood I-beam systems have compatible laminated rim joists, which may eliminate the need for extra crush blocking along the ends of the joists. Follow manufacturer's directions. In any case, build it strong so that the connections of the logs to the foundation, the connections between logs, and the connection of the roof to the logs are all designed to meet the engineering requirements of your specific earthquake zone, wind load, and snow load design levels (see seismic zones map, previous page).

Permafrost Foundations

One way to support a log structure on permafrost is to build it on pilings that are drilled, driven, or dug to below the active seasonal frost layer and deep enough to provide lateral sway bracing. It should be drilled deep enough into the permanently frozen ground to freeze the piling in place. The floor must be well insulated and situated





Examples of foundations for permafrost

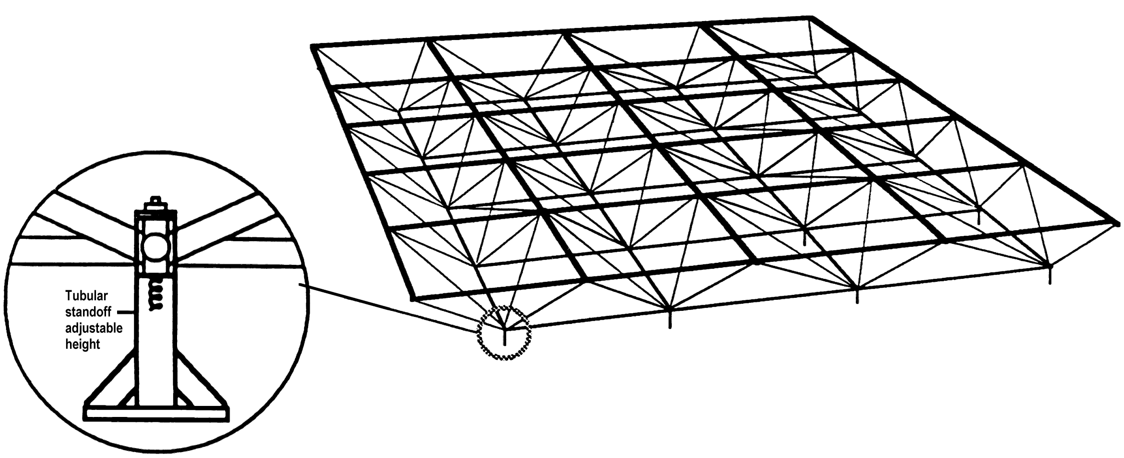
A nice-looking post and pad foundation installed near Fairbanks.

The Triodetic brand space frame is one option for building on permafrost.

about three feet above grade to allow outside air to flow under the house in winter to keep the ground frozen and to shade the surface in summer from the heat of the sun. Avoid disturbing the organic ground cover that insulates the soil. (See Building in the North by Eb Rice for an in-depth discussion. See Appendix D.)

Another permafrost foundation is post and pad, where a bed of gravel is placed on the undisturbed vegetation mat and treated wood timbers are embedded in the gravel and tightly stacked in alternating layers to support either posts or beams to support the building. Some builders are building a treated timber system of railroad ties and horizontal beams to support a home on a gravel pad.

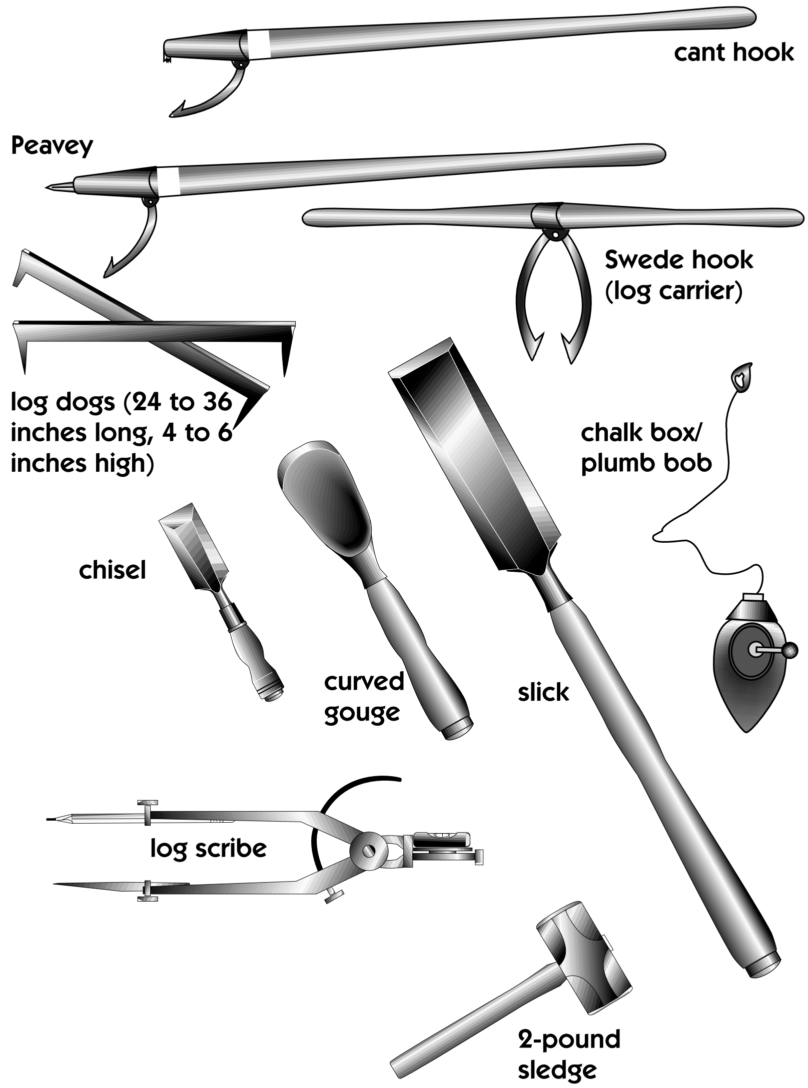
A promising new-high tech permafrost foundation called Triodetic has been used extensively in the Canadian north and has been used in arctic Alaska in the last few years with apparent success. The Triodetic foundation system incorporates a series of interconnected triangles of steel tubes to form a bridge over unstable soils.

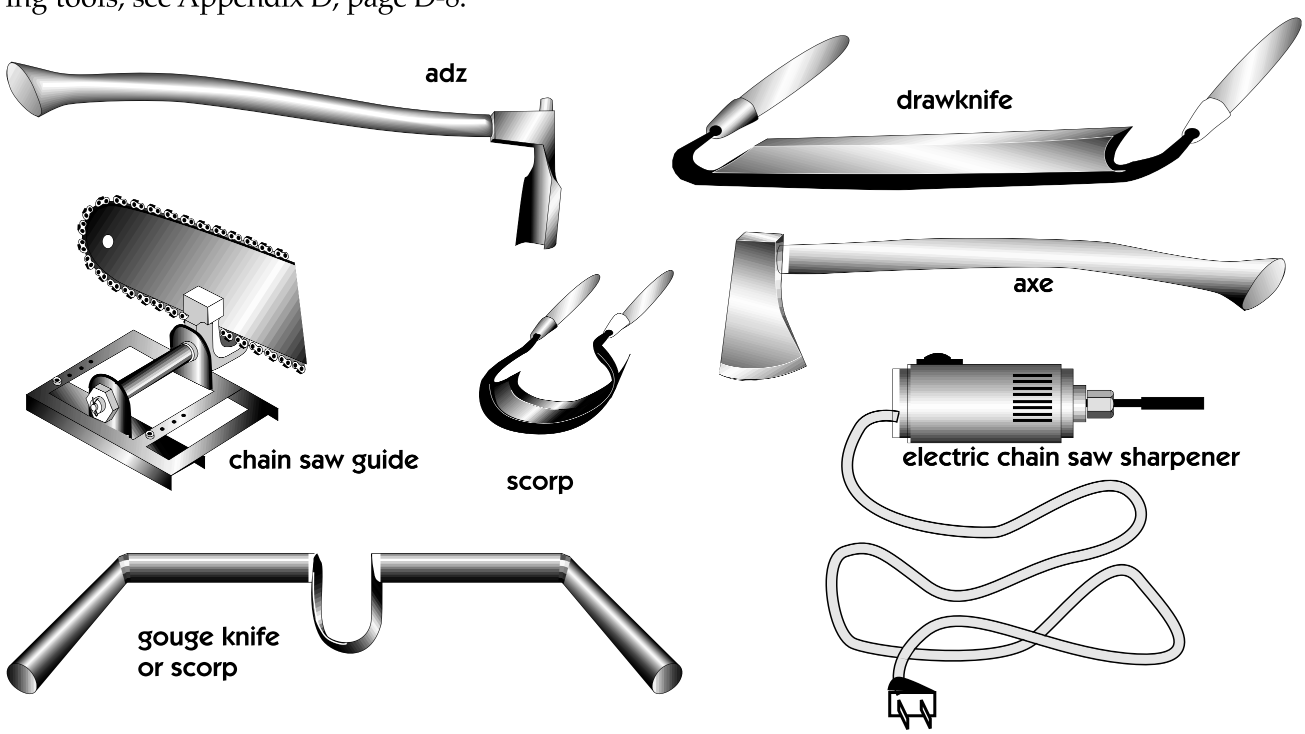


Log Working Tools

A log builder's tool kit can range in cost and complexity from an ax and a cross-cut saw to an array of chain saws, electric planers, routers, grinders, and drills. The main tool in a modern log worker's kit is a powerful, lightweight chain saw with a 16-to-20-inch bar. Rubber anti-vibration dampers should connect the handlebar to the saw to protect the operator from problems with his or her hands.

Other essential tools include a good sharp ax; a draw knife; a sharp pocket knife; a log scribe fitted with level bubbles; pencils, marking pens, and lumber crayons; a chalk-box string line; a two-foot carpenter's level; heavy-duty electric drill and auger bits; chisels; wooden mallet; claw hammer; and sledge hammers. For moving logs you will need Peaveys and a mechanical winch or a block and tackle system. For big logs you will need a crane or a high lift system of some sort. For sources of log working tools, see Appendix D, page D-8.





Half Logs

The first round begins with a pair of half logs. These are usually run the shortest length of the building. When supported at each end, either on the wall or on a pair of skids, a log will usually come to rest with the bow down and the straight edges to the sides. Roll the log back and forth with a Peavey to locate the very straightest lie and hold it in place with a log dog or with wedges with the straight edges of the log to the sides (see illustration #1, next page).

Use a chalk line to snap a line down the center of the mass of the log. Use a level to mark vertical lines on each end of the log at the centerline just established (see #2, next page).

Then roll the log over until the end marks are horizontal. Dog securely and snap a line down the length of the log on the other side.

If you have an attachment to turn your chain saw into a two-man saw, then sawing the half logs is relatively straightforward since each of you have a line to guide the saw. If you are cutting single handedly, you may want to place an observer on the far side to signal up or down.

If you cut the half log from a vertical position, with the log lying with the centerline on top, it is best to have only one sawyer cut the entire length of the log from one end to the next without changing direction. That way, if one person's sense of vertical is a little bit out, at least it will be consistent and won't compound any error.

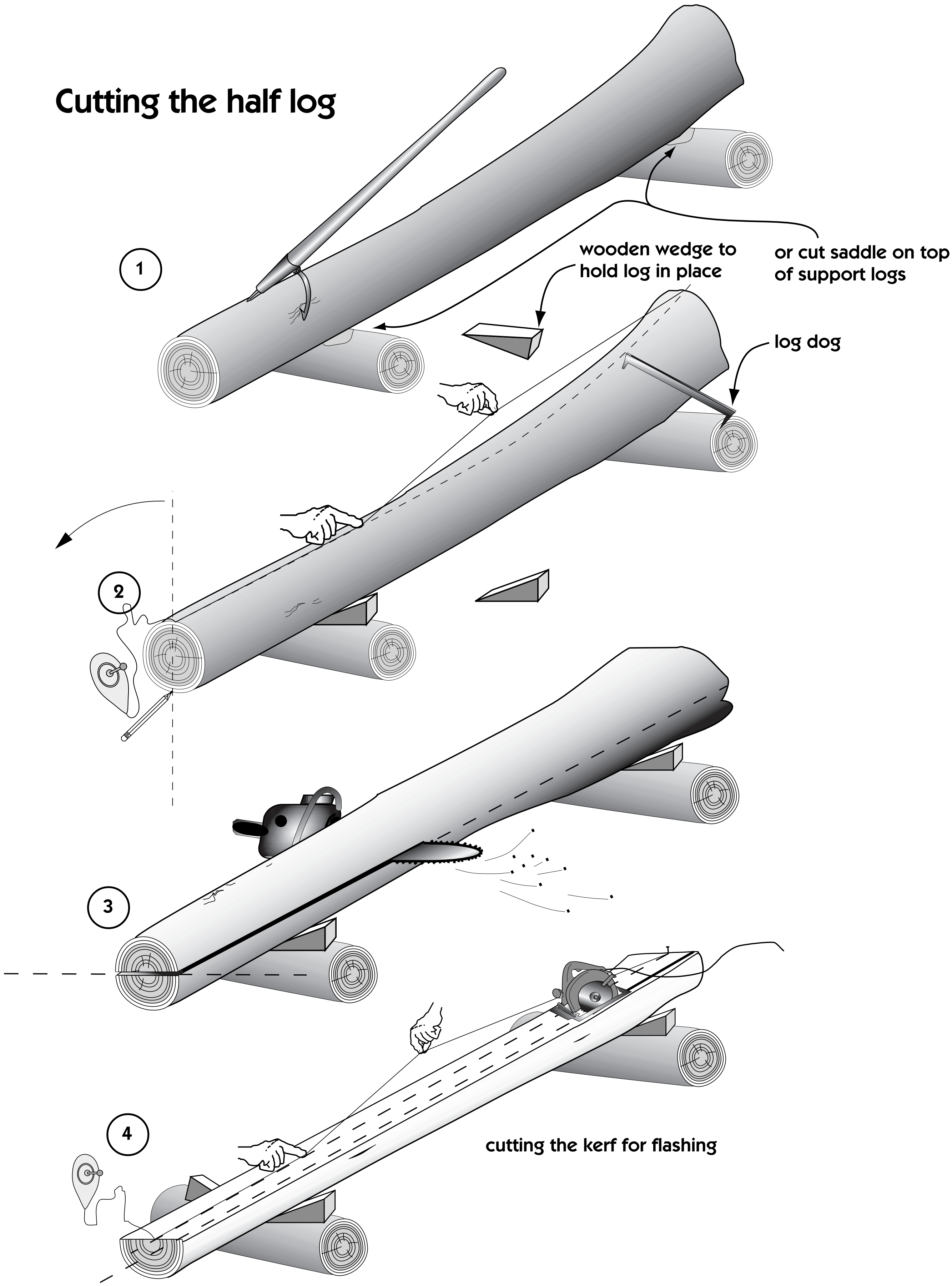
Once the log is sawn in half, secure both halves in a horizontal position and brush the surface straight and smooth with the edge of your chain saw. This is an acquired skill and will come with a little practice.

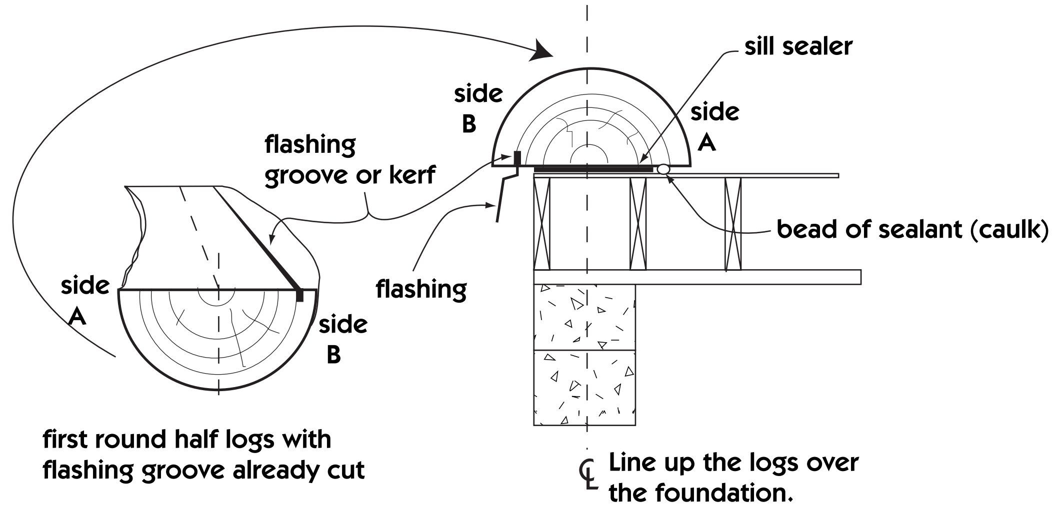
Snap a center line on the bottom of both half logs and snap another parallel line near the outer edge just outside the foundation (see #4, next page). Cut a $^1/_4$-inch-deep kerf at the outer line with a circular saw to hold a metal drip edge flashing. If you do not have metal flashing available, cut a $^1/_4$-inch deep groove with a chain saw to serve as a drip break and to prevent water from flowing under the first round of logs.

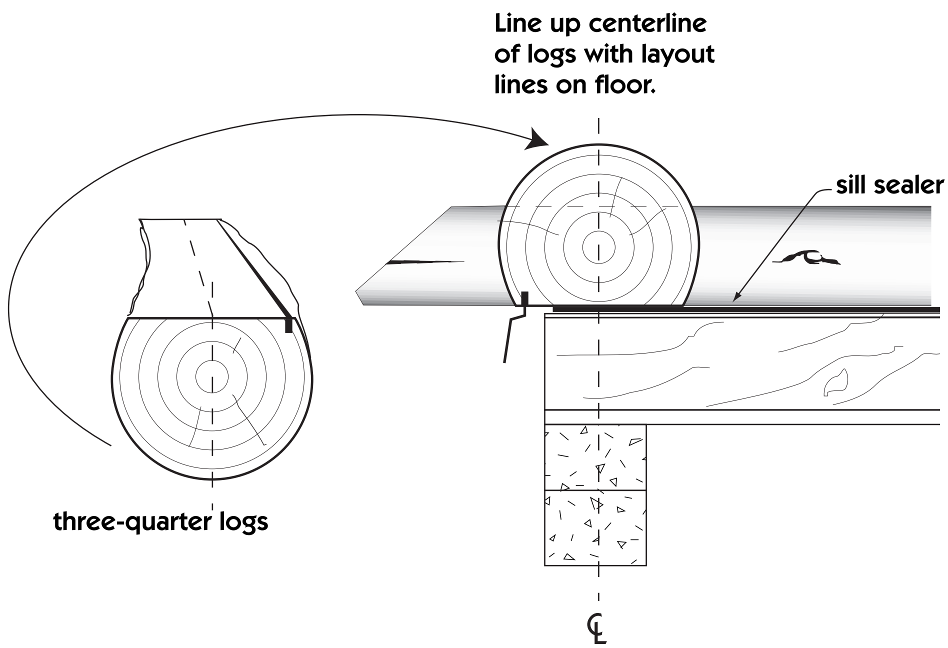
Transfer the center line to the top of each half log, using a level to extend a line on each end of the log. The half logs are then placed on the foundation with the center marks lined up with the wall centerlines marked on the foundation or floor. Place any bow to the outside. Butt ends should run the same direction so that when you reach the top of the wall, the top round will end up with the butts facing the same way to support a long roof overhang at the gable ends if desired, and the top round will be easier to finish in any case. Some builders choose to alternate the butt-tip lie of the half logs and subsequent plate logs.

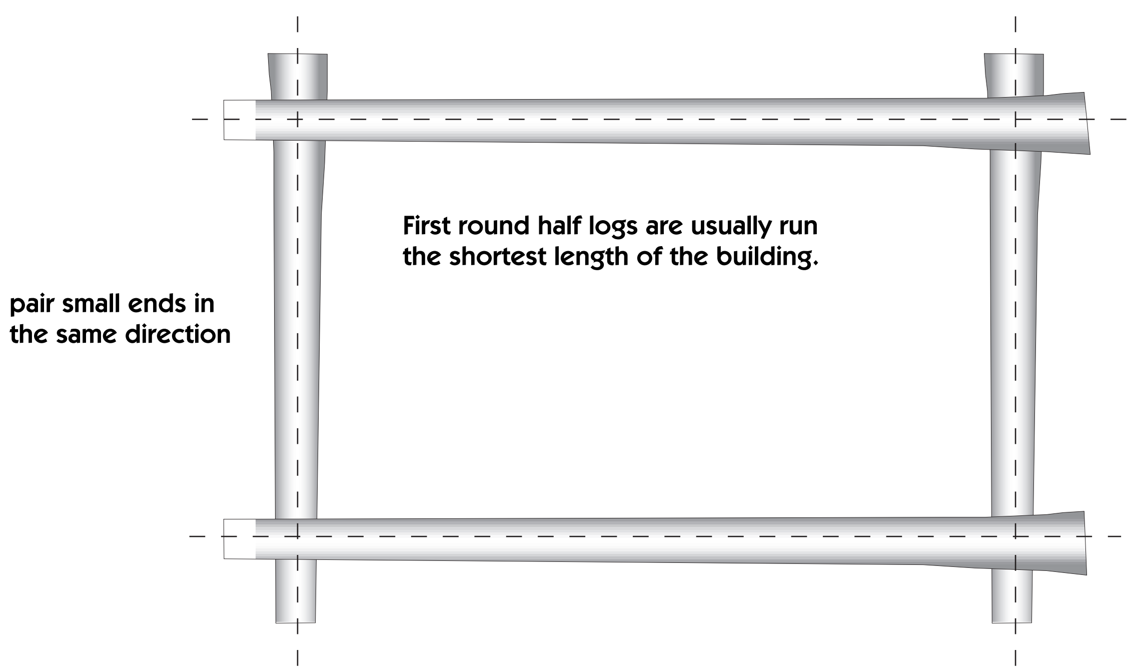
Use closed-cell sill seal or EPDM gaskets to provide a weather-tight seal between the half logs and the floor or foundation. Caulk the first logs to the floor with a bead of sealant along each side of the sill seal.

Cutting the half log




sill sealer
side
B
side
A
flashing
groove or kerf
bead of sealant (caulk)
flashing
side
A
side
B
first round half logs with
flashing groove already cut
℄ Line up the logs over
the foundation.


Line up centerline
of logs with layout
lines on floor.
sill sealer
three-quarter logs
℄


First round half logs are usually run
the shortest length of the building.
pair small ends in
the same direction

Three-quarter Logs

The second logs to be placed are often referred to as three-quarter logs because about a quarter of the log is cut off the bottom to rest squarely on the foundation or floor. Slab off the bottom of the three-quarter logs to provide a flat width of about six inches, using the same techniques described for cutting the half log. The width of the flat bottom of the three-quarter logs may vary from end to end in order to leave enough wood over the notches. Always consider the height of the log to be crossed and the diameter of the butt or tip that will be crossing over the log you are working on.

Cut a 1/4-inch deep kerf for flashing parallel to the centerline of the log just outside the foundation or floor line. Place the two three-quarter logs on top of and at right angles to the half logs, with the centerlines lining up with the centerlines marked on the floor or foundation.

Check to be sure that the flat bottoms are exactly parallel to the floor and shim them to level if required so that when notched to fit over the half logs, they will lay flat on the floor, evenly compressing the closed-cell seal sill gasket material under the bottom round.

There are several ways to notch this first round together. This and a host of other notches are discussed in detail by B. Allan Mackie in Building With Logs and Notches of All Kinds (see bibliography in Appendix D for these and other books). All notches should be self-draining and should restrict the flow of heat, air, and moisture in and out of the structure for the life of the building.

Compression-Fit Saddle Notch

The current notch of choice by professional log builders is the compression-fit saddle notch. The shoulders of the log below are saddle-scarfed off at an angle that forms, in cross section, the shape of a domed pyramid with the sides sloping toward the top, leaving about a 3-inch domed top. The top

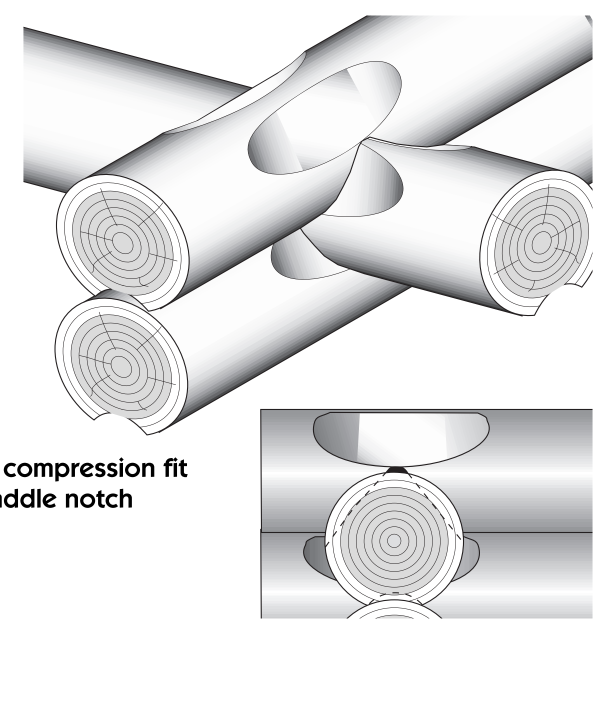
Prebuilding the log walls at a convenient place before reassembling at the final homesite. The logs are peeled just before use to keep them in good shape.

A good modern log home built with a compression-fit saddle notch.

should be about the same width as the lateral groove of the next log.

By cutting the scarfs (see page 34) you remove the sapwood, which tends to shrink and compress more than the heartwood does. You also create a better locking shape so that the top log fits over the log below like a huge pipe wrench, preventing it from twisting or turning. You have to cut a relief opening in the top of the notch so that the sides of the notch can bear the weight of the logs as they shrink and settle.

The compression-fit notch comes to us from Scandinavia via Canada thanks to the reinvention of an ancient Norwegian log building technique by Del Radomske, a Canadian log home builder, inventor, teacher, and author. Radomske noticed that his once-perfectly fit full-scribed round notches were opening up after a few years of shrinking and settling. After perfecting the saddle notch, he observed that if there should be 75 percent of the weight of a log resting on the notch and the remaining 25 percent of the weight on the long or lateral groove, then it would make sense to overscribe the lateral groove so that as the logs settled and shrunk, the lateral groove would not hang up and hold the notch open. He experimented with first a 1/8-inch overscribe, then 1/4-inch, and evolved into an average of 3/8-inch larger scribe setting for the lateral groove than for the notch. Over-scribing works best when combined with a saddle notch. The compression-fit notch, sometimes called shrink-to-fit, is designed to get tighter as the logs settle and shrink. Radomske is still experimenting with this shrink-to-fit system, as are numerous other log builders who search for perfection.



A compression fit saddle notch

Round Notch

The round notch full-scribe technique typically uses identical scribe settings for both the long groove and the round notches. It would probably be better to overscribe a round notch building, but the log should bear on the top of the notch and not on the sides. The round notch will not keep the log below from twisting. To tie the logs together, drive hardwood pegs, dowels, through-bolts, or lag bolts, or pin them with rebar into predrilled holes through each round of logs to the rounds below. Keep track of the pins with marks on the logs so that you don't hit them when cutting out a window or spline.

Log Scriber

A modern log scriber consists of a 10 or 12-inch divider fitted with a pencil holder and adjustable level bubbles. The principle of scribing is based on parallel lines. The bottom leg of the scriber rides along the lower log and the upper leg traces its shape on the upper log. The level bubbles are adjusted to maintain horizontal and vertical control of the dividers so that the exact shape of the lower log, including bumps or depressions, is transferred to the upper log. Many log builders use indelible pencils, and some spray the logs with water or window washing solution from a mist bottle to darken the line. Some builders adapt the pencil holder to accept Sharpie-style felt-tip pins. This type of marker is especially useful if you are scribing icy logs.

Use a benchmark to set the level bubbles for consistency.

The First Scribe

The first scribing you will do is to fit the three-quarter logs to the half logs. If you choose to use the saddle-notch technique, you may first cut scarfs on the shoulders of the half log. Some log builders round notch the half and three-quarter logs. The shape of the scarf is often marked on the log, using a template to lay out scarf dimensions to ensure consistency of appearance.

The scarf cut is made with a chain saw, using a sweeping motion somewhat similar to using a paring knife to remove a small bruise on an apple. The sloped plane of the scarf must be consistent to provide a uniform bearing surface for the sides of the notch in the log above. Sand or plane the face of the scarf smooth.

For the first round, the notches should be under-scribed about a half inch so that with shrinkage and settlement the flat bottom of the three-quarter log will not hang up on the floor and cause the notches to open. This first round will require a wide scribe setting,

Using a layout board to mark the log for a scarf. See drawing #3, page 37.

cutting the scarf

and considerable care must be taken to ensure that the level bubbles are set exactly so that the points of the scribe are perpendicular to the floor. This setting can be verified by checking against a plumb line marked on a perfectly vertical surface previously established near the building site.

Scribing the Notch

The log to be notched is placed so that the center line of its mass is exactly over the wall center line marked on the subfloor or foundation, with the straightest sides parallel to the floor. With the straightest sides top and bottom and any bow to the outside of the building, dog the log firmly in place so that it will not budge with people sitting or walking on it.

With the exception of the first round, which is flattened on the

brushing with the chainsaw to smooth the scarf bottom and therefore has a predictable depth of notch, all other logs must be "rough" notched or "first" notched to drop the new log to within 1 $^{1}/_{2}$ or 2 inches of the log below. This is easily done by opening the scribe to the space between the logs just inside the notch at each end. Mark this setting on the top of the log and reduce the scribe setting by the distance you wish to use for your final scribe, say 2 inches or three fingers width. Scribe the first notch with this new setting.

Hold the scribe gently with both hands, and keeping the level bubbles between the lines, scribe

Scarf is sanded smooth, ready for final scribing. Note stress relief kerf on top of logs to promote controlled checking.

Hold the scribe gently with both hands, keeping the level bubbles between the lines.

Scribing for the groove

from the bottom up and the top down on both sides of the lower log. Move to the other side of the new log and scribe with the same setting.

Move to the other end, open the scribe to the space between the logs and close the dividers down by the same amount as the other first notch. Repeat the same procedure for the other notch.

When you cut the rough notches and roll the log back in place, the log should be parallel to and 1 1/2 to 2 inches above the lower log. Place the center of the log exactly over the center of the wall below. Mark on top of the lower log with an indelible pencil and a plumbed 2-foot level the exact location where the new log crosses the lower log for future reference.

Final Scribing

Stand back and evaluate the general lay of the log to be final scribed. Note the largest gap and shim the log if necessary to maintain a consistent lateral notch width of about three or four inches.

Set the scribers to the largest gap between the two logs, then open them up about 1/8 inch and final scribe the two notches at this setting. Remember, you will open the final scribed setting at least 3/8 inch to over-scribe the lateral notch.

Overscribe the log end extensions another 1/4 inch to prevent them from hanging up, since the interior of the log walls are generally heated and will dry out more rapidly than the unheated log ends.

Back on the Ground

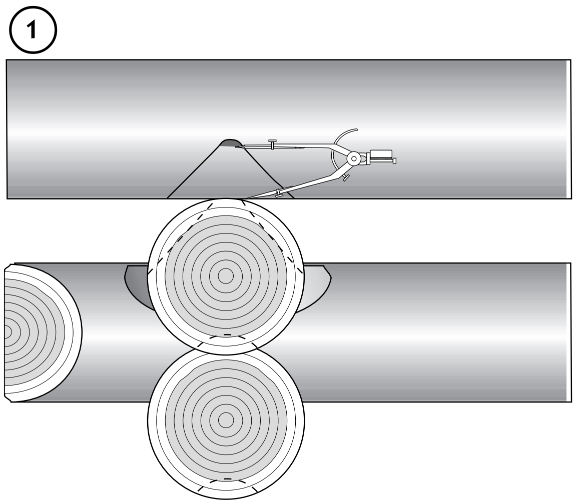
Once the log being worked on has been scribed all the way along both sides, up and over the logs at each intersecting wall, and around both ends with a continuous line outlining the shape of the logs below, then the log dogs can be removed and the log boomed down off the wall and placed on log cribbing of a comfortable height to do all the chain saw work with both feet on the ground.

We have found it faster and safer to do most of the chain sawing standing on the ground. If you don't have a crane to easily move the logs, which is often the case for owner builders, you can do all the chain saw work up on the wall. This is dangerous work, on or off the ground. Totally concentrate on the task at hand, yet be aware of what is going on around you. Practice safety at all times. Always wear eye and hearing protection.

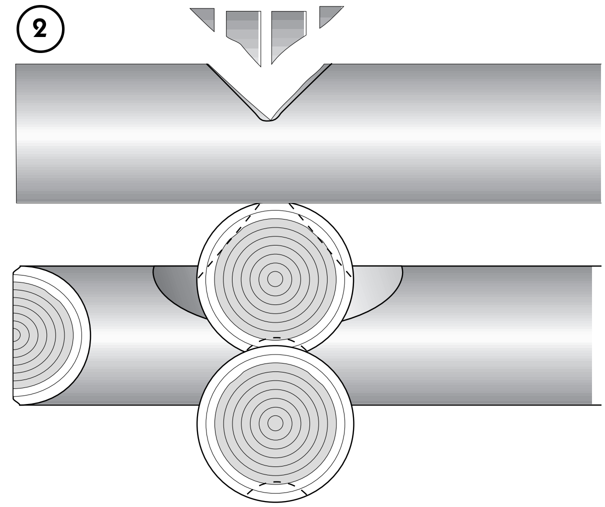
Do not get between a moving log and a hard place. When undoing a log dog, have someone hold the opposite end of the log with a Peavey with both of you standing to the inside of the house and no one below you on the ground. Sometimes a very crooked log can roll with a lot of force and throw a log worker off the wall. Work in pairs and look after each other.

Cutting the Notch

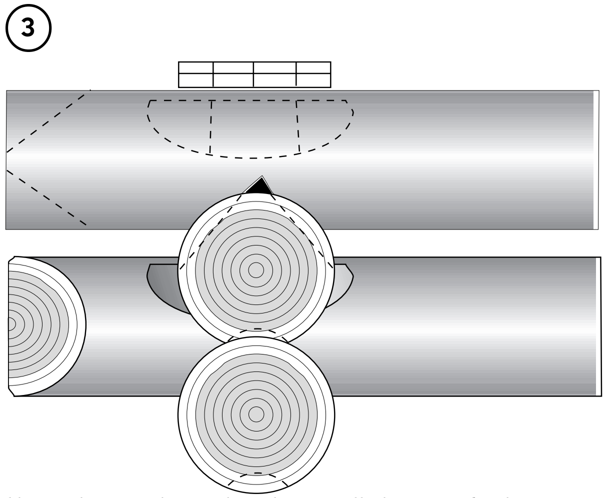
If you are using a chain saw to cut the notch and you are working with dry logs, it is a good idea to score along the scribe line with a sharp knife to prevent splinters from extending beyond the scribe line. You could also use a sharp ax held in one hand and a mallet to tap the



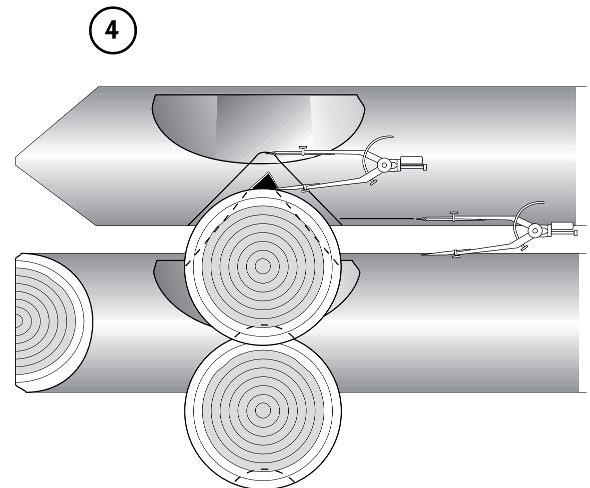
A rough or first scribe



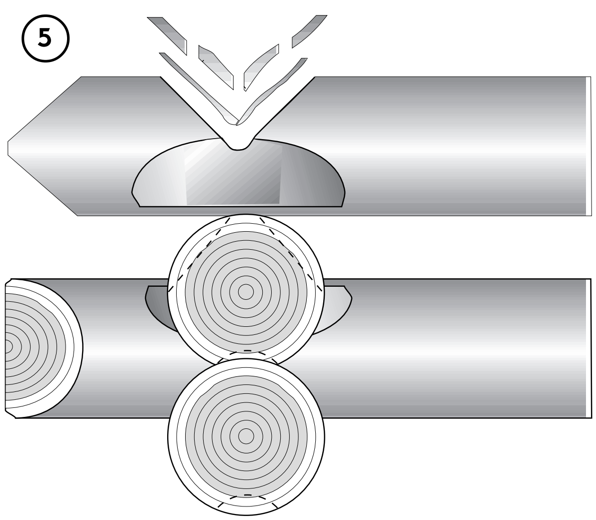
Remove the wood in pieces and roll the log over.



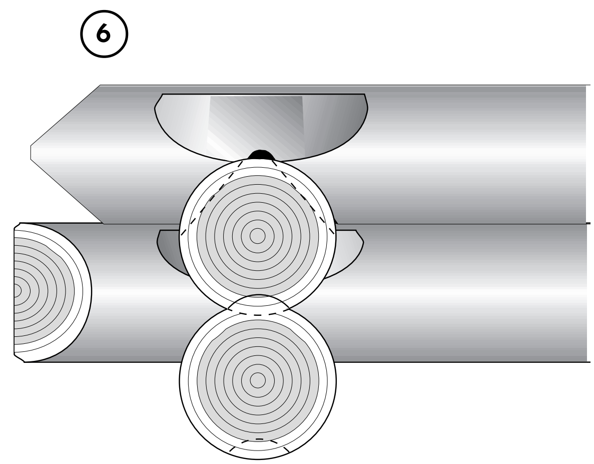
Use a layout board to keep all the scarfs the same.



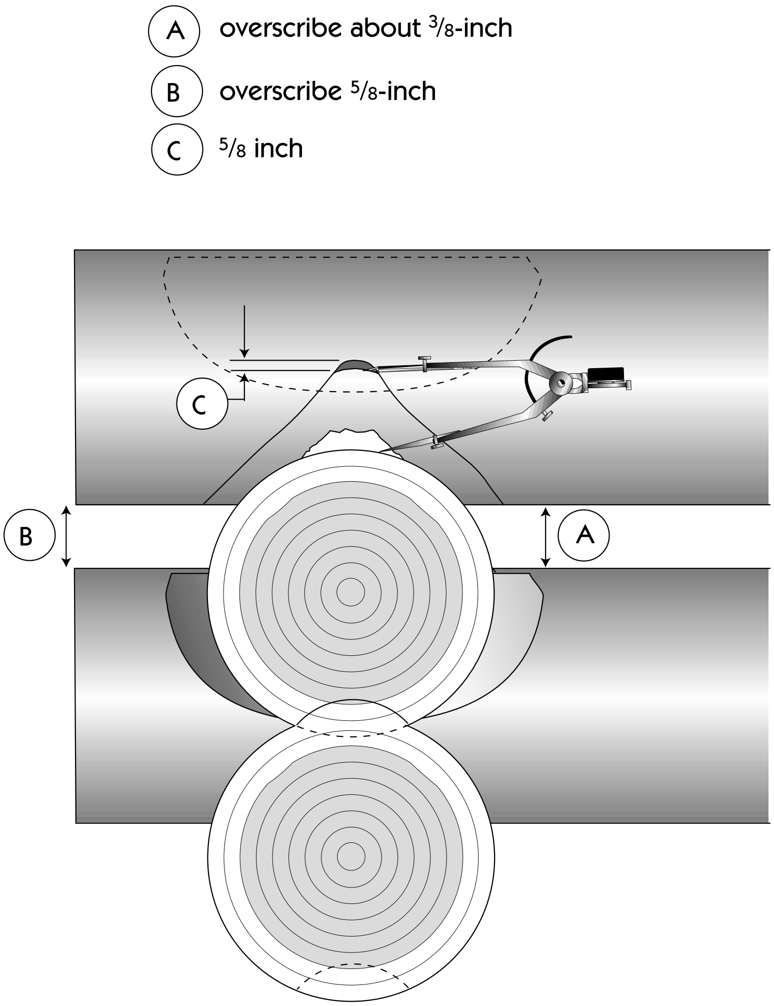
The final scribe



Most of the wood is cut with a chainsaw, but cut the last quarter inch with hand tools.



The notch should be smooth and slightly cupped to accommodate insulation and prevent hanging up on the lower log.



The final scribe is visible on this log on the skids, ready for cutting.

head of the ax as if it were a large chisel to score the line.

Cut from one side of the log at a time so that you can see when you are getting close to the scribe line. Leave about a quarter of an inch of wood between your saw and the line so that you don't turn an expensive log into firewood by cutting beyond the scribe line. Cut the remaining wood with a sharp axe, chisel, or a sharp pocket knife.

For a small notch you may only need to cut one vertical slice down the center of the notch and one angled cut along each side of the notch.

Repeat the three cuts from the other side of the notch, and knock out the chunks of wood with the back of your ax or with a hammer. A larger notch may require a few more slices. With practice, an experienced log worker can remove most of the wood within the scribe line in only a few large chunks.

Brush the remaining wood to be removed from the notch with the bottom quarter of the nose of the saw bar. Clean up the sides and the bottom by sweeping sideways back and forth with the bottom sector of the tip of the bar. Work from the top down and from the center of the log to just short of the scribe line.

When you're done, the notch should be smooth and slightly cupped to accommodate insulation and prevent hanging up on the lower log. The sides of a compression-fit notch must have strong edges to carry the weight of the log when the lateral notch is overscribed (see Appendix B, page B-13, Log Building Standards).

Cutting the Lateral Groove

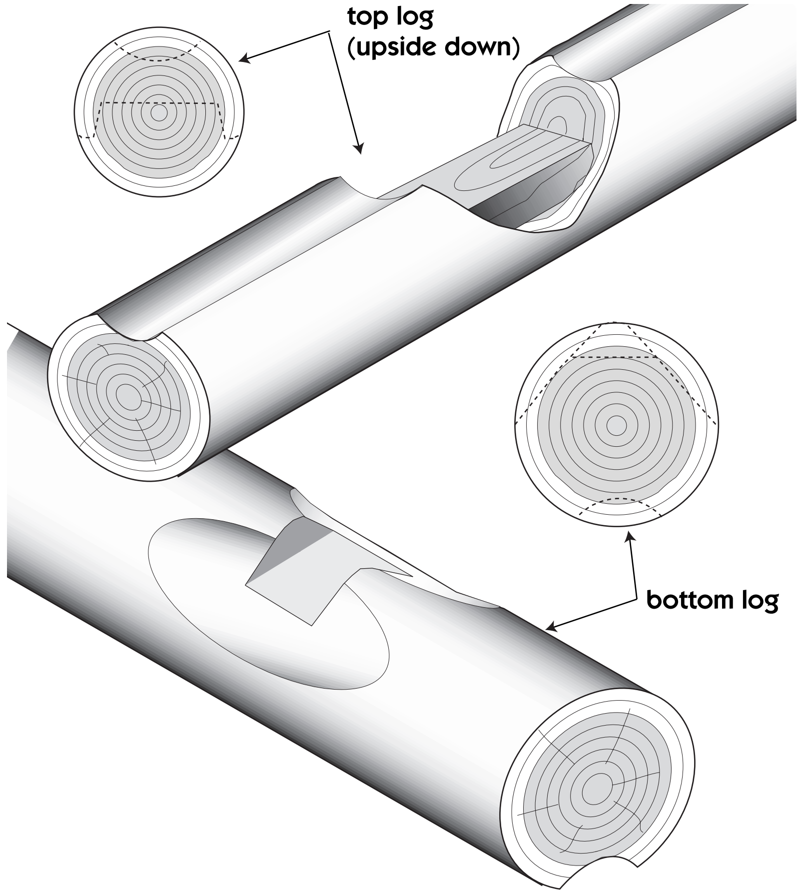
The long V groove is no longer in favor since it removes more wood than necessary and in some cases weakens the logs to the point where they slump on the wall and open up the notches, which are no longer carrying the weight. A more perfect groove is the continuous cope, which is tedious with a chain saw but can be done with a gouge-type adz or with a specialized tool called the Mackie gouge knife, also known as a scorp.

The W cut groove is most frequently used now by log building professionals. This cut removes much less wood than the V groove. Instead of making two deep cuts to create a V, you make four shallow cuts to form a W (see next page). A narrow groove is tighter and stronger and faster to cut than a wide groove.

