Alaska Housing Manual

4th edition

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The Bonneville Power Administration provided the graphics for their *Builder's Field Guide*. Many of our illustrations are adapted from the *Super Good Cents® Builder's Field Guide,* produced for the Bonneville Power Administration by Ted Haskell and Bryan Boe, Oregon State University Extension Energy Program. Original illustrations are by Coleen Stevenson and Thom Porterfield.

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

Appendix A is taken from the State of Alaska Building Energy Efficiency Standard (BEES).

Introduction to the Fourth Edition of the Alaska Housing Manual

This is now the fourth edition of this manual. It was originally devised as a construction manual to guide communities through construction of state-funded community buildings. In 1997, this public information guide was adapted for residential construction and distributed throughout Alaska. It has been used throughout the state as a valuable resource for cold climate homebuilding techniques and courses given by the Alaska Cooperative Extension Service and supported by the Alaska Housing Finance Corporation and the U.S. Department of Energy.

The previous edition contained an appendix of log building standards. This has been deleted since a separate manual entitled the *Alaska Log Building Construction Guide,* also published by Alaska Housing Finance Corporation, now covers the subject of log building.

A new appendix with examples of AkWarm energy ratings by region has been added to this new edition to provide guidance on how a home might meet certain energy efficiency levels such as 4-Star Plus, 5 Star, and 5-Star Plus. Please note that the sample ratings are examples only and should not be construed as prescriptive criteria for meeting a particular rating level.

Buildings of all types must be designed to work as a system and must control the flow of heat, air and moisture to and from the outside of the structure. They should include efficient lighting and heating systems. They should be built as air tight as possible and ventilated in a controlled manner. Water conservation is always an issue in Alaska where water limitations are a reality in a large majority of the state. The intent of this information is a betterment of the public welfare, an improvement in the housing stock for the long term interests of all Alaskans, and for maximizing the financial benefit and environmentally sustainable aspects of housing. Houses that are built properly with the best information and materials we have available today will last longer, be cheaper to operate, and be healthier for their occupants.

1 Introduction

This book is written for people involved in the building industry in Alaska: architects, engineers, materials suppliers, contractors, construction crews, municipal grant recipients, and permitting and regulatory agencies. The book is also intended as useful information for anyone interested in constructing or renovating energy-efficient, comfortable, and good quality buildings in Alaska. This book is not intended to supersede either local or national building codes.

Many existing buildings in Alaska suffer from chronic problems. These problems are divided into three main areas: (1) inappropriate design, (2) poor quality control during construction, and (3) inadequate maintenance.

Design

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

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

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

Construction

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

Maintenance

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

The Solution

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

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

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

Heat, Air, and Moisture

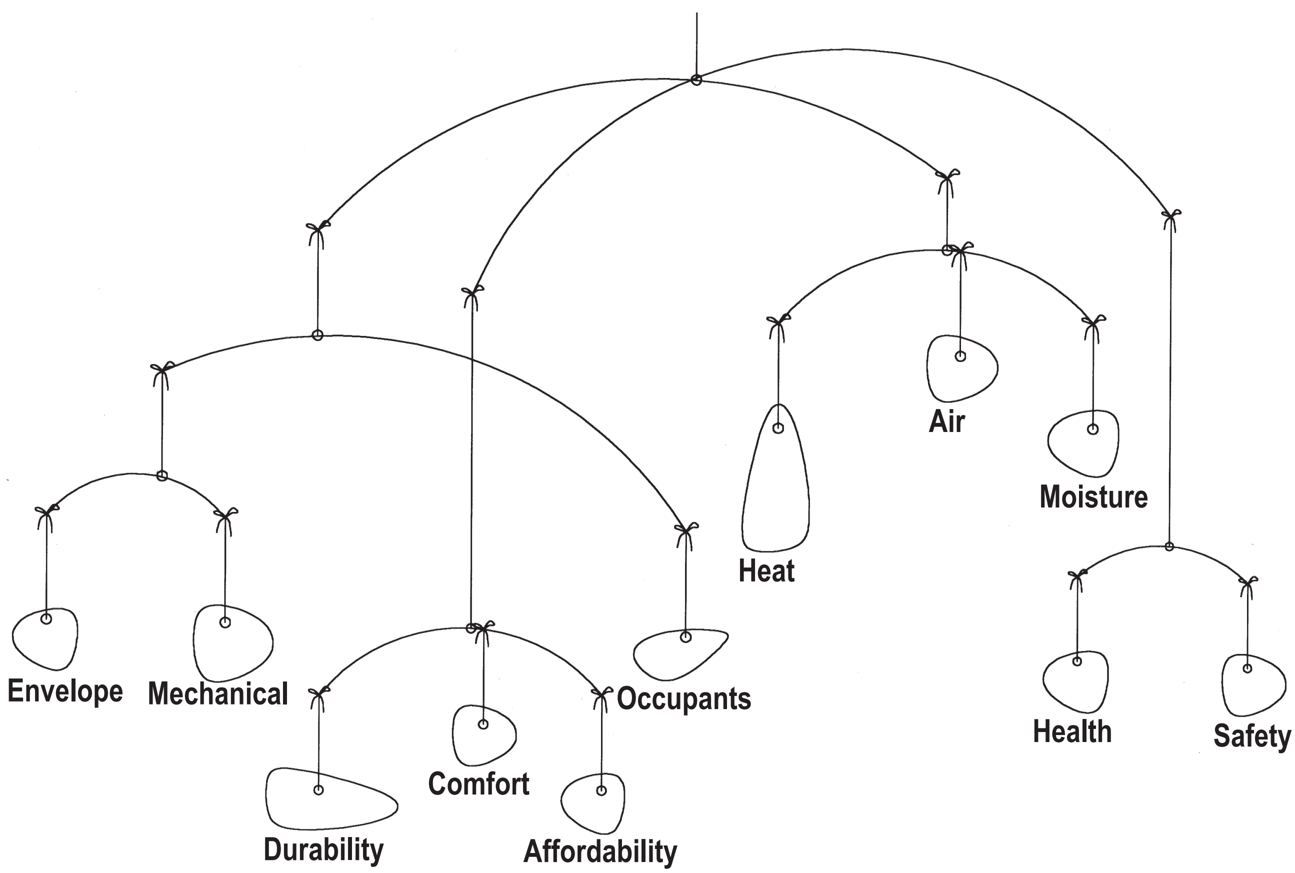
An energy-efficient building controls the movement of **heat**, **air**, and **moisture**. Heat movement out of the building is a direct cost in energy dollars. Movement of air causes convective heat loss and carries moisture into places it should not be, such as walls and attics. Movement of moisture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

The remainder of this book explains how to construct a new building or retrofit an existing building to meet Alaska standards. First, we give a brief discussion of building science and design considerations. Then, we take a regional approach to the state and describe how to meet current Alaska standards and how to build foundations, walls, floors, and ceilings that meet these standards. Finally, we treat each part of the building's system separately: foundations, floors, basements, and crawlspaces; walls; attics and roofs; windows and doors; and mechanical systems.