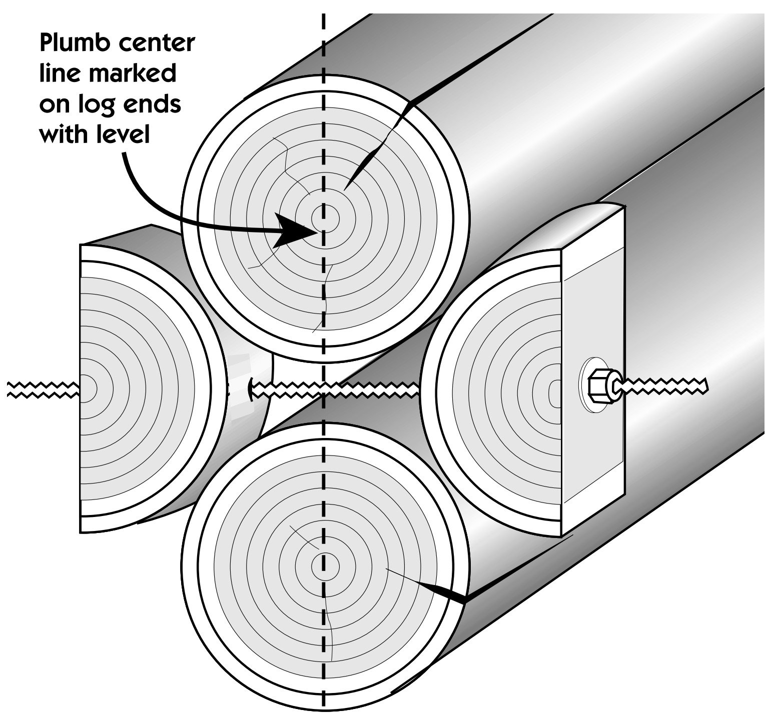
Begin by cutting just inside the scribe line with the saw aimed just above the center or radius point of the log. Make the first cut about an inch or two inches deep, depending on the size of the log and the shape of the log below.

The second cut is a repeat of the first cut from the other side of the groove. The third cut is a line starting at the top of the first cut and connecting at the bottom of the second cut. The fourth cut removes the wood remaining near the first cut, and a W will be formed in cross-section.

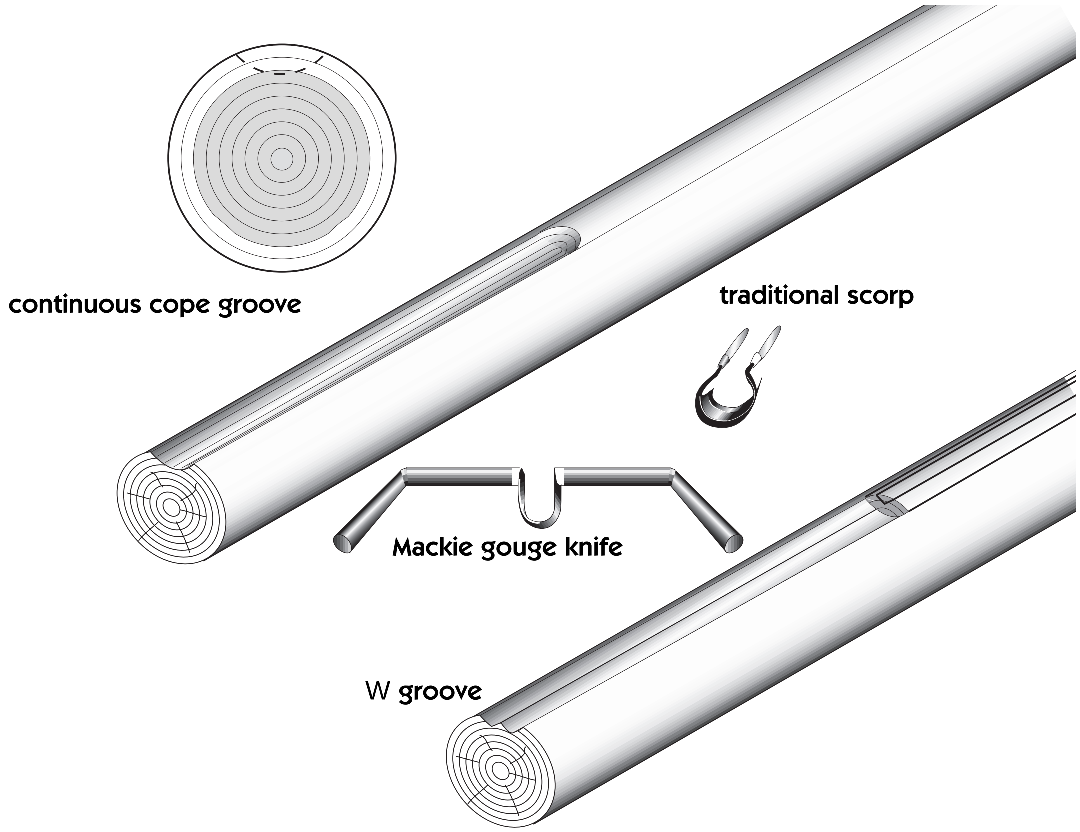
You may have to remove some of the center portion of the W if a trial fit with a short piece of log similar to the log below hangs up and will prevent the log being worked on from settling properly. If necessary, the center of the W is



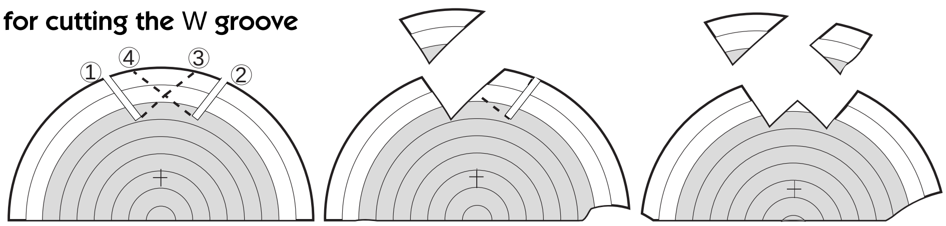
A lock notch is used when a log tip is too small to be notched without weakening it considerably. A lock notch can also be used on the plate log at the top of a wall for added strength to keep the walls from splaying outward.



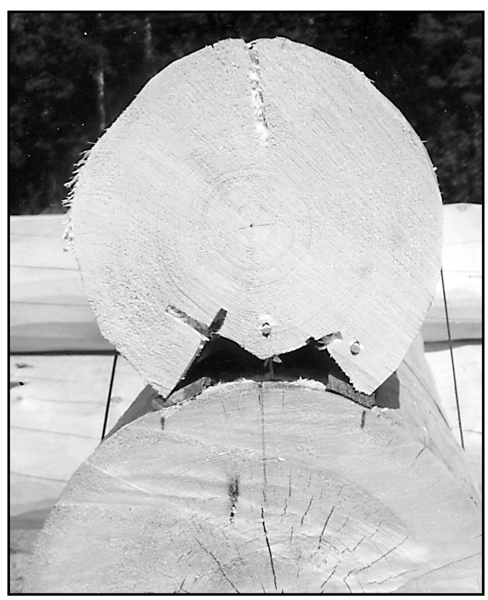
Site-made log holders keep logs aligned at a precut door or window during scribing.



A sequence for cutting the W groove



Cutting the groove with a chainsaw.



A W-groove in a log. Note shims to keep the clearance for the overscribe.

easily removed with a long-handled curved gouge or with a scorp as described earlier.

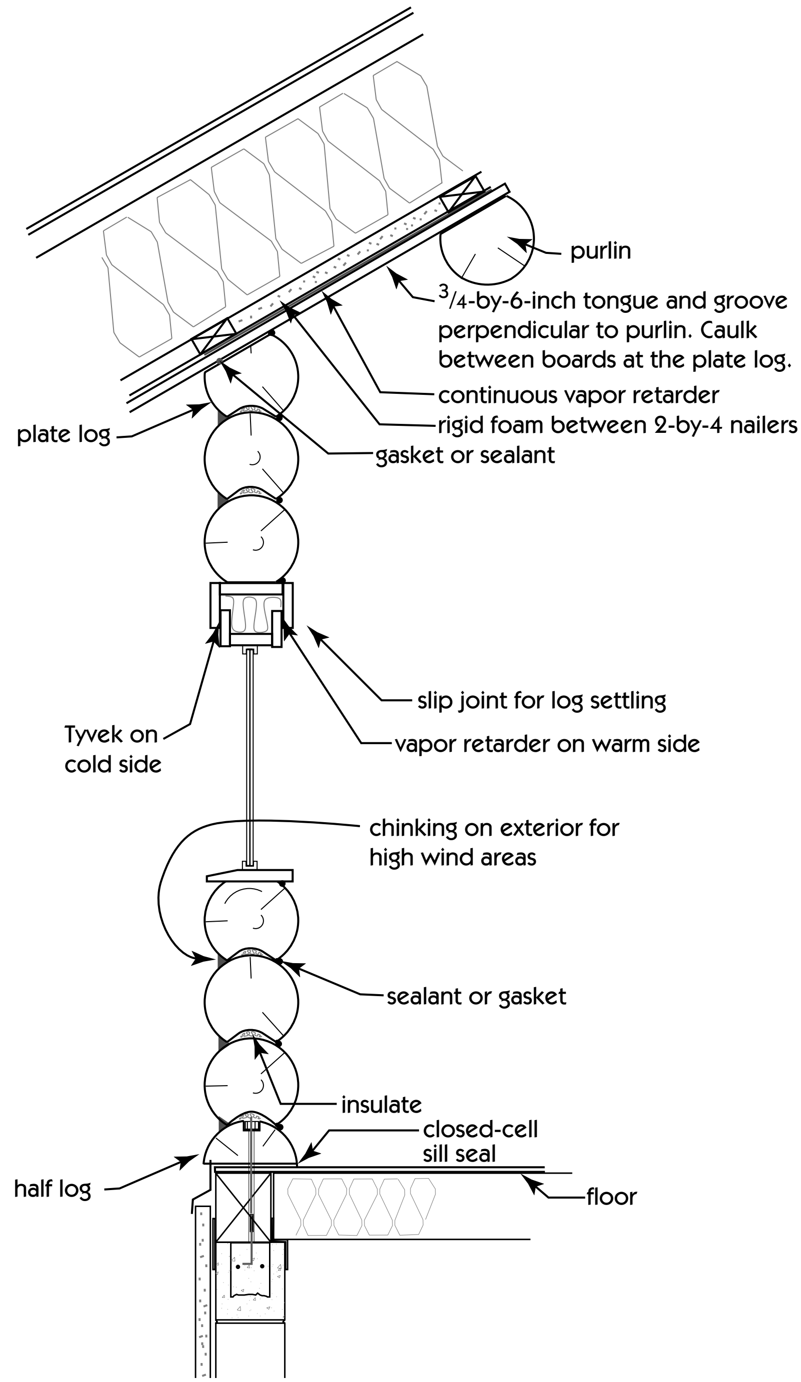
The Log Walls

Carefully align the center of mass of succeeding logs as they are positioned for scribing. Since you are working with a natural material, some of the logs will be curved. The overall objective is to have the average center of all the logs bear down on the center line of the wall, which in turn bears on the centerline of the foundation.

Considerable time should be taken rolling and sliding the log with a Peavey to be sure the log is well centered and the straightest sides are top and bottom with any curve to the outside of the building. Station a log worker at each end of the log to be aligned with Peaveys in hand. Each person should eyeball the log and make small adjustments until both ends are well centered. Stand back from the wall several feet and hang a plumb bob as a sight line to examine the lay of the log. Do this from each end to satisfy yourself that the wall is going up straight and plumb. Dog the log securely and scribe and notch as described above.

As the walls get higher, you need to keep a check on the height of all the walls and keep the even-numbered rounds about the same height. Carefully select logs that are of the correct diameter to maintain equal log wall heights. Strive at all times to cut about halfway through the log with the corner notches. This is of course the ideal and can only happen if the logs were turned on a lathe to exactly the same diameter.

If a small tip must notch over a large butt, a lock notch should be used to leave enough wood to avoid breaking the tip (see illustration, page 39). See Log Building Construction Guide by Rob Chambers for a detailed discussion of log selection (see Appendix D, References and Bibliography).



Airtight Log Walls

The log walls must be airtight to resist the flows of heat, air, and moisture. This can be accomplished with the use of tar-saturated foam strips such as EM Seal, EPDM gaskets, or backer rod and 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. Properly fitted, full-scribe logs will not require any visible chinking such as was used in the old days to keep out the weather and keep the cat inside. In high wind and rain environments you should air-seal both inside and outside the logs.

Finishing the Logs

On the inside, two coats of log oil or clear acrylic latex or polyurethane varnish should be enough of a vapor retarder to slow the flow of household water vapor through the logs. You will want to treat the outside of the logs with a UV-inhibiting water repellent preservative log oil or stain. Clear exterior finishes do not last as long or protect the logs as well as pigmented finishes. There are many products on the market designed to

Sealing the vapor barrier around a log ridge pole.

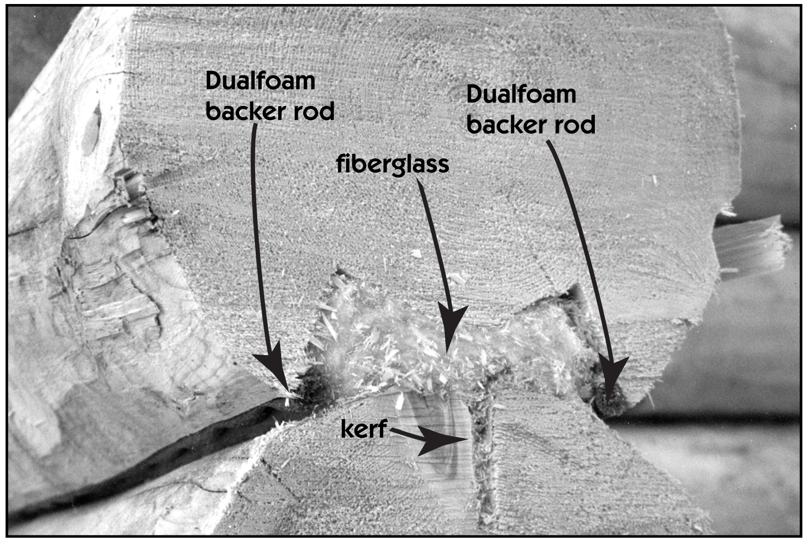
Both fiberglass and backer rod installed on a log.

Logs ready to be lifted into place.

finish logs, so do your homework to see what is recommended in the literature and by the various vendors or in the trade journals.

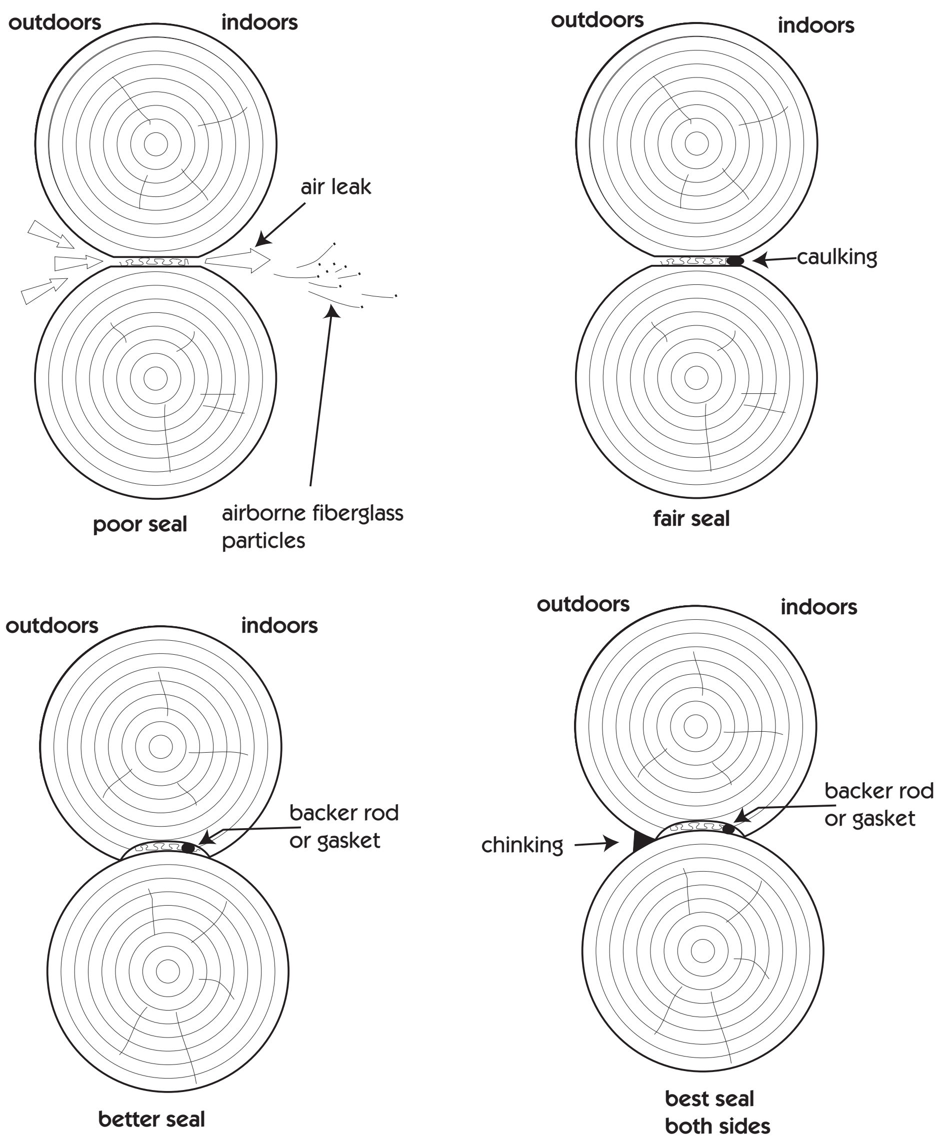
Chinking and Sealing

Fiberglass chinking or fiberglass sill seal alone will not create enough of an air seal to pass a blower door test. Unless the log work is very tight and will remain airtight over time, it is not likely to pass the airtightness requirements of BEES.



A closeup of the log in place with fiberglass and gaskets.

Fiberglass sealing of log walls: good and bad



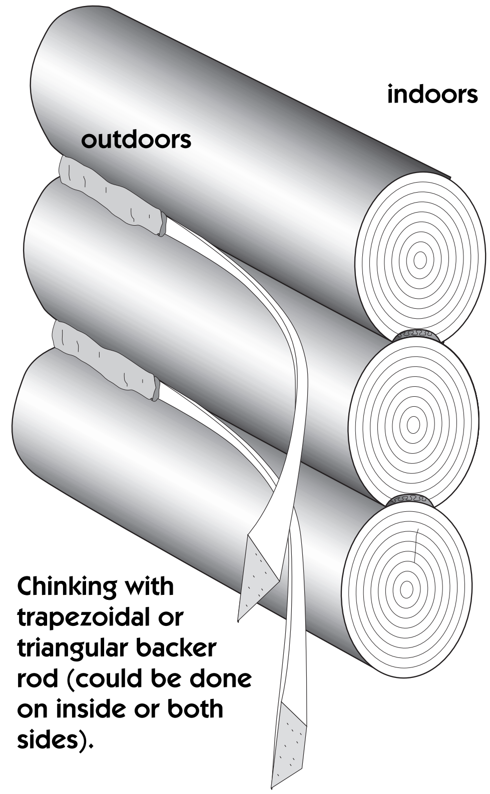
> "Fiberglass chinking or fiberglass sill seal alone will not create enough of an air seal."

There are several log chinking materials available to make a log house tight.

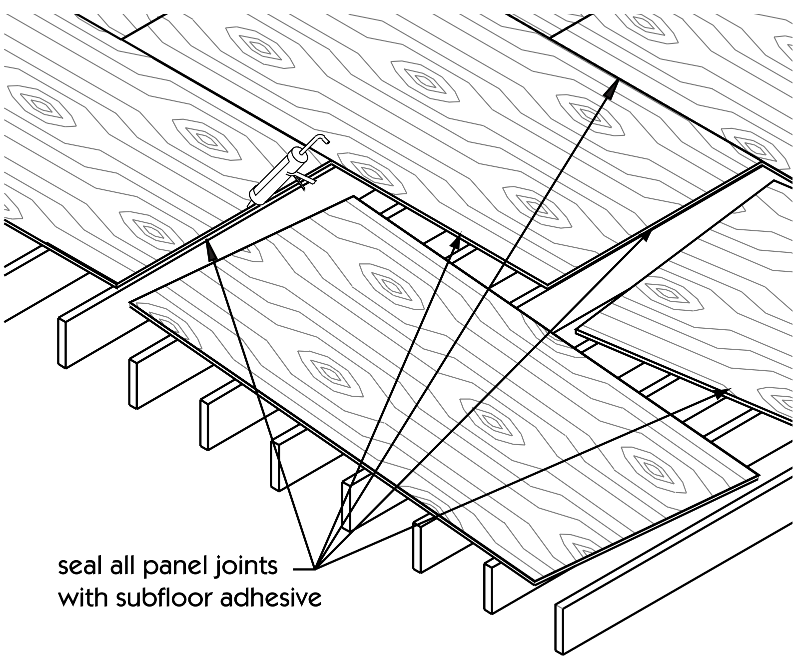
The log building details presented in this book describe how to construct scribe-fit chinkless log homes. However, some people like the looks of chinking, and many older log homes may be in need of chinking to reduce infiltration between the logs.

Modern chinking systems require the use of triangular or trapezoidal-shaped backer rod to form an even, flat surface upon which to spread the chinking material. Use a flexible chinking material such as Perma-Chink or Weatherall over the backer rod for a durable seal between the logs.

Old-time chinking materials such as sphagnum moss or oakum are rarely used in today's log homes. Clean sphagnum moss is a good alternative insulation for log building in the bush but may not be in the AkWarm computer files.



Chinking with trapezoidal or triangular backer rod (could be done on inside or both sides).



Glue joints between pieces of plywood and glue the plywood to the joists. Ideally, use 3/4" tongue and groove exterior grade plywood. Glue, nail, and screw for a squeak-free floor system.

Short Log Construction

If you do not have any lifting equipment, you can build a good log house using logs short enough to be handled by a couple of people. A traditional method of stacking up short logs to frame a wall is known by its French name as pièce-sur-pièce, or piece-on-piece in English. This is a variation of squared post and beam construction where a horizontal infill of round logs is fitted between vertical round log posts. The vertical posts are flattened on two sides and grooved to accept a tenon fashioned on each end of the log infill pieces.

An alternative to mortise and tenon joinery is to groove both the post and the infill log ends to receive a 2-by-4 spline to join them. This method of construction can use a wall jig to ensure consistency, allowing for all of the wall components to be prefabricated off site even before the foundation is completed. Combining post and beam and square timber framing techniques with round logs squared off only where two or more beams connect can allow you to fabricate precisely engineered structural timber frames or trusses in the shop.

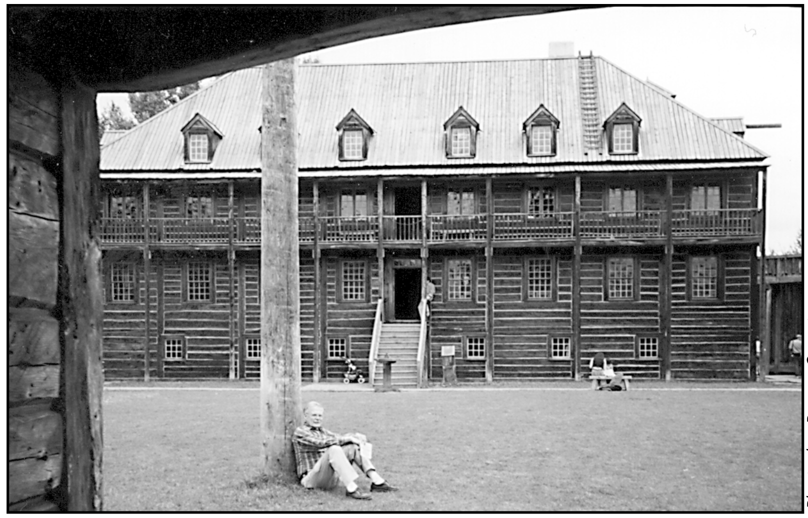
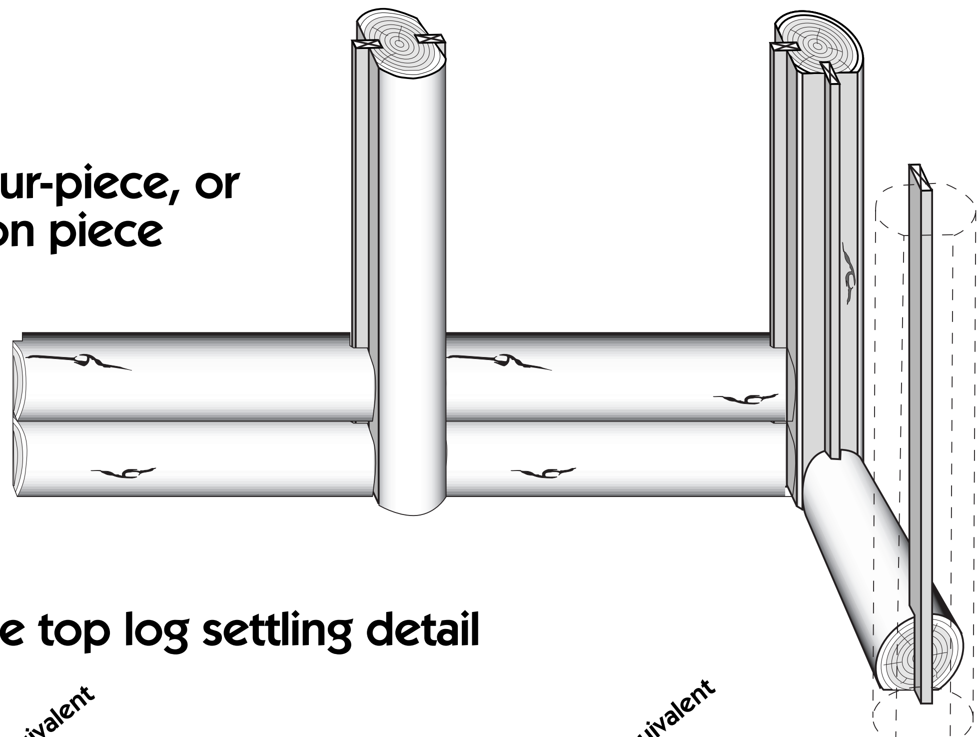


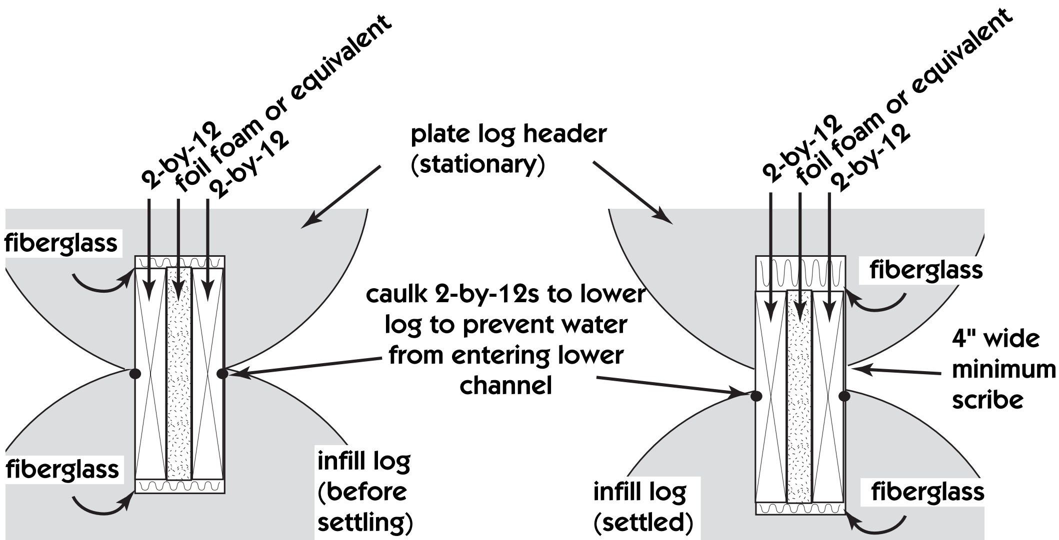
Photo by Peggy Swartz

This large building, rebuilt at the site of old Fort Edmonton, Canada, was built piece-sur-piece.

Piece-sur-piece, or piece on piece

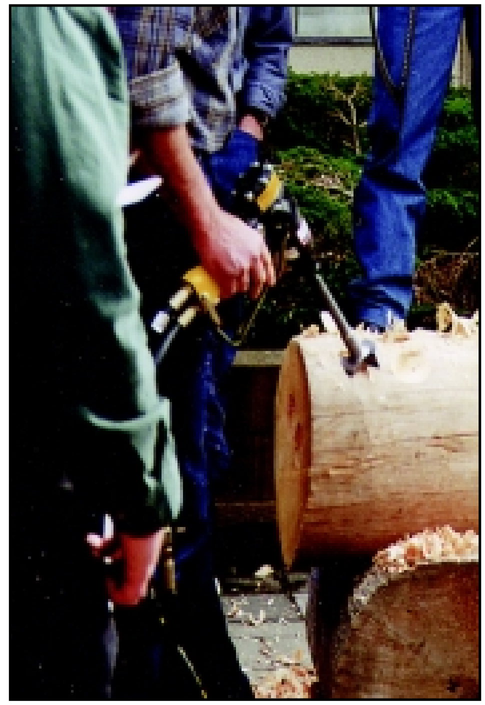


Piece-sur-piece top log settling detail



Making It Easier

Most timber framing tools and log working tools can be powered electrically or even hydraulically. Cutting out frames and trusses inside in the winter can greatly extend your building season and give you a jump on the spring building season. You can have the house structure ready to install on the foundation as soon as the floor is completed. However, gasoline-powered chainsaws should not be used when working inside a confined area because deadly exhaust fumes could build up inside the building. Hydraulic or electric tools are safer inside.



A hydraulic drill being demonstrated at a log building conference. Note the one-handed operation.

No exhaust fumes is one benefit from using hydraulic chain saws indoors during winter construction.

The portable hydraulic pump for driving the tools.

The Plate Log

The plate log, sometimes called the cap log, is the top wall log upon which the roof system rests. The plate logs and the purlins and ridgepole are usually picked out and set aside at the beginning of the job. They are straight and have straight grain and are usually the biggest and best, strongest and longest logs since they usually extend five or six feet beyond the gable ends. The plate logs should be chosen from this select group of the finest logs to end up level and the same height from the floor in all four corners. The plate logs may have to be fitted with locking notches to resist outward thrust from the roof components. The plate logs could also be through-bolted at the windows and door headers and pegged or pinned on close centers where there are no windows.

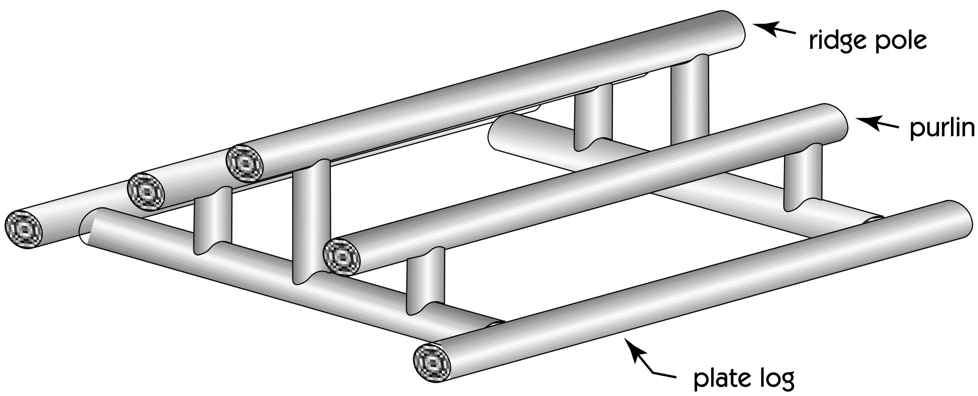


Plate logs, purlins, and ridgepoles are higher stress areas, and the biggest and best logs should be saved for them.

Choose the best logs for critical places such as plate logs, purlins, and ridgepoles.

More Than Just Logs

Traditional Athabascans used the spruce tree in many ways. One important way was for medicinal purposes. Several parts of the tree, including the top, the inner bark, needles, and the sap, were used to treat heart problems, kidney trouble, ulcers, stomach sicknesses, weak blood, colds, sore throat, sores, burns, and tuberculosis. Shamans used the top of the spruce to get rid of bad spirits. Dust from the spruce cone was prescribed to dry up runny ears, and the pitch was used as an antiseptic and to stop bleeding. People used the inner bark for bandages.

Spruce trees provided shelter long before Europeans used them for log cabins. Athabascans used the outer bark for roofing and flooring, the boughs for insulation, and of course logs for building walls and roofs. Spruce logs are also used to build weirs, fish traps, fish racks, canoes, rafts, and other things.

People still use the outer bark of the spruce tree on fish cutting tables to keep the fish from slipping off. They also use it as a dye. Boughs could be made into makeshift snowshoes or serve as mattresses for people and dogs.

Dead spruce wood was useful for smoke for tanning hides and keeping away mosquitoes, and made dye for moosehide. Of course, spruce is a good firewood. Also, the wood could be carved to make utensils, tools, toys, fish traps, and weapons. The roots became lashing for fish traps and snares and were woven into baskets and fishnets.

Spruce pitch is a useful glue, antiseptic, chewing gum, waterproofing, and hair dressing.

The information above comes from Eliza Jones and *Dena'ina K'et'una: Tanaina Plantlore*, compiled by Priscilla Kari, and *Upper Tanana Ethnobotany* by Priscilla Russell Kari.

Windows and Doors

Typically, heat loss through walls accounts for only about 20 percent of the overall energy use of a building. Air leakage typically accounts for 30 to 35 percent of heat loss.

Windows and doors need to be installed with airtight connections to the logs with a spline system notched into the ends of the logs, which allows the logs to settle without increasing air leakage.

Choose windows and doors carefully for your new log home. In order to score well on an energy rating, you must install windows and doors with high R-values. The most energy-efficient windows have some sort of low emissivity (low-E) coating on multiple panes. The panes should be separated with nonconductive spacers. The space between the panes may be filled with an inert gas such as argon or krypton to reduce convection currents between the panes and increase the insulation value of the window. This energy-efficient glazing system should be fitted into an airtight insulated frame. Windows should have an R-value of at least R-3, but R-4 or higher would further reduce heat loss and improve your energy rating.

Doors must be R-7 or better. Handmade doors are often crafted to complement a log home and can be built with a core of very high R-value rigid foam.

Caution! Door and window cutouts in a log wall are probably the most dangerous of all chain saw operations in a log house. Since the top of the window or door cutout is over the sawyer's head, the likelihood of a kickback and serious injury to the head and face is very high. If you must cut out window or door headers over your head, wear a hard hat and hang on tight to the chain saw.

The safest way to cut out the top of a door or window opening is while it is still on the skids where it was placed for notching. Measure the exact location for the window on the bottom side of the header log. This will be at the window height plus the rough frame dimensions plus the anticipated settlement space. This will usually be from 7 to 10 inches greater than the height of the factory-built window frame.

Straight, accurate side cuts can be made using a chain saw lumber mill attached to vertical 2-by-4s or 2-by-6s. If you have more than one window of the same size, a jig made of 2-by material can be fabricated and moved from window to window. In any case, the vertical legs of the jig should rest on the floor, and it should be accurately plumbed and temporarily nailed to the log wall to keep it from moving during the cutting operation.

Cutting the Splines

Windows and doors should be attached to the log walls using a vertical 2-by wood spline notched into the log ends on each side of the opening. If a log wall with a door or large window must hold up a huge snow load, it would be wise to use $^{1}/_{4}$"x1"x2" steel C-channel for spline material in addition to the wood spline.

These spline notches are often cut with a chain saw using a technique similar to cutting the long W-notch. Be especially careful as you approach the top of the window. Chances are that you will hit the header with the top of the saw bar, resulting in a dangerous kickback situation. Use a very sharp saw chain at high RPM to minimize kickback and hold on tight to the chainsaw. A much safer method of cutting these spline notches is to use a heavy-duty router to cut a spline groove in the log ends. Nail a vertical 1x4 to the log ends to guide the router.

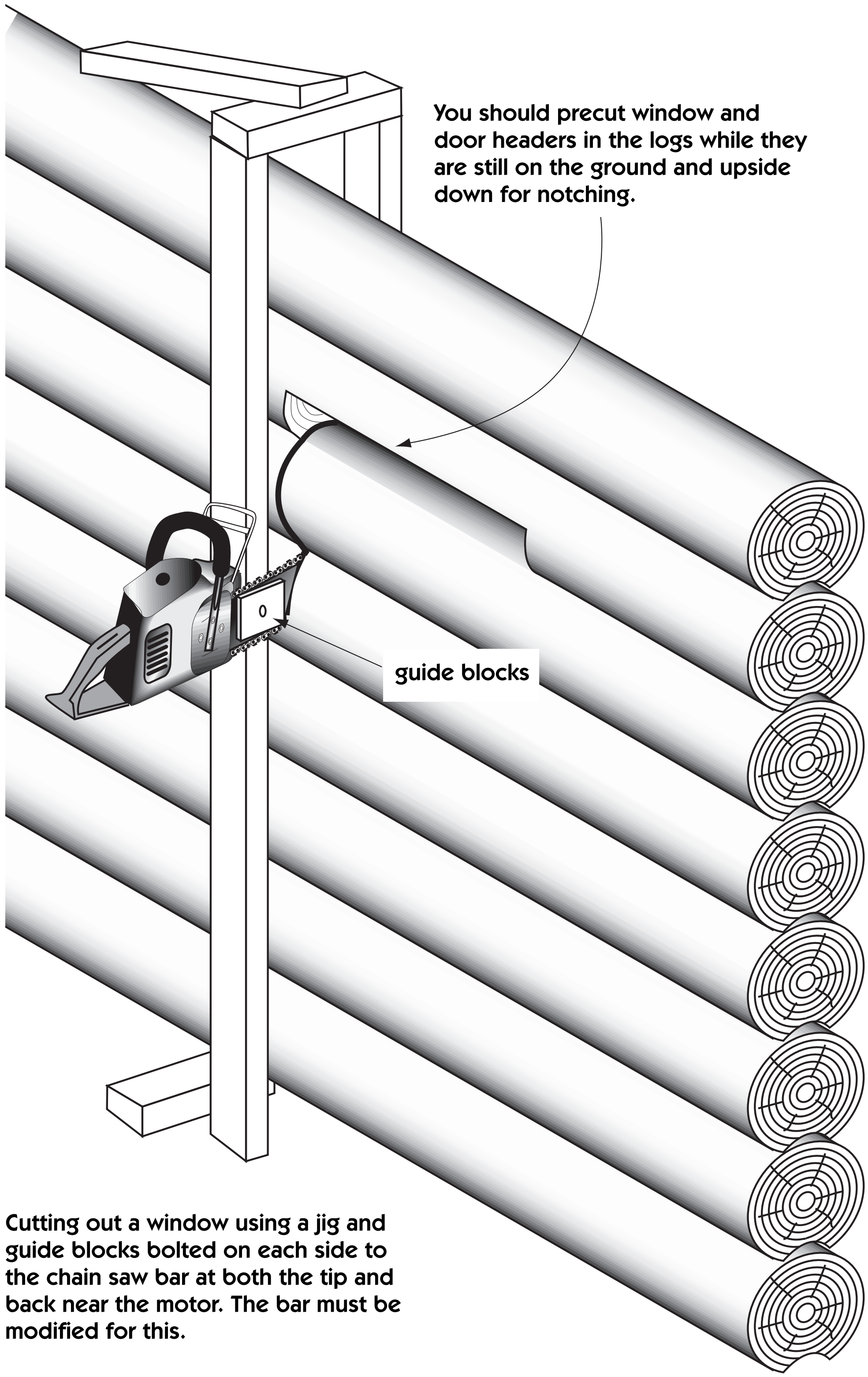
Door and window installation in a log structure requires unique details to maintain an airtight fit as the logs shrink and settle. The 4-to-6-inch settlement space over doors and windows must be insulated and fitted with an airtight vapor retarder that will remain effective over time.

Placement and Planning

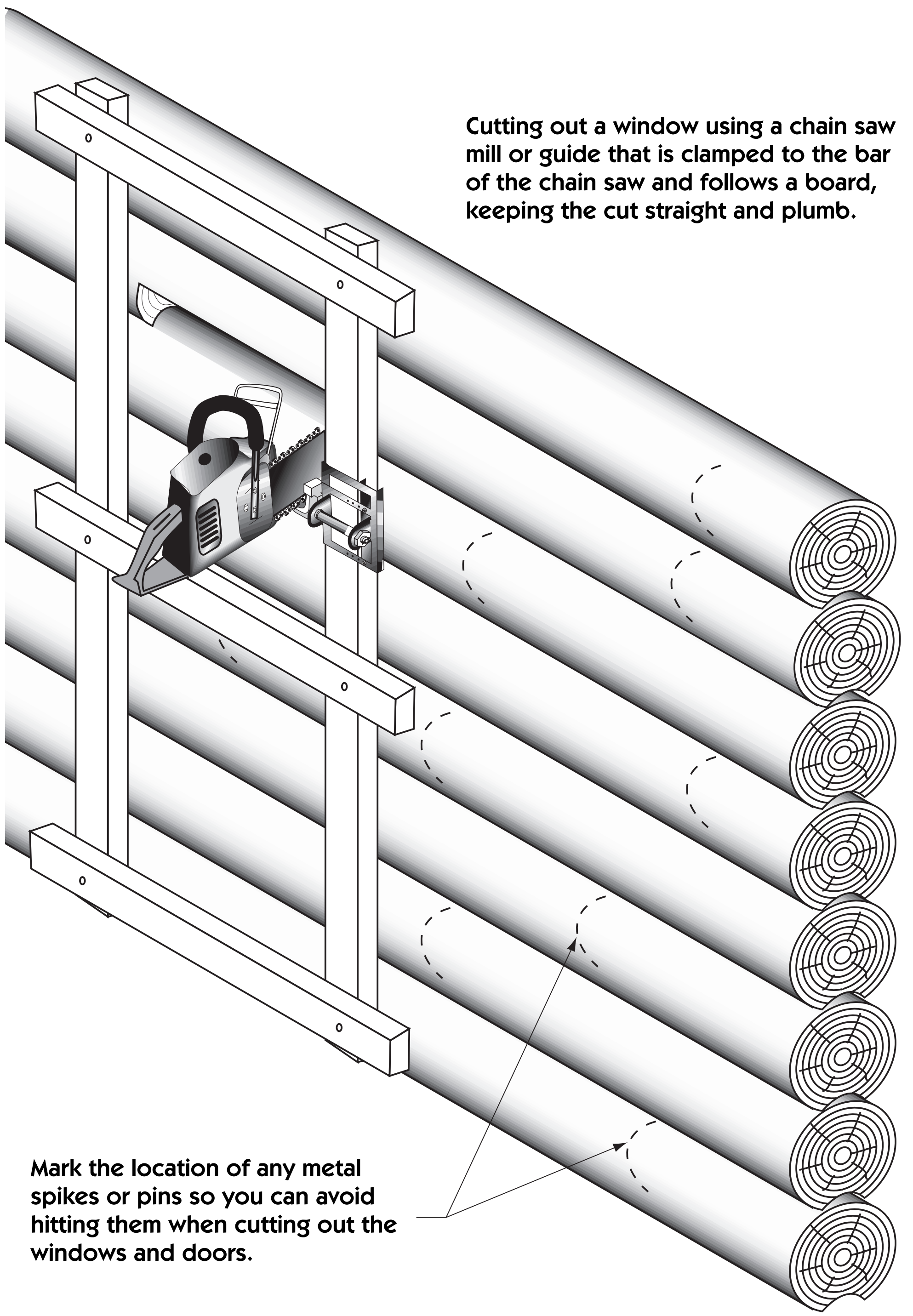
Windows and doors in a log home should be located with consideration for solar aspect, prevailing winter winds, roof avalanche potential, and the structural elements of log construction. Face the majority of windows south for natural light and passive solar heat.

Open doors in so that you can get out if snow drifts pile up outside the door. Better yet, orient the house so that prevailing winds keep your front porch clear of snow. Do not put yourself and others in harm’s way by placing an entry door under the eaves of an avalanche-prone roof. Metal roofs are notorious for dumping lots of snow all at once. Locate entry doors in the gable end of the house or under a protective roof.

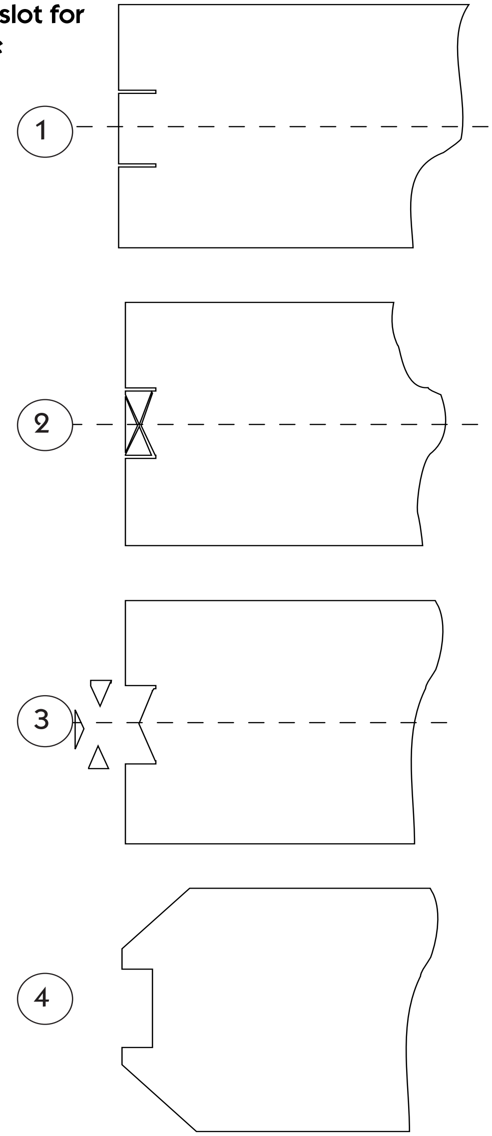
> “Air leakage typically accounts for 30 to 35 percent of heat loss.”



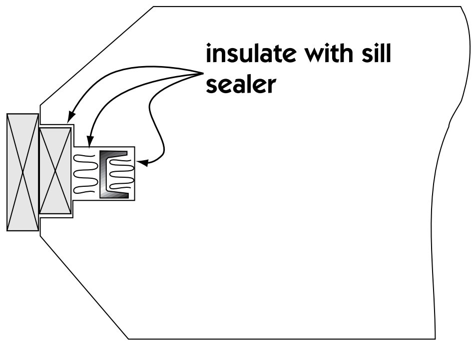
Cutting out a window using a jig and guide blocks bolted on each side to the chain saw bar at both the tip and back near the motor. The bar must be modified for this.

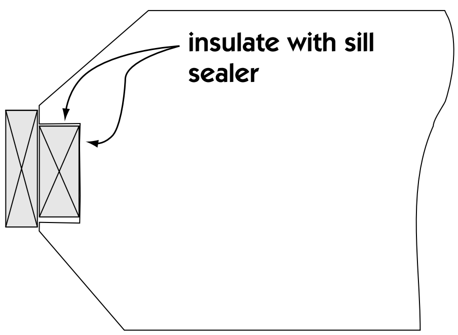

Cutting out a window using a chain saw mill or guide that is clamped to the bar of the chain saw and follows a board, keeping the cut straight and plumb.
Mark the location of any metal spikes or pins so you can avoid hitting them when cutting out the windows and doors.

Cutting a slot for the spline

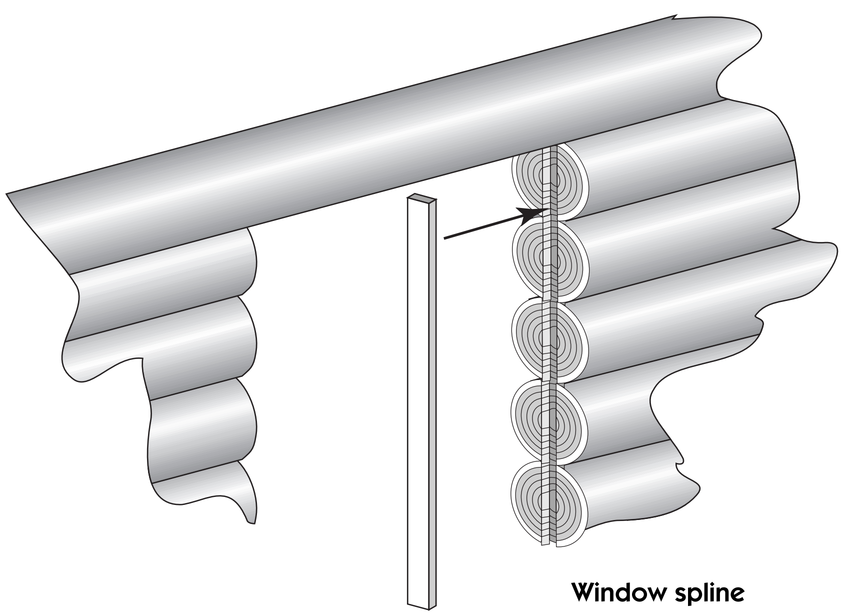


If the wall is considerably weakened by the window or door openings, you may have to use a steel C channel for reinforcing the spline.





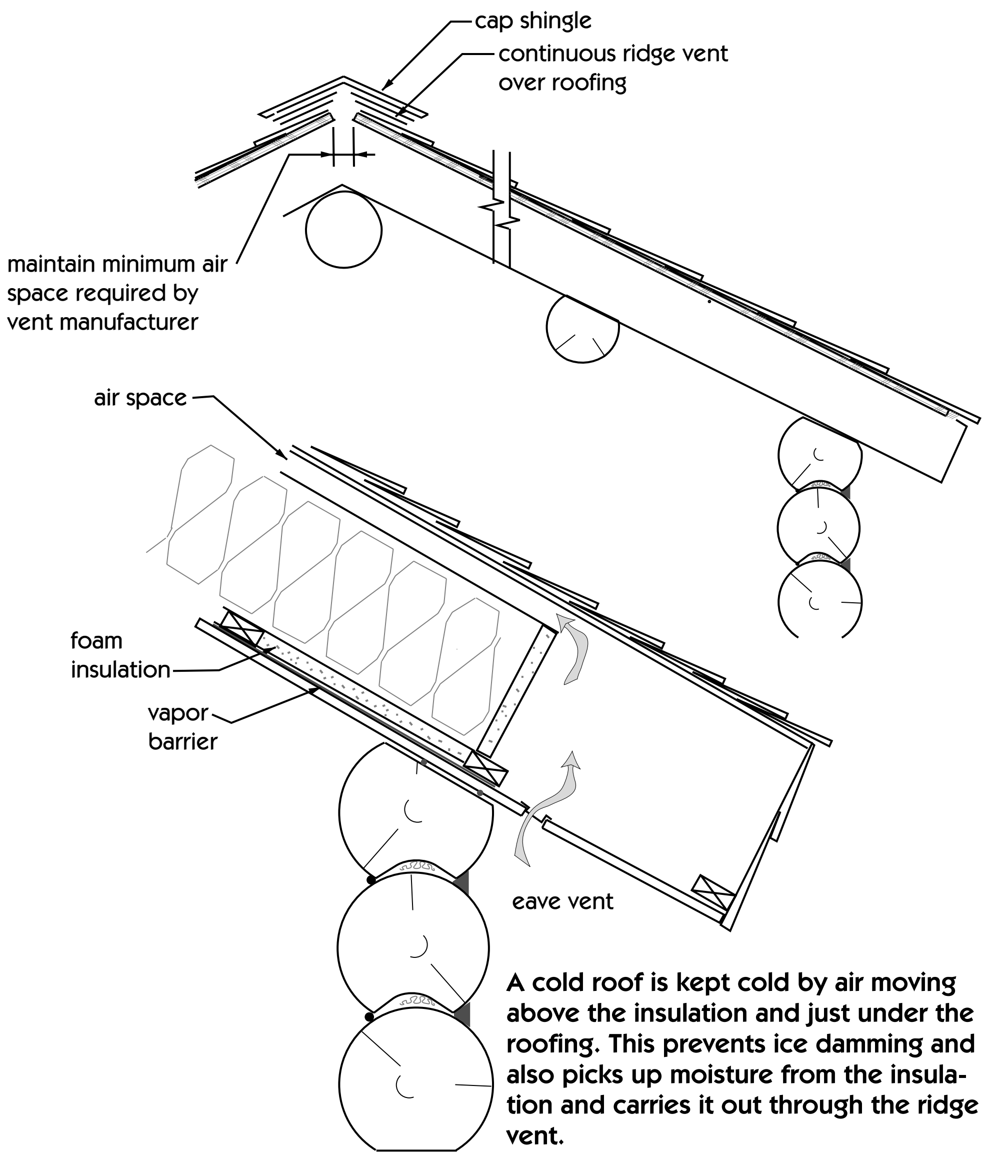
But much preferred is a wooden spline because it won't attract water condensation and the damage that comes with it.



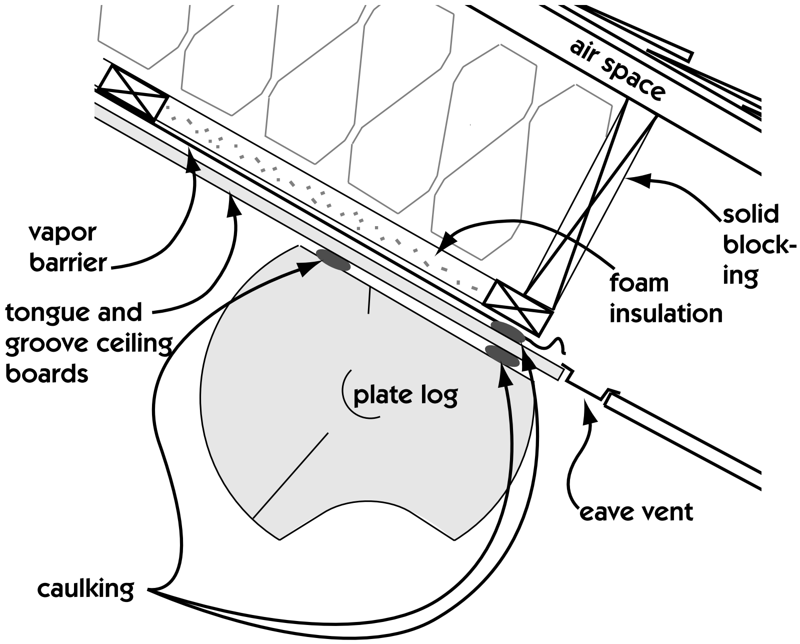
Window spline

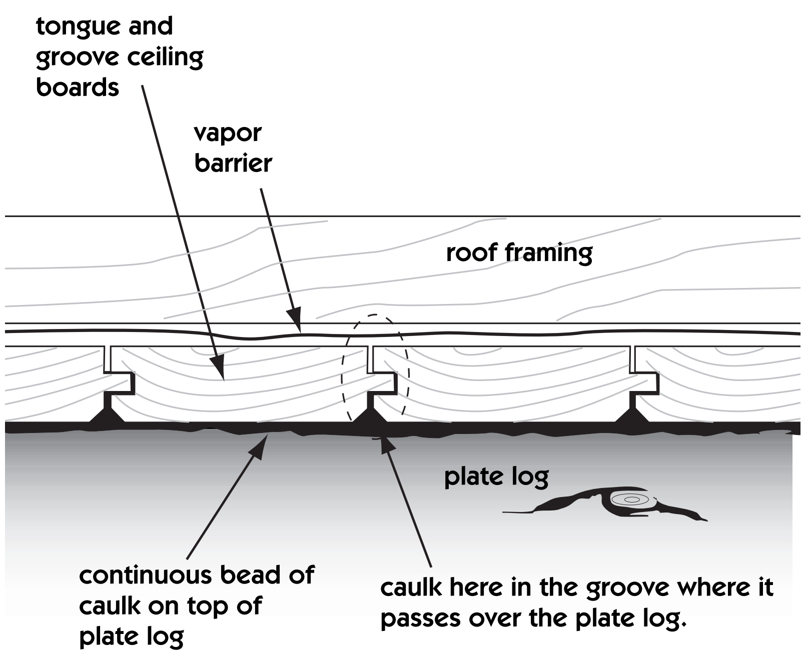
The Roof

Once you have built an airtight log wall, you must then follow up with an energy-efficient roof, air sealed with continuous sheets of 6-mil polyethylene with all penetrations taped or caulked and the ceiling tightly sealed to the log work. There are many ways to put a roof on your log creation to shelter it from the elements. The classic log house had a low-pitched roof with generous eave and gable end overhangs. The gables were made of logs, which supported purlins and a ridgepole and log rafters or a ceiling completely framed with evenly sized poles lying side by side. A modern equivalent uses the same log gables and purlins and ridgepole techniques but replaces the poles with tongue-and-groove spruce or pine paneling, topped off with an insulated rafter-framed roof.



A cold roof is kept cold by air moving above the insulation and just under the roofing. This prevents ice damming and also picks up moisture from the insulation and carries it out through the ridge vent.





Sealing the Ceiling

Any style of roof should have an airtight vapor retarder, and the joint between the plate log and the ceiling should be caulked. Each tongue and groove ceiling board should be caulked in the groove where it passes over the plate log. The roof rafters should be deep enough to reach the insulation levels required by BEES. There are many different ways to build log trusses or post and purlin or other log roof systems that are beyond the scope of this book. The bibliography has many good books on log building and roof framing (Appendix D).

Hot Roof or Cold Roof?

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 or metal roofing.

Liquid water in the roof cavity is a problem. The solution to this problem is to provide ventilation in the attic, so heat from the building does not melt the snow. Provide a minimum of 2-inch continuous air space over the insulation and continuous screened eave and ridge vents.

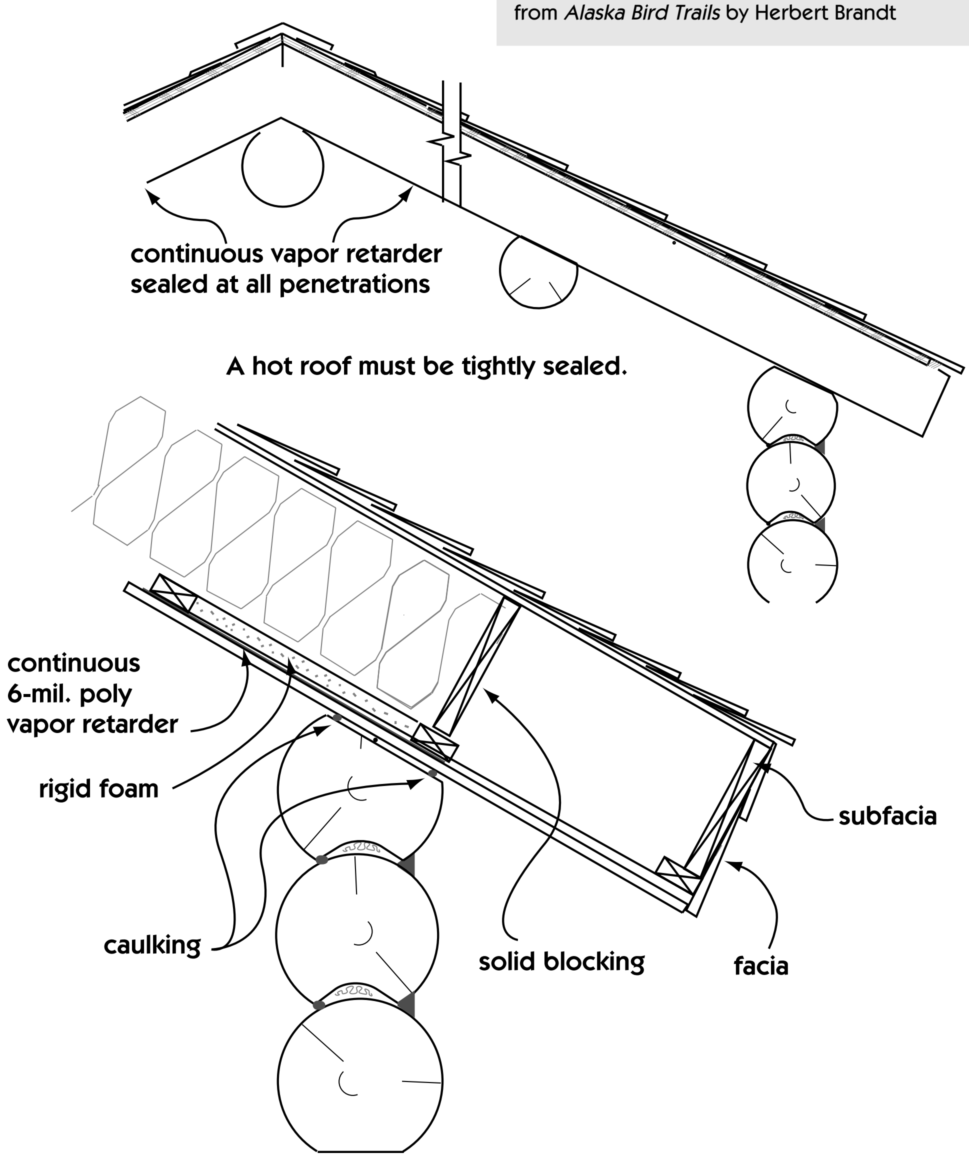
If the building is on a site exposed to high winds and no snow is likely to accumulate on the roof, an airtight hot roof may be desirable. A number of snow-resistant ventilated roof designs have been experimented with over the years with varying degrees of success. Whatever design you choose, keep in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

All roofs must be designed to accommodate snow loads and be securely anchored to resist wind and seismic loads.

The Roadhouse, 1926

"The Alaskan roadhouse is a unique institution, and turns a bleak, formidable country into one of hospitality. Nestled in a clearing in the spired spruce forest, built entirely of rough logs neatly notched together at the ends, the road house presents a cozy and picturesque appearance. The building is divided into a kitchen and a bunk room by means of a frail partition. In the center of the bunk room is a huge cast-iron stove capable of taking a four-foot green log, which burns all night. Above the stove is suspended a large rack on which the weary traveler hangs his damp shoes and clothes, that he may put on dry apparel in the morning. Everything is very comfortable and cozy. In one corner is a small space partitioned off for an occasional woman traveler. The beds are two-storied bunks made of strips of raw moose or caribou hide, called 'babish,' laced across the bottom. The bed is entirely without linen, but the blanket and quilts are ample. The floor is spread with shavings, and Cleanliness varies according to the owner, but as a rule, each takes pride in his place and keeps it fairly neat."

from *Alaska Bird Trails* by Herbert Brandt



Hot roof with no vents at eaves, gables, or ridge

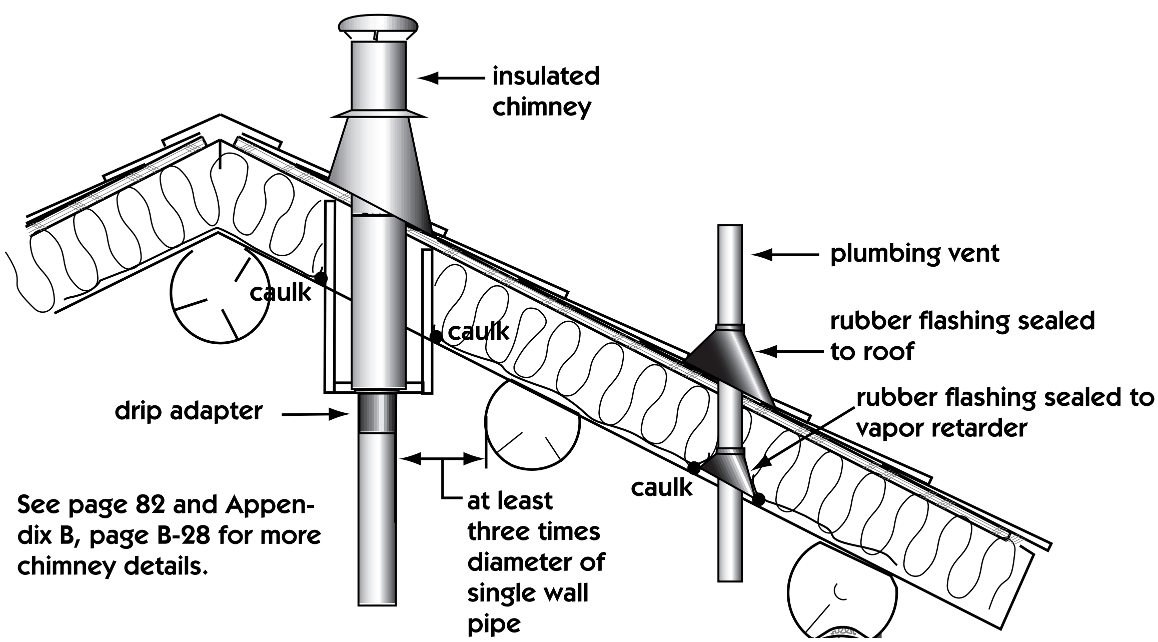
Chapter 5
Mechanical Systems

Mechanical, electrical, and plumbing systems must comply with all applicable national and local codes and regulations. Use low-flow shower and sink faucets and water-conserving toilets and install energy-efficient lighting and heating and balanced heat recovery ventilation. In most of Alaska you have to contend with below-freezing weather. Keep wet pipes out of the outside walls. All water entering and leaving the building must be kept from freezing and have a safe method of thawing if it does freeze.

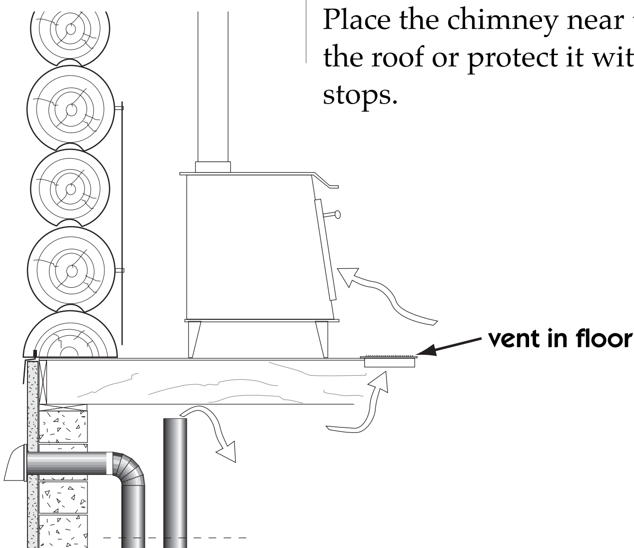
Chimneys and Vents

Any properly sized conventional heating system will heat a log home. However, a few precautions must be taken to maintain an airtight and watertight seal around penetrations through the ceiling and roof. All chimneys and plumbing vents that pass through the roof system must be designed to accommodate settlement. Flashing and counter flashing and step flashing around chimneys should be extra tall. Two tight-fitting rubber flashings or EPDM flashings should be installed over every plumbing vent. The first rubber flashing should be sealed to the polyethylene vapor retarder where the pipe passes through the ceiling, and the second flashing should be sealed to the roofing material.

Do not allow any connection between a masonry fireplace and logs. Take care when designing the layout of the roof system to avoid hitting the ridgepole or purlins and floor support beams with the chimney. Ideally, chimney runs are straight and short.



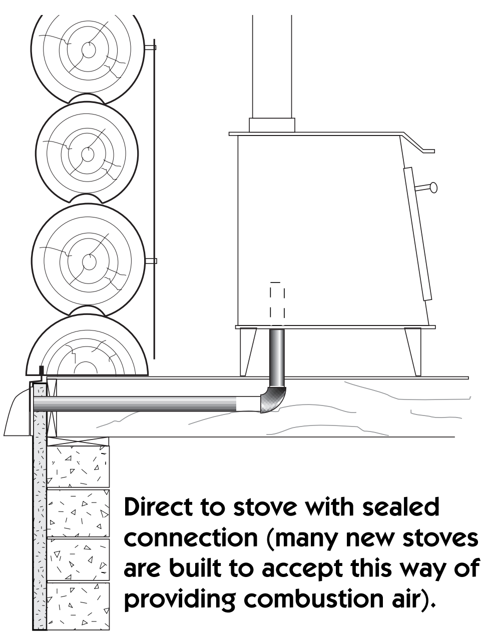
Maintain a minimum 2 inches clearance between an insulated chimney and combustible materials. Single-wall chimneys should be at least three times their diameter away from unprotected combustible materials. Be aware of the possibility of snow sliding on a metal roof and taking the chimney with it or bending it flat against the roof. This could result in a buildup of deadly gases inside the home. Place the chimney near the peak of the roof or protect it with snow stops.



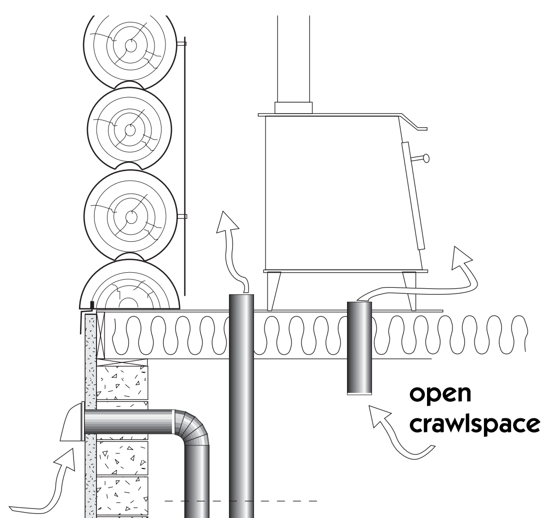
An option for providing combustion air when the crawlspace or basement is heated. A cold air "p-trap" in pipe stops cold air from siphoning into house when it is not needed.

Combustion Air

Fireplaces and wood stoves should have outside combustion air ducted directly to the fire box. Furnaces and boilers must be provided with combustion air per code and manufacturer's instructions. Keep in mind that in an airtight structure, you have to provide combustion air equal to the amount of air passing through the heating system and out the chimney. Combustion air should not be confused with make-up air. Combustion air is designed to supply only the air required by the furnace or stove. It should not provide make-up air for exhaust-only ventilation systems such as bath fans or a range hood or a clothes dryer. These exhaust appliances require their own source of air independent of the heating equipment. Don't let your wood stove or fireplace become the source of make-up air for exhaust appliances. This may result in backdrafting the products of combustion into the



Direct to stove with sealed connection (many new stoves are built to accept this way of providing combustion air).



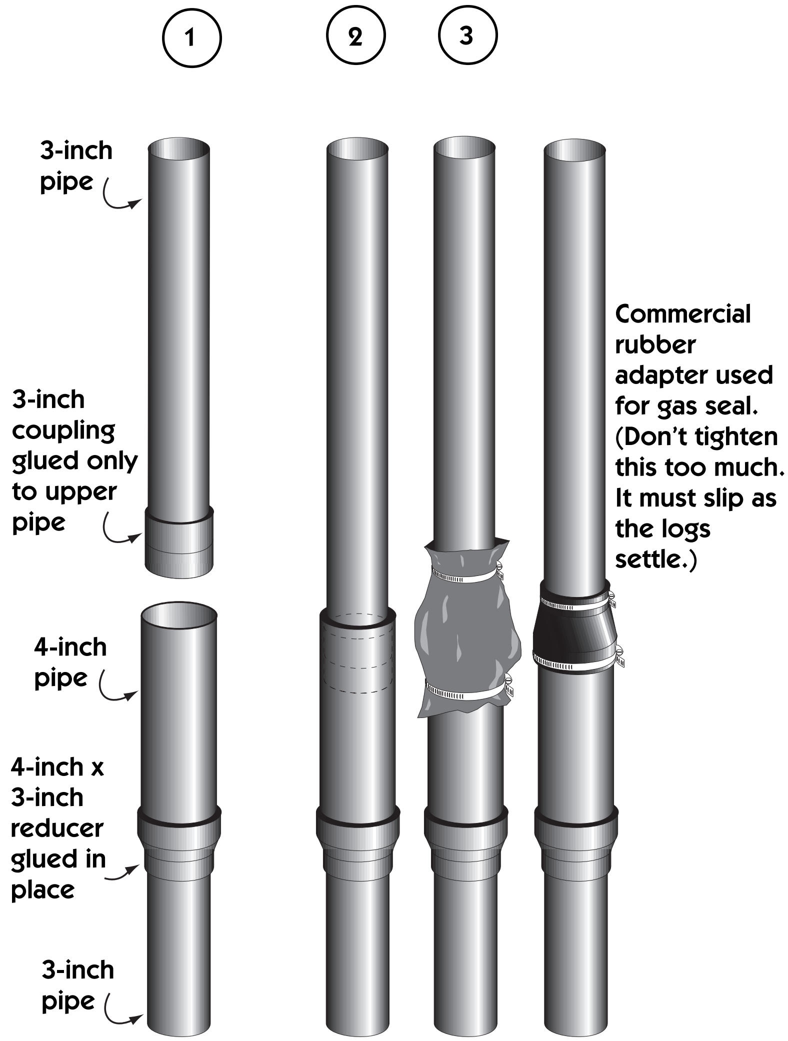
Options for providing combustion air for an unheated crawlspace or foundation.

house, causing potentially deadly carbon monoxide to be drawn into the home.

Plumbing

All plumbing between floor levels in a log house, such as to an upstairs bathroom, must be designed to accommodate settlement. Keep all plumbing runs out of the log walls. Consolidate all plumbing into a so-called "wet section" of the home, especially if it is more than one story. Frame double walls or extra-thick plumbing walls with the upstairs bathrooms stacked directly over lower-floor bathrooms.

Use a combination of slip joints and flashings for drain, waste, and vent pipes. Water supply lines can be entirely of flexible cross-linked polyethylene piping such as Wirsbo, or a settlement section of soft copper pipe can be used in combination with hard copper pipe. Hydronic heating runs should be fitted with flexible tubing wherever they change from horizontal to vertical, such as when the hot water supply and return pipes run between floors of a multi-story log structure. Provide an access panel for maintenance purposes.



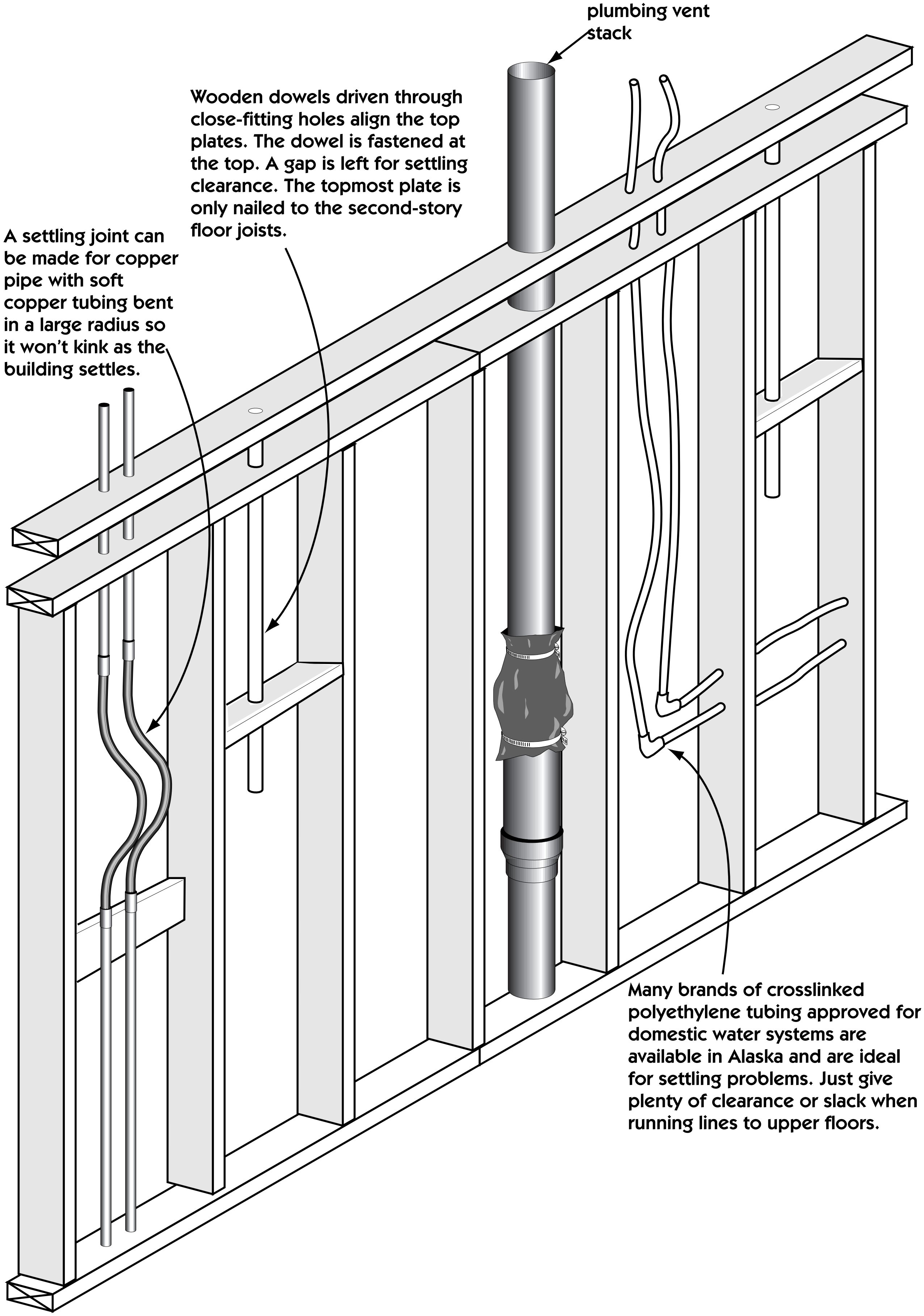
A site-built expansion/settling joint can be made from standard ABS pipe and fittings.

1. Prefit a coupling to fit inside the 4-inch pipe by sanding or filing it until it slips in snugly. Glue only to upper 3-inch pipe.

2. Assemble this with a waterproof grease.

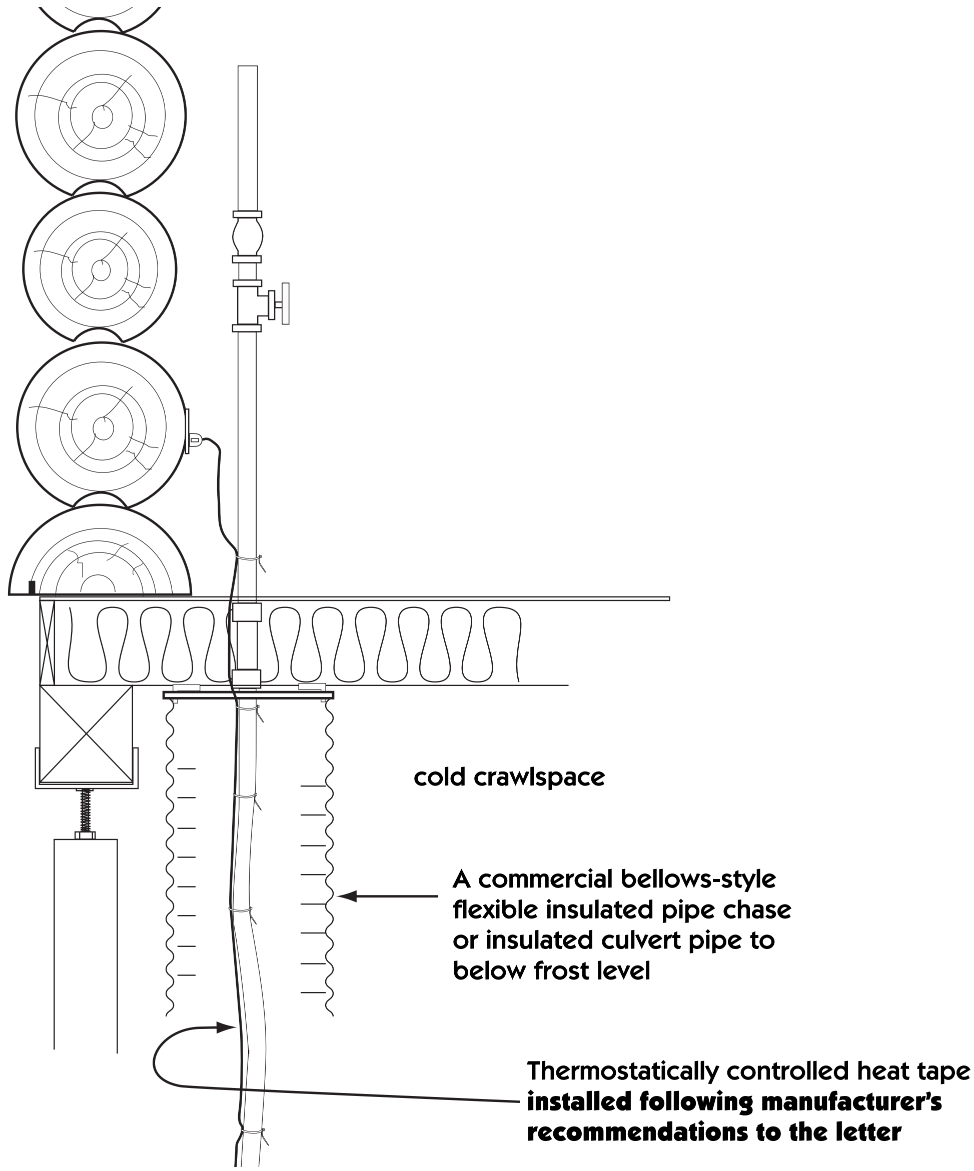
3. A gas seal can be made from a long-lasting rubber sheet and stainless-steel hose clamps (some types of rubber are destoyed quickly by organic vapors. A fuel-proof rubber should work well here).

See Appendix B, page B-27.


plumbing vent stack
Wooden dowels driven through close-fitting holes align the top plates. The dowel is fastened at the top. A gap is left for settling clearance. The topmost plate is only nailed to the second-story floor joists.
A settling joint can be made for copper pipe with soft copper tubing bent in a large radius so it won't kink as the building settles.
Many brands of crosslinked polyethylene tubing approved for domestic water systems are available in Alaska and are ideal for settling problems. Just give plenty of clearance or slack when running lines to upper floors.

Arctic Utility Chase

Water supply lines and drain lines leading to or from a house constructed on an unheated foundation system must be enclosed in an insulated utility chase to keep the water from freezing. Heat tapes are often installed to keep the pipes from freezing or to thaw them if they do freeze. Follow manufacturer's instructions to the letter when installing an electrical thawing system. Many houses have been burned to the ground because of incorrectly installed heat tape!



Arctic utilities run under the house through the crawlspace

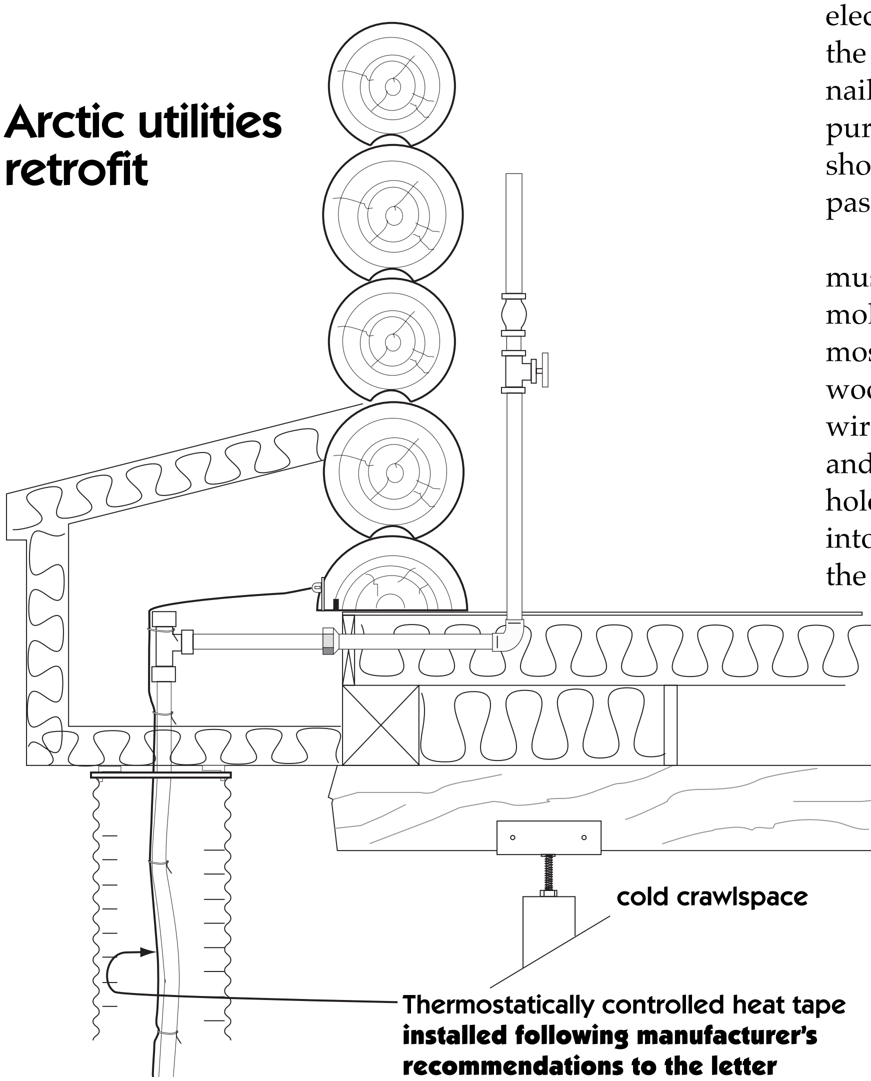
Early Utilities

Inventory included a cot from Sears, Roebuck, a clothesline, and a "honeybucket" toilet fashioned from a Chevron Pearl kerosene can with a graceful whittled willow handle for carrying.

The state-operated school with its adjoining apartment sat high on a hill outside the village and was complete with a generator. Often I'd envied the electric lights in that "ivory tower" but now I found that, for all their modern conveniences, the teachers envied me. They didn't like living apart from the village. It was a long walk for friends to visit and they would have preferred to live within the community. They'd tried unsuccessfully to buy David's sod house and hoped by summer to be rid of their electric lights and the problems that went with them.

from *And the Land Provides*, by Lael Morgan, 1974

Arctic utilities retrofit

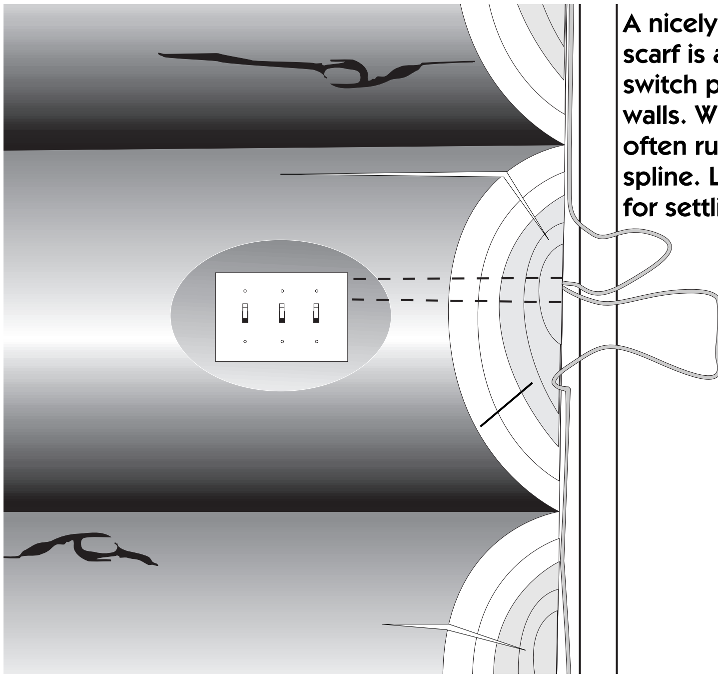


Electrical

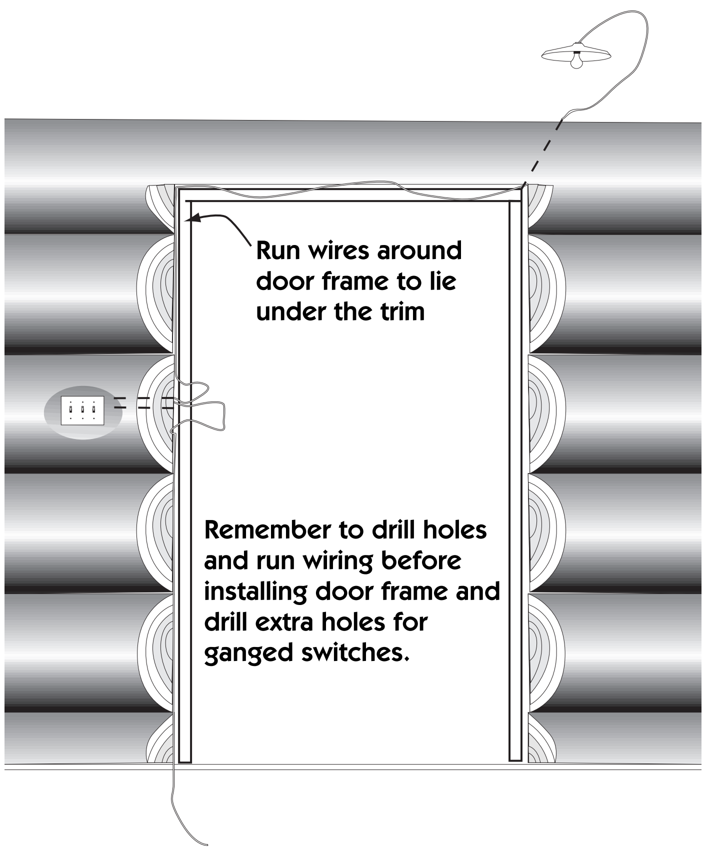
Logs are usually predrilled vertically to hide and protect wiring. Do not use rigid conduit inside a log wall because settling logs could break it. Switches and outlet boxes are usually mortised in so that the cover plate is flush with a flat surface planed on the log face. (See Appendix B, page B-26.)