2
Building Science

The Building as a System

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

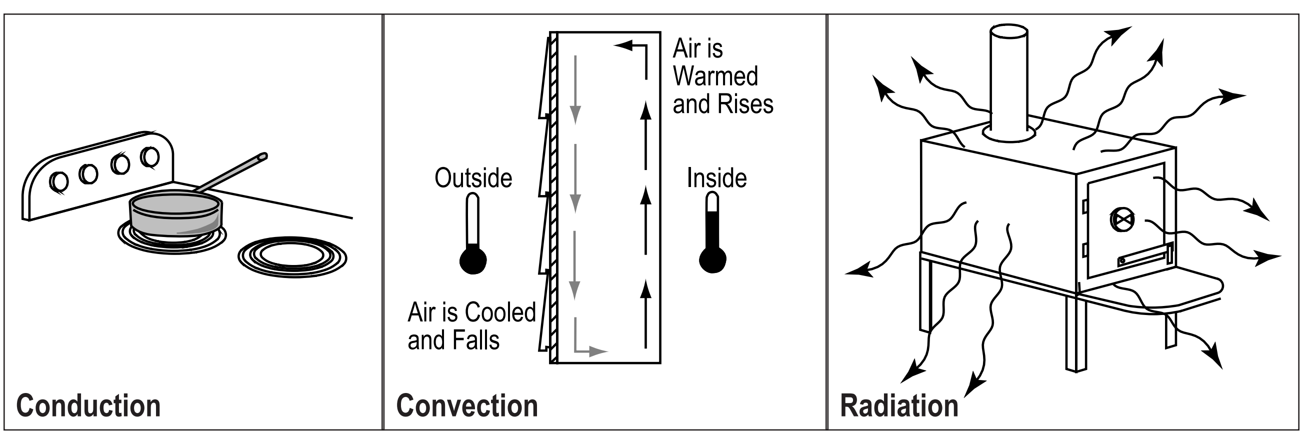


Building Science

Building science is the study of how buildings work. There are 10 fundamental concepts that must be understood before designing a new structure or retrofitting an existing building. Every subsystem should be designed with these concepts in mind to minimize the flows of heat, air, and moisture through the building envelope. Heat flow out of a building wastes precious fuel, air leaking out carries both heat and moisure, and moisture that escapes from the interior of a building can condense or freeze in the insulation, reducing the effectiveness of the insulation and causing damage by mold and rot. The following concepts of building science provide the foundation for designing a building as a system.

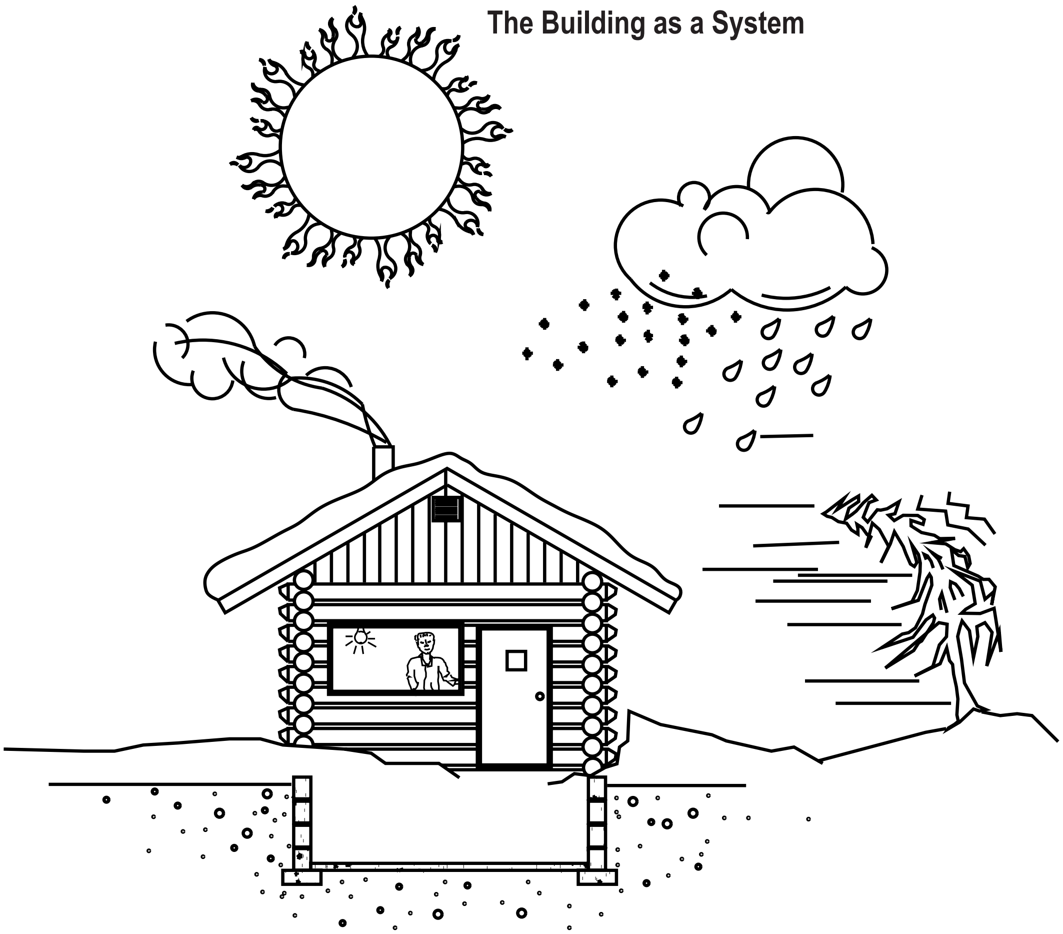
Top Ten Building Science Concepts

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



Three methods of heat transfer (Building Science Concept #3)