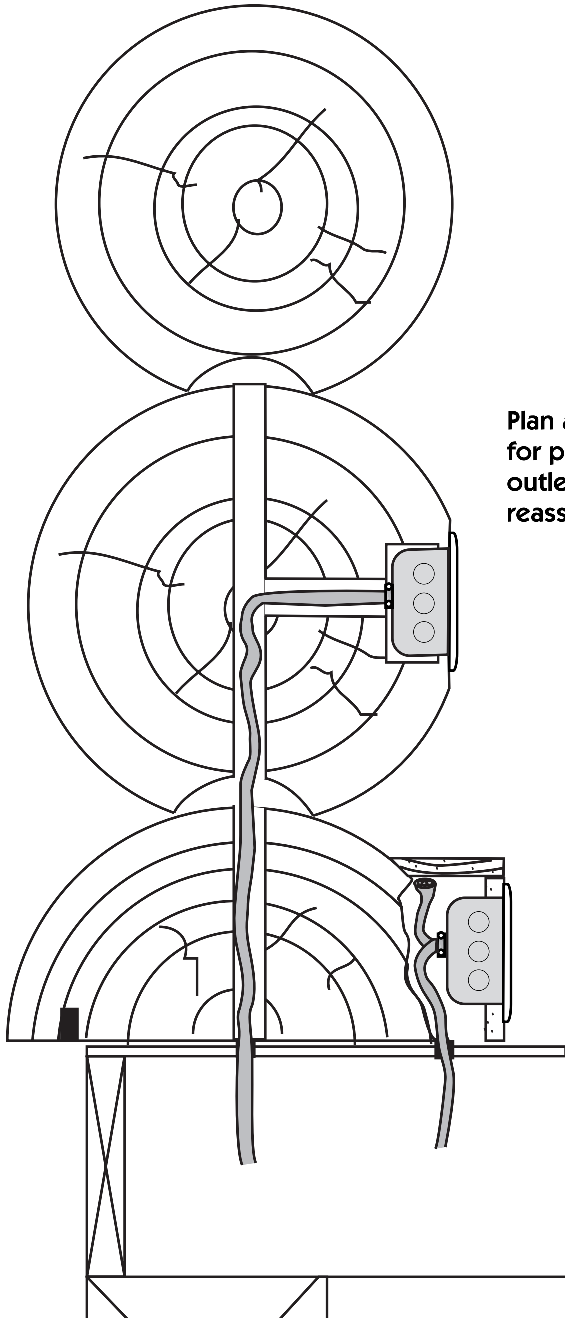
Wiring must accommodate settling. Before rigidly attaching the service entrance vertically onto the side of a log structure, be aware that the logs must be allowed to settle without the weight of the logs bearing down on the conduit passing horizontally through the log wall. It may be necessary to run electrical wiring in the roof cavity if the finished ceiling boards are nailed on top of the ridgepole and purlins. All ceiling penetrations should be caulked where the wire passes through the vapor retarder.

If you don't plan ahead and must surface wire, there is a wiremold conduit system available at most electrical stores that has a wood tone finish. Much of the wiring can be run in the floor cavity and brought up through predrilled holes in the bottom logs or fitted into custom-built wooden chases at the base of the log walls.



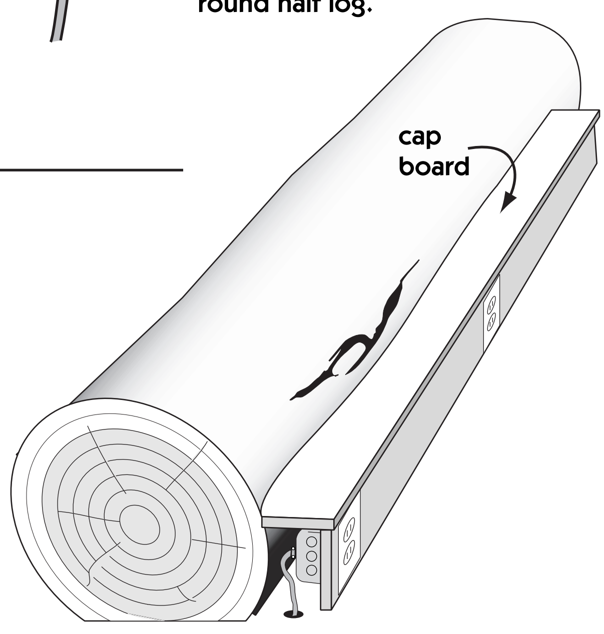
A nicely carved flat spot or scarf is a good way to fit the switch plate cover against the walls. Wiring to switches is often run behind the door spline. Leave slack in the wire for settling.





Plan ahead; drill holes for plenty of wires and outlets while building or reassembling walls.

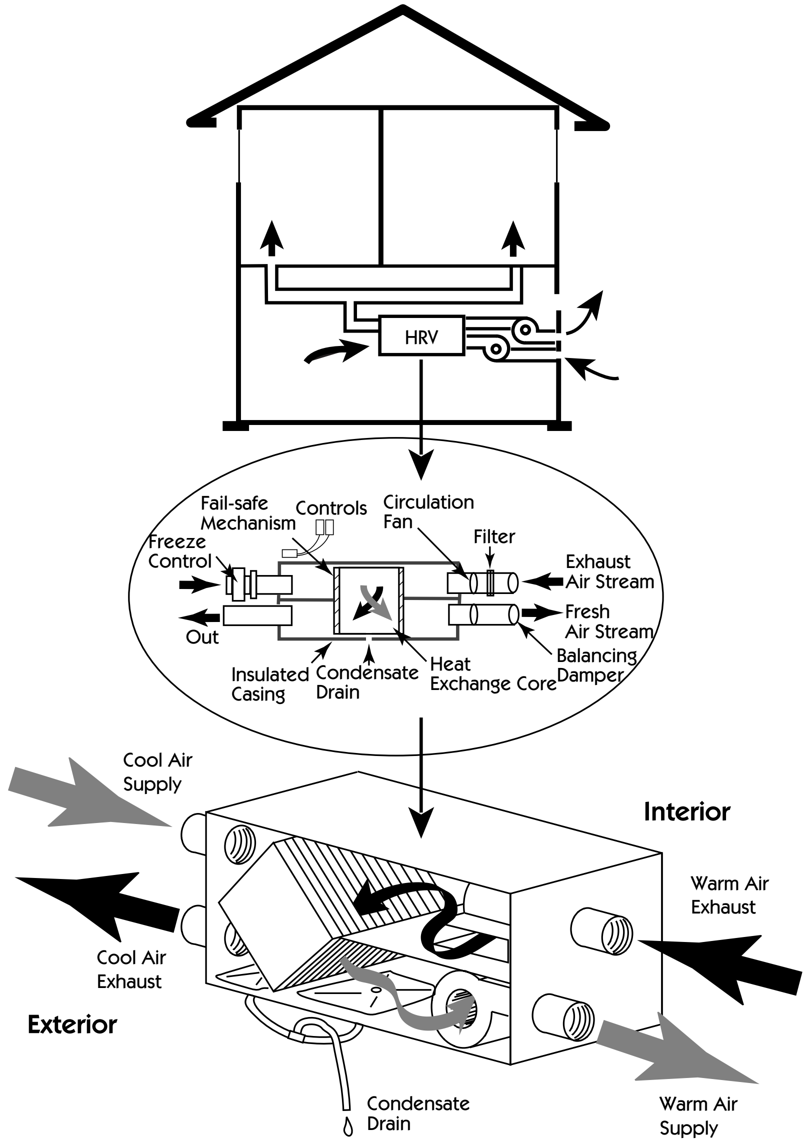
A site-built raceway or chase for wires. The cap board is scribed to fit the first round half log.



Ventilation

Now that you have constructed a tight log structure with all penetrations sealed against the flow of heat, air, and moisture, you must complete the equation and ventilate right (see Appendix A, page A-11).

The very best ventilation strategy for an airtight structure in Alaska that has a dependable source of reasonably priced electricity is to install a heat recovery ventilation system (HRV). The next best choice is to install a variable-speed controlled range hood in the kitchen, ducted to the exterior, and ultra-quiet bathroom fans, also ducted out, designed to run continuously but controlled with a dehumidistat or a push-button timer. Make-up air must be provided to avoid depressurizing the house and backdrafting heating appliances and to avoid sucking in soil gases, including moisture, radon, or mold and mildew spores. If you are building off the electrical grid, employ passive warm air rising strategies of low entry ports and high exhaust ports. This will not comply with BEES but will help ventilate the house when wind and temperature conditions allow.



A typical heat recovery ventilation installation. Install according to manufacturer's instructions.

Chapter 6
Retrofit

Should You Retrofit or Rebuild?

Log construction makes good economic sense in areas where there are local trees to cut and use. So does making the effort to rescue and rehabilitate our existing log structures since the cost to erect them has already been spent.

We call this cost "embodied energy." Embodied energy is all the manufacturing, shipping, and labor to build our homes the first time.

What is Payback?

Payback is all the money, work, and fuel that you save if you retrofit your house to become energy efficient.

It is usually true that if you have a log house that isn't rotting into the ground, it is probably worth retrofitting. This is especially true in remote communities of Alaska where shipping costs and heating fuel prices are very high.

Log building restoration projects may also be for historical or aesthetic reasons and not just for energy efficiency. Very old buildings may need many improvements to extend their life to reach their predicted payback time.

Retrofit Checklist

The following checklist is meant to guide you through the assessment process and to focus your efforts on areas needing improvement. Details on how to do some of the work follow.

Foundation and Floor Assessment

- ❑ Is foundation above the flood plain? Raise foundation elevation above high water mark.
- ❑ Is the floor level? Jack and level on existing foundation.
- ❑ Are foundation supports in good condition? Repair or replace pads/joists/plywood as necessary.
- ❑ Is foundation protected from moisture or wet soils? Raise floor joists at least 8 inches above ground—12 inches is even better. Install a capillary break between floor and foundation.
- ❑ Is the floor airtight without cracks and holes through the floor? Observe insulation installation at perimeter of floor below exterior walls and ensure the cavities are tight and full to minimize edge air intrusion. Air-seal at all floor penetrations, cracks, and perimeter

rim joists. Where space does not allow for working from below, airtight insulated skirting may be applied to the exterior of the rim joist area. Keeping the floor perimeter air tight is the key to comfortable and efficient floors. Do not interfere with the free flow of air under the house if it is built on permafrost.

- ❑ Does the floor insulation level meet the BEES R-value for the region (see Appendix A)? Add fiberglass or cellulose insulation between floor joists if space allows. Add rigid insulation to top of old floor with new plywood above where space does not allow placing fiberglass or cellulose in joist cavities.

- ❑ Is the insulation between the floor joists protected from critters? Sheath the bottom of the floor joists with plywood to support and protect insulation.

Log Wall Assessment

- ❑ Does air leak in between the sill log and the floor? Caulk and seal the perimeter sill log to the floor membrane inside the house.

- ❑ Does the floor protrude beyond the sill logs outside of the building? If so, this shelf area can allow moisture from rain and snow to enter the structure. Use a wedge of wood cut from 2-by-4 or 4x4 to fill this area and caulk the top and bottom to the sill log and floor or use metal flashing to protect the shelf from weather.

- ❑ Are the logs of sufficient size to provide adequate insulation for the region? Select a design for increasing wall R-value. Apply wall insulation and furring to the interior or exterior.

- ❑ Are joints between the logs tightly sealed and chinked against air leakage? Apply appropriate Weatherall/Perma-Chink type material to joints.

- ❑ Are the logs in good shape around window and door penetrations? Test logs with a probe to determine their condition. Replace or treat wood at penetrations to prevent further deterioration.

- ❑ Does air leak around windows and doors? Remove trim and inspect the gap between the rough opening and frame. Remove fiberglass chinking and install backer rod and fill cavity with minimally expanding foam if settling is over (older buildings). Air seal the perimeter of windows and doors between the frame and the rough opening.

- ❑ Are log wall corner joints tight and sealed against air leakage? Test log ends with probe and treat to prevent further deterioration. Air seal as necessary with caulks or chinking.

- ❑ Are the upper gable end wall purlin and ridge penetrations sound and air tight? Use a probe to ensure wood condition is adequate for supporting the roof. Apply air sealing measures to penetrations and purlin and ridge pole ends. Treat logs in these areas as needed to prevent further wood deterioration.

Roof and Ceiling Assessment

- ❑ Does the roof overhang protect the log walls from rain? Extend the overhang at eaves to move drip line away from walls and corners. Install gutters and direct runoff away from the foundation area.
- ❑ Does the top log to ceiling/roof joint show signs of leaking or staining? Apply air sealing measures to eliminate leakage. Add insulation as needed to improve thermal properties at this connection. Use a probe to ensure wood condition is adequate for supporting the roof.
- ❑ Does the roof show signs of water staining or dry rot? Inspect and probe the wood around chimneys and light (electrical) penetrations. Inspect areas around interior wall connections with ceilings. If the house has a cold roof, turn over insulation batts to locate air leaking from below. These leaks will show as dark and dirty areas in fiberglass batts. Seal air leaks from the attic side using acoustical sealant and poly patches. Seal air leaks in hot roofs from the interior using appropriate sealants if no major exterior roof replacement is planned. Treat chimney penetrations with utmost care and concern for fire potential. Replace or reinforce all roof supports that show signs of rot or deterioration. Add insulation to cold roofs only after all other work has been completed. Maintaining an airtight roof and ceiling is critical to the success of any project.
- ❑ Does the roof exterior show signs of potential leak areas or weather damage? Replace or repair shingles and metal as needed to prevent water entry. Replace or repair the flashing around penetrations in roofing. Install eave flashing to “kick” water away from facia boards.
- ❑ Does the roof cover all log ends? Cut off all log ends that extend beyond the drip line of the roof.
- ❑ Finish interior and exterior of logs as recommended in Chapter 7.
- ❑ Remember, use all resources available to you to make your decisions regarding log retrofits. The AHFC Resource and Information Center has a library of information available at no charge (1-800-478-4636). The University of Alaska Cooperative Extension has an energy and building specialist on staff to answer your questions (474-7201 or 1-800-478-8324). These and other resources are listed at the end of Appendix D.

So What Shape is Our House In?

Lower Log Condition

Check all lower logs for dry rot. The lower logs of buildings in ground contact will often be rotten beyond use and must be replaced. This can be a daunting task that requires digging, jacking, and sometimes rebuilding the floor-to-wall connection as the bottom few logs are replaced.

This may seem difficult, but it can help extend the life of a poorly insulated, energy-wasteful building 40 or 50 more years and save energy too. Where material and fuel transportation costs are high, this difficult job will still pay back good savings.

photo by Phil Loudon

A new roof in Arctic Village.

Looking for Rot Around Log Penetrations

Where air leaks occur in buildings, moisture will build up and cause rot. Inspect all mechanical and rough opening penetrations before making any decision to retrofit an existing log house. Use an awl, ice-pick, or a sharp knife point to probe the wood around any opening in the log walls. Where the wood is rotten the probe will go in easily. Areas of good wood will resist your efforts.

Usually, the lower openings will contain rot from outside moisture while the upper penetrations will rot from exposure to inside moisture. Because windows may let snow, rain, or ice collect on the exterior sills, be sure to probe the exterior logs in these areas.

photo by Phil Loudon

The lower logs of buildings in ground contact will often be rotten beyond use and must be replaced.

If wood around a window opening is rotten, there are two common ways to fix it: Option one is to make the rough opening bigger if it is possible to cut out the rot and make a surface for reinstalling the window, and add foam insulation to fill in the gap.

Option two is to remove and replace the logs in the area of the opening. This is more expensive and so takes a longer time to pay back.

If two or more windows have severe rot and logs need to be removed, go back and look at the project budget very closely. The building may not be worth retrofitting.

This cabin was almost destroyed by rot.

Top Log Condition

The top log (cap log or plate log) is an area where air leaks open up over the years and moisture from indoors starts wood rot. When the temperature on the interior surface of the log drops, moisture will collect and possibly freeze on very cold days. This wetting, freezing, and drying cycle promotes rot.

Use the same probing method to find rot in the logs and framing. You should also check the joint between the ceiling and the wall for air tightness and insulation.

The cabin was saved by cutting out all four log corners and installing large vertical log corner posts. A good solution to use as much of the old building as possible. Note the trimmed roof logs and shorter porch.

One way to fix the top wall log to ceiling joint is by spraying several inches of a two-part urethane foam into the wedge formed by the wall and ceiling (see illustration, page 81). Then add a vapor barrier (usually polyethylene sealed with an acoustical sealant), and finally cover it with a nice trim board.

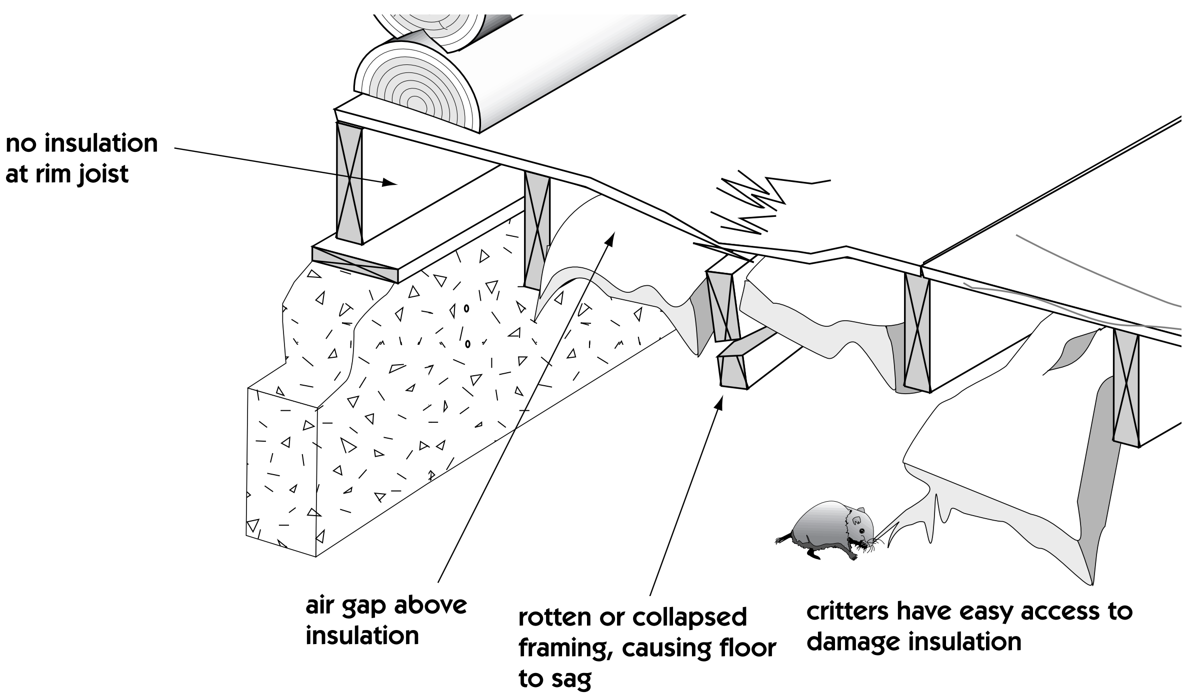
Let's Start at the Bottom

If you have enough room, a popular way to add insulation to the floor is to cover the existing floor with rigid foam, and cover this with plywood.

In many projects we have used two-inch extruded foam (usually blue, pink, or green) for the insulation overlay. This rigid insulation has a high compressive strength that makes it suitable for such installations. The covering plywood may be 3/4" tongue and groove. Use a structural adhesive and apply it to all plywood edges, including the tongue and groove, to construct an airtight floor membrane. Seal the joint between the perimeter plywood and the log wall with a durable polyurethane caulk. Drywall-type 3 1/2-inch screws are used to fasten the plywood through the foam, resulting in an additional R-10 insulation, an airtight floor, and a new durable surface for the finished flooring.

The negative associated with this approach is that rigid foam insulation is a higher cost per R-value insulation than "soft" insulations (fiberglass) and the

Some Problems to Look For



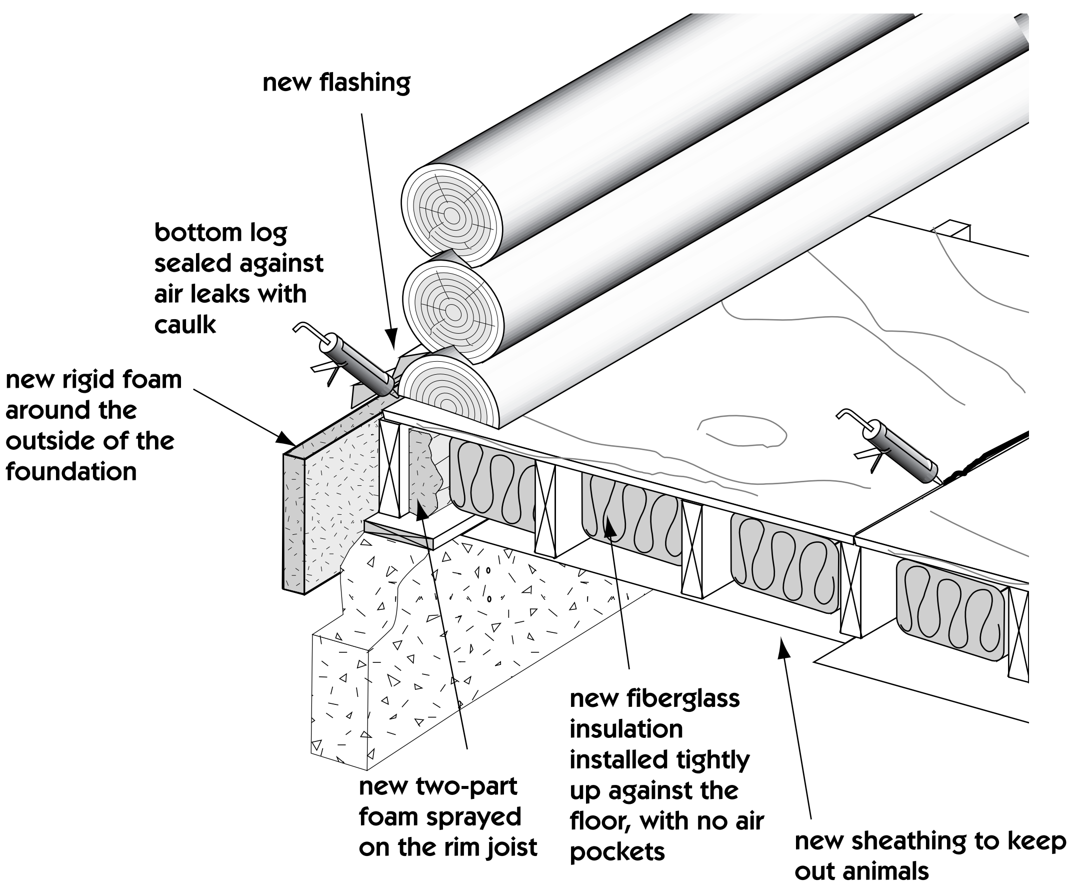
This floor is accessible and has floor joists that are deep enough for the minimum amount of insulation (see Chapter 3).

Observations from Arctic Village

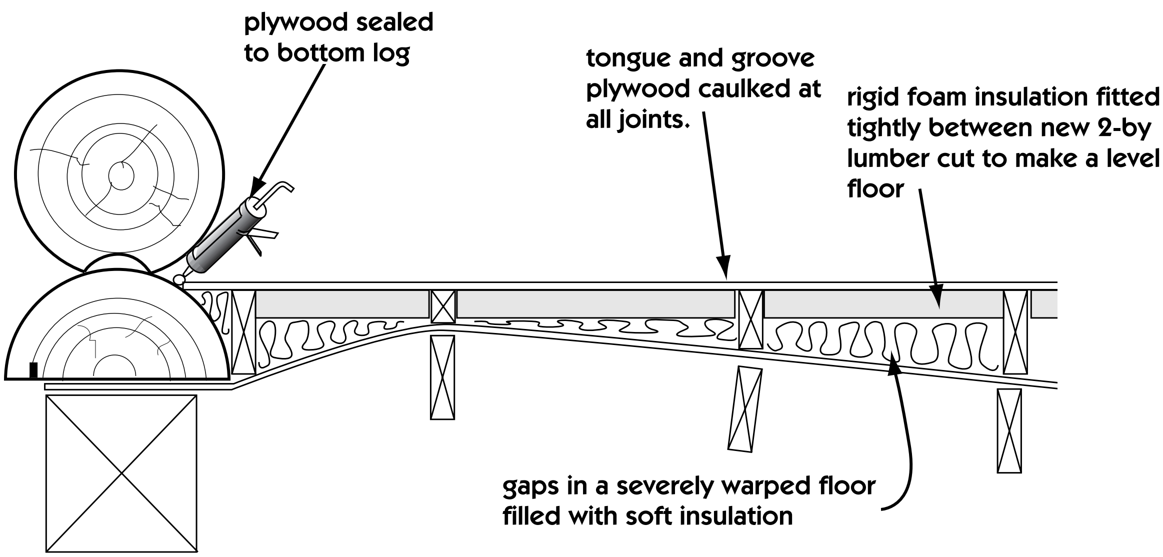
Sometimes, people cut logs in the spring and summer and then build with them in the fall. The logs may be only partially peeled or not peeled at all in some cases. When they build a house with logs like this, large cracks will develop in the logs after one year. First as the house is heated through the winter , the cracks will appear on the inside, and then the following summer as the sun heats the exterior, the cracks will appear on the outside. Eventually cold air will be able to travel completely through the cracks into the house, making the strucure very leaky .

Another problem that results is that the cracks and unpeeled areas will catch rain and snow, which will eventually rot the logs. This will speed up the process of failure of the bottom logs that are providing the foundation, which in turn will help to destroy the rest of the building. Homes that are built in this manner are falling apart much faster than they should.

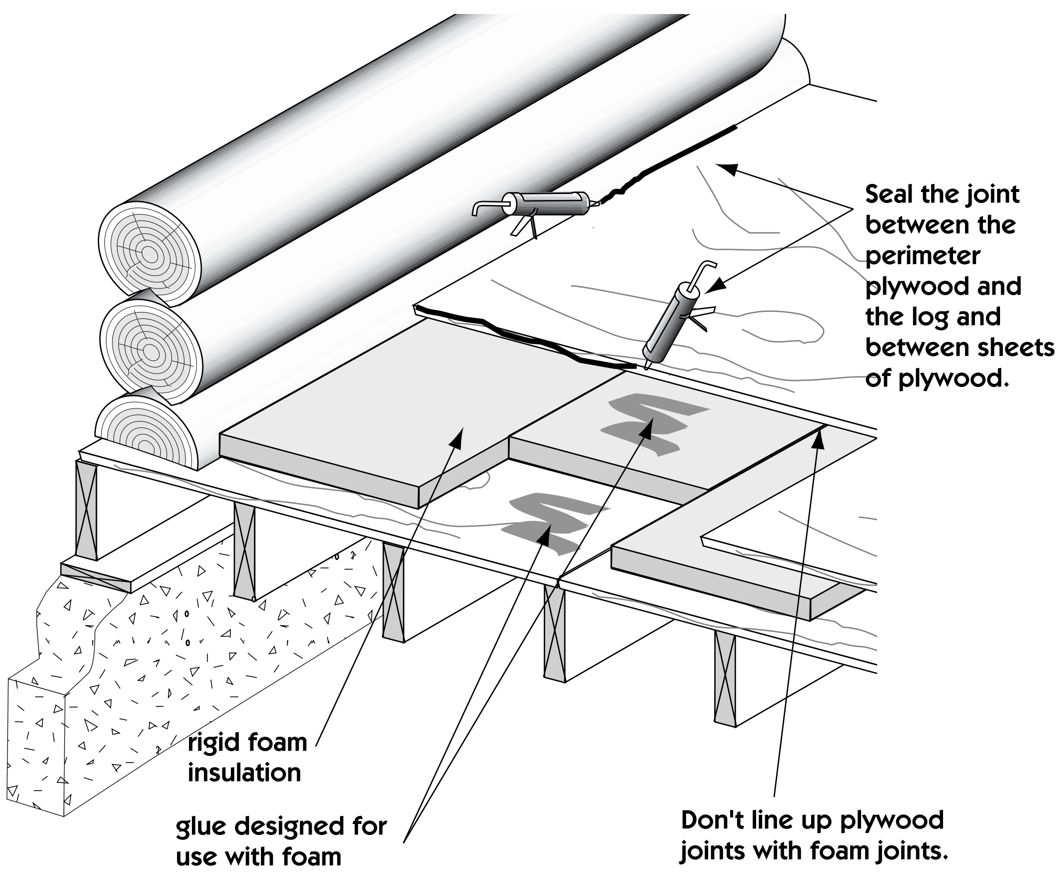
(comments from local resident, collected by Mimi Burbage)



A large part of the decision to fix the old floor and reinsulate or build up the floor from the inside of the house depends on whether you can even get under the house. It is usually more labor to go under the house and fix the old insulation, but the materials can be cheaper.



In spite of the insulation cost, it is less labor to install the insulation above the floor than working below the floor, framing additional cavities and making other labor-intensive modifications.



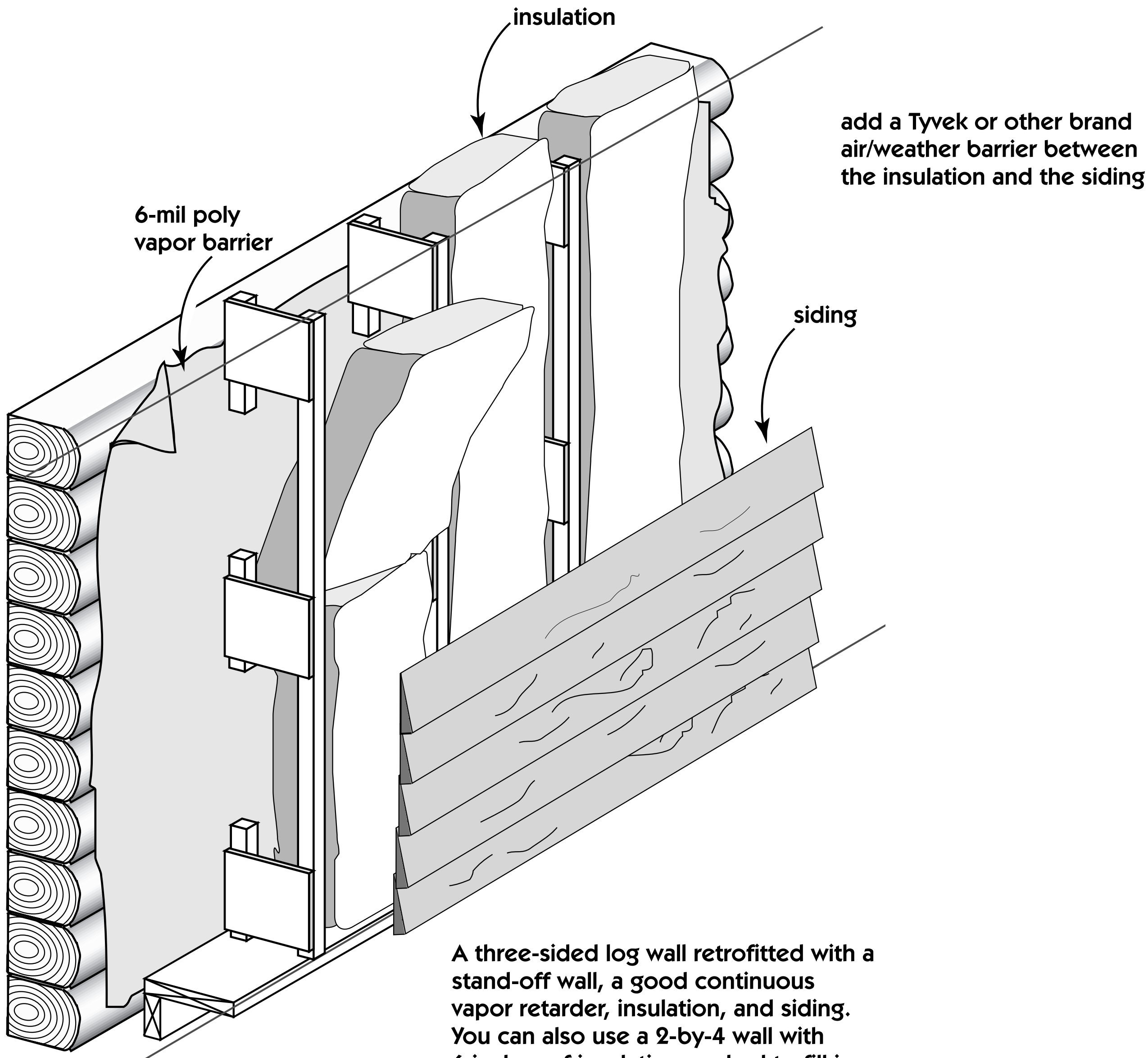
Here is an example of adding rigid foam to the top of the floor without any additional framing. Be sure to stagger the joints of the foam so they don't line up with the joints in the plywood.

added floor thickness of 2 3/4 inches makes adjustments to doorways necessary. However, in spite of the insulation cost, it is less labor to install the insulation above the floor than working below the floor, framing additional cavities and making other labor-intensive modifications.

Exterior Wall Retrofit

The most energy-efficient way to retrofit a log home is to attach an insulated curtain wall on the outside of the logs. This leaves the massive logs on the inside of the thermal envelope and provides very effective thermal storage. Once the logs are heated to room temperature, it may take days without heat for the logs inside the thermal envelope to cool off, even in an Alaskan winter.

An exterior retrofit of a log house typically involves chain sawing off the log extensions at all corners of the building. Do not compromise the structural integrity

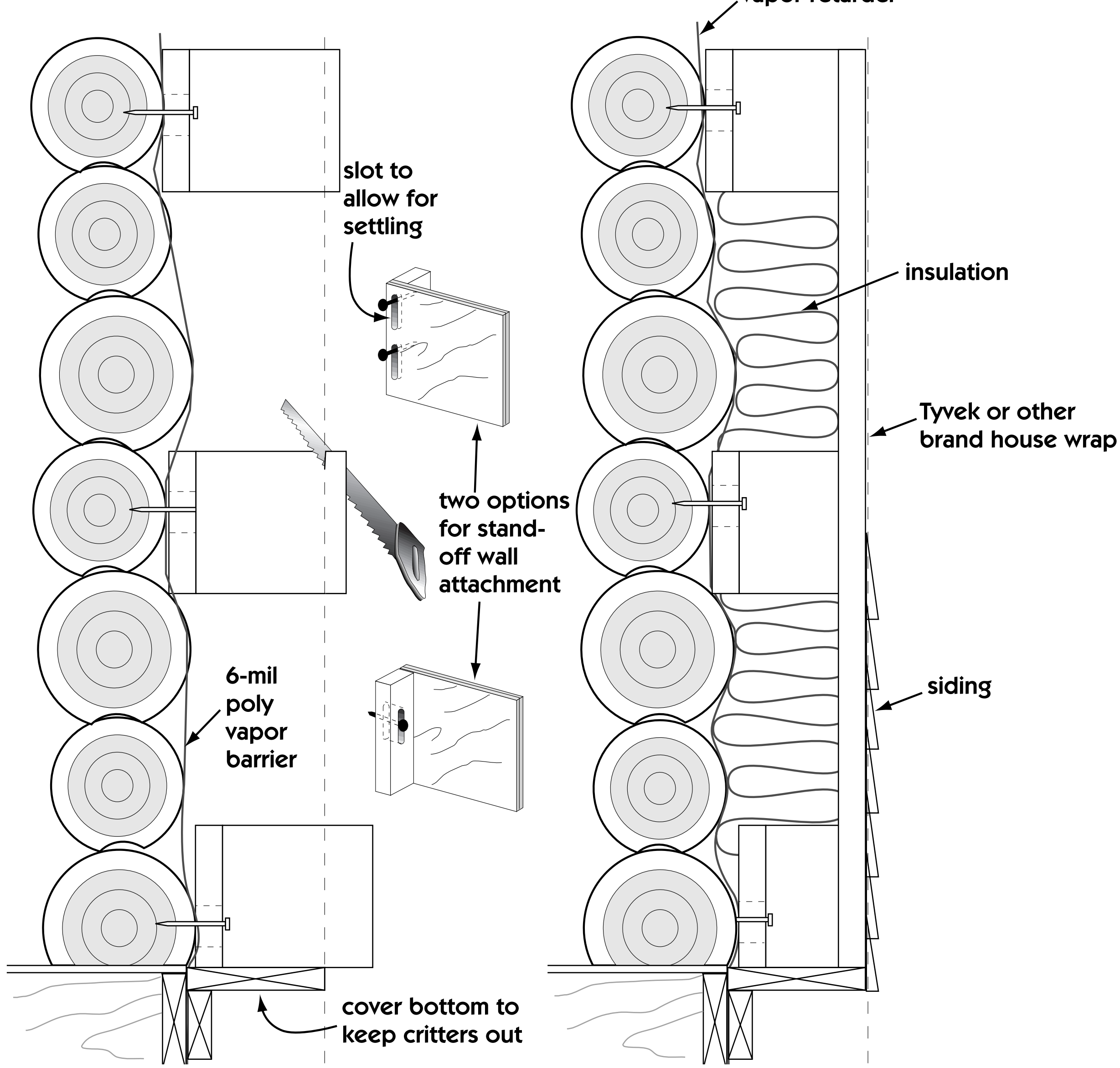


A three-sided log wall retrofitted with a stand-off wall, a good continuous vapor retarder, insulation, and siding. You can also use a 2-by-4 wall with 6 inches of insulation packed to fill in between uneven logs.

of the house by cutting off too much. The objective should be to remove any corner log ends that stick out beyond the curtain wall to be attached. Remove any other projections that would interfere with wrapping the exterior of the log walls with a continuous 6-mil poly vapor retarder. Pay particular attention to sealing the vapor retarder at the top and bottom and at all window, door, and utility penetrations.

Since log walls are irregular, it will be necessary to fit each stand-off stud with a system of blocking and plywood gussets attached to the logs on two-foot centers. First establish the corner stand-off studs plumb and at a distance from the log wall to accommodate the desired thickness of insulation. Use a string line pulled tight between the corner studs to establish the alignment of all the rest of the studs. Sometimes the roof rafters can support a hanging curtain wall. If the house has not completely settled (8 to 10 years in a dry climate), then be aware that the roof is still on its

Exterior Wall Retrofit



way down and attach the studs and the bottom plate in a manner that will allow for settlement.

It may be a good idea to wrap the insulated stand-off walls with a weather retarder house wrap such as Tyvek or Barricade before installing horizontal beveled or rough-cut spruce siding. The bottom of the wall should be covered with flashing, plywood, or dimensioned lumber to keep little creatures out.

Interior Wall Retrofit

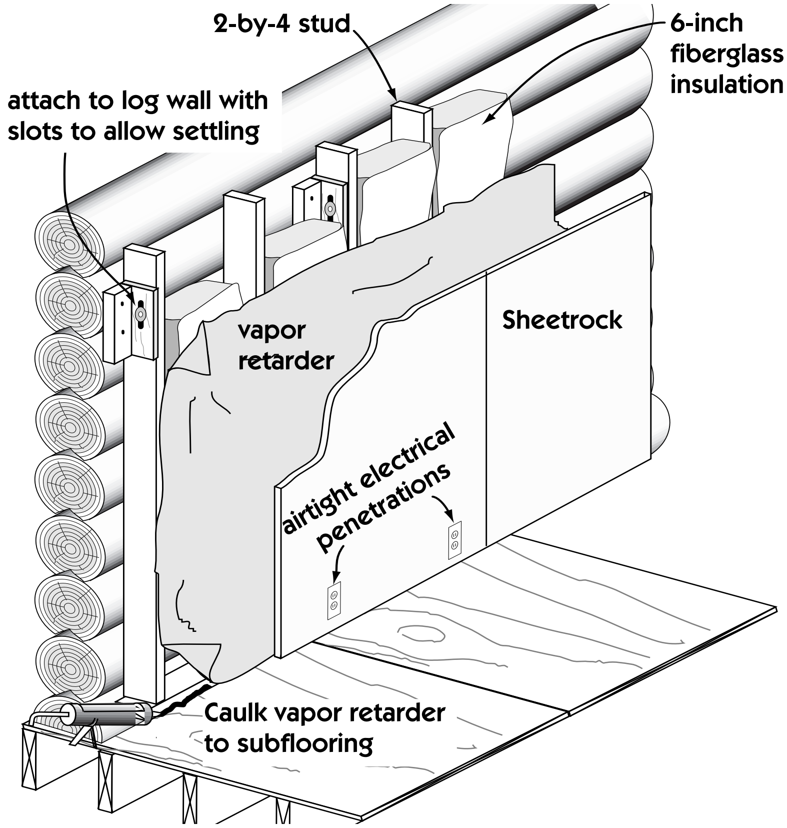
As stated in the introduction, an interior retrofit of a log home turns the logs into very heavy and expensive siding, with all the thermal mass on the outside of the thermal envelope. Nevertheless, it is very common to fur in, run electrical wiring, and insulate and vapor barrier walls constructed of small-diameter logs. This does indeed improve the thermal performance of the wall, not only by increasing the R-value but also by reducing the air leakage.

The interior retrofit also reduces space and can make a small cabin into a really small cabin.

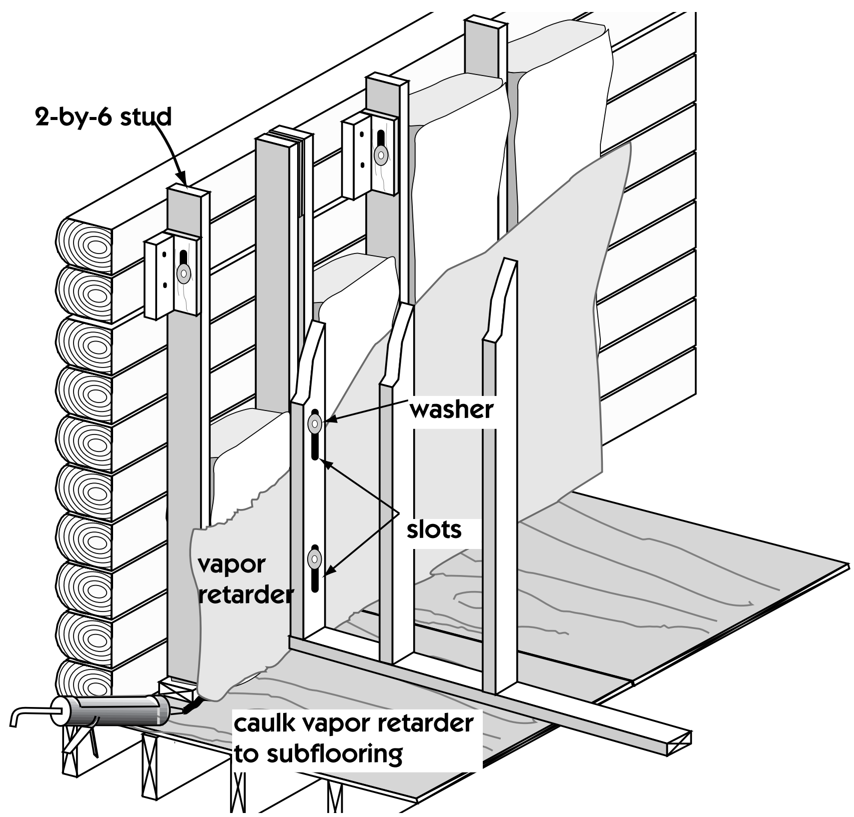
A simple way to add R-value to the inside without a lot of fastening problems is to use 2-by-4 studs and plates on the inside of the exterior walls. These should be installed tight to the logs and plumbed. Some shimming or shaving may be necessary to achieve a fairly straight wall, but this will depend on the quality of the original construction.