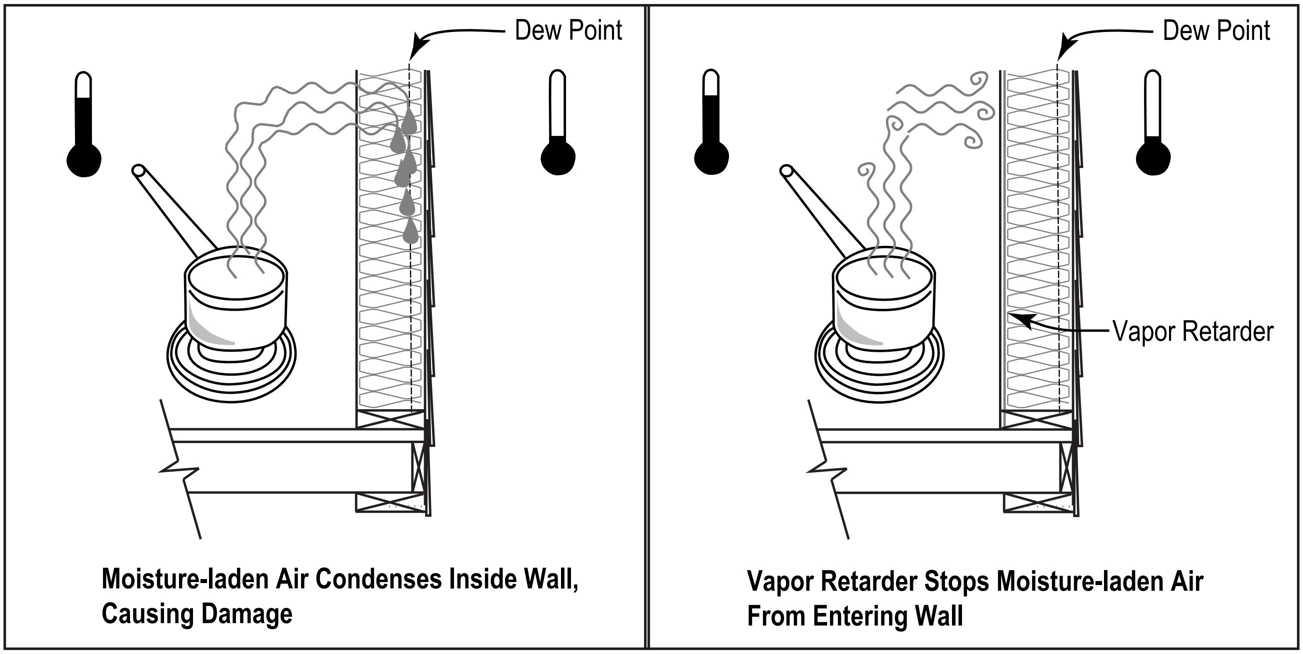
The Building as a System



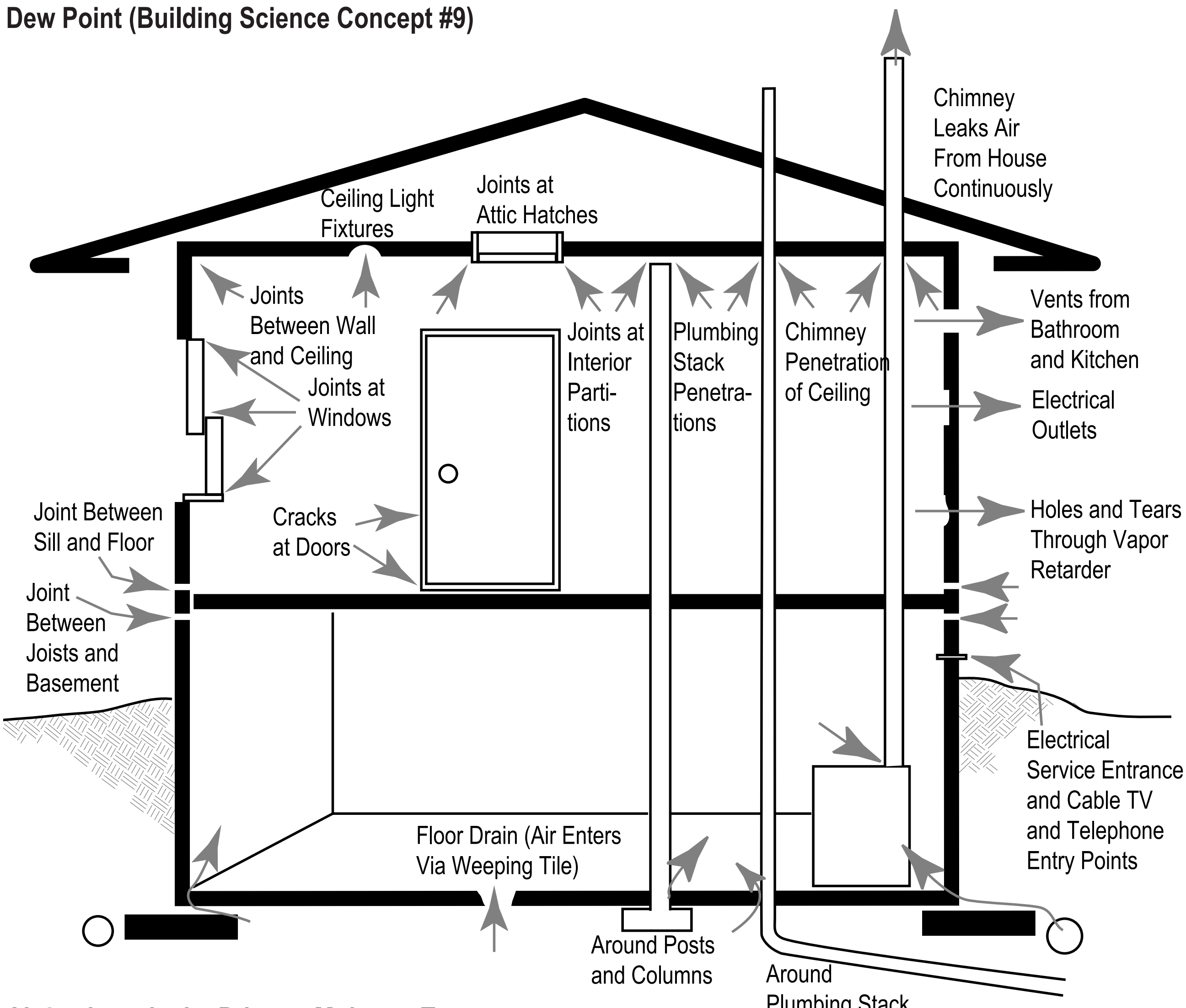
The total performance of the house as a system depends on a balance of envelope, mechanical systems, and occupants. All these parts of the house affect the flow of heat, air, and moisture into and out of the house.

The TwoThirds/ One Third Rule

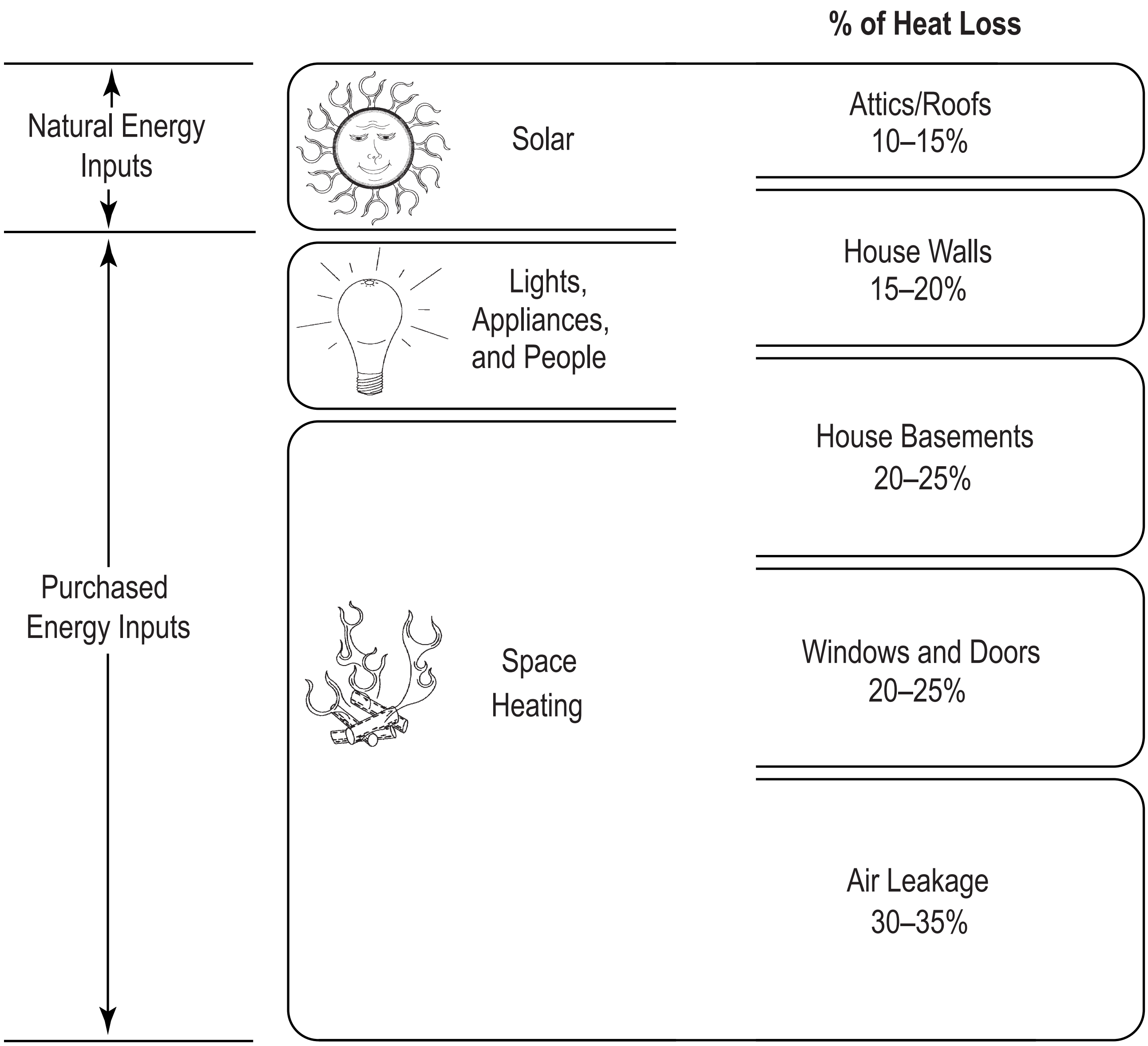
To prevent moisture from reaching the dew point inside the wall, no more than one third of the total R-value of the wall should be on the warm side of the vapor retarder in areas with less than 12,000 heating degree days. Heating degree days is a measure of the need for heating based on the number of days the outside temperature is lower than 65 dgrees F and by how much (see glossary). In areas with heating degree days of 12,000 to 14,000, no more than one quarter of the insulation should be on the warm side of the vapor retarder, and in climates of over 14,000 heating degree days, no more than a quarter (one-fifth is recommended) of the insulation should be on the warm side of the vapor retarder. Following this rule prevents water vapor from getting too cold and condensing before it is stopped by the vapor retarder. (For the heating degree days in your location, see map on page 10).



Dew Point (Building Science Concept #9)



Air Leakage is the Primary Moisture Transport Mechanism (Building Science Concept #7)

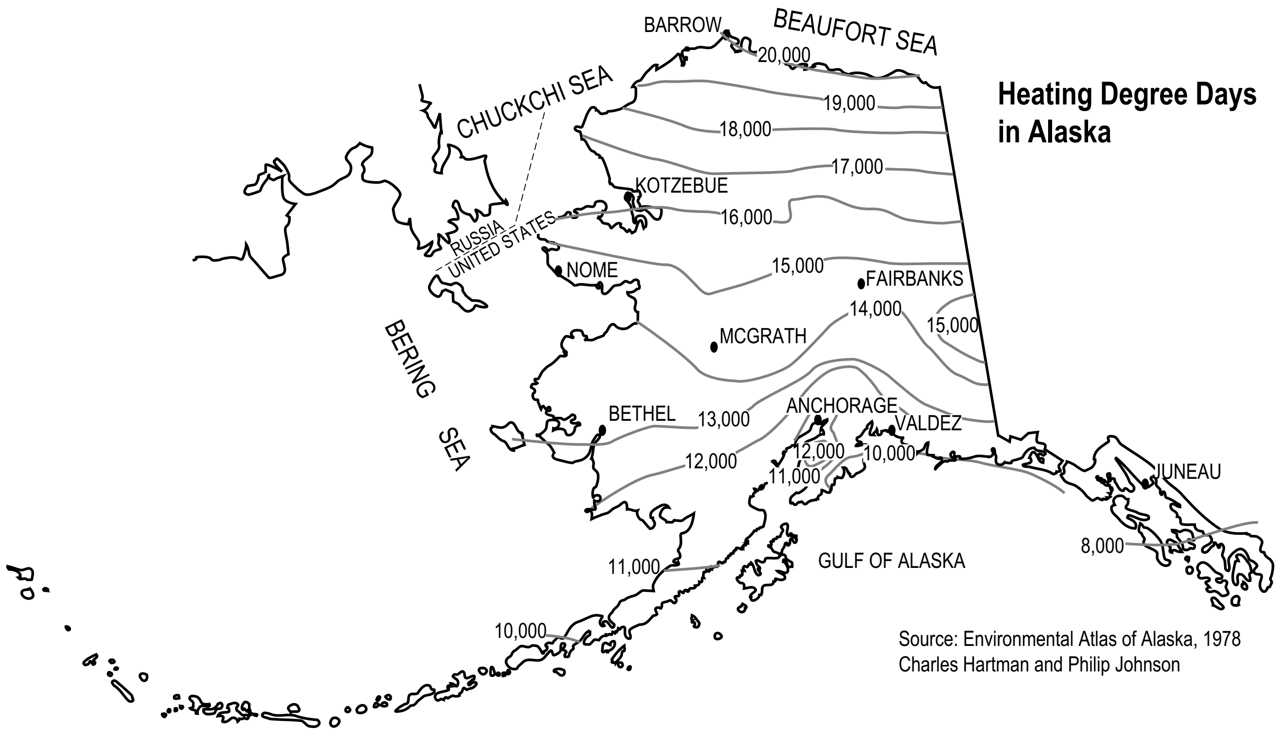


Energy Flows in Housing

Design

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

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



One of the most crucial items in cold climate construction is acheiving a truly continuous vapor retarder, air retarder, and weather retarder. This must include details for a continuous vapor retarder over partition top plates, at the end of partition walls, and through the rim joist area on multilevel structures. The plans and specifications must indicate the insulation values for the foundation or floor, walls, windows and doors, and ceilings, and these values must equal or exceed the R-values required by the standard. If you use the energy budget method, you must include a copy of the Hot 2000 or AkWarm printout.