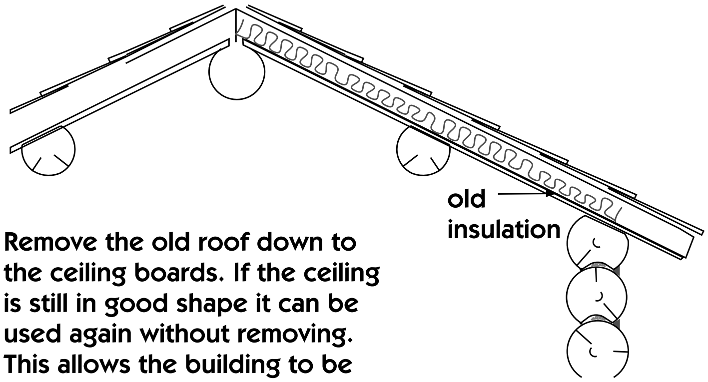
After the wall is fastened in place, use 6-inch fiberglass insula-

Interior retrofit on a log wall

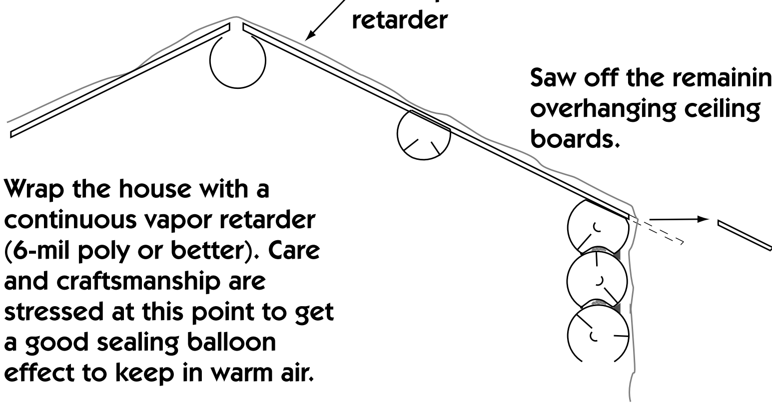


Attaching an interior wall to a three-sided log exterior wall with a 2-by-6

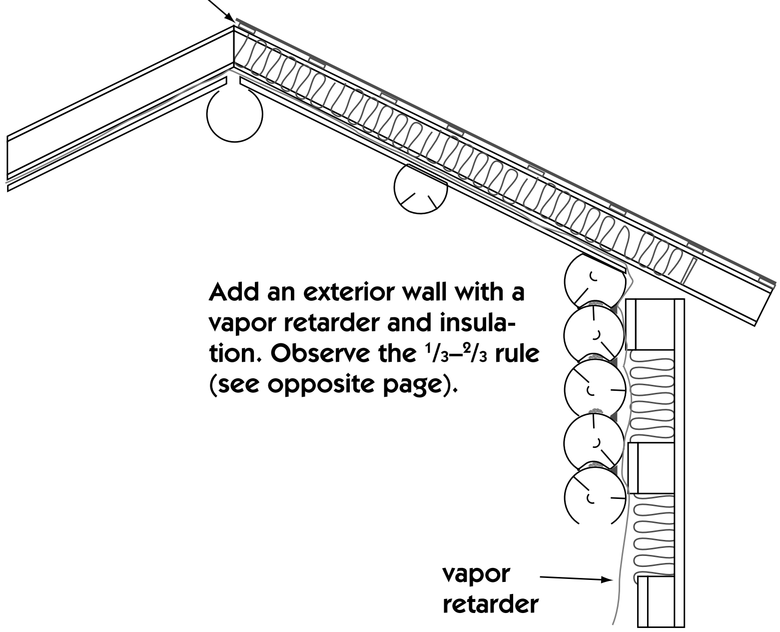




Remove the old roof down to the ceiling boards. If the ceiling is still in good shape it can be used again without removing. This allows the building to be occupied while the roof is being replaced.



Wrap the house with a continuous vapor retarder (6-mil poly or better). Care and craftsmanship are stressed at this point to get a good sealing balloon effect to keep in warm air.



Add an exterior wall with a vapor retarder and insulation. Observe the 1/3–2/3 rule (see opposite page).

tion and pack it into the stud cavities so that it fills the cracks between the logs and provides a good friction fit. Even though the insulation is compressed in some areas, it will still provide good insulating qualities since it will fill the voids adequately.

Install airtight electrical and mechanical outlets before installing the air-vapor barrier.

Roof Retrofit

If the finished ceiling is still in good shape but the roof is under-insulated or needs a vapor retarder, you may consider cutting off the eaves with a chain saw at the outside of the logs and running the new exterior wall vapor barrier of 6-mil poly up the wall and over the old roof and down the other wall. The gable-end wall vapor retarder should be caulked at the joint between the log and the ceiling as well as where the log meets the floor at the bottom of the wall. Lap over and seal the vapor retarder to the other sheets of poly at the four corners.

Place this exterior 6-mil polyethylene wrap on the warm side of the thermal envelope. Whether in the wall or roof system, at least two thirds of the R-value must be on the cold side of the vapor retarder to keep the humidity in the air warm enough so it doesn't condense into liquid water inside the wall or roof. Build up a new roof on top of the old, taking care to protect the vapor retarder during construction.

Hot Roof Retrofit

Hot roofs are typical in log buildings with traditional purlin and ridge pole exposed ceilings. Here the insulation is installed between the roof rafters. By definition, the hot roof does not provide ventilation. It usually has no access for installing additional insulation. Ventilated hot roofs are being constructed on newer log buildings, however, this is a recent development and it is rare to find such designs in older log cabins and houses.

You must first determine which surface to add the insulation to, inside or outside. If the roof consists of leaky shingles and rotten plywood, the obvious area to modify would be the outside. Strip off the shingles, install a vapor retarder, put insulation on the outside of the vapor retarder, and reinstall roofing.

The inside is a better approach because it is easier to get an airtight installation. Framing additional ceiling surface supports and insulating between the top log and purlin and between the purlin and ridge pole have proven successful, although this covers most of the log ceiling and may not appeal to some owners.

It is most important to locate the surface that will serve as the air barrier or vapor retarder if you put more insulation on the outside of a hot roof. If it will be the interior surface, great care must be taken to make it truly airtight, because if air leaks into the roof, the moisture carried in the air will damage the roof.

If you put a new air barrier on top of the existing roof, and more insulation and roofing above it, then the building science one-thirds/two-thirds rule must be rigidly adhered to. This rule helps you locate the air/vapor retarder in instances where the barrier might be placed between two insulation layers. If there is an air gap over the old insulation, pack the area above the outside walls to maintain a continuous blanket of insulation on all six sides of the house: four walls, floor, and roof.

> "At least two thirds or more of the R-value must be on the cold side of the vapor retarder. In the far north, at least three quarters should be on the cold side."

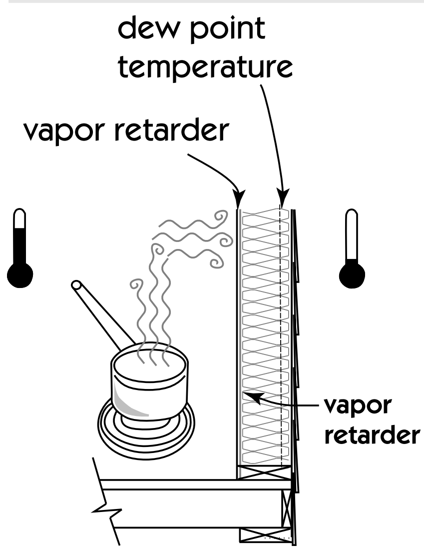
photo by Phil Loudon

An interior retrofit of a ceiling in progress; note new electrical wires being installed.

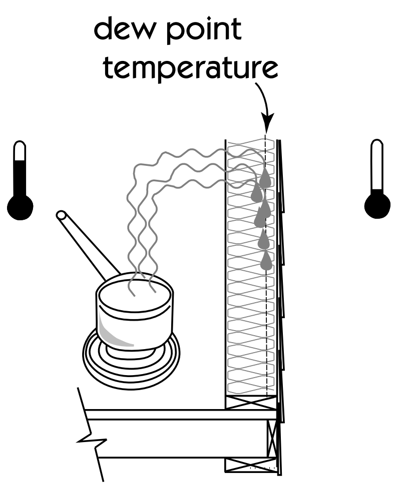
> “Water vapor in the air gets cooler as it moves out through the wall and roof. If it condenses inside the wall of the house, it will cause rot.”

What's a Dewpoint ?

The dewpoint is the temperature at which moisture condenses from vapor into water. Water vapor in the air in the house gets cooler as it moves out through the wall and roof, and at some point it condenses. If this temperature is inside the wall of the house, it will cause rot. This is why at least two-thirds of the R-value of your insulation must be outside of the vapor retarder. In the far north at least three quarters should be on the cold side.



vapor retarder stops moisture-laden air from entering wall space



moisture-laden air condenses inside wall, causing damage

Cold Roof Retrofit

We typically call a truss roof a cold roof because the space above the insulation is ventilated to the outside. While not always ventilated, this attic space is designed to be significantly colder than a hot roof, where ventilation space is minimal or nonexistent. The cold roof can receive more insulation since space is usually available.

Before putting more insulation in the attic, seal all ceiling and attic penetrations to prevent any air leakage from carrying moisture into the attic space. This is usually done from the attic (top) side by finding each leak and applying a heavy bead of acoustical sealant around the penetration and embedding a patch of polyethylene into the sealant. Tape this patch in place so it won't move around. Do this to all penetrations and breaks in the air/vapor barrier, including partition walls. This is not the place to skimp or save on acoustical sealant.

After all air sealing has been done, you should measure the distance between the outside edge of the wall and the underside of the roof plywood or metal. If room exists for meeting the minimum recommended BEES insulation, then proceed with putting new insulation in place. However, most older roofs don't have enough space to allow for high levels of insulation over the wall. Use a rigid insulation that has a high R-value per inch such as foamboard where space is tight. Cutting the rigid material to fit tightly into the cavity is important! By placing three layers of two-inch polyisocyanurate rigid foam insulation (R-48), you can come closer to meeting the minimum recommended BEES standards than would be possible using soft insulations (fiberglass) in this tight space over the wall.

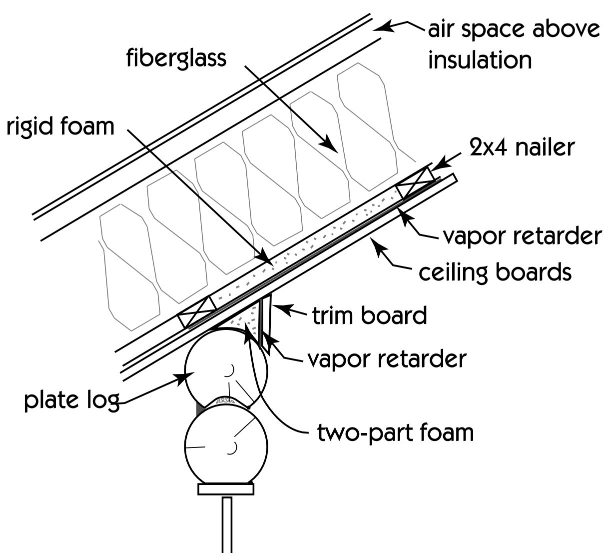
Chimney and Flue Penetrations

This is an area of frequent failure in all types of roofing. There are two potential problems: chimneys located too close to wood are a fire hazard, and leaks can develop in the roof around chimney penetrations, leading to rot.

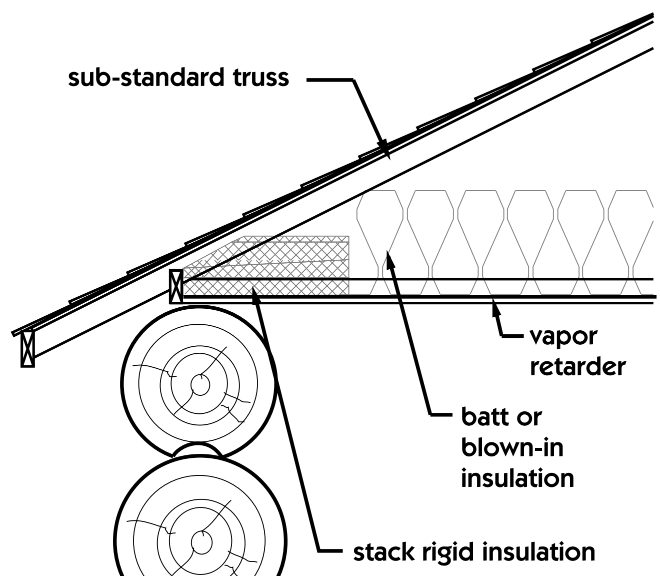
Research has shown that where heating appliances are near wood, a significant drop in the wood ignition temperature occurs. It will ignite and burn easily at much lower temperatures.

Maintaining a good air gap around the insulated pipe above the ceiling is also necessary, and more is better here. If the attic contains lots of insulation, you should extend the insulation dam (a sheet-metal cylinder around the chimney) to prevent insulation from getting into the air gap surrounding the chimney. The dam should always be left open at the top to allow air currents to cool the space between the dam and chimney. Always follow the manufacturer's instructions. Just following codes and regulations may not be enough to prevent the wood framing from turning into fuel.

Chimneys typically found in older buildings must be improved



One way to fix the joint between the top wall log and the ceiling is by spraying several inches of a two-part urethane foam into the wedge formed by the wall and ceiling. Then add a vapor barrier (usually polyethylene sealed with an acoustical sealant), and finally cover it with a nice trim board.

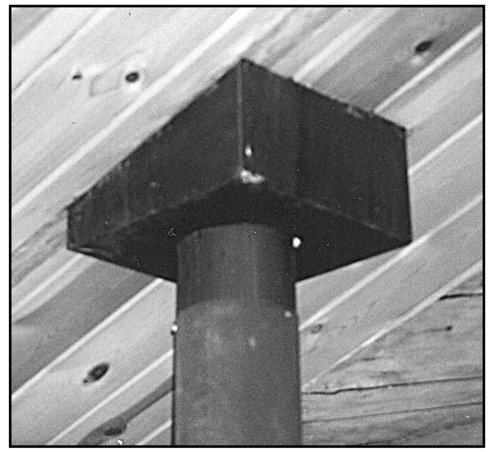


rigid foam in truss-style roof with attic

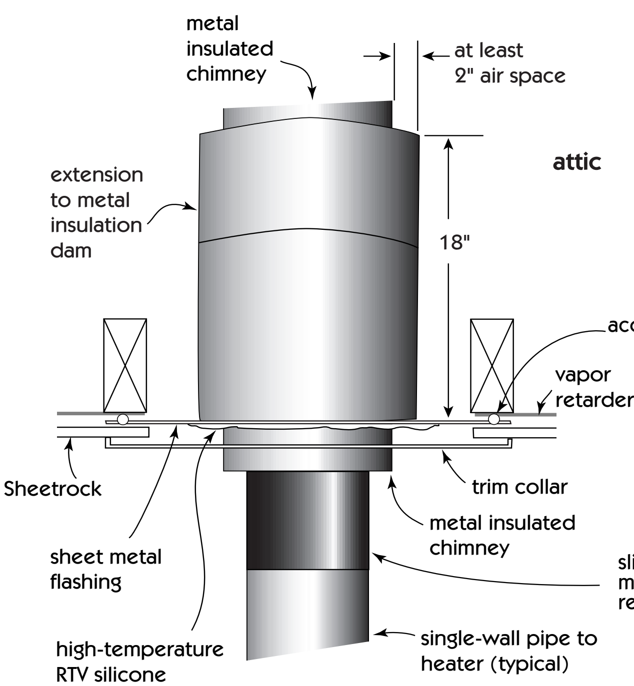
to prevent moisture from entering framing members in the roof and ceiling. Therefore, care must be taken to eliminate all air leakage around chimneys. See the illustrations for examples of how to do this safely.

Note that different caulks and sealants are used to provide for a complete and airtight seal around the chimney and to the surrounding drywall. Use a high-temperature heat rated RTV silicone caulk for air-sealing the trim ring to the insulated chimney.

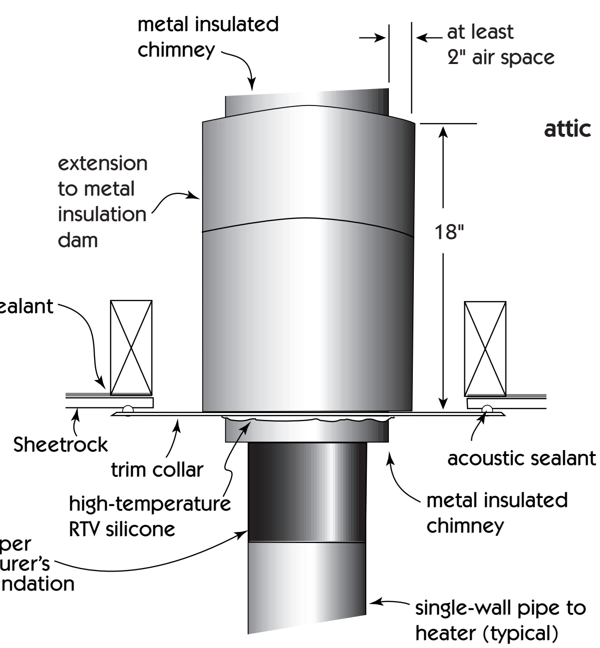
This stove pipe and chimney are overdue for a good safety upgrade and retrofit.



This is an example of a proper installation of a chimney and stove pipe.



Attic side air seal (typical on new construction)



Interior side air seal (typical on retrofit)

Chapter 7
Maintenance

Log Homes Require Maintenance

Walk around the house once in the summer, preferably after a rain, and check to see that any rainwater that reaches the logs beads up on the finish rather than soaking in and that no log ends are receiving more than their share of any wind-blown rain. It is imperative to keep logs dry. Wet logs rot faster than most people realize. If water does not bead up on the surface of the logs, it is time to refinish. Any log ends sticking out too far should be chain-sawed off and refinished.

Check to make sure that the gutters are doing their job and that all rainwater flows rapidly away from the house. Also make an inspection tour around the house on a cold winter day. Look for frost crystals forming where warm, moist air is leaking out through the logs, condensing and freezing on the exterior. Take a photograph of any frost that you locate for future reference in the summer, which is the best time to do any caulking or sealing on the exterior of the logs.

Washing and Finishing the Logs

The exterior of the logs should be washed every one to five years as the effectiveness of the water-repellent preservative begins to fade. First rinse the logs with a pressure washer set at 400 or 500 pounds per square inch (psi). Do not hold the pressure sprayer on any spot for more than a few seconds since it could damage the surface of the wood and make it hard to finish. Then spray the logs with a solution of one gallon chlorine bleach, three gallons water (50-50 if logs are stained with mold), and a cup of trisodium phosphate mixed in a five-gallon garden sprayer.

Start at the bottom and work your way up, keeping the logs wet with the solution for about 30 minutes. Scrub dirty areas with a soft brush dipped in the bleach solution. Power wash thoroughly to remove all traces of the residues. If you don't have a pressure washer, a garden hose with a sprayer will work. Wear rubber gloves and protective eye glasses.

Allow to dry for several days before applying two coats of a water-repellent preservative that contains a pigment and ultraviolet (UV) inhibitor.

Find and Caulk the Leaks

Check again in the spring, looking for water stains that usually indicate leaks. Refer to the winter photos and go around the house, looking for moisture stains on the soffits and the top surface of the plate log that supports the roof. Look for water stains at the exterior of the notches for the ridge pole and purlins. These signs of leakage could be the result of warm moist air leaking out at the ceiling/log interface or from liquid water running down from above. These sources can be reduced by caulking and sealing. Air leakage is best sealed on the inside. Wind-blown rain penetration can be reduced by well-maintained rain gutters, ample roof overhang, and a thorough caulking of the exterior joints and checks of any windward log walls.

Caulking and Sealing

After the passage of time, most log houses will require air sealing around log notches that have shrunk open or twisted enough to allow heated air to escape. Large checks or splits that connect to the outside should also be caulked to prevent heat loss and moisture migration that may condense in the cavity and begin to mold and cause the logs to rot. Large exterior checks in logs that can catch rain or blowing snow should also be sealed. Small cracks between logs can often be sealed with caulk alone. Larger cracks or splits should first be filled with triangular or trapezoidal backer rod to ensure a good seal with a minimum of caulking material. Backer rod comes in many sizes from 1/4" to 2" and greater and can be used to back up caulk around window and door installations as well as cracks in the logs. Use a caulk that remains flexible and is compatible with the finish material on the logs.

Carpenter Ants

Signs of Infestation

The most obvious sign of infestation is the presence of ants inside the house. Ants are active all year if they are nesting in heated places; otherwise, they are inactive during cool weather. During the spring and early summer, there may be winged ants (swarmers) inside and around the house.

The presence of carpenter ants can be detected by piles of sawdust-like material (frass) expelled from cracks or slit-like openings made by the ants. This frass is often found in dark closets, attics, under porches, along sills, around the base of infested trees or elsewhere. Unused nest openings are sometimes sealed with wooden plugs. Carpenter ant frass can be distinguished from regular sawdust by the presence of fragments of ants and other insects mixed with wood fibers.

Damage

Damaged wood is discovered when its surface is broken open. The only external evidence of attack is the small, inconspicuous cracks and slit-like openings made in the surface by the ants. The galleries extend both along the grain of the wood and around the annual rings.

Gallery surfaces are smooth and clean; frass is completely removed except for occasional deposits in unused galleries.

All kinds of houses, from the newest to the oldest, located in rural areas or cities, become infested. In cities, the ants usually infest houses in wooded areas, but are sometimes found in crowded residential districts as well. Carpenter ants show some preference for moist, rotting wood around the foundations. Once a nest is established, the workers will extend the galleries into sound wood that is adjacent to the partially decayed portion.

Control Measures

The most difficult and most important part of carpenter ant control is locating the nest. Once the nest or nests have been located, control is relatively easy. Simply treating the areas where ants are seen and not locating and treating the nests is seldom satisfactory.

The most obvious places to look for carpenter ants are in areas that are most likely to have a high moisture content. However, carpenter ants have been found nesting in virtually every part of the house. Edges of floors and ceilings and window and door trims should be carefully examined.

Once the nests are found, they should be treated with residual contact insecticides, such as Diazinon, applied as a dust or spray. Dusts are quite effective in the nests. **When using insecticides, follow all label directions exactly!**

(Carpenter Ants is from the Alaska Cooperative Extension brochure Carpenter Ants: Insect Pests of Wood Products, by Edward H. Holsten.)

Conclusion

Alaska has vast intact wood lands, capable of providing countless generations of people with meaningful and satisfying jobs in timber occupations. These high-paying jobs range from logging to cabinet-making to building our homes and offices with wood products made from sustainably grown, locally harvested and processed conifers and hardwoods.

The role of each generation is to pass on to our children the best information and tools for living in this unique place on the planet that we call home. This book was written from the perspective that there are many ways of living long and well, wherever you are. Building with logs may be one of the best ways to stay safe, warm, and healthy in an affordable home that will last a hundred years or more with minimal maintenance.

Fairbanks Log House

At Alaskaland, at a few locations around town and out in the bush one sees log cabins all of a style sod roof on a low-pitched gable that extends out over the porch, the overall structure being rather low. Go to Nome or to other coastal towns in western Alaska and you will see a completely different style of architecture involving frame houses with glassed-in porches, usually facing the sea. These houses are reminiscent of the houses found in the old whaling villages of New England.

It seems likely that the Nome-style house had its genesis in the New England houses, but where did the Fairbanks-style log house come from? Travelers to Siberia, particularly in the regions around Irkutsk, will be struck by the similarity of the Fairbanks log house to the log cabins there. In the Siberian cities the log houses frequently have ornate painted window shutters and eaves but the style is unmistakable. To stroll through a country village today in Siberia is to stroll through Fairbanks 30 or 40 years ago; the houses are identical. It is not too farfetched to think that the Fairbanks log house had its origin in Siberia. Irkutsk used to be the effective capital of Alaska before Sitka was. Also the original wave of Russian influence was reinforced by a second wave of emigrants during gold rush days and up until the 1920s. Many Russians settled in interior Alaska and built log houses like those they lived in at home.

From *Alaska Science Nuggets* by Neil Davis, 1982

Appendix A
Alaska Building Energy Efficiency Standard

**Note: These standards are subject to change.
Please contact the Alaska Housing Finance Corporation at
1-800-478-AHFC for the latest version.**

Appendix A
Alaska Building Energy Efficiency Standard

October 24, 1996

Dear Alaskan Home Builder or Building Material Supplier,

On October 1, 1993, a Federal court judge ruled that Pacific Inspection and Research Laboratory of Redmond, Washington, failed to test window energy efficiency properly and must retract its results for tests that were performed between 1984 and 1992.

This ruling affects the Alaska building industry. A large portion of the windows manufactured and/or distributed in Alaska were tested by Pacific Inspection and Research Laboratory during this period.

Alaska's Building Energy Efficiency Standard for new residential construction requires window product performance testing by independent test laboratories. State financing for new residential dwellings demands compliance with the Building Energy Efficiency Standard. Additionally, Energy Rated Homes of Alaska uses these test results for determining window U-values for rating a home's energy efficiency. Financing incentives for energy efficient housing are based on these energy ratings.

After extensive research and consultation with members of the Alaska Homebuilders' Association and window manufacturers and distributors throughout the state, the Alaska Housing Finance Corporation has adopted emergency regulations that will allow homeowners and the building industry to continue to meet the requirements of the Building Energy Efficiency Standard and to seek State financing.

These regulations provide a "Window U-value Default Table" that has also been approved for use in Washington and Oregon states. Any window that cannot meet the performance test requirements, either because of no testing or because the results have been invalidated by this federal court ruling, will be required to use the U-value listed in the table for that particular product. We recognize that U-values in the default table are generally more conservative than actual testing. This table is, however, more lenient than the U-value default table listed in the existing State energy standard, which it supersedes for window values only.

Please note that this regulation does not invalidate any test results that were properly performed by other certified test laboratories. Also note that any affected window manufacturer's product test claims that have been since validated by other laboratory tests or by the National Fenestration Rating Council test procedure may still be used to validate thermal performance claims.

This emergency regulation took effect on November 17, 1993 and held until March 30, 1994, after which time new regulations were formally adopted.

Sincerely,

Robert L. Brean, Director
Research & Rural Development Division

U-VALUE DEFAULT TABLE

Description [3,4,5,6,7]			Frame Type [8]
	Alum. Thermal Break[9]	Wood/Vinyl	Alum. Clad/Wood Reinforced Vinyl[10]
Double, Clear 1/4"	0.66	0.56	0.59
Double, Clear 1/4" + argon	0.63	0.53	0.56
Double, low-e^{4} 1/4"	0.61	0.52	0.54
Double, low-e^{2} 1/4"	0.58	0.49	0.51
Double, low-2^{1} 1/4"	0.55	0.47	0.49
Double, low-e^{4} 1/4"+ argon	0.55	0.47	0.49
Double, low-e^{2} 1/4" + argon	0.52	0.43	0.46
Double, low-2^{1} 1/4" + argon	0.50	0.41	0.43
Double, Clear 3/8"	0.63	0.54	0.57
Double, Clear 3/8" + argon	0.60	0.51	0.64
Double, low-e^{4} 3/8"	0.57	0.48	0.51
Double, low-e^{2} 3/8"	0.54	0.45	0.48
Double, low-2^{1} 3/8"	0.51	0.43	0.46
Double, low-e^{4} 3/8" + argon	0.53	0.44	0.47
Double, low-e^{2} 3/8" + argon	0.49	0.41	0.44
Double, low-2^{1} 3/8" + argon	0.47	0.39	0.41
Double, Clear 1/2"	0.60	0.50	0.54
Double, Clear 1/2" + argon	0.58	0.48	0.51
Double, low-e^{4} 1/2"	0.53	0.44	0.47
Double, low-e^{2} 1/2"	0.50	0.41	0.44
Double, low-2^{1} 1/2"	0.47	0.39	0.42
Double, low-e^{4} 1/2" + argon	0.50	0.42	0.44
Double, low-e^{2} 1/2" + argon	0.46	0.37	0.38
Double, low-2^{1} 1/2" + argon	0.43	0.35	0.38
Triple, Clear 1/4"	0.52	0.42	0.44
Triple, Clear 1/4" + argon	0.49	0.39	0.42
Triple, low-e^{4} 1/4"	0.50	0.40	0.40
Triple, low-e^{2} 1/4"	0.48	0.39	0.41
Triple, low-2^{1} 1/4"	0.47	0.38	0.40
Triple, low-e^{4} 1/4" + argon	0.46	0.37	0.39
Triple, low-e^{2} 1/4" + argon	0.43	0.34	0.37
Triple, low-2^{1} 1/4" + argon	0.42	0.34	0.36
Triple, Clear 1/2"	0.46	0.37	0.40
Triple, Clear 1/2" + argon	0.45	0.36	0.38
Triple, low-e^{4} 1/2"	0.43	0.35	0.37
Triple, low-e^{2} 1/2"	0.41	0.32	0.35
Triple, low-2^{1} 1/2"	0.39	0.31	0.33
Triple, low-e^{4} 1/2" + argon	0.41	0.32	0.35
Triple, low-e^{2} 1/2" + argon	0.38	0.30	0.32
Triple, low-2^{1} 1/2" + argon	0.37	0.29	0.31

1. Subtract 0.02 from the listed default U-value for insulated spacers. Insulated spacer material includes fiberglass, wood, and butyl or other material with an equivalent K-value.
2. Solariums may subtract 0.03 from the default U-value.
3. 1/4" = a minimum dead air space of 0.25 inches between the panes of glass. 3/8" = a minimum dead air space of 0.375 inches between the panes of glass. 1/2" = a minimum dead air space of 0.5 inches between the panes of glass.
   Products with air spaces different than those above shall use the value for next smaller air space: i.e., 3/4" = 1/2 inch U-values: 7/16" = 3/8 inch U-values; 5/16" = 1/4 inch U-values
4. Low-e^4 (emissivity) shall be 0.4 or less.
   Low-e^2 (emissivity) shall be 0.2 or less.
   Low-e^1 (emissivity) shall be 0.1 or less.
5. U-values listed for argon shall consist of sealed, gas-filled, insulated units for argon. CO_2, SF_6, and argon SF_6 mixtures. The following conversion factor shall apply to Krypton gas-filled units: 1/4-inch or greater airspace with Krypton gas-filled = 1/2-inch airspace with argon gas-fill.
6. Dividers placed between glazing: The U-values listed shall be used where the divider has a minimum gap of 1/8 inch between the divider and lite of each inside glass surface. Add 0.03 to the listed U-value for True Divided Lite windows.
7. "Glass block" assemblies may use a U-value of 0.51.
8. Insulated fiberglass framed products shall use wood/vinyl U-values.
9. Alum. Thermal Break = an aluminum thermal break framed window shall incorporate the following minimum design characteristics:
   (a) The thermal conductivity of the thermal break material shall be not more than 3.6 BTU-in/hr/ft^2/F.
   (b) The thermal break material shall not be less than 0.210 inches; and
   (c) All metal framing members of the produce to interior and exterior air must incorporate a thermal break meeting the criteria in (a) and (b).
10. Aluminum clad wood windows shall use the U-value listed for Alum. Clad Wood/Reinforced Vinyl windows. Vinyl clad wood windows shall use the U-values listed for Wood/Vinyl windows. Any vinyl frame window with metal reinforcement in more than one rail shall use the U-values listed for Alum. Clad Wood/Reinforced Vinyl windows.

Notice of Simplified Procedure To Comply With Window Test Requirements

The Alaska Housing Finance Corporation (AHFC) will accept window, door, and skylight product performance test claims if testing was performed using the protocols specified by the National Fenestration Rating Council (NFRC) and conducted by an independent laboratory certified by NFRC to perform such a test. Product performance certification by NFRC will not be required by AMEC. AHFC will require that the manufacturer self-certify that all of the products it manufactures that reach the marketplace are built in the same manner as the product samples simulated and tested. Alaska-based window manufacturers who choose to complete the NFRC performance certification process will still be eligible for AHFC's Rebate for NFRC Certification.

Background

The Alaska Building Energy Efficiency Standard (BEES) dated September 1, 1991 adopted by the Alaska Housing Corporation as 15 AAC 155.010 of the Alaska Administrative Code, provides acceptable levels for a building's thermal envelope and other energy efficiency and safety measures.

Section 2.6a: Windows, Doors, and Skylights of the BEES requires that, after January 1, 1995, a window, door, or skylight product performance claim shall be acceptable only if testing was performed using the protocols specified by the National Fenestration Rating Council (NFRC).

AHFC's original interpretation of this requirement placed emphasis on the term "NFRC protocols," which involves a three-step process including computer simulation, physical testing of baseline products, as well as independent certification that the windows being manufactured are consistent with the product samples that were tested.

AHFC recognized that the cost of NFRC testing and certification would be more significant for Alaskan manufacturers that do business only in Alaska than for the larger nationwide or regional manufacturers. Consequently, in November 1994, the AHFC Board of Directors authorized the use of corporate funds to provide financial assistance, of up to $5,000 each, to Alaska-based window manufacturers for NFRC certification.

After being asked to re-examine the content of the BEES requirement, AHFC has concluded that Section 2.6a addresses the NFRC test procedure as described in NFRC 100-91, but does not require the full performance certification process developed by NFRC.

NFRC Test Results Must Be Submitted

A window, door, or skylight manufacturer making product thermal performance claims in conjunction with the BEES must submit complete copies of certified NFRC test reports on those products to the Alaska Housing Finance Corporation's Housing Resource Center. AHFC will also require that the manufacturer self-certify that all of the products it manufactures that reach the marketplace are built in the same manner as the product samples simulated and tested. These reports will be available for public inspection to allow consumers to verify performance claims.

Rebate Program Still Available

Alaska-based window manufacturers who choose to complete the NFRC performance certification process will still be eligible for AHFC's Rebate for NFRC Certification. Contact our office for more information on this program.

BUILDING ENERGY

EFFICIENCY STANDARD

September 1, 1991

Alaska Housing Finance Corporation

Affordable Housing and Energy Efficiency

Chapter 1
Title, Scope, and General

1.1 Title

This document, dated September 1, 1991, shall be known as the "Building Energy Efficiency Standard" and is referred to herein as this "Standard."

1.2 Purpose

The purpose of this Standard is to promote the construction of energy-efficient buildings. This document sets standards for thermal resistance, air leakage, moisture protection, and ventilation as they relate to efficient use of energy in buildings.

1.3 Policies

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

a. Foster housing that is comfortable, healthy, and affordable to heat;
b. Develop public awareness of energy-efficient building designs, technologies, and systems;
c. Establish acceptable and appropriate energy standards for buildings based upon practical and cost-effective measures that reduce energy consumption;
d. Permit flexibility in compliance by allowing alternative methods of meeting the requirements of this Standard; and
e. Except where stated otherwise in this Standard, a review and monitoring of this Standard and its administration will be done every three years to make it responsive to users, technological developments, and other changes in the building industry.

1.4 Scope

This Standard shall not be used to abridge any structural, safety, fire, health, or environmental requirements of locally adopted codes, Federal standards, or current editions of the Uniform Building, Mechanical, Plumbing, and Fire Codes as adopted by the International Conference of Building Officials (ICBO) and the National Electrical Code as adopted by the National Fire Protection Association. In case of conflict between this Standard and any of the above codes or standards, the most stringent shall apply. This Standard is intended to supplement these codes.

1.5 Compliance Methods

One of four alternative methods shall be used to comply with this standard. These methods are:

Prescriptive Method—Chapter 3. This method requires minimum R-values for each thermal envelope assembly. R-values for things such as sheetrock, paint, carpeting, paneling, sheathing, siding, brick facing, interior and exterior boundary air films, or backfill shall not be included. Only insulation R-values and air spaces provided specifically for insulating value may be included.

This method shall not be used to trade-off R-value requirements between different envelope assemblies or between different components of the same assembly. To do that, Chapter 4, 5, or 6 shall be used.

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

Performance Method—Chapter 4. The Performance Method allows the trade-off of insulation requirements between elements within a particular thermal envelope assembly. For example, if window area above the allowed 15 percent prescriptive maximum is desired, the Performance Method allows such an increase provided the wall insulation R-value is increased to offset the extra heat loss resulting from the increased window area.

Trade-offs between different thermal envelope assemblies are not allowed with this method. In other words, more insulation in the ceiling does not allow for decreased insulation in the wall. For this kind of trade-off, Chapter 5, Building Budget Method or Chapter 6, Energy Rating Method shall be used. The Performance Method, however, may be used in combination with the Prescriptive Method.

Some calculations are necessary with the Performance Method. The formulas to calculate trade-offs are provided in this chapter.

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

Building Budget Method—Chapter 5. The Building Budget Method requires proof of compliance through a HOT-2000 computer energy use analysis or manual calculations. This option requires calculating space heat loss values. Specific insulation requirements are not given. Any design may be chosen, provided the building does not exceed the maximum energy use and heat loss values given for the region and building type. When using this option, all mandatory measures given in Chapter 2 shall also be accomplished.

Energy Rating Method—Chapter 6. This option currently requires achieving a Four Star Energy Rated Homes of Alaska rating and complying with the ventilation requirements given in this Standard. On January 1, 1995, the requirement shall be increased to a Four Star Plus rating. The energy rating shall be done by a certificated Energy Rated Homes of Alaska rater.

1.6 Alternate Materials and Construction Methods

The provisions of this Standard do not prevent the use of a material or method of construction not specifically prescribed by this Standard provided the alternative has been approved and its use authorized as complying with this Standard by the Rural Housing Division of the Alaska Housing Finance Corporation. The division will require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding alternatives. The details of any action granting approval of an alternate will be recorded and entered in the files of the division.

Chapter 2
Mandatory Design Measures

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.

This chapter specifies mandatory energy conservation measures. These measures shall also be complied with when using Chapter 3, 4, or 5 to demonstrate compliance with this Standard. This chapter may be used as a guide for building to ensure compliance with Chapter 6.

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 2 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 non-collapsible. 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 blocking 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.
   Exception: A required insulation level may be reduced in an area over a top plate of an envelope wall to accommodate a differing roof design provided the reduction is no more than 20 percent of the required R-value.
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˚ Fahrenheit 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 caulk, 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 caulk has proven to be an effective sealant. 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 6 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 Air Tightness

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.

One of the three methods below shall be used for compliance with air tightness requirements for this Standard:

a. Sealing Measures. All cracks, joints, and openings in or through a thermal envelope shall be caulked, gasketed, taped, weather-stripped, or otherwise sealed. Such locations include, but are not limited to:
   - Between rough framing and a window or a door frame, between an exterior wall sole (bottom) plate and floor, between a mudsill and a foundation wall;
   - Around a utility penetration such as for plumbing, electricity, telephone or fuel line;
   - Around a penetration in a ceiling or floor such as for a chimney, flue, vent, attic access panel, or crawl space access panel;
   - At a break, penetration, puncture, or tear in a vapor retarder (as stated in Section 2.2, Vapor Retarder);
   - At a hole in a stud or top or bottom plate of an interior or exterior wall where piping or electric wiring pass through the thermal envelope;
   - Around an electric outlet or junction box;
   - Around an HVAC duct;
   - Around a fan enclosure, supply or exhaust grill, or diffuser;
   - At all other such openings in the thermal envelope.

   A caulking, gasket, or sealing material and the manner in which it is applied shall conform to applicable ICBO codes and the manufacturer's recommendations. Stuffing fiberglass insulation into a crack is not an adequate sealing method.

b. Blower Door T esting. Air tightening may be accomplished in any manner provided total air changes per hour (ACH) for a building does not exceed the value given in Table 2.1 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."

Table 2.1
Airtightness Requirements
@ 50 Pascals

Building Type	Region	ACH
Detached single-family or duplex	1, 2, & 3	4
Detached single family or duplex	4 & 5	3
All other	All	3

c. Tracer Gas T esting. Air tightening may be accomplished in any manner provided total natural air changes per hour (NACH) for a building does not exceed the value given in Table 2.2 when tested in accordance with ASTM E741 "Practice for Measuring Air Leakage Rate by the Tracer Dilution Method" or the National Association of Home Builder's "AIMS" test.

Table 2.2
Airtightness Requirements
Natural ACH

Building Type	Region	NACH
Detached single family or duplex	1, 2, & 3	0.26
Detached single family or duplex	4 & 5	0.19
All other	All	0.19

2.4 Fireplaces and Wood Stoves

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

a. A tight-fitting, closeable metal or glass door covering the entire opening of the firebox;
b. A means to utilize 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: A 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 will be reviewed in two years and modifications made as necessary to improve this Standard.

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 on page A-15.

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 on pages A-15–16 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 either:

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 Table 2.3.

Table 2.3
Minimum Ventilation Air Requirements, CFM

Space	Base Flow Rate	Exhaust Continuous	Exhaust Intermittent
Category A Rooms			
Master Bedroom	20		
other Bedrooms	10		
Living Room	10		
Dining Room	10		
Family Room	10		
Recreation/Hobby Room*	10		
Non-partitioned Basement	20		
Other Habitable Rooms	10		
Category B Rooms			
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.
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, Air Tightness. The air flow rate shall be stated in terms of CFM and shall be derived using the Lawrence Berkeley Laboratories (LBL) methodology. A modification of this methodology is not allowed. The test shall be conducted by a person trained and certificated by the Alaska Craftsman Home Program to do such work. The accuracy of airflow measurement for blower door equipment shall be accurate within +_ 10 percent of the actual measured flow rate. Pressure measurement apparatus shall be accurate to within +_ 2 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 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 for a residential building 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 5 percent.
e. A backdraft 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 6 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 the effect of 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˚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 semi-rigid) 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, but shall not exceed more than 12 hours per day. A manual shutoff capability shall be provided for extended periods of non-occupancy such as vacations.
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 a homeowner 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 backdrafting of heating and cooking appliances. Backdraft 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.

For these reasons, it is highly recommended that the considerations in Air Pressure Limitations be followed (page A-43).

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 3 to 5 percent of the total envelope area. A common double-glazed window loses 10 times more heat per square foot than a 2x6 insulated wall.

Window, door, and skylight requirements will be reviewed in two years and modifications will be made as necessary to improve this standard. 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.

A product performance claim referencing a test conducted under the AAMA 1503.1-80, AAMA 1503.1-88, ASTM C236-80, or ASTM C236-87 test method prior to January 1, 1995 shall be acceptable. Thereafter, only a performance test conducted under the NFRC protocols shall be acceptable. In addition, the following restrictions apply to the AAMA test methods.

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 size closest to the model size stated above.

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

c. A laboratory test report showing all relevant product performance values shall be submitted to the Alaska Housing Finance Corporation, Research Information Center, 4300 Boniface Parkway, Anchorage, AK 99504. Telephone: (907) 338-6100 or (800) 478-INFO (478-4636) within Alaska. 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 regardless of which method (chapter 3, 4, 5, or 6) is used to comply with this Standard.

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

f. A window, door, or skylight whose performance is not documented by a test report shall be given a default R-value as follows:

Product	Default R-Value
double-glazed window or skylight	1.7
triple-glazed window or skylight	2.5
insulated metal door	5.0
solid core wood door	2.5
door with glazing	1.7

g. 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 which 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 determine how easily vapor within a thermal envelope assembly migrates to the outdoors. These materials shall therefore have a dry cup perm rating of 5 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, do not tape joints between boards.

2.9 Attached Garages

A wall, ceiling, or floor of 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 residential building. In a highly insulated residential 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 showerhead 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.
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 3 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 3-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˚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 3 inches of a cold-water pipe, shall be insulated to a minimum R-4.0.

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˚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 prior to being turned over to a homeowner.
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 backdrafting problems.
d. A heating appliance and its related components shall meet or exceed the manufacturer's federal requirements for energy-efficiency performance current at time of installation.

Chapter 3
Prescriptive Method

This chapter establishes minimum thermal envelope insulation requirements for buildings. Exceeding these minimums is encouraged.

The Prescriptive Method does not require extensive calculations. It is the least flexible of the four possible compliance methods. This method shall not be used to trade-off an R-value requirement between a different thermal envelope assembly or different element of the same assembly. For example, more insulation in the ceiling does not decrease the required insulation in the wall. If this is desired, Chapter 4, 5 or 6 shall be used as the means of compliance.

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

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

3.1 Insulation Minimums

R-value minimums given in this chapter are for insulation installed between or over structural members. Only the insulation R-value is counted. R-value for an air film or a material such as sheetrock, paneling, plywood, siding, or earth backfill, for example shall not be included.

R-value minimums refer to the installed R-value. Compression of some insulating products results in a lower R-value. For example, placing a standard R-30 batt into a 2x8 wall compresses the batt from 9 inches down to 7 $^{1}/_{4}$ inches. This results in a decreased R-value from the listed R-30 down to approximately R-26. Table 3.1 (see top of next page) shows nominal examples of resultant R-values when fiberglass batts are compressed.

3.2 Ceilings

a. A thermal envelope ceiling shall be insulated to the minimum R-value shown in Table 3.2.

3.3 Above-Grade Walls

a. An above-grade thermal envelope wall shall be insulated to the minimum R-value shown in Table 3.2. This includes the floor rim joist area.

Table 3.1

Example of resultant R-values when fiberglass batt insulation is compressed into a confined space such as in wall stud or floor joist spaces. Product thickness and density differ among manufacturers and therefore resultant R-values also differ slightly.

		Initial R-value and thickness					
Nominal		R-38	R-30	R-22	R-19	R-13	R-11
Lumber	Actual	12"	9 1/2"	6 3/4"	6 1/8"	3 5/8"	3 1/2"
Size	Width	Installed R-value at final thickness					
2" x 12"	11 1/4"	37					
2" x 10"	9 1/4"	32	30				
2" x 8"	7 1/4"	27	26				
2" x 6"	5 1/2"		21	20	18		
2" x 4"	3 1/2"		14	13	13		
2" x 3"	2 1/2"					10	9
2" x 2"	1 1/2"					6	6

3.4 Below-Grade Walls (Foundation Walls)

a. A below-grade thermal envelope wall shall be insulated to the minimum R-value shown in Table 3.2.
b. A required R-value for crawl space wall insulation shall be maintained for the full height of the wall.
c. A required R-value for basement wall insulation shall be maintained for the upper-most four feet of the wall. The remaining length of wall shall maintain at least one-half the required R-value.
d. Exterior insulation may extend in a horizontal or diagonal manner out from a wall provided the length of insulation meets or exceeds that which would be placed in a vertical manner.
e. An insulation material shall have appropriate weather-resistant properties for the intended use and shall be applied as recommended by the insulation manufacturer.

3.5 Floors

a. A thermal envelope floor shall be insulated to the minimum R-value shown in Table 3.2.
b. A rim joist area of a thermal envelope floor shall be insulated to the same requirement as given for an envelope floor.
c. A rim joist area of a non-thermal envelope floor (such as where a crawl space wall is insulated but the floor is not, or a second-story floor) shall be insulated to the same requirement as given for an Above-Grade or Below-Grade envelope wall, as appropriate.

3.6 Slab-on-grade Floors

a. A concrete slab-on-grade floor of a conditioned space or enclosed semiconditioned space shall be insulated to the minimum R-value shown in Table 3.2.

b. An insulation material shall have appropriate weather-resistant properties for below-grade application and shall be applied as recommended by the manufacturer. Insulation damaged during construction shall be replaced.
c. Insulation for a thickened edge or grade beam concrete slab floor shall extend downward from the top of the slab to the bottom of the footing, then horizontally beneath the footing for its full width. Alternatively, insulation may extend downward from the top of the slab to the bottom of the footing, then diagonally out from the footing for a minimum horizontal distance of 18 inches.
d. Horizontally placed insulation under the perimeter of a basement concrete slab floor shall be continuous around the entire perimeter of the slab and shall be a minimum of 24 inches wide. Additionally, a thermal break shall be provided between the foundation wall and the slab edge.
e. Permafrost areas require engineering analysis for proper application of insulation in contact with the ground. Improper application can result in ground thawing and cause severe damage to the structure.

3.7 Windows and Sliding Glass Doors

a. An exterior window R_0-value (overall R-value, including the frame) shall not be less than specified in Table 3.2.
b. A sliding glass door shall be considered a window for the purpose of determining total allowable glazed area percentage (see paragraph c below) and required R-value. A window or sliding glass door shall also comply with mandatory requirements stated in Chapter 2, Section 2.6.
c. Total window and sliding glass door area shall not exceed 15 percent of the total gross above-grade thermal envelope wall area. If more than 15 percent window area is desired, Chapter 4, 5, or 6 shall be used as the method of showing compliance with the overall energy efficiency of a building.
d. A window for special architectural or decorative purpose may have an R-value less than required by Table 3.2 provided:
    1. it is double glazed or more, and
    2. total decorative window area does not exceed 5 percent of the allowable window area specified in paragraph c up to a maximum of 16 square feet.

3.8 Skylights

a. A skylight shall have a minimum R_0-value of 2.5 (U_0-value of 0.4).
b. Skylight area shall not exceed 1 percent of the total ceiling thermal envelope area.
c. A skylight sidewall that is not an integral part of the skylight product shall be insulated to the same R-value as the ceiling.
d. A skylight shall also conform to the requirements stated in Chapter 2, Paragraph 2.6.

3.9 Doors

a. An exterior door R_0-value shall not be less than specified in Table 3.2.
b. Door glazing shall be minimum double glazed with a one-half inch minimum air space.
c. An exterior door shall also conform to the requirements stated in Chapter 2, Paragraph 2.6.
d. A sliding glass door shall be considered as a window for the purpose of determining R-value and area requirements. See Section 3.7 above.

3.10 Log House

If a wall of a log house does not meet the prescriptive insulation value of Table 3.2, the house shall comply with this Standard by use of Chapter 5 or 6.

TABLE 3.2

Thermal Envelope R-value Requirements

This table lists minimum thermal envelope insulation requirements for buildings. Any method of constructing a building's thermal envelope may be used provided clear compliance with the listed R-values is shown and is acceptable to approving officials. R-value minimums refer to the installed R-value, which may be different from the listed product R-value. Higher R-values may be used if desired.

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

			Thermal Envelope R-Value Requirements							
Region Number	Region Name	Heating Fuel	Ceiling	Above grade Wall	Floor	Below grade Wall	Slab Floor Base-ment	Slab Floor On Grade	Window	Door[1]
1	Southeast	All Fuels	38	21	30	15	10	15	3.0	2.5, 7
2G	Southcentral	Nat. Gas	38	18	19	10	10	10	3.0	2.5, 7
2A	Southcentral, Aleutian, Kodiak	All Fuels Other Than Natural Gas	38	25	30	15	10	15	3.0	2.5, 7
3	Interior, Southwest	All Fuels	38	25	38	19	10	15	3.0	7
4	Northwest	All Fuels	38	30	38	19	10	15	3.0	7
5	Arctic Slope	All Fuels	52	35	43	-	-	-	3.0	7

Note:

1. Not more than one exterior door in a residential building in Region 1 or 2 may have an R-value less than 7, but not less than 2.5.

Chapter 4
Performance Method

The Performance Method allows a trade-off of insulation requirements between elements of a particular thermal envelope assembly. For example, if window area above the allowed 15 percent maximum (as given in Chapter 3) is desired, the Performance Method allows such an increase provided the opaque wall R-value is also increased. Compliance is met when the opaque wall R-value increases enough to offset the extra heat loss resulting from the increased window area.

A trade-off between different thermal envelope assemblies is not allowed under this method. In other words, more insulation in the ceiling does not allow for decreased insulation in the wall. For this kind of trade-off, Chapter 5, Building Budget Method, or Chapter 6, Energy Rating Method shall be used.

The Performance Method may be used together with the Prescriptive Method. For example, if the ceiling and floor meet compliance to this Standard through the Prescriptive Method, but the wall does not, compliance for the wall may be met through the Performance Method which allows for R-value trade-offs between wall elements.

The Performance Method requires some calculations. R-value for an air film or a material such as sheetrock, paneling, plywood, or siding, for example, may be included when calculating the overall transmittance value (U_0-value) of an assembly. Insulation value for earth backfill, however, shall not be included. A workbook is available to help with these calculations.

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

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

Calculations used to determine compliance with the U_0-values shown in Table 4.1 shall be submitted to division officials for verification.

4.1 Relationship of U-values and R-values

To convert R-value to U-value, divide 1 by the R-value. For example, to convert R-38 to U-value: $1 \div 38 = 0.026$. To convert U-value to R-value, divide 1 by U-value. For example, to convert U-0.026 to R-value: $1 \div 0.026 = 38$. An example of how to calculate an overall thermal transmittance value (U_0) is given in Appendix B (page A-41).

When R-values are converted to U-values, at least the first three decimal places shall be used. Do not round the third digit. For example, the U-value of R-19 insulation carried to four decimal places is: $U = 1/19 = 0.0526$. Use $U = 0.052$ or $U = 0.0526$. Do not round to $U = 0.053$.

4.2 Overall U_0-Values

The stated U-value of any one element of an envelope assembly may be increased while another element is decreased, provided the overall U_0-value of the entire assembly does not increase. Equations 1, 2, and 3 shall be used to determine U_0.

4.3 Ceilings

a. Overall thermal transmittance value (U_0) for gross ceiling thermal envelope area shall not exceed the value shown in Table 4.1 for ceiling.
b. Equation 1 shall be used to determine acceptable combinations to meet the required ceiling U_0-value.

$$U_0 \text{ ceiling} = \frac{(U_{ceiling} \times A_{ceiling}) + (U_{skylight} \times A_{skylight})}{A_0}$$ Equation 1

Where:

U_0ceiling = the overall thermal transmittance value of the gross ceiling thermal envelope area expressed as Btu/ft^2 • hr • ˚F

A_0 = the gross overall ceiling thermal envelope area in ft^2

$U_{ceiling}$ = the composite thermal transmittance of all elements of the opaque ceiling expressed as Btu/ft^2 • hr • ˚F

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

$U_{skylight}$ = the composite thermal transmittance of all elements of the skylight, including the frame, expressed as Btu/ft^2 • hr • ˚F

$A_{skylight}$ = the area of the skylight(s), including the frame, in ft^2

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

$$U_0 \text{ ceiling} = \frac{(U_{ceiling\ 1} \times A_{ceiling\ 1}) + (U_{skylight\ 2} \times A_{skylight\ 2}) + \ldots, \text{etc.}}{A_0}$$ Equation 1.1

4.4 Walls

a. Above-grade W all: Overall thermal transmittance value (U_0) for gross above-grade thermal envelope wall area shall not exceed the value shown in Table 4.1 for above grade wall.
b. Below-grade W all: Overall thermal transmittance value (U_0) for gross below-grade thermal envelope wall area shall not exceed the value shown in Table 4.1 for below-grade wall.
   1. Required U_0-value for crawl space wall insulation shall be maintained for the full height of the wall.
   2. Required U_0-value for basement wall insulation shall be maintained for the uppermost four feet of the wall. The remaining length of wall shall maintain one-half or more the required insulation value.
c. An insulation material shall have appropriate weather-resistant properties for the intended use and shall be applied as recommended by the insulation manufacturer.
d. U-value for earth backfill shall not be included when calculating U_0 for a below-grade wall.
e. Equation 2 shall be used to determine acceptable combinations to meet the required wall U_0-value. Above-grade walls and below-grade walls are calculated as separate envelope assemblies.

$$U_0 \text{ wall} = \frac{(U_{wall} \times A_{wall}) + (U_{window} \times A_{window}) + (U_{door} \times A_{door})}{A_0}$$ Equation 2

Where:

U_0wall = the overall thermal transmittance value of the gross wall thermal envelope area expressed as Btu/ft^2 • hr • ˚F

A_0 = the gross overall wall (above or below grade wall, as appropriate) thermal envelope area in ft^2

U_{wall} = the composite thermal transmittance of all elements of the opaque wall expressed as Btu/ft^2 • hr • ˚F

A_{wall} = the gross opaque wall thermal envelope (above or below grade wall, as appropriate) area in ft^2

U_{window} = the composite thermal transmittance of all elements of the window area, including the framing and sash expressed as Btu/ft² • hr • °F
A_{window} = the area of the window(s), including the framing and sash, in ft2
U_{door} = the composite thermal transmittance of all elements of the door expressed as Btu/ft² • hr • °F
A_{door} = the area of the door(s) in ft²

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

$$U_0 \text{ ceiling} = \frac{(U_{wall1} \times A_{wall1}) + (U_{wall2} \times A_{wallw2}) + \ldots, \text{etc.}}{A_0} \qquad \text{Equation 2.1}$$

4.5 Floors

a. Overall thermal transmittance value (U_0) for gross thermal envelope floor area shall not exceed the value shown in Table 4.1 for floor.
b. A rim joist area of a thermal envelope floor shall be insulated to the same requirement as given for an envelope floor.
c. A rim joist area for a non-thermal envelope floor shall be insulated to the same requirement as given for an above-grade or below-grade envelope wall, as appropriate.
d. Equation 3 shall be used to determine an acceptable combination to meet the required floor U_0-value.

$$U_0 \text{ floor} = \frac{(U_{floor} \times A_{floor})}{A_0} \qquad \text{Equation 3}$$

Where:
U_0floor = the overall thermal transmittance value of the gross floor thermal envelope area expressed as Btu/ft² • hr • °F
A_0 = the gross overall floor thermal envelope area in ft²
U_{floor} = the composite thermal transmittance of all elements of the opaque floor expressed as Btu/ft² • hr • °F
A_{floor} = the gross opaque floor thermal envelope area in ft²

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

$$U_0 \text{ floor} = \frac{(U_{floor\,1} \times A_{floor\,1}) + (U_{floor\,2} \times A_{floor\,2}) + \ldots, \text{etc.}}{A_0} \qquad \text{Equation 3.1}$$

4.6 Slab-on-grade Floors

a. Overall thermal transmittance value (U_0) for a concrete slab floor of a conditioned space or enclosed semiconditioned space shall not exceed the value shown in Table 4.1 for slab-on-grade floor.
b. Insulation material shall have appropriate weather-resistant properties for below-grade application and shall be applied as recommended by the manufacturer. Insulation damaged during construction shall be replaced.
c. Insulation for a thickened edge or grade beam concrete slab floor shall extend downward from the top of the slab to the bottom of the footing, then horizontally beneath the footing for its full width. Alternatively, insulation may extend downward from the top of the slab to

the bottom of the footing, then diagonally out from the footing for a minimum horizontal distance of 18 inches.

d. Horizontally placed insulation under the perimeter of a basement concrete slab floor shall be continuous around the entire perimeter of the slab and shall be a minimum of 24 inches wide. Additionally, a thermal break shall be provided between the foundation wall and the slab edge.

f. A permafrost area requires engineering analysis for proper application of insulation in contact with the ground. Improper application can result in ground thawing and cause severe damage to the structure.

4.7 Framing Factors

a. The following factors may be used for a wood framed wall, ceiling, or floor when calculating the overall U-value required in this chapter. A framing factor accounts for the estimated amount of wood framing contained in an opaque thermal envelope area.
Ceiling or Floor:
18 percent for 2-inch joists at 12 inches on center
10 percent for 2-inch joists at 16 inches on center
6 percent for 2-inch joists at 24 inches on center
10 percent for 2-inch plank and 4-inch beams at 48 inches on center
Wall:
15 percent for 2-inch studs at 16 inches on center
12 percent for 2-inch studs at 24 inches on center

b. Alternatively, a framing factor may be ignored, provided only an insulation R-value is counted. An R-value for an air film or other materials (such as exterior siding or interior finish) shall be ignored along with framing factors.

TABLE 4.1
Maximum Allowable Thermal Envelope U_0-values

Caution: A permafrost area requires engineering analysis for proper application of insulation in contact with the ground.

			Performance Thermal Envelope U_0-value Maximums					
Region Number	Region Name	Heating Fuel	Ceiling	Above grade Wall	Floor	Below grade Wall	Slab Floor Basement	Slab Floor On Grade
1	Southeast	All Fuels	0.024	0.089	0.032	0.066	0.100	0.066
2G	Southcentral	Natural Gas	0.024	0.099	0.046	0.100	0.100	0.100
2A	Southcentral, Aleutian, Kodiak	All Fuels Other Than Natural Gas	0.024	0.085	0.032	0.066	0.100	0.066
3	Interior, Southwest	All Fuels	0.024	0.078	0.028	0.059	0.100	0.066
4	Northwest	All Fuels	0.024	0.073	0.028	0.059	0.100	0.066
5	Arctic Slope	All Fuels	0.018	0.069	0.022			

Chapter 5
Building Budget Method

This chapter sets limits on the total amount of space heating energy used by a building. The Building Budget Method requires a HOT-2000 computer energy use analysis or manual calculations in a format similar to that shown in the Building Energy Efficiency Standard Workbook.

5.1 Submission Requirements

Documents used to determine compliance with the building budget values shown in Table 5.1 may include, but are not limited to: plans and specifications showing details of all pertinent data, features, equipment, and systems of a building including complete descriptions of materials, engineering data, test data, manufacturer's data, and all other data necessary to allow proper identification of components that affect a building's energy use. Submissions lacking sufficient detail to verify a building's energy budget may be rejected.

5.2 Compliance

a. A building designed in accordance with this option shall not exceed the Btu budget given in Table 5.1 expressed in Btu per square foot of floor area of conditioned space per year. Compliance shall be verified by a hard copy printout of a HOT-2000 analysis or copies of manual calculations. Copies of the HOT-2000 computer program may be obtained from:

   Alaska Craftsman Home Program, Inc.
   900 West Fireweed Lane, Suite 201
   Anchorage, AK 99504
   Telephone (907) 258-2247
   (800) 699-9276 within Alaska

b. A heat recovery ventilator (air-to-air heat exchanger) included in the design of a building can lower the building's heat loss. This energy savings, in Btu's, may be used to trade off (lower) a thermal envelope insulation requirement while still meeting the maximum heat loss budget given in Table 5.1. However, no thermal envelope assembly, such as a ceiling, skylight, wall, window, door, or floor shall have an R-value level lower than 80 percent of that given in Chapter 3, Table 3.2, Prescriptive Envelope R-value Requirements, except a log wall (not a window or a door) is exempt from this requirement.

c. A heat loss maximum shall be verified by dividing the Gross Space Heating Load, as listed in the HOT-2000 printout under Annual Space Heating Summary, by a building's total conditioned space floor area.

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

5.3 Design Parameters

The following design parameters shall be used in conjunction with the HOT-2000 computer energy use program:

a. Indoor design dry bulb temperature shall be set no lower than 70˚F for space heating;

b. Select heating degree days, outdoor design dry bulb temperature, solar gains, internal gains, and other data inputs from the HOT-2000 data base menu and other sources that most closely approximate the long term conditions expected for the structure or site.

TABLE 5.1
Minimum R-Values, 80% of Table 3.2

Region Number	Region Name	Heating Fuel	Building Budget Thermal Envelope R-Value Requirements: Ceiling	Above grade Wall	Floor[1]	Below grade Wall[1]	Slab Floor[1]: Basement	Slab Floor[1]: On Grade	Window	Door[2]
1	Southeast	All Fuels	30	16	24	12	8	12	2.4	2.5, 5.6
2G	Southcentral	Natural Gas	30	14	15	8	8	8	2.4	2.5, 5.6
2A	Southcentral, Aleutian, Kodiak	All Fuels Other Than Natural Gas	30	20	24	12	8	12	2.4	2.5, 5.6
3	Interior, Southwest	All Fuels	30	20	30	15	8	12	2.4	5.6
4	Northwest	All Fuels	30	24	30	15	8	12	2.4	5.6
5	Arctic Slope	All Fuels	41	28	34	—	—	—	2.4	5.6

Note 1: It is not required that the floor and the below-grade wall both be insulated. Generally, one or the other is insulated.

Note 2: Not more than one exterior door in a residential building in Region 1, 2G, or 2A may have an R-value less than 5.6 but not less than 2.5.

TABLE 5.2
Maximum Allowable Heat Loss
(BTU/ft² of floor area/year)[1]
These Heat Loss maximums are for space heating only.

Region Number	Region Name	Heating Fuel	Detached Single-Family Building	Multi-family and Community Building
1	Southeast	All Fuels:		
		crawl space[2]	28,750	11,900
		exposed floor[3]	21,600	9,500
		basement[4]	21,000	11,700
2G	Southcentral	Natural Gas:		
		crawl space[2]	42,050	20,000
		exposed floor[3]	34,500	17,800
		basement[4]	30,400	18,000
2A	Southcentral, Aleutian, Kodiak	All Fuels Other Than Natural Gas:		
		crawl space[2]	36,000	15,700
		exposed floor[3]	27,600	12,800
		basement[4]	25,800	14,900
3	Interior, Southwest	All Fuels:		
		crawl space[2]	67,650	33,300
		exposed floor[3]	39,050	22,200
		basement[4]	35,200	23,300
4	Northwest	All Fuels	43,100	26,400
5	Arctic Slope	All Fuels	57,100	38,100

NOTES:

1. The gross floor area of all conditioned spaces and including a basement.
2. Where a crawl space wall is insulated rather than the floor and a crawl space is heated indirectly by heat loss through a floor.
3. Where a floor is insulated and the crawl space is unheated.
4. Basement wall insulated down to the footing.

Chapter 6
Energy Rated Homes Method

Compliance with this Standard for a residential building may be shown through a rating from the Energy Rated Homes of Alaska program.

6.1 Rating Requirements

a. A building shall achieve at least a Four Star rating on the Energy Rated Homes of Alaska rating sheet. On January 1, 1995 the requirement shall be increased to Four Star Plus.
b. A structure shall achieve a level C, D, or E air tightness rating on an Energy Rated Homes of Alaska rating sheet.
c. Only a person trained and certificated by the Energy Rated Homes of Alaska program shall submit a rating for compliance. A copy of the Energy Rated Homes of Alaska energy rating shall be provided to state officials. A list of persons certificated by Energy Rated Homes of Alaska may be obtained from:
   Alaska Housing Finance Corporation
   520 E. 34th Avenue
   Anchorage, AK 99503
   (907) 338-6100 or
   (800) 478-INFO or (800) 478-AHFC within Alaska
d. A building shall comply with ventilation requirements in Chapter 2 of this Standard. A rater shall specify which of the two ventilation options was used.

Chapter 7
Definitions

(These are for BEES. See also Appendix E, Glossary)

1. Above-grade W all is any portion of a thermal envelope wall more than 12 inches above an adjacent finished grade.
2. 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 and/or the effect of differences in indoor and outdoor air density.
3. 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.
4. Below-grade W all is any portion of a wall which extends no more than 12 inches above an adjacent finished grade.
5. 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.
6. Ceiling is a group of members which define the boundaries of a space and has a slope of 60 degrees or less from the horizontal plane.
7. Conditioned Space is a room or other enclosed space which is intentionally or unintentionally heated to a temperature of 50 degrees Fahrenheit or higher. A bedroom, living room, or kitchen is an example of a conditioned space.
8. 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.
9. 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.
10. Energy Rated Homes of Alaska is a national program developed by Energy Rated Homes of America and adapted for use in Alaska. The program is a public/private partnership between Alaska Housing Finance Corporation and the Alaska State Homebuilders Association. Energy Rated Homes of Alaska uses trained persons to survey and rate residential buildings for their energy efficiency. There are ten rating levels—from a low of One Star to the highest at Five Star Plus.
11. 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 glazed portion of a door.
12. Gross Ceiling Thermal Envelope Area is the sum of all ceiling thermal envelope areas, including the area directly above exterior walls.
13. Gross Floor Thermal Envelope Area is the sum of all floor thermal envelope areas, including a basement, mezzanine, or intermediate floored tier of headroom height, measured from the exterior face of an envelope wall or from the center line of a wall separating a building, but not including:
    - A covered walkway, open roofed-over area, porch, or similar space;
    - An exterior terrace, step, chimney, roof overhang, or similar feature.
14. Gross W all Thermal Envelope Area is the sum of all wall thermal envelope areas including opaque wall areas, window areas, and door areas and 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/ceiling structural member.

15. Heating Degree Days (HDD65) is a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying the nominal heating load of a building in winter. For any one day, when the mean temperature is less than 65 degrees 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.
16. HOT-2000 is a computer-based energy use analysis program developed by Canada for use in the R-2000 building program.
17. Opaque Thermal Envelope Area is all thermal envelope areas except openings for glazed area (windows, skylights, or sliding glass doors) or door area.
18. 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.
19. R_0-value is a measure of the overall ability of a gross area to resist heat flow. Heat may flow through various materials along various parallel paths. R_0 is the numerical reciprocal of U_0. Thus, $R_0 = 1/U_0$; expressed as ft • hr • ˚F/Btu.
20. Semiconditioned Space is a room or other enclosed space which 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.
21. Skylight Area is an opening in a roof surface which is glazed with a transparent or translucent material, including the frame.
22. 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.
23. Thermal Envelope is an assembly of a building which is exposed to conditioned or semiconditioned space on one side and the outdoor environment on the other.
24. Thermal T ransmission 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/hr.
25. Unconditioned Space is a room or other enclosed space which is not intentionally heated and generally experiences temperatures of 50˚F or less.
26. 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.
27. U_0-value is the overall thermal transmittance of a gross area of a thermal envelope, expressed as Btu/ft • hr • ˚F. U_0-value applies to the combined effect of the time rate of heat flow through various parallel paths.
28. 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.
29. Wall is a group of members which define the boundaries of a building or space and which has a slope of 60 degrees or greater from the horizontal plane.
30. Window Area is an opening (other than a door) in a wall surface which is glazed with a transparent or translucent material, including the framing or sash.

Appendix B
Log Building Standards

(from Canadian and American Log Builders Association)

Appendix B
Log Building Standards

1996 Log Building Standards
for Residential, Handcrafted, Interlocking, Scribe-fit Construction

Canadian and American Log Builders Association

The association, founded in 1974, is a worldwide 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 1996.

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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.

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Standards

Preface

1. In these standards the word "shall" means mandatory, and the word "may" means discretionary.
2. The 1996 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-quarter (1/4) of the vertical height of the wall.

c. Right-hand severe spiral grain logs shall not be used for splicing, and shall be used only in the lowest one-

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.

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quarter (1/4) of the vertical 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 in the top round of logs.

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

f. The top round of 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°

2.B. Log Walls

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

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 right 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.

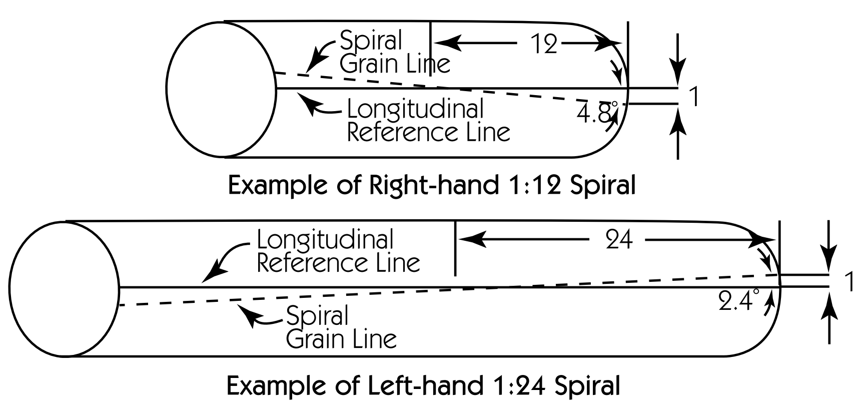

Figure 2.A

Standards

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 bearing 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 have gaskets, 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 width shall extend for no more than 30.5 centimeters (12 inches) in continuous length, at which point a wider long groove shall continue. At all times, however, the long groove shall conceal and protect through-bolts, pins, dowels, kerfs, electrical

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, Piece en Piece, 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,

Standards

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 no more than one-quarter ($^1/_4$) the diameter of the log (see also Section 2.J.2).

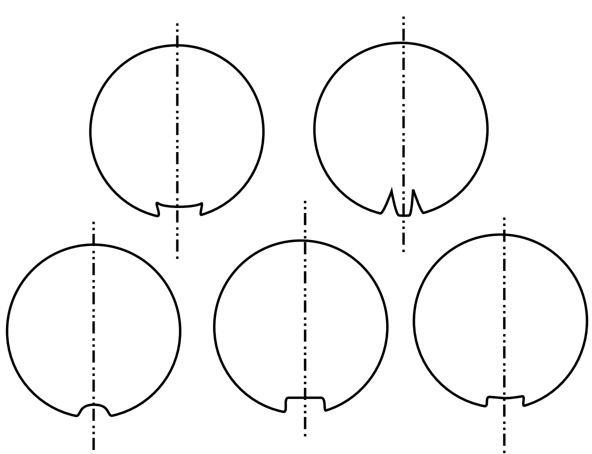

Figure 2.D

Commentary

in contrast, has a continuous 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 have gaskets 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).

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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, then 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 or other means.

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

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 that preserves 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.

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.

Commentary

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 more stable laterally 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.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.

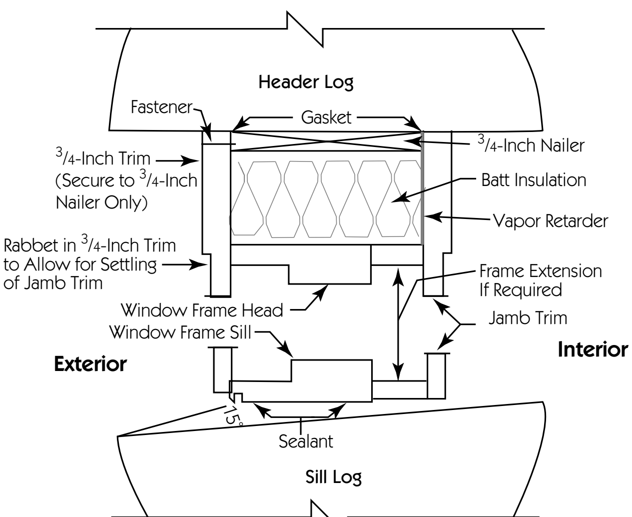


Figure 2.H

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 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

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. The number, type, size and spacing of mechanical fasteners used for this purpose must be determined by accepted engineering practice. Continuous gable end plate logs are very effective at resisting roof thrust, and so are recommended when it is necessary to counteract these forces. When continuous gable end plate logs are not used, or are not used in a manner that will resist roof thrust, this force must be restrained or eliminated by other methods.

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 re-

Standards

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-half ($^1/_2$) 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.

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

Commentary

quired 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.

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 the 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 usually 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 $^1/_2$ 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 no more 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 no more

Standards

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 as in Figure 2.D. #2, as long as the groove and kerf along the top of the log is at least $^1/_4$ of the diameter of the log.

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.

Commentary

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 or by a notch (also see Section 2.D.3). In practical terms, this means that kerfs are never visible in a completed wall.

2.J.4. The kerf should run the full length of the top of every log, either stopping before reaching a notch or continuing through a notch. 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 still 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.

Standards

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.

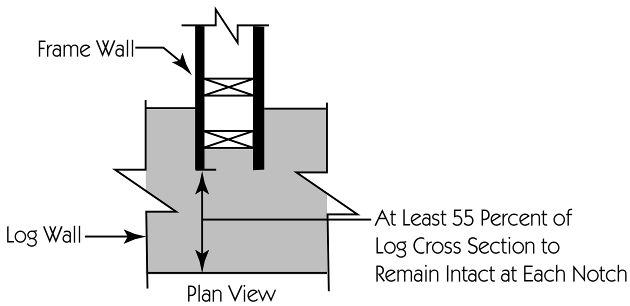


Figure 2.K.1

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.

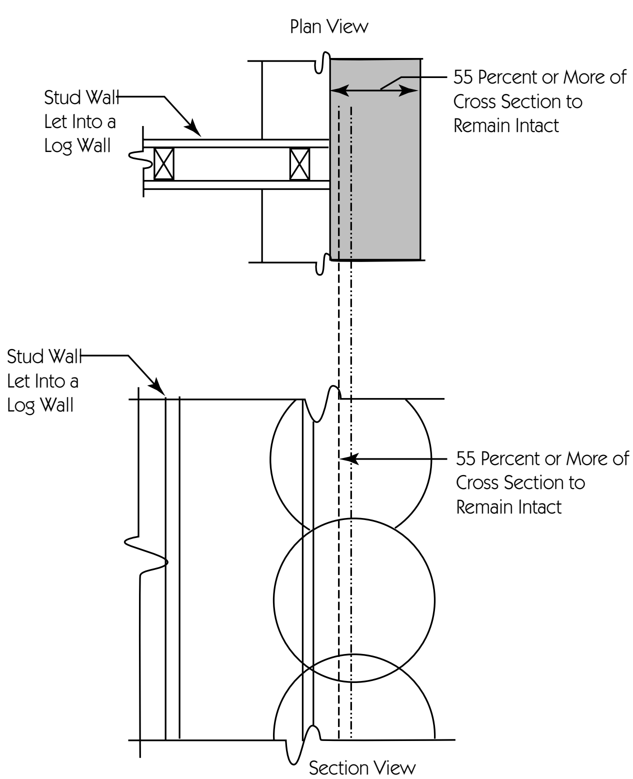


Figure 2.K.2

Commentary

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.

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.

Standards

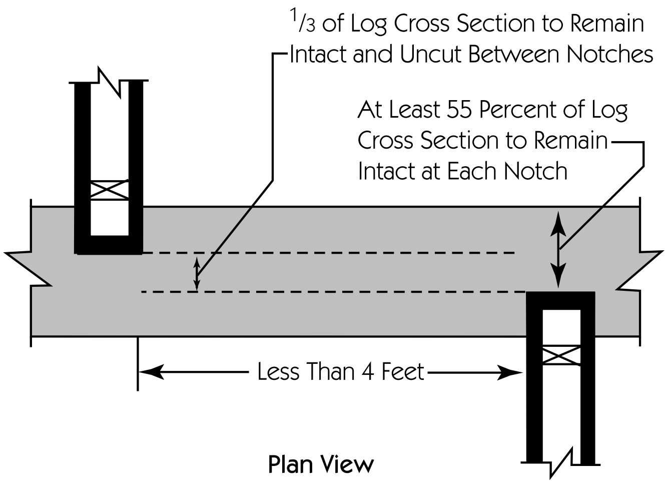


Figure 2.K.3

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.

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.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.)

2.L. Tall log walls should be closely evaluated 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.
- 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.

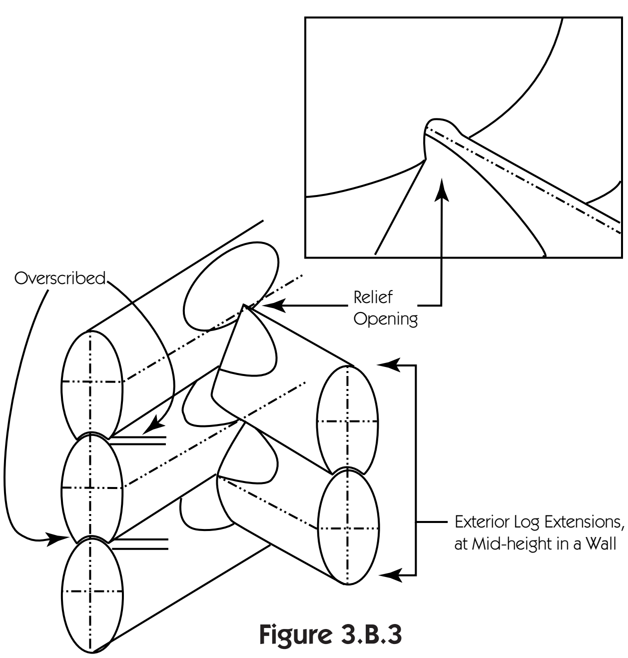


Figure 3.B.3

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 also 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.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:

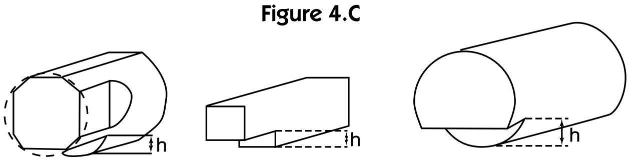
4.B.1. Shall have straight grain or shall be right-hand spiral grain with spiral no more than 1:12, and shall be of sound wood. (See Section 2.A.4 for more on spiral grain.)

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.

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.

Figure 4.C



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.

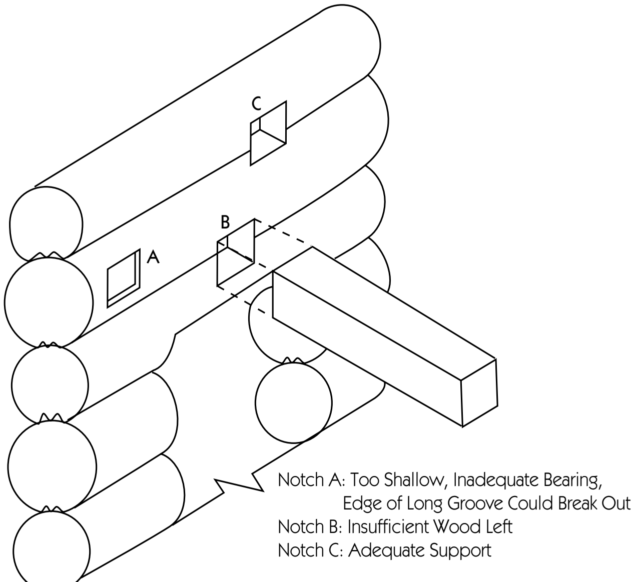


Figure 4.D

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.

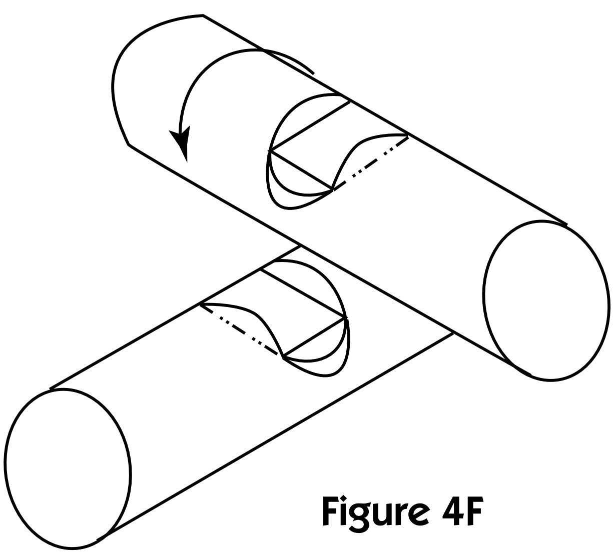


Figure 4F

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.

Standards

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.

4.H. Log joists and beams shall be flattened on top to a minimum of 2.5 centimeters (1 in.) 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 after all settling is completed. A vapor barrier shall be installed within this space, on the heated side of the insulation.

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

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.

Commentary

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

Standards

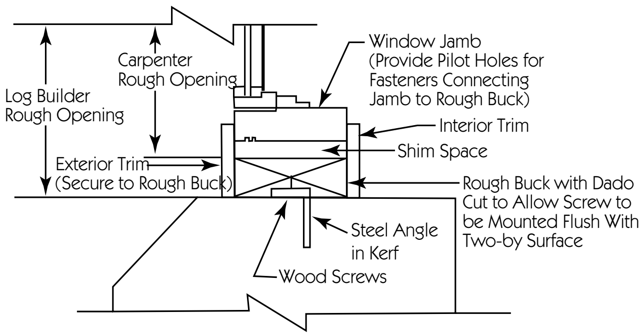


Figure 5.D.1

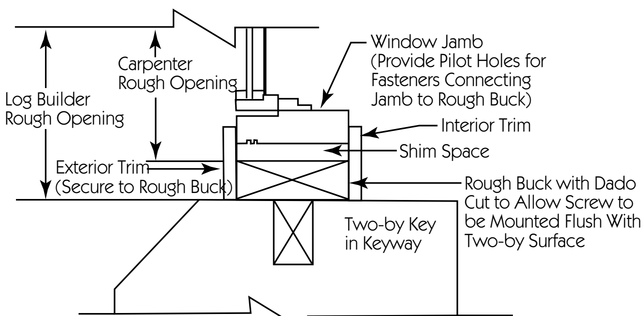


Figure 5.D.2

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).

Commentary

the height of the bucks is less 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 hold the bucks in place and because they laterally stabilize the log wall at openings: they restrict logs from moving horizontally while still allowing logs to move vertically. See Figures 5.D.1 and 5.D.2.

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, unless they are part of a column and screw jack settling system.

Standards

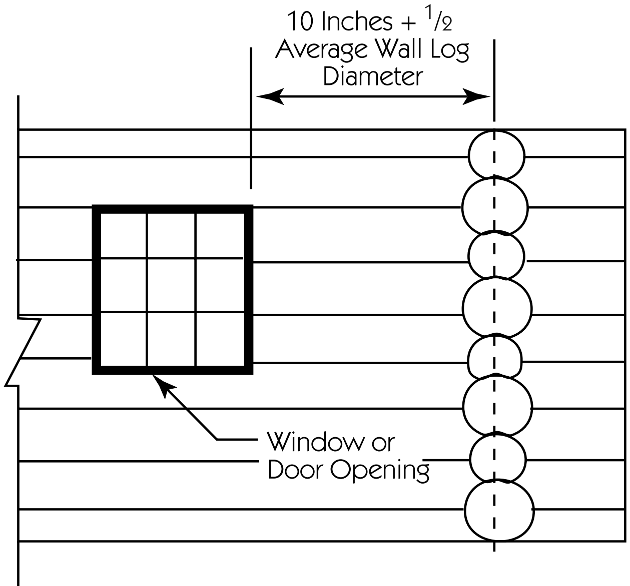


Figure 5.F

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.

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 time needed to reach 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 (more than 15 meters (50 feet) long), 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 "green" log, but these two logs will obviously differ very little in the amount

Standards

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, kitchen cabinets 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

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

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.

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 ($1^1/_2$ inches) where they support lumber or finish materials.

Commentary

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.

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.

Standards

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.

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.)

Commentary

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.

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 (8:1) 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 8-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 8-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 by 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 8-to-1 ratio, if desired, though they are not required to do so. At all points around a building, this 8-to-1 reference line should be used, and no log or log end should project beyond this reference line.

Standards

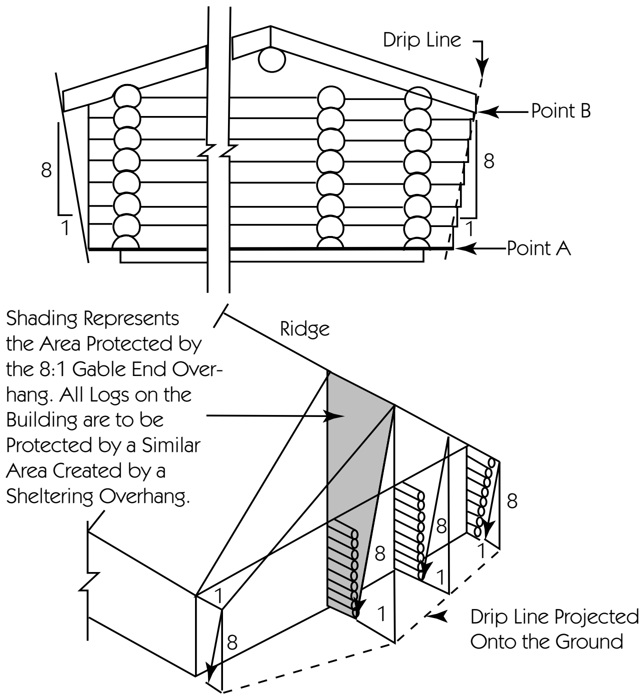


Figure 7.D

Commentary

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.

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 $1^{1}/_{2}$ 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 often 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).

Standards

Section 8 Electrical

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

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.

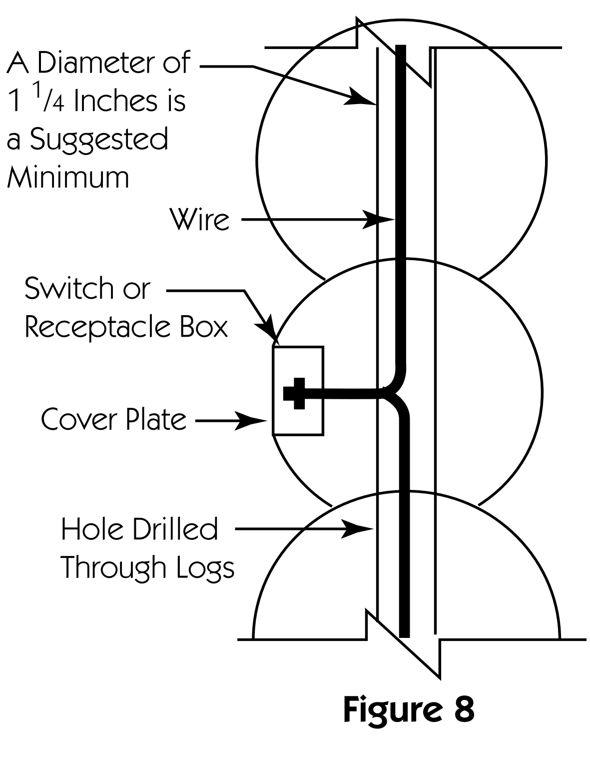


Figure 8

Commentary

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 1/4 inches is often used as a minimum). Do not use conduit inside a log wall. Do not attach conduit to a log wall surface 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.

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 approximately 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 may leak, and because the venting of sewer gases is a matter of health and safety, it is best to not locate any plumbing in log walls.

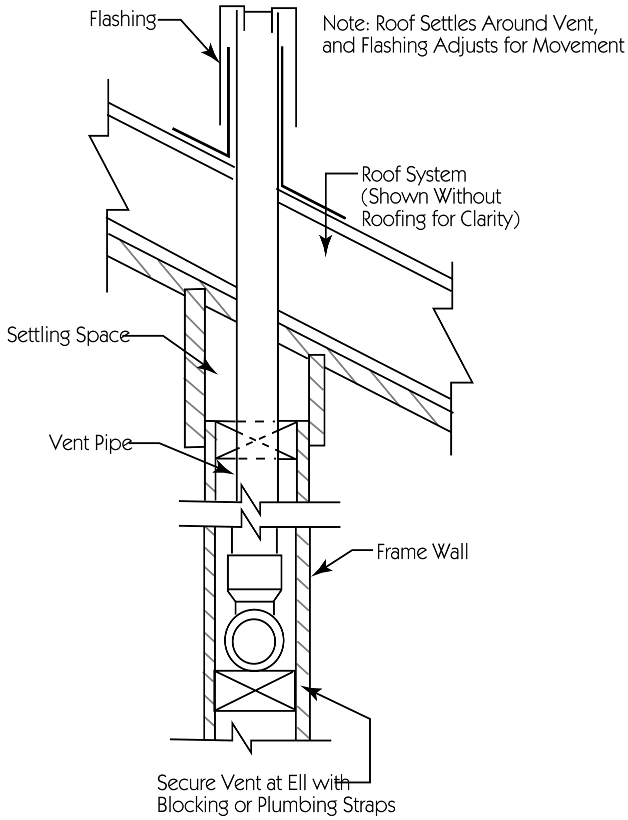


Figure 9.A
Use of roof flashing to allow for settling in a straight run of vent pipe.