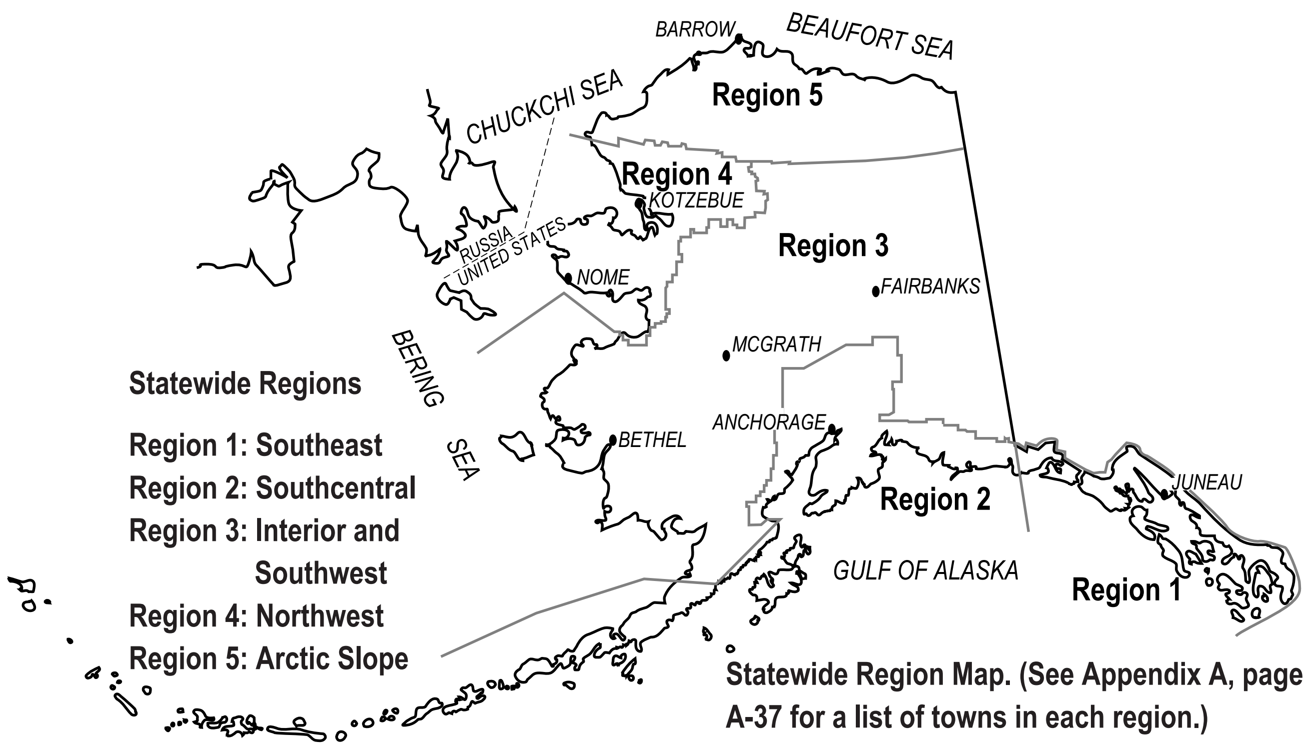
Face windows south toward the midday winter sun for natural light and passive solar heat.

Site Plan

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

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

3
Regional Geography and Climate



Statewide Region Map. (See Appendix A, page A-37 for a list of towns in each region.)

This chapter describes how to build the various foundation, floor, wall, and ceiling systems required to meet the prescriptive R-values for each region. We will examine the climatic, geographic, and demographic conditions of each region and relate these factors to the design considerations specific to each region.

There are **four methods of compliance** with the energy standard: the prescriptive method, the performance method, the building budget method, and the energy rating method. All of these methods must meet minimum standards of balanced mechanical ventilation.

The prescriptive method requires minimum R-values for all six sides of the building envelope: the ceiling, floor, and four walls, including windows and doors (see Table 1). This method is very much like following a recipe in a cookbook. If you design in all of the required insulation levels, fulfill all the statewide mandatory measures, and build an airtight home, your home should meet your needs for many years to come.

The performance method allows the trade-off of insulation requirements between elements of the thermal envelope. For instance, the wall insulation could be increased to compensate for additional square footage of windows.

The building budget method requires the use of Hot 2000 or AkWarm energy analysis software or a manual calculation as shown

Table 1
Prescriptive Standards

Region	Heating Fuel	Thermal Envelope R-value Requirements: 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.

in the Building Energy Efficiency Standard (BEES) workbook. This method allows for more flexibility in design and allows the designer to optimize insulation levels. The software program calculates an annual energy target for a structure and takes into account all of the systems in the building: the heating system, the ventilation system, air leakage, domestic hot water use, electrical use, the building envelope efficiency, as well as solar gain and internal heat generated by occupants and electrical equipment.

The energy rating method requires achieving a four-star plus or better rating by a certified energy rater. Contact AHFC for a list of certified energy raters.

There are many ways to meet the prescriptive standard R-values in Table 1 or to comply with the results of a Hot 2000 or AkWarm energy analysis. It is not the authors' intent to select any "best" method of achieving these prescriptive standards. We only intend to provide several examples, illustrating the flexibility available to designers and builders.

Region 1: Southeast Alaska

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

Weather in this region is tempered by warm ocean currents, so that relative to the rest of Alaska, winters are warm but summers are cool. Southeast Alaska is noted for its nearly year-round rainfall and persistent surface winds. The heating degree days range from about 7,000 in Ketchikan to about 9,500 in Yakutat. These are the same conditions that Norwegian builders have faced for centuries, and they have developed ways to build successfully in this type of climate. (See the bibliography on page 97 for several publications by the Norwegian Building Research Institute.)

Control of Underground Water

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

Prescriptive R-Values for Southeast Alaska

If following the prescriptive method, the minimum thermal envelope insulation values are R-38 in the ceiling; R-21 for above-grade walls; R-15 for below-grade walls; R-30 in an unheated crawl space floor; R-10 for a slab; R-3 for windows; and R-7 for doors. You must also comply with all mandatory measures described in BEES.