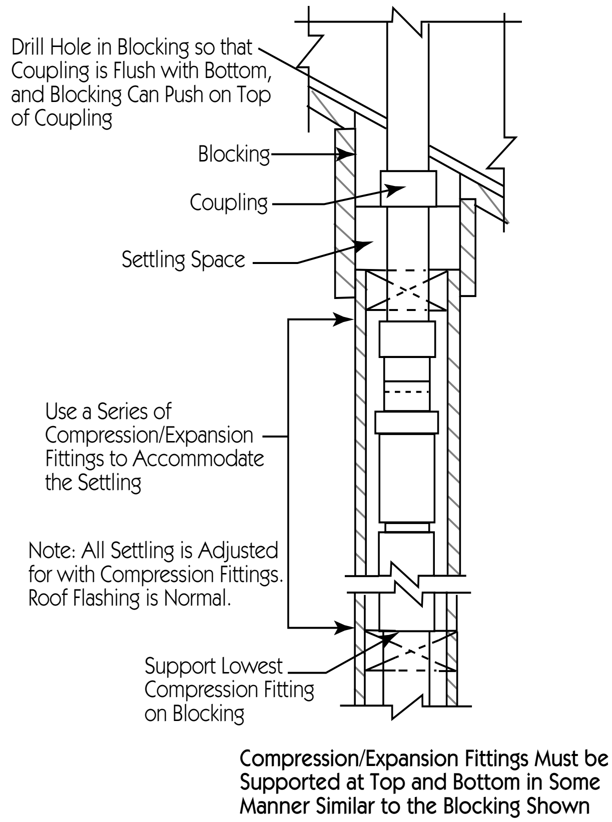


Figure 9.B
Use of compression and expansion fittings to allow for settling.

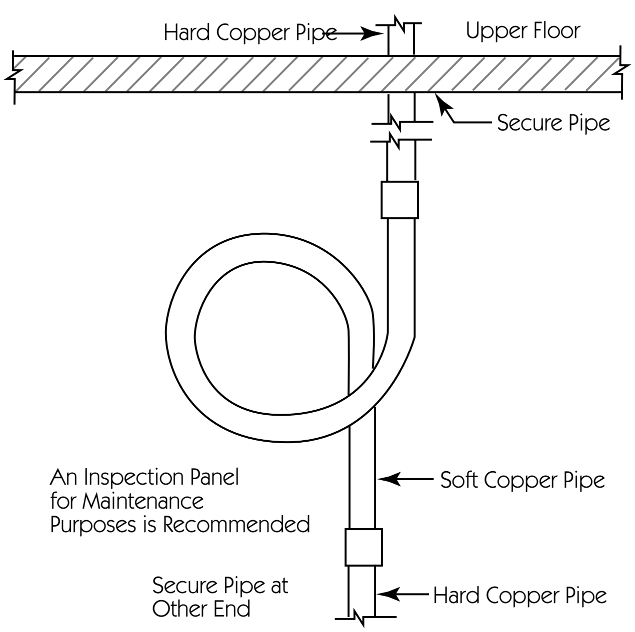


Figure 9.C
Use of a combination of hard and soft copper pipe to allow for settling in water supply lines. Pipe

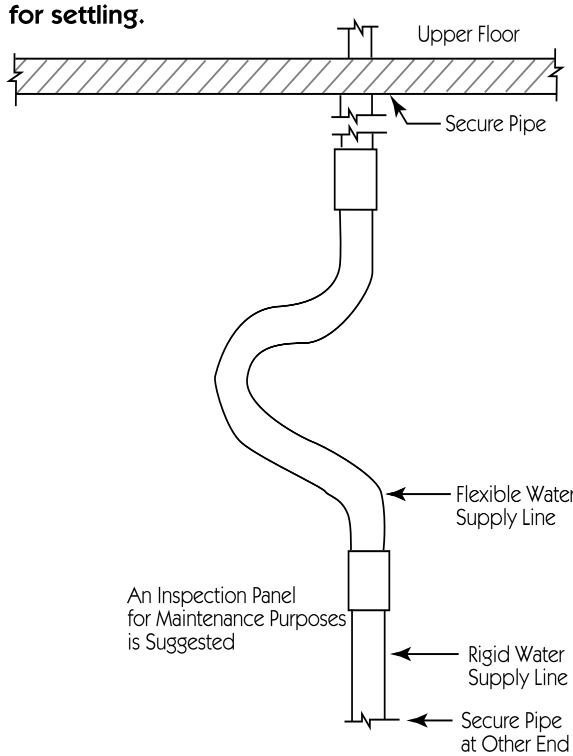


Figure 9.D
Use of a combination of flexible water supply line and rigid pipe to allow for the needed settling.

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.

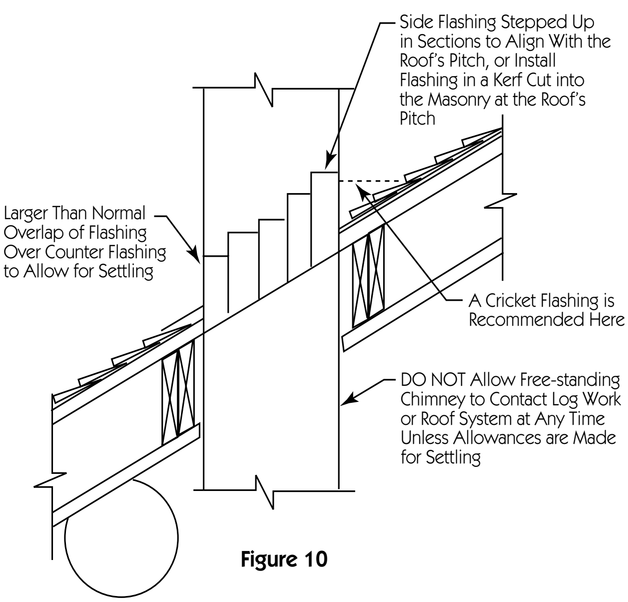


Figure 10

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 very tall areas of flashing can be exposed (30 centimeters (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 and purlins.

Executives of the American Log Builders Association

President

Ed Shure, 300 N. 63rd St., Boulder, CO 80301; (303) 449-1336

Vice President

Del Radomske; RR #5 S-13 C-9, Philpott Rd., Kelowna, BC Canada V1X 6K4; (604) 765-5166

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John Boys, 3388 Boyd Rd., Merritt, BC Canada V0K 2B0; (604) 378-4977
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Brian Lloyd, 9635 Whitepoint Rd., Vernon, BC Canada V1T 6Y5; (604) 542-6050
Duane Sellman, 24411 Esquire Rd., Forest Lake, MN 55025; (612) 464-3843
Wayne Sparshu, RR #2, Barrhead, AB Canada T0G 0E0; (403) 674-4813
Pat Wolfe, RR #3, Ashton, ON Canada K0A 1B0; (613) 253-0631

Affiliated Organizations:

Great Lakes LogCrafters Association
PO Box 86
Grand Rapids, MN 55744

Rocky Mountain Log Builders Association
c/o Paul Wellman
PO Box 771253
Steamboat Springs, CO 80477

New Zealand Log Builders Association
c/o Angus McCallum
Rural Delivery 2
Masterton, New Zealand

Korean Log Builders Association
Jay W. Yu
Woorim Bldg. 90-10 Banpo-Dong
Su Cho-ku, Seoul
Korea

Association of Latvian Craft
c/o Ivars Strautins
Rozu-iela 21-27
Riga, Latvia LV-1056

Inquiries, comments, suggestions, and additional recommendations are welcomed. Technical questions may be addressed to:

Robert Chambers, N 8203 1130th St., River Falls, WI 54022; (715) 425-1739
Del Radomske, RR #5 S-13 C-9, Philpott Rd., Kelowna, BC Canada V1X 6K4; (604) 765-5166
Tom Hahney, 7928 Lynwood Dr., Ferndale, WA 98248; (360) 354-5840

Appendix C
Sample Energy Ratings Using AkWarm

The following sample energy ratings were done by Phil Kaluza, energy specialist for the Alaska Housing Finance Corporation, using AkWarm software. They represent a small log home that meets the Buildng Energy Efficiency Standards (BEES), a five-star rated and a five-star plus rated log home. They are intended to provide guidance on how a log home might meet these standards. These examples use the minimum size logs that still meet the standards. These are examples only. Each home design should have its plans rated, since local weather data will change energy use.

LOG HOME COMPARISONS

Four Star Plus Home (BEES) 83 points

	Southeast	Southcentral	Interior
Below grade floor perimeter insulation (blueboard)	2' - 4" (2"in, 2"out)	none	2' - 4" (2"in, 2"out)
Below grade floor center insulation	none	none	none
Below grade wall insulation (blueboard)	2"	2"	3"
Above grade log wall diameter	6"	6"	8"
Exterior door	steel insulated	steel insulated	steel insulated
Window - non south 80 sqft	R-3, LowE	R-3, LowE	R-3, LowE
Window - south 60 sqft	R-3, LowE	R-3, LowE	R-3, LowE
Ceiling Insulation	R-49	R-49	R-49
Air Leakage ach50	4 ACH@50	4 ACH@50	4 ACH@50
Ventilation	non-hrv	non-hrv	non-hrv
Space Heating - efficient boiler w/cold boiler control	85% AFUE	84% AFUE	85% AFUE
H20 heater - integrated	.8 EF	.79 EF	.8 EF

Five Star Home 88 points

	Southeast	Southcentral	Interior
Below grade floor perimeter insulation (blueboard)	2' - 4" (2"in, 2"out)	2' - 4" (2"in, 2"out)	2' - 4" (2"in, 2"out)
Below grade floor center insulation	none	none	none
Below grade wall insulation (blueboard)	4"	4"	4"
Above grade log wall diameter	8"	8"	10"
Exterior door	steel insulated	steel insulated	steel insulated
Window - non south 80 sqft	R-3, LowE	R-3, LowE	R-4, HM88
Window - south 60 sqft	R-3, LowE	R-3, LowE	R-4, HM88
Ceiling Insulation	R-49	R-49	R-60
Air Leakage ach50	2 ACH@50	4 ACH@50	1.8 ACH@50
Ventilation	hrv	non-hrv	hrv
Space Heating - boiler	85% AFUE	84% AFUE	85% AFUE
H20 heater - integrated	.8 EF	.79 EF	.8 EF

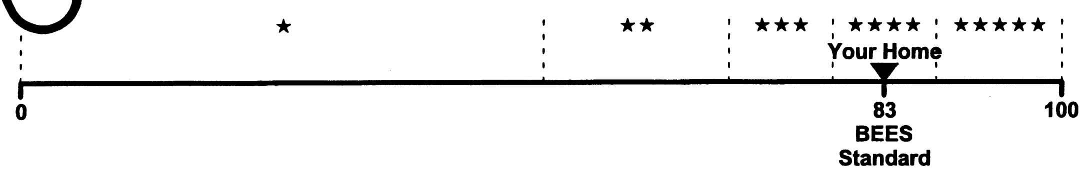
HOME ENERGY RATING CERTIFICATE

Alaska Housing
FINANCE CORPORATION

The Home Located At:
xxx
Juneau, Alaska

Has Been Energy Rated As:
★★★★+
Four Stars Plus

Overall Efficiency of Home
83.0 points



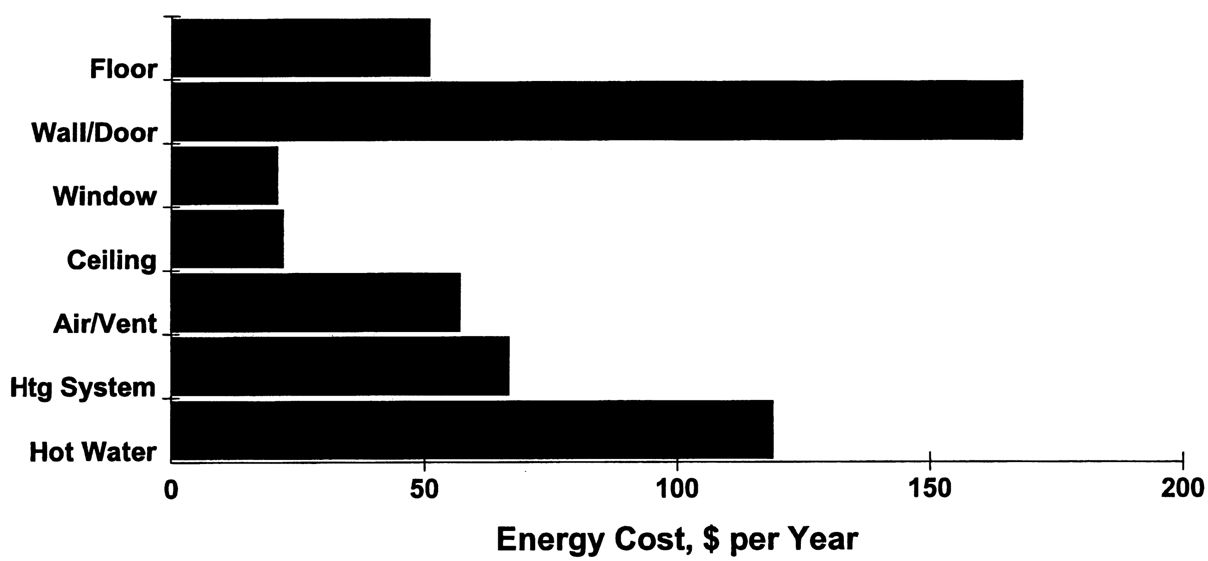
Projected Annual Energy Costs

$1,079 per year

Amount of CO2 Produced by the Home

9,221 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property:	Log Home xxx Juneau, Alaska	**Rater:**	Phil Kaluza Alaska Housing Finance Corp. 4300 Boniface PKWY Anchorage, AK 99504
House:	Single Family Living Floor Area: 837 square feet No Attached Garage	**Rating:**	Proposed from Plans

---

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-22 *
Wall/Door Insulation	R-9.1 *
Ceiling Insulation	R-51
Window R-Value	R-3.0
Window to Wall Ratio, Living Space	13.7%
South Facing Window Area	60 square feet
Air Leakage	4.0 Air Changes per Hour at 50 Pascals 0.19 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	85%
Fuel Type	#1 Oil
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	80%
Location	Conditioned Space
Fuel Type	#1 Oil

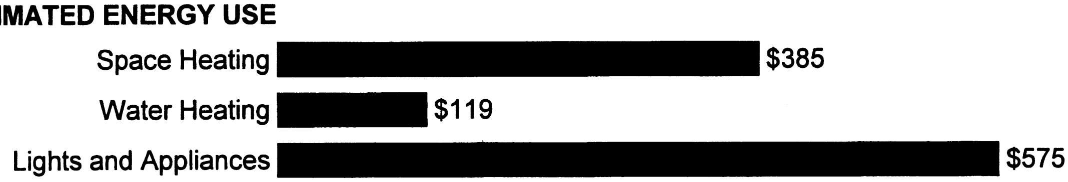
Ventilation

System Type	Continuous Ventilation without Heat Recovery

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	109 kWh of Electricity, 329 gallons of #1 Oil
Water Heating	104 gallons of #1 Oil
Lights and Appliances	6,017 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

4 Star Plus Home:

below floor perimeter 2' - 4" (2"in, 2"out)
below floor center - none
below wall - 2" blueboard
above wall - 6" logs
doors - steel insulated
Windows non-south 80sqft, R-3, LowE
Windows south 60 sqft, R-3, LowE
ceiling R-49
air leakage - 4 ach, non-hrv
heater - 85% boiler with indirect h20 heater

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Juneau, AK 99801

ANNUAL ENERGY FLOWS

Gross Loss: 64.9 MMBtu

Gross Internal: 20.1 MMBtu
Useable Internal: 20.0 MMBtu
Internal Utiliz.: 0.993

Gross Solar: 9.2 MMBtu
Useable Solar: 7.7 MMBtu
Solar Utiliz.: 0.840

Net Heat Load: 37.2 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 286.5 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 19,766 Btu/hr

HOME ENERGY RATING CERTIFICATE

Alaska Housing Finance Corporation

The Home Located At:

xxx

Juneau, Alaska

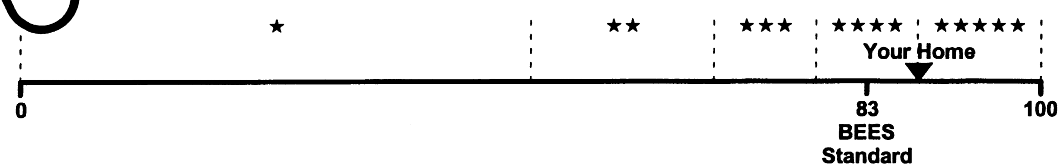
Has Been Energy Rated As:

★★★★★

Five Stars

Overall Efficiency of Home

88.1 points



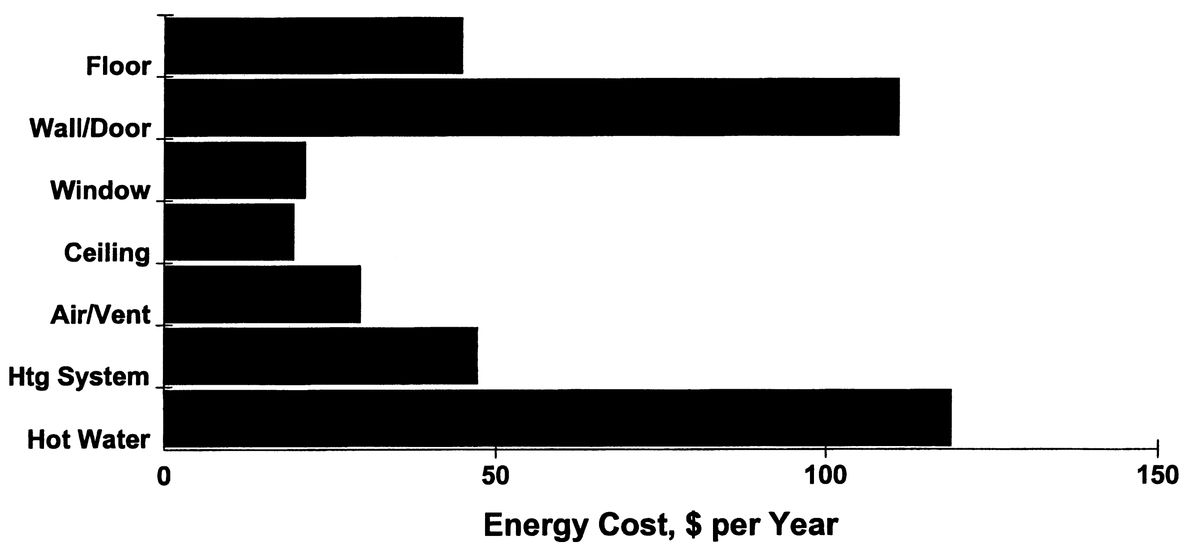
Projected Annual Energy Costs

$981 per year

Amount of CO2 Produced by the Home

7,197 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property:	Log Home xxx Juneau, Alaska	**Rater:**	Phil Kaluza Alaska Housing Finance Corp. 4300 Boniface PKWY Anchorage, AK 99504
House:	Single Family Living Floor Area: 837 square feet No Attached Garage	**Rating:**	Proposed from Plans

---

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-22 *
Wall/Door Insulation	R-12.2 *
Ceiling Insulation	R-51
Window R-Value	R-3.0
Window to Wall Ratio, Living Space	13.7%
South Facing Window Area	60 square feet
Air Leakage	2.0 Air Changes per Hour at 50 Pascals 0.10 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	85%
Fuel Type	#1 Oil
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	80%
Location	Conditioned Space
Fuel Type	#1 Oil

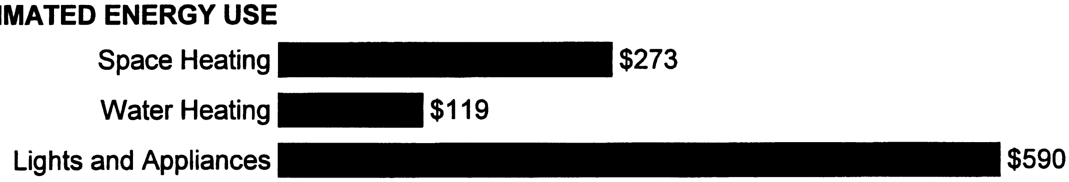
Ventilation

System Type	Heat Recovery Ventilator

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	77 kWh of Electricity, 233 gallons of #1 Oil
Water Heating	104 gallons of #1 Oil
Lights and Appliances	6,203 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

5 Star Home:

below floor perimeter 2' - 4" (2"in, 2"out)
below floor center - none
below wall - 4" blueboard
above wall - 8" logs
doors - steel insulated
Windows non-south 80sqft, R-3 LowE
Windows south 60 sqft, R-3 LowE
ceiling R-49
air leakage - 2 ach, hrv
heater - 85% boiler with indirect h20 heater

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Juneau, AK 99801

ANNUAL ENERGY FLOWS

Gross Loss: 52.8 MMBtu

Gross Internal: 20.1 MMBtu
Useable Internal: 19.7 MMBtu
Internal Utiliz.: 0.978

Gross Solar: 8.8 MMBtu
Useable Solar: 6.7 MMBtu
Solar Utiliz.: 0.767

Net Heat Load: 26.4 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 233.3 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 16,100 Btu/hr

Alaska Housing
FINANCE CORPORATION

HOME ENERGY RATING CERTIFICATE

The Home Located At:

xxx

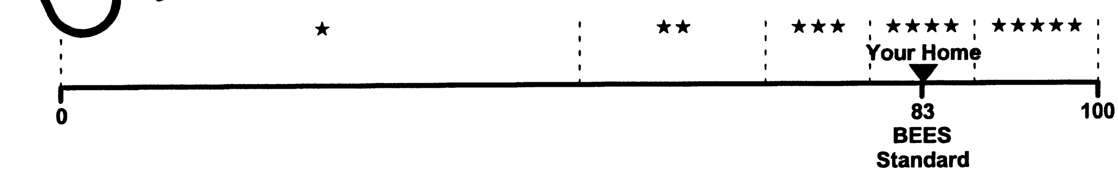
Palmer, Alaska

Has Been Energy-Rated As:

★★★★+

Four Stars Plus

Overall Efficiency of Home
83.1 points



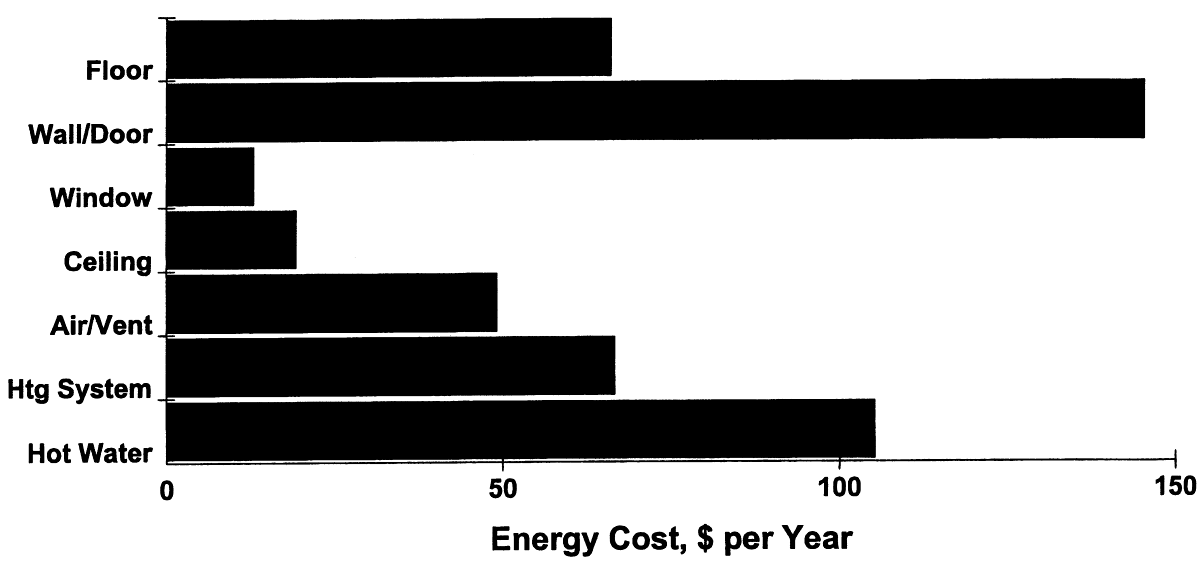
Projected Annual Energy Costs

$1,221 per year

Amount of CO2 Produced by the Home

17,009 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property: Log Home
xxx
Palmer, Alaska

Rater: Phil Kaluza
Alaska Housing Finance Corp.
4300 Boniface PKWY
Anchorage, AK 99504

House: Single Family
Living Floor Area: 837 square feet
No Attached Garage

Rating: Proposed from Plans

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-14.9 *
Wall/Door Insulation	R-9.1 *
Ceiling Insulation	R-51
Window R-Value	R-3.0
Window to Wall Ratio, Living Space	13.7%
South Facing Window Area	60 square feet
Air Leakage	4.0 Air Changes per Hour at 50 Pascals
	0.22 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	84%
Fuel Type	Natural Gas
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	79%
Location	Conditioned Space
Fuel Type	#1 Oil

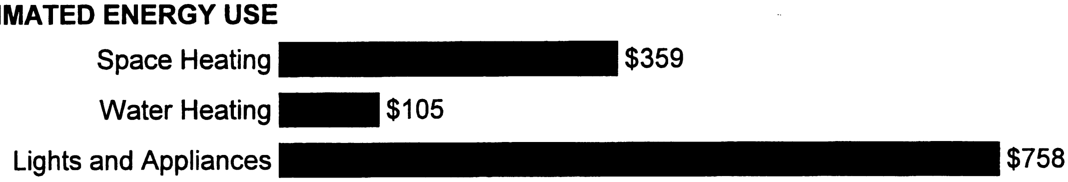
Ventilation

System Type	Continuous Ventilation without Heat Recovery

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	86 kWh of Electricity, 696 ccf of Natural Gas
Water Heating	106 gallons of #1 Oil
Lights and Appliances	5,997 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

4 Star plus Home:

below floor perimeter none
below floor center - none
below wall - 2" blueboard
above wall - 6" logs
doors - steel insulated
Windows non-south 80sqft, R-3, LowE
Windows south 60 sqft, R-3, LowE
ceiling - R-49
air leakage - 4 ach, hrv
heater - 84% boiler with indirect h20 heater

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Palmer, AK 99645

ANNUAL ENERGY FLOWS

Gross Loss: 90.8 MMBtu

Gross Internal: 20.3 MMBtu
Useable Internal: 20.3 MMBtu
Internal Utiliz.: 0.999

Gross Solar: 13.3 MMBtu
Useable Solar: 11.7 MMBtu
Solar Utiliz.: 0.876

Net Heat Load: 58.8 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 306.2 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 26,947 Btu/hr

Alaska Housing FINANCE CORPORATION

HOME ENERGY RATING CERTIFICATE

The Home Located At:

xxx

Palmer, Alaska

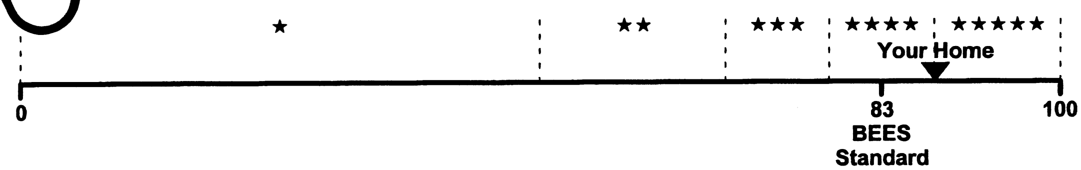
Has Been Energy Rated As:

★★★★★

Five Stars

Overall Efficiency of Home

88.1 points



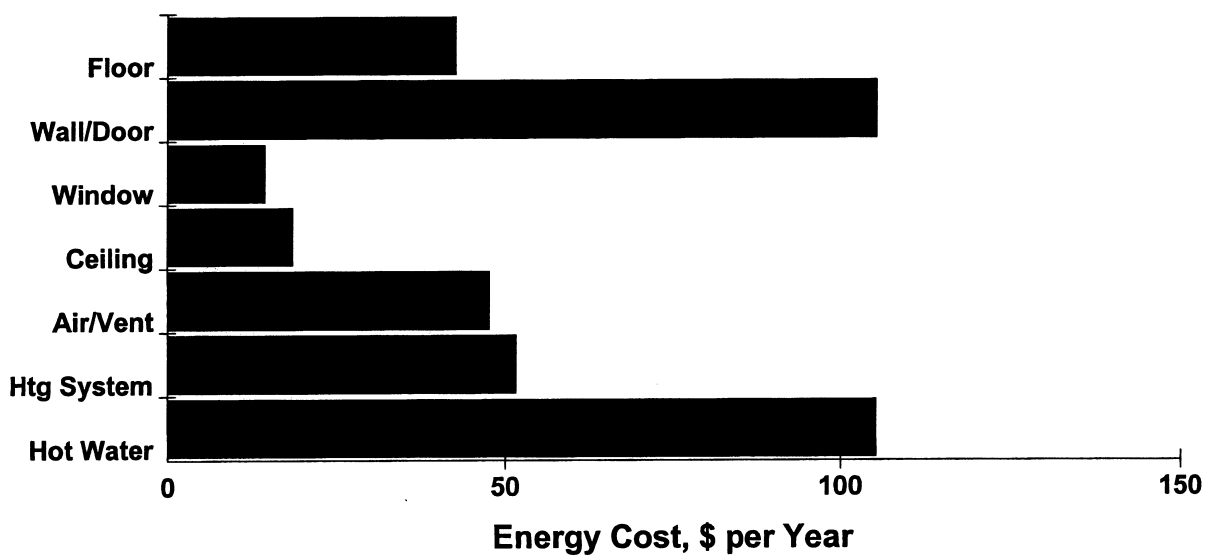
Projected Annual Energy Costs

$1,143 per year

Amount of CO2 Produced by the Home

14,901 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property: Log Home
xxx
Palmer, Alaska

Rater: Phil Kaluza
Alaska Housing Finance Corp.
4300 Boniface PKWY
Anchorage, AK 99504

House: Single Family
Living Floor Area: 837 square feet
No Attached Garage

Rating: Proposed from Plans

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-22 *
Wall/Door Insulation	R-12.2 *
Ceiling Insulation	R-51
Window R-Value	R-3.0
Window to Wall Ratio, Living Space	13.7%
South Facing Window Area	60 square feet
Air Leakage	4.0 Air Changes per Hour at 50 Pascals 0.22 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	84%
Fuel Type	Natural Gas
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	79%
Location	Conditioned Space
Fuel Type	#1 Oil

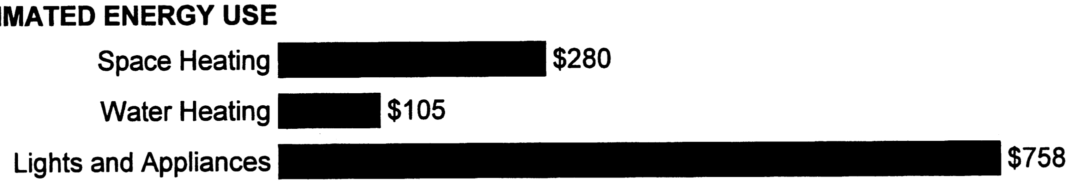
Ventilation

System Type	Continuous Ventilation without Heat Recovery

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	64 kWh of Electricity, 516 ccf of Natural Gas
Water Heating	106 gallons of #1 Oil
Lights and Appliances	5,997 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

5 Star Home:

below floor perimeter 2' - 4" (2"in, 2"out)
below floor center - none
below wall - 4" blueboard
above wall - 8" logs
doors - steel insulated
Windows non-south 80sqft, R-3, LowE
Windows south 60 sqft, R-3, LowE
ceiling - R-49
air leakage - 4 ach, non-hrv
heater - 84% boiler with indirect h20 heater

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Palmer, AK 99645

ANNUAL ENERGY FLOWS

Gross Loss: 74.4 MMBtu

Gross Internal: 20.3 MMBtu
Useable Internal: 20.2 MMBtu
Internal Utiliz.: 0.993

Gross Solar: 12.8 MMBtu
Useable Solar: 10.6 MMBtu
Solar Utiliz.: 0.826

Net Heat Load: 43.6 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 250.4 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 22,036 Btu/hr

HOME ENERGY RATING CERTIFICATE

Alaska Housing FINANCE CORPORATION

The Home Located At:

xxx

Fairbanks, Alaska

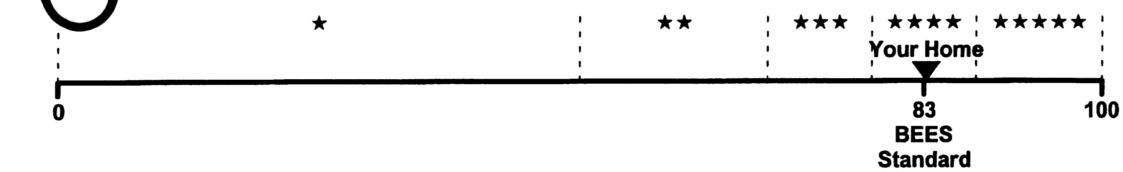
Has Been Energy Rated As:

★★★★+

Four Stars Plus

Overall Efficiency of Home

83.2 points



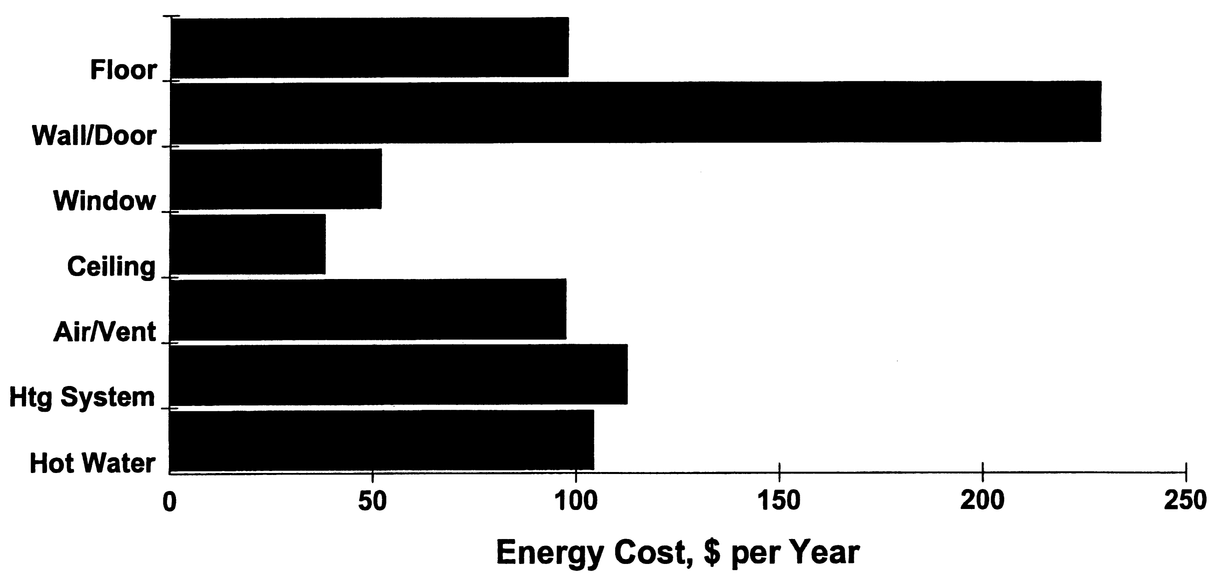
Projected Annual Energy Costs

$1,387 per year

Amount of CO2 Produced by the Home

29,137 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property: Log Home
XXX
Fairbanks, Alaska

Rater: Phil Kaluza
Alaska Housing Finance Corp.
4300 Boniface PKWY
Anchorage, AK 99504

House: Single Family
Living Floor Area: 837 square feet
No Attached Garage

Rating: Proposed from Plans

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-20 *
Wall/Door Insulation	R-11.7 *
Ceiling Insulation	R-51
Window R-Value	R-3.0
Window to Wall Ratio, Living Space	13.7%
South Facing Window Area	60 square feet
Air Leakage	4.0 Air Changes per Hour at 50 Pascals
	0.19 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	85%
Fuel Type	#1 Oil
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	80%
Location	Conditioned Space
Fuel Type	#1 Oil

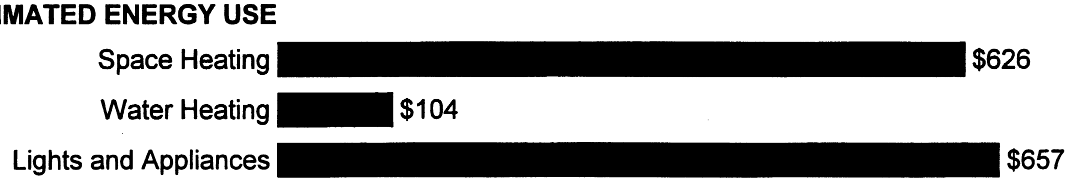
Ventilation

System Type	Continuous Ventilation without Heat Recovery

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	201 kWh of Electricity, 604 gallons of #1 Oil
Water Heating	104 gallons of #1 Oil
Lights and Appliances	6,018 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

5 Star Home:

below floor perimeter 4' - 2" blueboard
below floor center - none
below wall - 3" blueboard
above wall - 8" logs
doors - steel insulated
Windows non-south 80sqft, R-3, LowE
Windows south 60 sqft, R-3, LowE
air leakage - 4 ach, non-hrv
heater - 85% boiler with indirect h20 heater
ceiling - R-49

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Fairbanks, AK 99708

ANNUAL ENERGY FLOWS

Gross Loss: 96.7 MMBtu

Gross Internal: 20.1 MMBtu
Useable Internal: 19.7 MMBtu
Internal Utiliz.: 0.979

Gross Solar: 11.8 MMBtu
Useable Solar: 8.5 MMBtu
Solar Utiliz.: 0.725

Net Heat Load: 68.5 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 257.3 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 30,102 Btu/hr

HOME ENERGY RATING CERTIFICATE

The Home Located At:

xxx

Fairbanks, Alaska

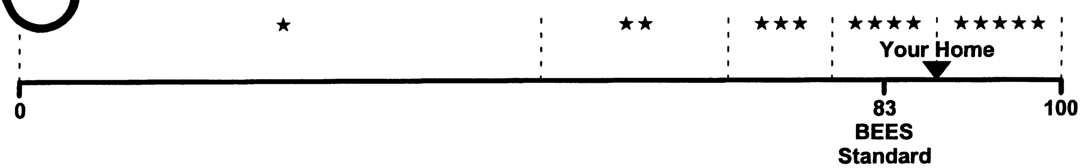
Has Been Energy-Rated As:

★★★★★

Five Stars

Overall Efficiency of Home

88.0 points



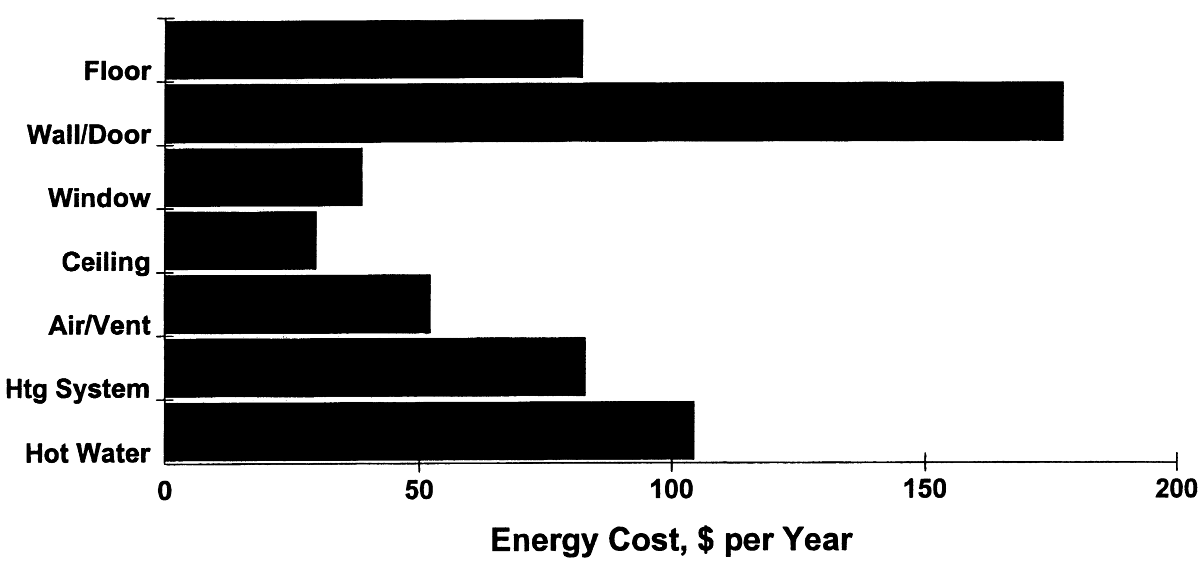
Projected Annual Energy Costs

$1,241 per year

Amount of CO2 Produced by the Home

26,131 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property: Log Home
xxx
Fairbanks, Alaska

Rater: Phil Kaluza
Alaska Housing Finance Corp.
4300 Boniface PKWY
Anchorage, AK 99504

House: Single Family
Living Floor Area: 837 square feet
No Attached Garage

Rating: Proposed from Plans

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-22 *
Wall/Door Insulation	R-14.2 *
Ceiling Insulation	R-62
Window R-Value	R-4.0
Window to Wall Ratio, Living Space	13.7%
South Facing Window Area	60 square feet
Air Leakage	1.8 Air Changes per Hour at 50 Pascals 0.09 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	85%
Fuel Type	#1 Oil
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	80%
Location	Conditioned Space
Fuel Type	#1 Oil

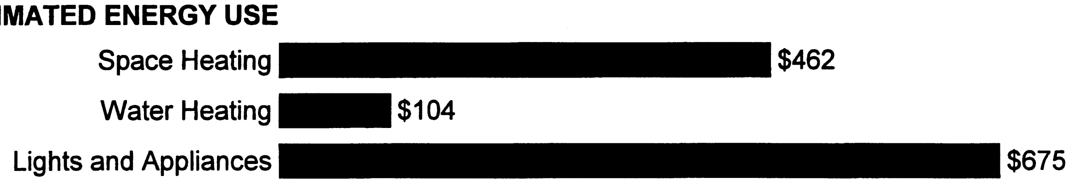
Ventilation

System Type	Heat Recovery Ventilator

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	148 kWh of Electricity, 446 gallons of #1 Oil
Water Heating	104 gallons of #1 Oil
Lights and Appliances	6,218 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

5 Star Home:

below floor perimeter 4" (2"in, 2"out)
below floor center - none
below wall - 4" blueboard
above wall - 10" logs
doors - steel insulated
Windows non-south 80sqft, R-4 HM88
Windows south 60 sqft, R-4, HM88
ceiling R-60
air leakage - 1.8 ach, hrv
heater - 85% boiler with indirect h20 heater

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Fairbanks, AK 99708

ANNUAL ENERGY FLOWS

Gross Loss: 76.1 MMBtu

Gross Internal: 20.1 MMBtu
Useable Internal: 19.3 MMBtu
Internal Utiliz.: 0.957

Gross Solar: 9.5 MMBtu
Useable Solar: 6.3 MMBtu
Solar Utiliz.: 0.668

Net Heat Load: 50.5 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 203.4 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 23,799 Btu/hr

HOME ENERGY RATING CERTIFICATE

Alaska Housing
FINANCE CORPORATION

The Home Located At:

xxx

Fairbanks, Alaska

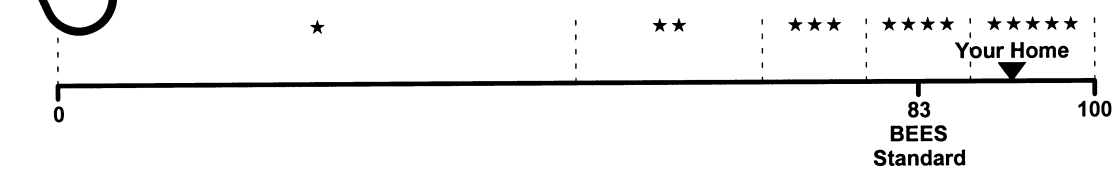
Has Been Energy-Rated As:

★★★★★+

Five Stars Plus

Overall Efficiency of Home

92.0 points



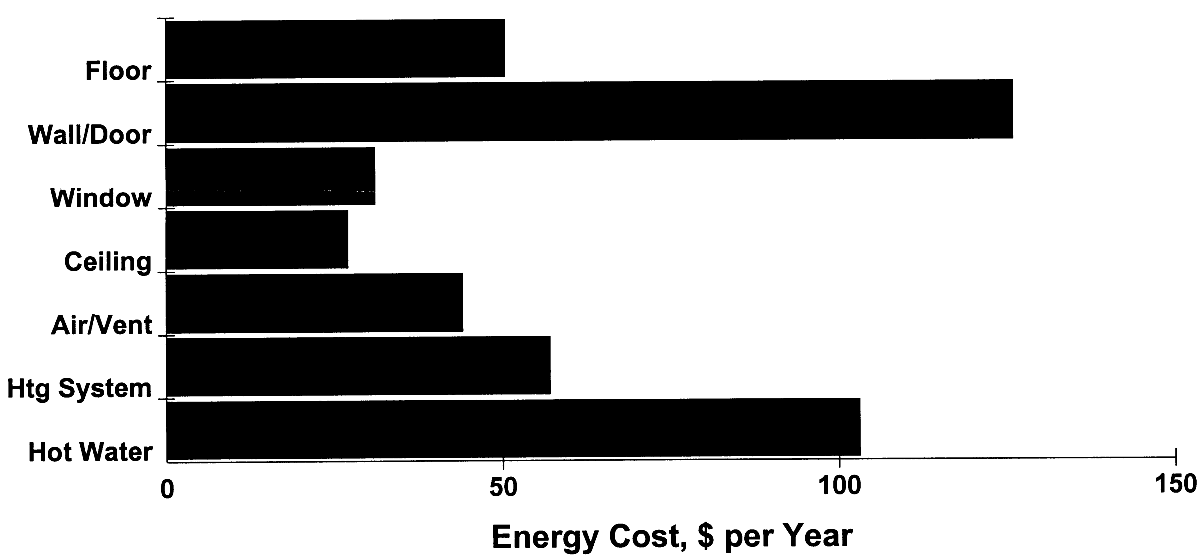
Projected Annual Energy Costs

$1,116 per year

Amount of CO2 Produced by the Home

23,481 pounds per year

BREAKDOWN OF HEATING COSTS



Client: Log Home **Rater:** Phil Kaluza, Alaska Housing Finance Corp. **Date:** 7/8/98

Rater's City: Anchorage, AK 99504 **Phone:** (907) 338-6100 **FAX:** N/A

ver. 1.03, library: 6/30/98

ENERGY COST AND FEATURES REPORT

Property: Log Home
xxx
Fairbanks, Alaska

Rater: Phil Kaluza
Alaska Housing Finance Corp.
4300 Boniface PKWY
Anchorage, AK 99504

House: Single Family
Living Floor Area: 837 square feet
No Attached Garage

Rating: Proposed from Plans

The points awarded for air leakage and ventilation assume that the builder will comply with those requirements of the State of Alaska Building Energy Efficiency Standard.

The measured air tightness of this home indicates that it may not provide sufficient ventilation air (for acceptable indoor quality) as defined by ASHRAE 62-89, without adequate mechanical ventilation equipment. If whole house mechanical ventilation equipment has been installed, it is recommended that it be properly maintained and operated. If no whole house mechanical ventilation equipment has been installed, it is strongly recommended that the homeowner consider an investment in this improvement. (A test of the building's ventilation air rate would help determine the importance of a mechanical ventilation system in this home.)

ENERGY FEATURES

Envelope Efficiency

Floor Insulation	R-33 *
Wall/Door Insulation	R-18.8 *
Ceiling Insulation	R-62
Window R-Value	R-4.0
Window to Wall Ratio, Living Space	11.8%
South Facing Window Area	60 square feet
Air Leakage	1.5 Air Changes per Hour at 50 Pascals 0.07 Air Changes per Hour Natural

* Includes the insulating value of the ground in contact with these envelope components.

Space Heating System

System Efficiency	86%
Fuel Type	#1 Oil
Supplemental Fuel	None
Thermostat Setting	70.0 degrees F
Setback Thermostat	Yes, Controls Entire Home

Water Heater

Efficiency	81%
Location	Conditioned Space
Fuel Type	#1 Oil

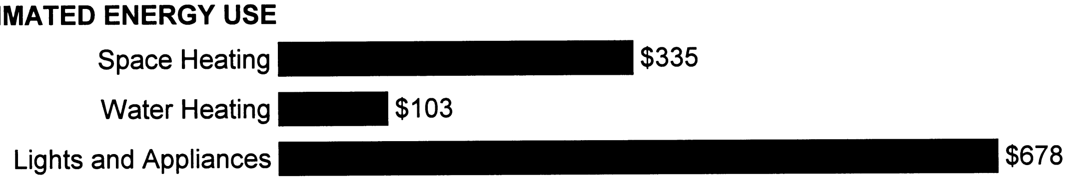
Ventilation

System Type	Heat Recovery Ventilator

Other

Number of Occupants	2
Clothes Dryer Fuel	Electricity
Cooking Range Fuel	Electricity
Miscellaneous Lights/Appliances Use	Average

ESTIMATED ENERGY USE



Space Heating	109 kWh of Electricity, 323 gallons of #1 Oil
Water Heating	103 gallons of #1 Oil
Lights and Appliances	6,240 kWh of Electricity

Actual use and costs may vary from these estimates depending upon weather conditions, occupant life styles and utility rates currently in effect.

RATER NOTES

5 Star Plus Home:

below floor perimeter 4' - 4"
below floor center - 2"
below wall - 2" blueboard + R21 batt
above wall - 12" logs
doors - steel insulated
Windows non-south 60sqft, R-4 HM88
Windows south 60 sqft, R-4, HM88
ceiling R-60
air leakage - 1.5 ach, hrv
heater - 86% boiler with indirect h20 heater

ver. 1.03, library: 6/30/98

Client: Log Home
Home at: xxx
Fairbanks, AK 99708

ANNUAL ENERGY FLOWS

Gross Loss: 61.0 MMBtu

Gross Internal: 20.1 MMBtu
Useable Internal: 18.7 MMBtu
Internal Utiliz.: 0.931

Gross Solar: 8.3 MMBtu
Useable Solar: 5.1 MMBtu
Solar Utiliz.: 0.623

Net Heat Load: 37.1 MMBtu

DECEMBER UA VALUES AND DESIGN HEAT LOSS

Living Space UA: 162.6 Btu/hr/deg F
Garage UA: 0.0 Btu/hr/deg F
Design Heat Loss (70 deg Indoor, 70 deg Garage): 19,019 Btu/hr

Appendix D
References and Bibliography

Appendix D
References and Bibliography

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By Steve Chappell. Fox Maple Press, 1998.

Alaska Craftsman Home Building Manual
University of Alaska Cooperative Extension Service, 2nd ed. June 1991.

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Alaska Northwest Publishing Co., Sales and Circulation Office, 130 2nd Ave South, Edmonds, Washington 98020.

American Log Homes
By Arthur Thiede & Cindy Teipner. Gibbs Smith, Publisher, 1992.

Build a Classic Timber Frame
By J. Sobon. Storey Books, 1994.

Build Your Own Low-Cost Log Home
By Roger Hard. Storey Books, 1985.

Builder's Guide, Cold Climate
By Joseph L. Stiburek. Building Science Corporation, Energy Efficient Building Association, and Shelter Source, 1997.

Builder's Guide to Energy Efficient Construction
1991 Super Good Cents Program and 1987 Northwest Energy Code. Produced for the Bonneville Power Administration by Oregon State University Extension Energy Program.

The Builder's Guide to Running a Successful Construction Company
By David Gerstel, Taunton Press, 1992.

Builder's Manual: Health House Advantage
American Lung Association Health House, 1998.

Building a Log House in Alaska
By Axel Carlson, Cooperative Extension Service, University of Alaska, Fairbanks, Pub #P-SOA, 1977.

Building in the North
By Eb Rice. Publications, Institute of Water Resources/Engineering Experiment Station, University of Alaska Fairbanks, Fairbanks, Alaska 99775-1760, 3rd ed. 1984.

Building the Alaska Log House
By Tom Walker. Alaska Northwest Books, 1998.

Building the Timber Frame House: A Revival of a Forgotten Craft
By Tedd Benson. Taunton Press, 1997.

Building With Logs
By Clyde Fickes and Ellis Groben, 1945, facsimile reprint in 1981 by Shorey Books, 110 Union Street, Seattle, Washington 98101.

Building With Logs
By B. Allan Mackie. Firefly Books, Ontario, Canada, 8th ed., 1997.

Canadian Standards Association Publication F326: Residential Mechanical Ventilation Requirements
Heating, Refrigeration, and Air Conditioning Institute of Canada (HRAI), Suite 322, 5468 Dundas St. W, 1 Slington, Ontario M9B 6E3, Canada.

Complete Guide to Building Log Homes
By Monte Burch. Sterling Publications, 1990.

The Complete Guide to Sharpening
By Leonard Lee. Taunton Press, 1996.

The Complete Japanese Joinery
By Hideo Sato and Yasua Nakahara. Hartley & Marks, 1998.
A compilation of Sato's Japanese W oodworking and Nakahara's Japanese Joinery .

The Craft of Log Building
Written in German by Hermann Phleps. Translated into English by Lee Valley Tools.

Design Values for Wood Construction
National Forest Products Association, 1619 Massachusetts Ave NW, Washington, DC 20036.

Handbook of Canadian Log Building
By Dan Milne. Out of print, may be available from Schroeder's Log Home Supply and Sun Country Log Works.

The Home Design Handbook
By J. C. Myrvang and S. Myrvand. A.I.A. Henry Holt, 1992.

How to Afford Your Own Log Home: Save 25% Without Lifting a Log
By Carl Heldmann. Globe Pequot Press, 1997.

Log Bridge Construction Handbook
By G. V. Wellburn, M. M. Nagy, and J. T. Trebett. Forest Engineering Research Institute of Canada, 2601 East Mall, Vancouver, BC, V6T 1Z4, 1980.

A Log Builders Handbook
By Drew Langsner. Rodale Press, 1982.

Log Building Construction Guide
By Robert W. Chambers. 1998.

Log Home Book: Design. Past and Present
By Cindy Teipner-Theide and Arthur Theide. Gibbs Smith, Publisher, 1995.

The Log Home Owner's Manual: A Guide to Protecting and Restoring Exterior Wood
By Jim Renfroe. Advance Marketing, 1994. Distributed by Wood Care Systems, 1075 Bellevue Way NE, Suite 181, Bellevue, WA 98004.

Log Homes Made Easy: Contracting and Building Your Own Log Home
By Jim Cooper. Stackpole Books, 1993.

Log House Plans
By B. Allan Mackie. Log House Publishing Co., 1997

Log Span Tables
By Allan Mackie, Norman Read, and Tom Hahney. Published by the CLBAI-ALBA. Being revised in 1998.

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National Center for Appropriate Technology, P.O. Box 3838, Butte, Montana 59702.

Modern Carpentry
By Willis Wagner. The Goodheart-Wilcox Company, 1983.

Natural Design for the Real World
By Victor Papanek. Thames & Hudson, 1995.

Northern Comfort: Advanced Cold Climate Home Building Techniques
Alaska Craftsman Home Program, 1995.

Norwegian Wood, A Tradition of Building
By Jerri Holan. Rizzoli International Publications, 1990.

Notches of All Kinds
By B. Allan Mackie. Log House Publishing, 1977.

The Passive Solar Energy Book
By Edward Mazria. Rodale Press, 1979.

A Pattern Language
By Christopher Alexander and others. Oxford University Press, 1977.

Picture Book of Log Homes
By Allan Mackie. Log House Publishing, 1989: out of print. Try Schroeder Log Home Supply, Sun Country, or Bibliofind.

R-2000 Canadian Home Builders Association Builders Manual
Canadian Home Builder's Association, 200 Elgin St., Suite 702, Ottawa, Ontario K2P 1L5, Canada, 1989.

The Real Log Cabin
By Chilson D. Aldrich, new edition with Harry Drabik. Nodin Press, 525 North Third St. Mpls, MN 55401, 1928 and 1994.

A Reverence for Wood
By Eric Sloane. American Museum of Natural History, Ballantine Books, N.Y., 1965.

Roof Framing
By Marshall Gross. Craftsman Book Company, 1986.

Router Joinery
By Gary Rogowski. Taunton Press, 1997.

Rustic Traditions
By Ralph Kylloe. Gibbs-Smith, Publisher, 1993.

The Short Log and Timber Building Book
By James Mitchell. Hartley and Marks Publishers, 1984. Recently reissued as The Craft of Modular Post and Beam , 1997.

State of Alaska Building Energy Efficiency Standard (BEES)
Alaska Department of Community and Regional Affairs (see Appendix A.), Sept. 1991.

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By Wayne Gudmundson. Minnesota Historical Society Press, St. Paul, MN, 1991.

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By Jack Sobon. Garden Way Publishing, 1984.

The Timber-Frame Home: Design, Construction, Finishing
By Tedd Benson. A Fine Homebuilding Book, Taunton Press, 1998.

The Timber Framing Book
By Stewart Elliott and Eugene Wallas. Housesmiths Press, 1977, P.O. Box 157, Kittery Point, Maine 03905.

Understanding Wood: A Craftsman's Guide to Wood Technology
By R. Bruce Hoadley. Fine Homebuilding Book, 1980.

Wood Handbook: Wood as an Engineering Material
USDA, Forest Products Lab, Ag Handbook # 72.

Wood Structural Design Data
National Forest Products Association, 1619 Massachusetts Ave. NW, Washington, DC 20036.

The Woodworker's Guide to Hand Tools
by Peter Kom. Taunton Press, 1998.

Magazines on Log Building

Dividends from Wood Research
This is a list of recent articles written by scientists at the Forest Products Laboratory. US Department of Agriculture, Forest Service, Forest Products Lab, One Gifford Pinchot Drive, Madison, Wisconsin 53705-2398 USA. Articles also on Internet at <www.fpl.fs.fed.us/>.

Energy Design Update: The Monthly Newsletter on Energy Efficient Housing
Cutter Information Corp., 37 Broadway, Arlington, Massachusetts 02174-5539.

Fine Homebuilding Magazine
Taunton Press, Newtown, CT 06470.

Home Energy: The Magazine of Residential Energy Conservation
2124 Kitteredge St., No. 95, Berkeley, California 94704.

Joiners Quarterly
Snowville Road, West Brownfield, Maine 04010.

The Journal of Light Construction—The New England Builder
P.O. Box 278, Montpelier, Vermont 05602.

Log Building News

Published by the American Log Builders Association/Canadian Log Builders Association, International. ALBA/CLBAI, P.O. Box 28608, Bellingham, WA, 98228-0608. Phone 800-532-2900 or e-mail LogBldAssn@aol.com

Log Home Guide Magazine and Books

May be available from Schroeder Log Home Supply, Grand Rapids, MN; phone 800-359-6614 and from Sun Country Log Works 800-827-1688 or 503-324-0922.

Videos

Building with Logs, a Complete Guide to Log Building

A series of 15 videos available through the B. Allan Mackie School of Log Building, care of Diazon Log Homes, 1285 Springhill Road, Parksville, B.C., Canada V9P 2G1.

Log Building Video—Full Scribe Method

Lazy Dog Productions. (three tapes, over 5 1/2 hours)

Log Cabin—As seen on PBS Hometime Series

Home Time Video, Dec. 1991.

Making Mortise-and-Tenon Joints with Frank Klausz

(60 Minutes)

The Video Course: Handcrafting Log Homes

Montana School of Log Building. (6 tapes, 10 hours)

Wonderful World of Log Homes

Sunrise Productions. (62 Minutes)

Where to find books:

In print books

- Your local bookstore can order it for you, if it is in print.
- Schroeder Log Home Supply 800-359-6614
- Sun Country LogWorks 503-324-0922 or 800-827-1688
- Amazon Books <www.amazon.com>
- Lofty Branch Bookstore 716-289-3220
- Into the Woods Bookstore 907-479-7701

Out of print books

- Bibliofind <www.bibliofind.com>
- Publisher's Overstock 800-736-7736
- Book Express 888-402-7323

Resource Libraries

- Research Information Center, Alaska Housing Finance Corporation, P.O. Box 101020, Anchorage, AK 99510. Phone: (907) 338-6100 in Anchorage, 1-800-478-INFO outside Anchorage, in Alaska. <www.AHFC.state.ak.us/RIC.htm>

- Canada Mortgage and Housing Corporation Library, 700 Montréal Road, Ottawa, Ontario, Canada K1A 0P7. Phone: (613) 748-2000. <www.cmhc-schl.gc.ca/cmhc.html>
- Energy Efficient Building Association, Inc., 1300 Spring St., Suite 500, Silver Spring, MD 20910. Phone: (301) 589-2500
- Energy Efficiency and Renewable Energy Clearinghouse, P.O. Box 3048, Merrifield, VA 22116. (800) 523-2929

Sources of Log Working Tools

Bailey's (Western Division)
12 East River Street
P.O. Box 550
Laytonville, CA 95454
Ph: (800) 322-4539

Cutter's Choice
20008 East Third Street
Erie, PA 16514
Ph: (800) 824-8521

Magard Ventures Ltd.
Specialty Log Building Tools
RR#3 Site 3 Comp 1
Prince George, BC V2N 2J1
Canada
Ph: (250) 962-9057

Northern Hardware
P.O. Box 1499
Burnsville, MN 55337
Ph: (800) 222-5381

Schroeder Log Home Supply, Inc.
4301 W. US Hwy 2
P.O. Box 864
Grand Rapids, MN 55744
Ph: (800) 359-6614

Veritas Tools Inc.
12 East River Street
Ogdensburg, NY 13669
or
1080 Morrison Drive
Ottawa, ON K2A 8K7
Canada

The Wood House
P.O. Box 801
Ashton, ID 83420

WoodCraft Supply
P.O. Box 1686
Parkersburg, WV 26102-1686
Ph: (800) 225-1153

Woodworker's Supply
1108 North Glenn Road
Casper, WY 82601
Ph: (800) 645-9292

Hardware Specialties
424 W. 54th Ave.
Anchorage, Ak. 99518
Ph: (907) 563-1312

Appendix E
Glossary

Appendix E
Glossary

Adfreezing. The process whereby wet soils freeze to below-grade materials such as foundation walls or insulation, forcing movement of the material.

Air barrier. A material carefully installed within a building envelope assembly to minimize the uncontrolled passage of air into and out of a dwelling.

Air changes per hour (ach). The rate at which the volume of air in a home changes; the number of air changes per hour can vary from as low as 0.35 to as high as 4 or 5 in uncontrolled air leakage situations.

Air-dried. Refers to seasoning of wood. Dried by exposure to air, usually in a lumber yard, without artificial heat.

Air leakage. The uncontrolled flow of air through the building envelope, when a pressure difference is applied. Infiltration refers to inward flowing air leakage and exfiltration refers to outward flowing air leakage.

Air permeability. The property of a building component to let air pass when it is subjected to a differential pressure.

Air pressure. The pressure exerted by the atmosphere. This may refer to static (atmospheric) pressure, or dynamic components of pressure arising from air flow, or both acting together.

Air sealing. The practice of sealing unintentional gaps in the building envelope (from the interior) in order to reduce uncontrolled air leakage.

Air tightness. The degree to which unintentional openings have been avoided in a building's structure.

AkWarm. A computer program developed for the Alaska Housing Finance Corporation for energy rating of new and existing houses.

Alcove. An expanded portion of a room. It is not a separate room.

Ambient temperature. Temperature of the air (1) outside the building or (2) within a room.

ASHRAE. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1791 Tullie Circle, N.E. Atlanta, GA 30329. Phone: (404)636-8400. Fax: (404)321-5478

ASTM. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Phone: (610) 832-9585. Fax: (610) 832-9555

Automatic flue damper. A damper added to the flue pipe downstream of a furnace or boiler and connected with automatic controls to the burner. Its function is to reduce heat loss up the chimney when the unit is not operating.

Back draft. 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 it can occur when the pressure differential is too high for the chimney to draw.

Balloon framing. A type of framing wherein the first-floor studs continue upward, unbroken, past the second-floor joists, to become the second-floor studs as well. A ledger is used to support the second-floor joists.

Batter boards. A combination of stakes and boards to which string is attached to locate the building lines. The boards are installed level and all boards are at the same level. The batter boards and/or lines then serve as a vertical reference as well as for locating building lines. They must be kept far enough back from the actual building corners (normally 3 to 5 feet) so that the excavation does not interfere with them. Either single or double batter boards may be used.

Beam. A main structural member that supports other members or loads that are applied perpendicular to the grain lines of the beam. Also called a girder.

BEES. Short for Building Energy Efficiency Standards. Developed for the Alaska Housing Finance Corporation (AHFC) to ensure minimum standards for homes being financed by AHFC.

Bir d's mouth. See "crow's foot."

Boards. Lumber less than two inches thick and one or more inches wide.

Bow. The distortion in a piece of lumber that deviates from flatness along its length but not across its width.

Bracing. Materials or the installation of materials to form rigid geometric figures—usually a triangle—to reduce or eliminate movement of framing components.

British thermal unit (Btu). The amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.

Building orientation. The siting of a building on a lot, generally used to refer to solar orientation which is the siting of a building with respect to solar access.

Butt. The large end of a tree cut from the stump.

Cap. See "plate."

Cap log. Logs that notch over log second floor joists.

Capillary br eak. A break between a moisture source and porous materials, to prevent movement of the moisture by capillary action.

Casing. Pieces of trim board used to finish off the edge of a jamb. Used to close the opening between the edge of the jamb and the face of the wall.

CGSB. The Canadian General Standards Board is a government agency within the Canadian Federal Department of Supply and Services. CGSB has been accredited by the Standards Council of Canada as a national standards writing organization.

Check, checking. A lengthwise separation of wood that usually extends across the rings of annual growth and commonly results from stresses set up in wood during seasoning.

Cheek cut. A bevel cut. Necessary, for example, where a jack rafter joins the hip rafter. Also called a side cut.

Cladding. Covering applied to the outside of a structure to protect the inner core.

Cleat. A block, usually shorter than a ledger but serving the same purpose. used to support another member. For example, in one stair-framing method, cleats are nailed to the stringers to support the treads.

Clerestory. An outside wall of a room or building that rises above an adjoining roof and contains windows.

Cold roof. A ventilated roof.

Collar beam. See "collar tie."

Collar tie. A horizontal member used to tie a pair of opposing rafters together. May be high to hold the upper joint together or may be low to serve as a ceiling joist. Also called a collar beam.

Combustion air. The air required to provide adequate oxygen for fuel burning appliances in the building. The term is often used to refer to the total air requirements of a fuel burning appliance, including both air to support the combustion process and air to provide chimney draft (dilution air).

Common rafter. A roof member extending from the plate to the ridge, except valley or hip rafter.

Compression fit notch. A log notching technique that gets tighter as the weight of the building materials causes the logs to settle.

Concrete. A combination of cement, water, and other inert materials such as sand and gravel, which hardens as it dries because of the chemical action between the water and the cement. The water and cement bind the other aggregates together.

Condensation. The beads, drops of water, or in extremely cold weather, the frost that accumulates on building elements or surfaces (most often windows) when warm, moisture-laden air from the interior reaches the point at which the temperature no longer permits the air to sustain the moisture it holds.

Conduction. The transfer or travel of heat through a body by molecular action and/or direct contact.

Controlled ventilation. Ventilation brought about by mechanical means through pressure differentials induced by the operation of a fan.

Convection. The transfer of heat from one point to another by the motion of fluid.

Corner post. Forms the corner of the wall.

Cornice. A group of moldings used to enclose the ends and bottom of the rafter tails. It forms the finish for the eaves. Sometimes applied to the finish on the ends of the roof. See "rake."

Cricket. The small "gable dormer" built behind a chimney to direct water around or to the sides of the chimney. Also called a saddle.

Cripple jack rafter. A rafter that is cut to fit between a hip rafter and a valley rafter and touches neither the plate nor the ridge.

Cripple jack stud. A stud that touches neither the shoe nor the plate. For example, the stud used to form a window opening.

Crook. The distortion in a piece of lumber that deviates from a straight line along its edge, from end to end.

Cross-bridging. Bridging that consists of either metal straps or narrow pieces of wood. Two members are used, for example, between each pair of joists so as to form an "X." Also called diagonal bridging.

Crow's foot. One type of rafter bottom cut, consisting of a level cut and a plumb cut, making a notch to set over the plate. Also called a bird's mouth.

Cup. The distortion in a piece of lumber that deviates from flatness across its width but not along its length.

Dampproofing. The process of coating a floor or the interior or exterior of a foundation wall with bituminous emulsions and plastic cements. The purpose of dampproofing is to prevent or interrupt the capillary draw of moisture into the wall or floor system and to the interior of the foundation. Polyethylene can also be used for exterior dampproofing.

Degree day. The number of degrees of temperature difference on any one day between a given base temperature and the mean outdoor temperature. The base is usually 65°F. The total number of degree days over the heating season indicates the relative severity of the winter for a specific location.

Dehumidistat. An electronic sensing and control device used to regulate mechanical ventilation according to relative humidity in the building. When the relative humidity surpasses the preset limit, the dehumidistat activates the ventilation system to exhaust house air and bring in drier outdoor air.

Delamination. Separation of plies through failure of the adhesive holding the plies together, as in plywood. The term is often used in reference to the durability of the glue line.

Design heat losses. A term expressing the total predicted envelope losses over the heating season for a particular house design in a particular climate.

Dewpoint. The temperature at which a given air/water vapor mixture is saturated with water vapor, that is, it has reached 100% relative humidity. Consequently, if air is in contact with a surface below this temperature, condensation will form on the surface.

Diagonals. The interior or web members of a truss which form triangles—rigid geometric figures—between or in conjunction with the top and bottom chords. See "truss."

Diffusion. An intermingling of molecules or ions resulting from random thermal agitation, as in the dispersion of a vapor in air or water vapor through a building product such as plywood.

Dilution air. The air required by some combustion heating systems in order to isolate the furnace from outside pressure fluctuations and to maintain an effectively constant chimney draft.

Dimension lumber. Lumber from two inches to, but not including, five inches thick and two or more inches wide.

Direct gain. A term referring to a type of solar heating system in which the solar collection area is an integral part of the building's useable space; for example, windows.

Dormer, gambrel. See "gambrel dormer."

Dormer, gable. See "gable dormer."

Dormer, shed. See "shed dormer."

Dormer. An addition to a roof and attic to provide extra space and to allow windows in the attic space.

Dressed lumber or sized. The finished size of a piece of lumber after drying and surfacing by a planing machine. For example, a 2-by-4-inch stud actually measures $1^1/_2$ by $3^1/_2$ inches after drying and being planed. See "nominal size."

Eaves. The lower end or bottom of the rafters. With no rafter tail, the junction of the wall and rafters form the eaves.

Energy. The capacity to do work and overcome resistance or potential forces, inherent power, capacity for action and such forces or power in action.

EPDM. Ethylene propylene diene monomer. A synthetic rubber gasket material.

Equivalent leakage area (ELA). The total area of all the unintentional openings in a building's envelope, generally expressed in square inches.

Exfiltration. The uncontrolled leakage of air out of a building.

Expansive soils. Fine grained soils such as clay, silt, and fine sand that are frost susceptible and therefore are more subject to frost heaving.

Fan depressurization. Exhausting air from a building with a large fan in order to create a pressure difference across the building envelope. An analysis of the flow rate through the fan at different pressure differences provides a measurement of air tightness.

Fascia. The part of the cornice that encloses or covers the ends of the rafter tails or the part of the rake trim that covers the outer side of the fly rafter.

Fire stop. A horizontal wood member cut to fit between the studs. Usually placed at each floor level to help keep fire from spreading from floor to floor. Primarily necessary with balloon framing. Helps to prevent the space between studs from functioning as a chimney. May also be used between joists.

Flashings. The process or materials used in making a joint watertight by fitting tin, lead, zinc, copper, or other material in such a way as to prevent the water from penetrating the joint.

Flight of stairs. The series of steps leading from one landing to another.

Fly rafter. A rafter located beyond the end wall of the house. It forms the extreme outer edge of the structural part of the roof.

Footing. The lower and expanded portion of a foundation that rests on the excavated surface. The purpose of the footing is to provide a larger bearing surface over which the weight of the building is spread so that the bearing pressure created by the weight of the building does not exceed the allowable bearing pressure of the soil.

Foundation coating. A material, usually of a bituminous composition, applied to the outside surface of a foundation to retard or prevent moisture migration through the foundation.

Foundation. Walls, piers, or other supports placed below grade or curb levels to support the building. Usually made of materials that are not susceptible to damage from soil, moisture, or soil organisms. Concrete and preservative-treated wood are examples.

Framing. The lumber used as structural members in a building, such as studs and joists. Also refers to the process of erecting the structural members of a building.

Frieze board. The board that forms the junction between the finish siding and the plancher.

Frost heaving. 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 surface to heave.

Full scribing. See scribing.

Furring strip. Any piece of material (though usually a 1-by-2 or 1-by-3) used to form an air space, as between a basement wall and paneling; or to form a mounting material for a new siding or ceiling, such as used when applying ceiling tiles over a plaster ceiling.

Gable dormer. A dormer with a gable-type roof and its own ridge board perpendicular to the ridge board of the main roof.

Gable roof. A roof with two equal slopes meeting at the ridge. The end of the roof is vertical and appears to be an inverted cone.

Gable. Refers to the end wall area of a building, located between the end wall plate (bottom of rafters or trusses) and the roof.

Gambrel dormer. A dormer with a gambrel-type roof and its own ridge board perpendicular to the ridge board of the main roof.

Gambrel roof. A modified gable roof in which each side of the roof has two distinctly different slopes—a steeper slope at the bottom and a smaller or lower slope near the ridge. The slopes on each side of the roof are equal. A "true" gambrel roof has a slope inclined 60 degrees above the horizontal at the bottom and 30 degrees above the horizontal at the top. This roof style is typical of "Dutch Colonial" homes.

Girder. A main horizontal member, on edge, intended to support secondary structural members, such as joists.

Girt. Horizontal framing members between vertical posts.

Gusset. The parts of a truss that hold the joints together. May be plywood, metal, sawn boards, or any other material of adequate strength.

Head casing. The horizontal casing used along the top of an opening such as a door or window opening. Also called the architrave.

Head jamb. A horizontal member used to form the finished top of an opening, such as for a door.

Header. A horizontal member, on edge, that closes off space between joists. Also used to form an opening through joists, such as when making an opening through which stairs will pass.

Heat recovery. The process of extracting heat (usually from a fluid) that would otherwise be wasted. For example, heat recovery in housing generally refers to the extraction of heat from exhaust air.

Heat. A form of energy that is transferred by virtue of a temperature difference.

Heating capacity of air (HC). The amount of heat required to raise the temperature of 1 ft^3 of air 10˚F. This amount of heat depends on the density of the air and varies from area to area. It will generally be within the range of 0.018–0.022 Btu/ft^3F

Heel cut. A cut on a rafter where it meets the plate; it is horizontal when the rafter is properly located.

Hip rafter. The main rafter of the hip which forms the roof break line.

Hip roof. A roof in which both sides and both ends lean towards the center of the building, with the same slope.

Hip. An outside corner in the roof.

HOT-2000. A computer program for estimating the space-heating requirements of residences. It is based largely on equations developed by the National Research Council of Canada, including calculations for home heat balance, below grade heat loss, and solar gains through windows.

Hot roof. An unventilated roof.

Impermeable. Not permitting water vapor or other fluid to pass through.

Induced draft flue system. A term referring to a type of gas heating system equipped with a fan downstream of the furnace. The fan pulls gases from the furnace and propels them to the outside, thereby eliminating the requirement for dilution air.

Infiltration. The uncontrolled leakage of air into a building.

Insulation (thermal). Materials that retard the transfer of heat.

Intrinsic heat. Heat from human bodies, electric light bulbs, cooking stoves, and other objects not intended specifically for space heating.

Jack rafter, cripple. See "cripple jack rafter."

Jack stud, cripple. See "cripple jack stud."

Jack stud. A stud that touches either the plate or the shoe but not both, such as the studs above or below a window.

Jamb side. See "side jamb."

Jamb, head. See "head jamb."

Jamb. A member used to form the finished sides of an opening, such as door jambs.

Joist hanger. A metal U-shaped bracket for supporting the ends of joists. The use of joist hangers permits joists to be supported along the side of the support beam or girder, thereby increasing headroom.

Joist. A horizontal member, usually placed on edge to support floor or ceiling; one of a series of parallel beams.

KD. Abbreviation for kiln-dried.

Kerf. A cut or incision made by a saw or the like in a piece of wood.

Kiln-dried. Dried in a kiln with the use of artificial heat.

Kiln. A heated chamber used for drying lumber, veneer, and other wood products.

Laminate. A product made by bonding together two or more layers (laminations) of material or materials. Plywood is an example.

Landing. A horizontal resting place in a flight of stairs. Used in long flights or at turns.

Lath. Thin strips of wood or metal that are nailed to studs to form supports for a plaster wall. The plaster is applied over the lath.

Let-in. To notch one member to form a socket to receive a second member. A ribband is sometimes "let-in" to the studs that support it. Likewise, corner bracing may be "let-in" to the studs it is bracing.

Level cut. Any cut which, when the member is properly located, is horizontal or level.

Lintel. A horizontal member over an opening, such as a door or window, which carries the weight of the studs, joists, or rafters above it.

Log. A section of the trunk of a tree of suitable length for sawing into commercial lumber or used in its natural shape to build log structures.

Long groove. Also known as a lateral groove. It is a groove cut the entire length of a log to fit two logs together.

Lookout rafter. Roof-framing members that tie together the fly rafter and the first common rafter in from the end wall. They lie on the end wall and support the fly rafter.

Lumber. Any product of the saw and planing mill produced by sawing, resawing, passing lengthwise through a standard planing machine, and crosscutting to length with no further manufacturing.

Mechanical systems. A term widely used in commercial and industrial construction, referring to all the mechanical components of the building: plumbing, heating, ventilation, air conditioning, and heat recovery.

Millwork. Generally, all building materials made of finished wood and manufactured into such items as doors, windows, moldings, etc. It does not include flooring, ceiling, or siding materials. See "planing mill products."

Mitre. The angular joint formed by two pieces of material each sawed at an angle to match when joined. Casings (head and side) are usually mitred where they meet.

Negative pressure. Below atmospheric pressure. In residential construction, negative pressure refers to pressure inside the house envelope that is less than the outside pressure. Negative pressure will encourage infiltration of air.

NFS. Non-frost-susceptible.

Nominal size. As applied to timber or lumber, the rough-sawed commercial size by which it is known and sold in the market. See "dressed lumber or sized."

Normalized leakage area (NLA). The NLA is calculated by dividing the equivalent leakage area (ELM) from the fan test by the area of the exterior envelope of the house.

Nosing. The outer or front edge of the step that projects beyond the riser.

Orientation. The direction with respect to point of the compass in which the building axis lies or external walls face.

Over scribing. A technique that uses a slightly larger scriber setting for scribing the long groove than the setting for the corner notch. See "scribing" and "scribe."

Pascal. A unit measurement of pressure. House air tightness tests are typically conducted with a pressure difference of 50 Pascals between the inside and outside. Fifty Pascals is equal to .2 in. of water at 55°F.

Peavey. A hand tool used to rotate or move logs. Named after its inventor, Joseph Peavey.

Perm. A vapor transmission rate of 1 grain of water vapor/ft^2/hr/in. of mercury pressure difference.

Permafrost. Perennially frozen subsoil in arctic or subarctic regions. Any material of the earth's crust that remains below 32°F (0°C) for two consecutive years or more.

Permeance. Water vapor permeance is the rate of water vapor diffusion through a sheet of any thickness of material (or assembly between parallel surfaces). It is the ratio of water vapor flow to the differences of the vapor pressures on the opposite surfaces. Permeance is measured in perms (grams/ft^2/hr/in. mercury).

Pitch. The slant of a roof; the total roof rise divided by the total roof span. For example, for a 24-foot span and a 6-foot rise, pitch would equal 6/24 or 114. See "slope."

Planing mill products. Products worked to pattern, such as flooring, ceiling, and siding materials.

Plank. A broad board, usually more than one inch thick, laid with its wide dimension horizontal.

Plate log. The top wall log to which the roof system is attached.

Plate. A horizontal member that rests on the upper end of the studs and upon which upper floor joists or roof rafters rest. May be a single or double member. Also called a girt or cap.

Platform framing. A type of framing wherein the first and secondfloor studs are separate pieces of wood. The first floor studs have a plate on top of them upon which the second floor joists rest. The second floor studs continue upward from a shoe placed on the second floor joists.

Plenum. The space in which a gas, usually air, is contained at a pressure greater than atmospheric pressure.

Plumb cut. A cut that is vertical when the member is properly located. For example, the cut on a rafter where it meets the ridge board. Also called a top cut when referring to rafters.

Plywood. A cross-banded assembly made of layers of veneer or of veneer in combination with a lumber core or plies joined with an adhesive. The grain of adjoining plies is usually at right angles and almost always an odd number of plies is used to obtain balanced construction.

Porch. A covered platform at the door of a house, usually having steps with baluster guards and sometimes seats at the sides. (Note distinction between porch and stoop.) Also commonly called a piazza or verandah.

Positive pressure. Greater than atmospheric pressure. In residential construction, this refers to pressure inside the house envelope that is greater than the outside pressure; a positive pressure difference will encourage exfiltration.

Preservative. Any substance that, for a reasonable length of time, is effective in preventing the development and action of wood-rotting fungi, borers of various kinds, and harmful insects that deteriorate wood.

Pr essure difference. The difference in pressure of the volume of air enclosed by the house envelope and the air surrounding the envelope.

Purlin. Longitudinal member in a roof frame, supporting the rafters. See illustration on page 9.

R-values in log homes . See "resistance value."

Radiant heat transfer. The transfer of heat energy from a location of higher temperature to a location of lower temperature by means of electromagnetic radiation.

Radon. A radioactive gaseous chemical element formed, together with alpha rays, as the first product in the atomic disintegration of radium.

Rafter. Usually an inclined member that supports the roof. Can also be flat or horizontal.

Rafter, common. See "common rafter."

Rafter, cripple jack. See "cripple jack rafter,"

Rafter, fly. See "fly rafter."

Rafter, hip. See "hip rafter."

Rafter, jack. See "jack rafter."

Rafter, lookout. See "lookout rafter."

Rafter, valley. See "valley rafter."

Raised grain. A roughened condition on the surface of dressed lumber in which the hard summer wood is raised above the softer spring wood but not torn loose from it.

Rake. The portion of the roof projecting beyond or overhanging the end wall. Sometimes called a cornice.

Relative humidity . The amount of moisture in the air compared with the maximum amount of moisture that air at the same temperature could retain. This ratio is expressed as a percent.

Resistance value (R-value). Thermal resistance value. Measurement of the ability of a material to resist heat transfer.

Reveal. The portion of the edge of a jamb or stile that is exposed by keeping the casing back a small amount—usually $^{3}/_{16}$ to $^{1}/_{4}$ inch.

Ridge board. A member made of 1-or 2-inch board, against which the upper part of the rafters rest. The rafters of one side of the roof meet the rafters from the other side of the roof at the ridge board.

Rise. The difference in height between one end of a rafter and the other or the vertical distance between the treads of a set of stairs or the difference in height of the top and bottom of a set of stairs.

Riser. The board forming the vertical portion of the front of a step.

Rough lumber. Lumber as it comes from the saw.

Round notch. In a round notch, the natural shape of the log to be crossed is not changed.

Run. The horizontal distance over which a rafter stretches. For example, as measured from a plumb line dropped at the ridge to the outside of the plate.

Saddle-notch. In a saddle notch, the shape of the log to be crossed is scarfed off to provide sloping sides. As the logs shrink and settle, the notch maintains a tight fit.

Sandwich, str uctural. See "structural sandwich construction."

Sash. The portion of a window into which the glass is set or mounted. Roughly, the movable part of a window.

Scaffold. A platform built against the side of a building for the support of workmen. A one-story structure suitable for work on low buildings. See "staging."

Scarf. (see illustrations on page 34) removing the sapwood, which tends to shrink and compress more than the heartwood, and creating a locking shape so that the top log fits over the log below like a huge pipe wrench, preventing it from twisting or turning.

Scribe. A divider-like tool for scribing logs. See illustration on page 27.

Scribing. The process of duplicating the shape of one logs onto another, outlining the wood to be removed to fit them together.

Sealants. Flexible materials used on the inside of a building to seal gaps in the building envelope, preventing uncontrolled air infiltration and exfiltration.

Seasoning. Removing moisture from green wood in order to improve its serviceability.

Seat cut. See "heel cut."

Shake. A separation along the grain, the greater part of which occurs between the rings of annual growth.

Sheathing. A floor, wall, or roof covering that forms a solid surface for attachment of the finishing flooring, siding, or roofing.

Shed dormer. A dormer with a one-slope roof. Usually used when a dormer is desired over the full length of the main roof.

Shed roof. A roof with only one slope. Also called a lean-to.

Shoe. A horizontal member upon which the lower end of studs rest. May also be called a sole.

Side casing. A vertical casing used along the sides of an opening such as a door or window opening.

Side cut. See "cheek cut."

Side jamb. A vertical member used to form the finished sides of an opening, as for a door.

Sill. A horizontal framing member placed across the bottom of door or window openings (not always used on interior openings). Also, a horizontal member that lies on top of a stone or masonry wall, usually bolted down to tie the wood construction to the masonry or stone construction.

Skylight. A window placed in the roof of a building, or ceiling of a room, for the admission of light and usually also for ventilation.

Slope. The angle of a roof; the total roof rise divided by the total roof run. For example, with a 24-foot span and a 6-foot rise, each side of a gable roof would have a run of 12 feet and slope would equal 6/12 or 1/2. See "pitch."

Soffit. The portion of the rake trim that encloses the bottom of the lookout rafters.

Solar heat gain. In passive solar heating, a term referring to the amount of heat gained through windows over the heating season. Net solar gain refers to the solar heat gain less the heat losses through the windows.

Sole. See "shoe."

Solid bridging. Bridging consisting of pieces of wood of the same size as the member being braced (joist or stud) and cut to fit between each two members.

Span. The horizontal distance from the outside of one plate to the outside of the other.

Spiral grain. A twist in the grain of a log.

Spline. A rectangular strip of wood that is fitted into grooves in door and window openings to maintain vertical alignment of the wall while allowing the logs to settle.

Stack effect. Pressure differential across a building caused by differences in the density of the air resulting from an indoor-outdoor temperature difference.

Staging. An elevated platform built against the side of a building to support workmen. More substantially built than scaffolding and suitable for greater heights. See "scaffold."

Stile. The vertical, or side, pieces of a window frame that form the finished sides—similar to the side jambs of a door opening.

Stoop. An uncovered platform at the door of a house, usually having steps with baluster guards and sometimes seats at the sides. (Note distinction between stoop and porch.) Essentially a primitive porch without a roof.

Strapping. In framing, additional horizontal wood members used to add depth to the wall to provide a wiring chase and allow for more insulation.

Stringer. The inclined member used to form the main supports for a set of stairs.

Structural lumber. Lumber that is two or more inches thick and four or more inches wide. It is intended for use where working stresses are required.

Structural sandwich construction. A layered construction comprising a combination of relatively high-strength facing materials intimately bonded to, and acting integrally with, a low-density core material.

Stud. A vertical framing member that is used to form partitions or outside walls.

Surfaced lumber. Lumber that is dressed by running it through a planer.

Tail beam. A joist that has been cut off in order to provide an opening for a set of stairs, chimney, etc.

Tail. That portion of a rafter or truss that extends beyond the bottom side edge of the plate.

Take off. To estimate or measure the amount of material needed. An estimation of material.

Thermal break. A material of low conductivity used in an assembly to prevent flow of heat by conduction from one side of the assembly to the other; materials used for this purpose in the frame of metal windows.

Thermal bridge. A low thermal-resistance path connecting two surfaces; for example, framing members in insulated frame walls or metal ties in cavity wall and panel construction. The opposite concept of a thermal break.

Threshold. The finished bottom of a door opening. The purpose is to raise the bottom of the opening, which in turn permits the door to be shorter so that it has clearance at the bottom when opened but still closes tightly.

Timbers. Lumber five or more inches in its least dimension.

Top cut. See "plumb cut."

Tread. The horizontal or step part of a set of stairs.

Truss. A structural member used in place of common rafters on longer spans. Consists of an upper chord in place of the rafter and a lower chord that replaces the top-floor ceiling joists. Diagonals or web members are placed between the chords. See "diagonals."

Twist. A distortion caused by the turning or winding of the edges of a piece of lumber so that the four corners of any face are not in the same plane.

Valley rafter. The main rafter of the valley which forms the roof break line.

Valley. An inside corner in the roof.

Vapor barrier. Any material of low water-vapor permeability used to restrict the movement of water vapor due to vapor diffusion. A membrane resistant to moisture penetration, used to prevent warm, moist air from traveling through the wall, ceiling, etc. Also called vapor retarder.

Vapor diffusion. The movement of water vapor between two areas caused by a difference in vapor pressure, independent of air movement. The rate of diffusion is determined by (1) the difference in vapor pressure, (2) the distance the vapor must travel, and (3) the permeability of the material to water vapor. Hence, the selection of materials of low permeability for use as vapor retarders in buildings.

Vapor pressure. The pressure exerted by a vapor either by itself or in a mixture of gases. For example, when referring to water vapor, the vapor pressure is determined by the concentration of water vapor in the air.

Vapor retarder. See "vapor barrier."

Veneer. A thin layer or sheet of wood.

Wainscoting. Wood or paneling used to line the walls of rooms.

Warp. Any variation from a true or plane surface. Warp includes bow, crook, cup, and twist, or any combination thereof.

Weather barrier. The weather barrier is the exterior wind and water protective material.

Web members. See "diagonals" and "truss."

Western framing. See "platform framing."

Winders. Steps that are not parallel to each other—as in stairs that go around a turn without a landing.