R-15 Foundations

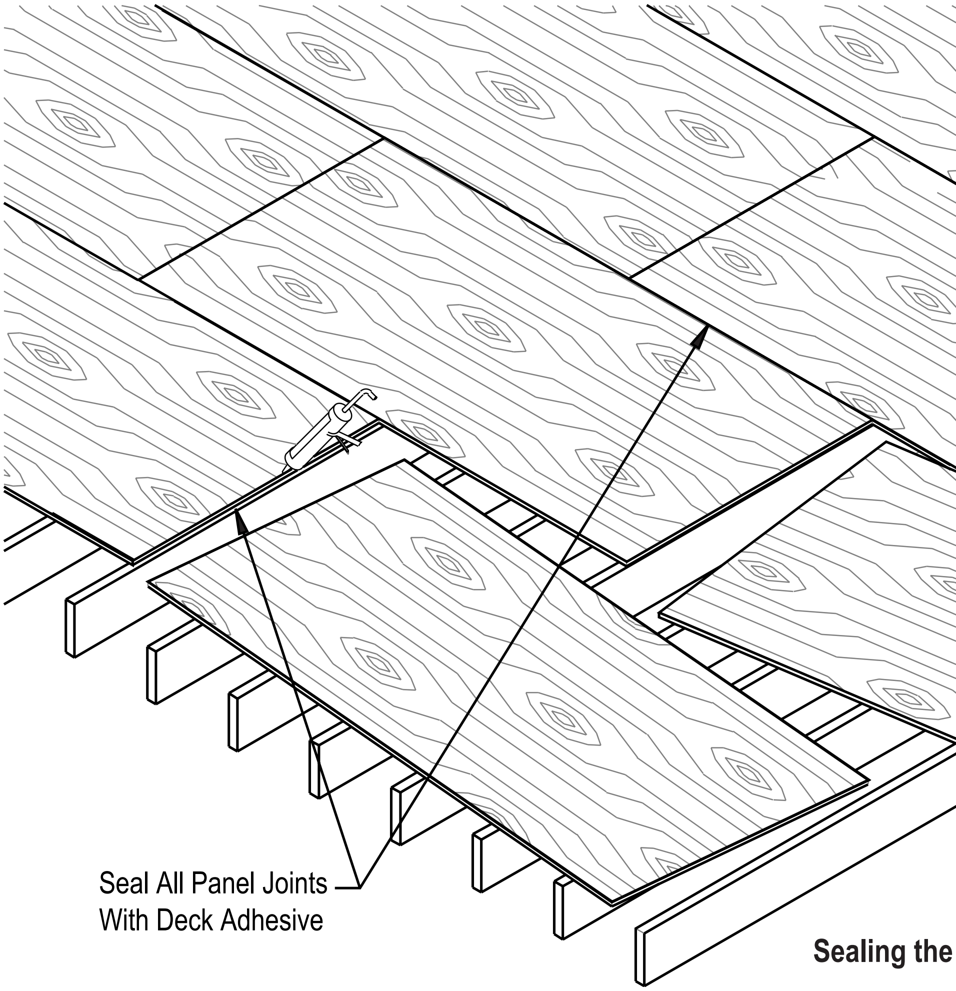
Foundations, if heated, must be thought of as part of the thermal envelope. If soil conditions permit, a heated crawl space or a full basement may be constructed to meet the standard. A simple way to meet the standard for Southeast Alaska with a concrete foundation is to insulate the exterior and under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

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

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

R-30 Floors

In Southeastern Alaska, open crawl spaces are common and the foundation will usually not be insulated. In this case, the floor must be insulated to a minimum of R-30 if following the prescriptive method of compliance. This can be easily accomplished by 9-inch-thick fiberglass. Insulate the perimeter of the floor to the full depth of the joists. The underside of the floor joists should be covered with a weather retarder house wrap of Typar, Tyvek, Barricade, or equivalent. This house wrap should extend up the outside of the rim joist where it can be overlapped by the wall weather retarder. All seams, laps, and penetrations in the house wrap must be sealed with a compatible tape designed for use with these products. This will keep wind from intruding into the floor system and carrying away heat and lowering effective R-values. It will also prevent drafts on the floor and provide the occupants with a comfortable, draft-free environment. The topside of the joists should be fitted with a minimum ¾-inch exterior-grade tongue-and-groove subfloor plywood glued and screwed to the floor joists and sealed on all edges with waterproof adhesive. The underside of the joists should be covered with plywood to prevent physical damage by animals or high winds. If access to the underside of the floor system is limited, the builder can glue tight-fitting rips of plywood on top of the bottom flanges of plywood I-beam floor joists. Butt joints between these plywood panels should be air sealed with compatible tape to prevent air intrusion



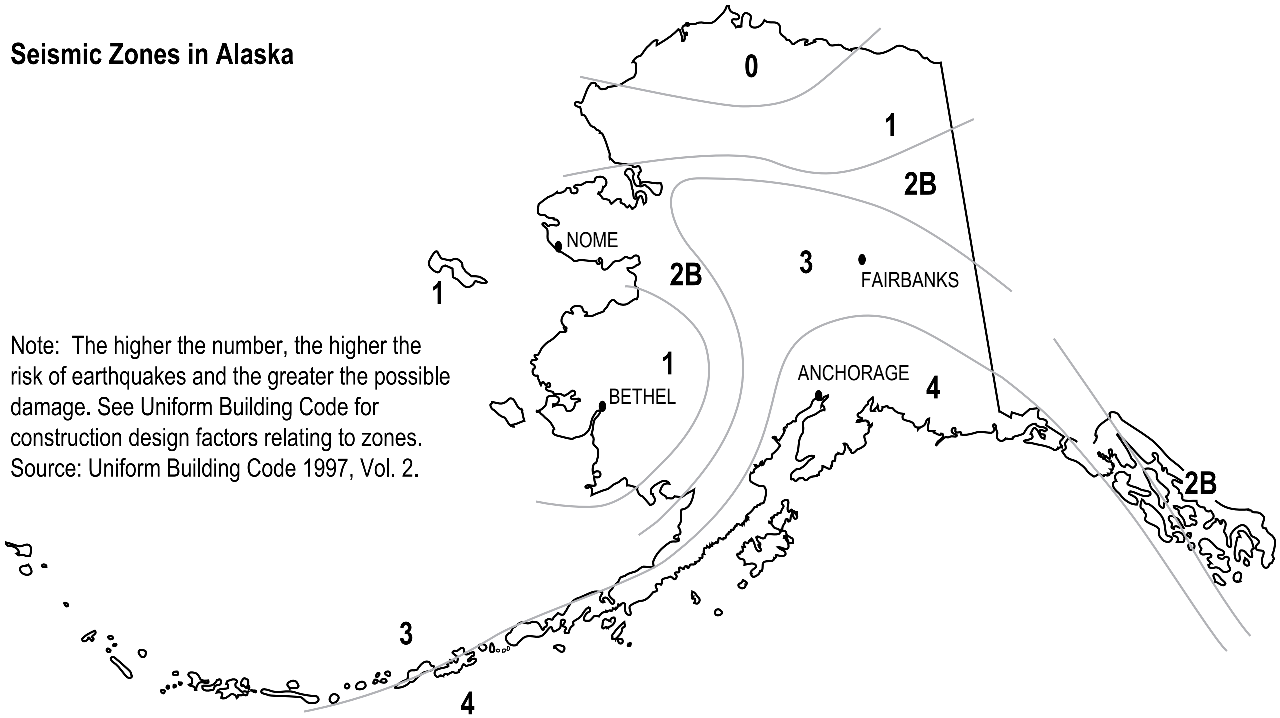
Sealing the Subfloor

but allow water vapor to escape. R-30 insulation can then be placed from above if weather permits or if the roof is dried in. Alternatively, foam core panels are available that meet the R-value requirements for floors.

Seismic, Snow, and Wind Loads

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

Seismic Zones in Alaska

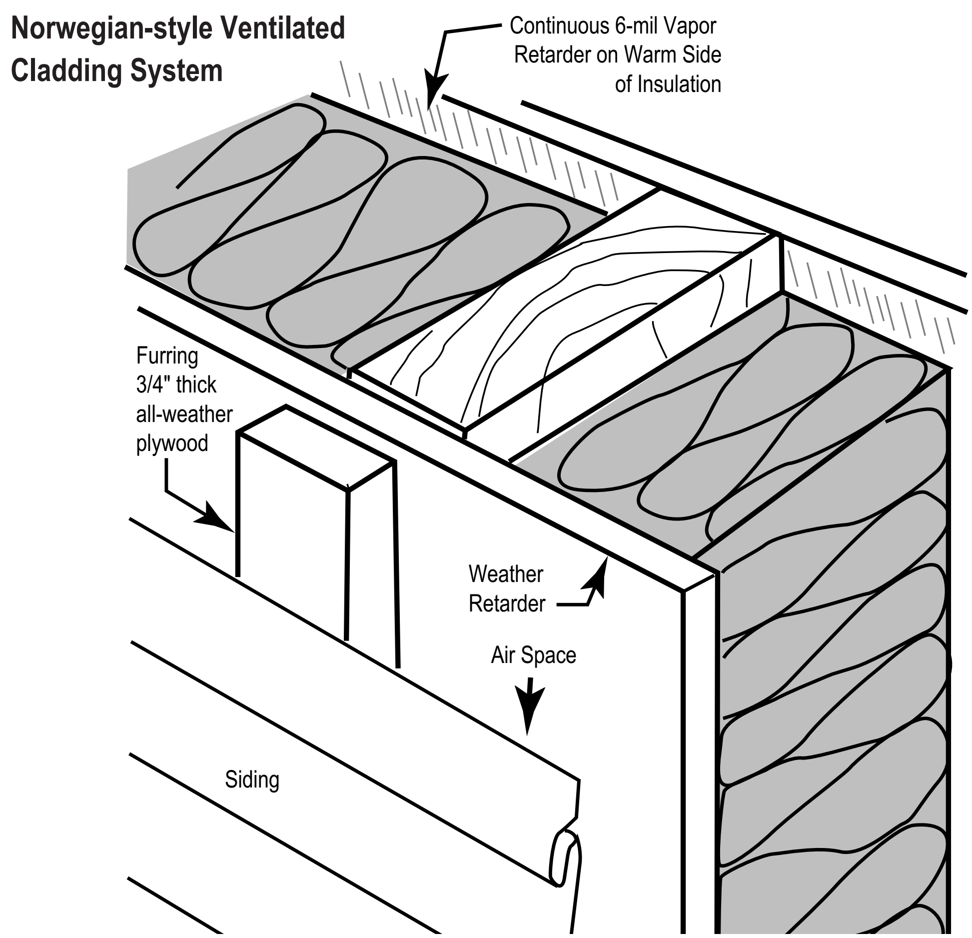


Note: The higher the number, the higher the risk of earthquakes and the greater the possible damage. See Uniform Building Code for construction design factors relating to zones. Source: Uniform Building Code 1997, Vol. 2.

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

Exterior Ventilated Cladding

The construction of insulated walls exposed to the ravages of wind and rain is a fairly new science relative to the length of time mankind has been living in these conditions. It is only since the cost of energy has made insulation a good investment that Norwegian engineers have begun to solve the wet wall insulation syndrome. They do this by making the structure absolutely airtight on the inside, with an exterior ventilated cladding system that allows the wall to dry rapidly. A contractor in Juneau has adopted this strategy and is wrapping the exterior of the wall framing with a weather barrier and furring out the framing with ¾ x 3-inch pressure-treated plywood strips, over which he nails either horizontal siding or T1-11 sheathing. The bottom openings are screened to allow drainage.



R-21 Walls

One of the easiest ways to comply with the R-21 wall insulation requirement of the prescriptive standard is to frame the building with 2-by-6 studs at 24 inches on center and insulate the wall cavity with relatively low-cost cellulose or high-density fiberglass R-21 insulation. Spraying a 2-by-4 stud cavity with urethane foam with an aged R-value of about six per inch will easily meet the minimum R-value requirements, but since urethane is not a vapor retarder you will have to install polyethylene on the inside face of the studs, as you will with the other systems mentioned in this manual. A new foam product on the market called Icynene insulation has an R-value of about 3.6 per inch, which results in about R-20 in a 2-by-6 wall. Icynene does not contain CFCs, which are known to contribute to the greenhouse effect and resultant global warming.

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

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

R-38 Ceiling

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

Region 2: Southcentral

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

While most of this region is in the maritime climatic zone and transition climate zone, it also includes areas of continental climate in the center of the Kenai Peninsula and the northern reaches near the Alaska Range (see map p. 13). This region is somewhat cooler than Southeast, with heating degree days ranging from about 9,500 on the south to about 12,000 in the north. Southcentral Alaska is one of the most active earthquake regions in the world, with a seismic zone 4 designation. This means that here is a possibility of a major earthquake greater than 8 on the Richter scale.

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

Prescriptive R-Values for Southcentral Alaska

If following the prescriptive method, the minimum insulation values are R-38 in the ceiling, R-25 in the above-grade wall, R-15 in a below-grade wall, R-30 in the crawl space floor, R-10–15 for the slab; R-3 windows, and R-7 doors. If you are heating with natural gas, the R-values are lower. See Table 1, page 14. In addition, you must comply with all mandatory measures in BEES.

R-25 Walls

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

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

R-30 Floors

Floors insulated to R-30 can most easily be constructed with 2-by-10 floor joists or 9 ½-inch plywood I-beam joists and 10 inches of fiberglass insulation. If plywood I-beams are used as joists, carefully cut insulation to fit tightly around the irregular profile of the I-beam, eliminating voids in the insulation. Densely packed cellulose insulation in 10-inch joists will also meet the standard. Smaller joists can be used with higher R-value urethane foam insulation or with a layer of rigid foam applied to the underside of the floor joists. Rigid foam can also be installed between plywood I-beam joists and supported by the bottom flange, with fiberglass or cellulose installed from above. Foam core panels are available that meet the standard for R-30 floors. Insulation should be protected by a layer of plywood nailed to the underside of the floor joists.

R- 38 Ceiling

An R-38 ceiling requires about 12 inches of fiberglass insulation, preferably two R-19 batts installed at right angles. Since the mandatory measures in BEES require that no less than 80 percent of the minimum ceiling R-value can be installed over the wall, this means that the raised heel truss height over the wall can be no less than 10 inches. The truss engineer must know these details in order to design a truss that will comply with the standard if you plan to use fiberglass insulation. If only substandard trusses (formerly considered standard) without a raised heel over the wall are available, then a two-foot-wide band of higher R-value foam insulation can be used along the bearing walls to obtain the minimum required insulation level.

Region 3: Interior and Southwest

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

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

Prescriptive R-values for Interior and Southwest

If following the prescriptive method, the minimum thermal envelope R-values for Region 3 are R-38 in the ceiling, R-25 in above-grade walls, R-19 in below-grade walls, R-38 in exposed crawl space floors, R-10–15 under slabs, R-3 windows, and R-7 doors.

Permafrost

The choice of foundations for buildings in Interior and Southwest Alaska is as varied as its geology, geography, and climate. Most of this region is underlain with discontinuous permafrost. The annual mean temperature of the soil is just barely below freezing, so any disturbance to the temperature balance can result in catastrophic structural failure of a building. Permafrost is often absent from south slopes and from free-draining sand and gravels left by rivers or glaciers. Permafrost is usually found on north-facing slopes and beneath thick layers of vegetation and peat in the valleys. While vegetation is commonly used as an indicator of whether or not permafrost is present, there is only one kind of tree that will guarantee the absence of ice: a palm tree. The only way to be sure is to test (see permafrost map on page 32).

R-15 Below-Grade Foundation Wall and R-10–15 Slab

If soil conditions are suitable for a conventional crawl space foundation or full basement and if you are following the prescriptive method of compliance with the standard, then you must insulate the below-grade wall to R-19 and the slab to R-10 for a below-grade basement and R-15 for a slab on grade. This can most easily be accomplished by insulating outside the foundation wall with four or more inches of high-density foam insulation for an R-value of 20. An R-10 slab will require two or more inches of high-density rigid foam. An R-15 slab will require three or more inches. At a minimum, put the insulation in a 24-inch wide band around the perimeter of the slab. It is better to insulate under the entire slab. Be sure to place a below-grade foundation wall or slab on non-frost-susceptible soil.

If ice-rich soils cannot be avoided, the best strategy will be to preserve the permafrost by disconnecting the building from the ground. This is commonly accomplished by building on pilings with a heavily insulated floor three or four feet off the ground to allow the free flow of cold air to carry away any heat from the building. A new type of foundation known as a space frame (see drawing on page 33) that relies on a combination of triangles of structural tubing joined by hubs into a rigid foundation system may be a cost-effective alternative to piling foundations. The manufacturer claims that this type of foundation will eliminate differential settlement. If borne out in practice, this will solve the problem of rapid self-destruction from foundation failure all too common in piling and post and pad foundations.

R-38 Crawl Space Floor

An R-38 floor can be constructed of 11 7/8-inch engineered plywood I-joists or 2-by-12 joists with plywood sheathing under the joists and cellulose insulation blown in the floor cavity to a density of at least two pounds per cubic foot. If a blower machine is not available, it is possible to hand pack the floor joist cavity to sufficient density to meet the standard. Twelve inches of fiberglass batts will also meet the standard.

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

R-25 Walls

Single-stud walls insulated to R-25 are easily constructed with 2-by-6 studs 24 inches on center and insulated with high-density fiberglass batt insulation, Blown In Blanket, blown-in cellulose, or Icynene Insealation, all of which provide an insulation of about R-21. The rest of the R-value can be made up with rigid foam insulation placed on the inside or the outside. If urethane foam is available, it can be sprayed into the stud cavity to easily meet the standard. Only taped foil-faced rigid insulation will not require an air/vapor retarder on the warm side of the wall. Foam core panels will also comply with the standard. Beyond about R-30, the high cost of foam insulation makes a double-stud wall insulated with fiberglass batts cost effective.

R-38 Ceiling

An R-38 ceiling is most easily constructed using an energy-heel truss with about 12 inches of fiberglass or cellulose insulation. Allow for at least 80 percent of the required depth of insulation over the bearing walls. You must also provide for about two inches of air space over the insulation if building a cold roof. Baffles should be installed at the eaves to prevent air intrusion into the insulation and to provide an open channel for ventilation over the insulation.

Region 4: Northwest

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

The Northwest region is mostly in seismic zone 2B (see region map page 13 and seismic map page 19), which means that there is a probability of structural damage from moderate earthquakes of magnitude 4.5 to 6.0 on the Richter scale to the south of Norton Bay and a probability of major structural damage in the northern half of the region, with earthquakes greater than 6.0 on the Richter scale. Wind load and snow load are about 30 pounds per square foot in the coastal regions, with an increase in snow load as you move inland and increase in elevation. Check with local building officials and local weather service offices for snow load and wind load and seismic design criteria.

Prescriptive R-values for Northwest

If you are following the prescriptive method, insulation values for the Northwest region are R-38 in the ceiling, R-30 in above-grade walls (below-grade walls and slabs will be considered in Region 4 only in special cases based upon sound geotechnical engineering principles), R-38 in the floor, R-3 windows, and R-7 doors.

R-38 Floors and R-30 Walls

Most foundations in this region will be piling, post and pad, or space frame to reduce the risk of melting the permafrost that underlies most of northern Alaska. As such, elevated insulated floors above open crawl spaces insulated to R-38 will be the norm. These floor and wall systems can be constructed using any one of the systems described for Region 3. Foundations of buildings that are on permafrost soils must be engineered to prevent differential settlement.

R-38 Ceilings

Check with local building code officials before even beginning to design the roof system for buildings in the Northwest region. In Kotzebue, for example, the building official requires a tightly sealed hot roof design only. Buildings in sheltered inland areas such as Ambler or Shungnak will have deep snow piled up on their roofs and will be best served with well-designed and well-constructed cold roofs. An R-38 ceiling will require about 12 inches of fiberglass or cellulose insulation in a 10-inch high-heel truss system. Insulation baffles must be installed at the eaves in a cold roof system to keep blown-in insulation out of the eaves and to prevent blocking the ventilation space over the insulation. Expanded polystyrene (EPS) foam panels are usually built to fit standard framing materials. An 11 ¼-inch EPS-filled panel will have about an R-45 insulation value.

Region 5: Arctic Slope

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

Permafrost

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

Prescriptive R-values for Arctic Slope

If following the prescriptive method, the minimum thermal envelope values for the Arctic Slope region are R-52 in the ceiling, R-35 in above-grade walls (below-grade walls and slabs in Region 5 will be considered only in special cases based upon sound geotechnical engineering principles), R-43 in an insulated floor above an open crawl space, R-3 windows, and R-7 doors. Comply with all of the mandatory measures in BEES.

R-43 Floors

An R-43 floor will require about 14 inches of fiberglass or cellulose. Deeper floor joists will be necessary to meet the prescriptive standard for this region. Engineered plywood I-joists up to 24 inches deep can be purchased from most large building supply stores. Parallel chord floor trusses are also easily obtained. The advantage of these kinds of floor systems is that they allow room for running utilities within the joist spaces on the warm side of the insulation. If plywood I-beams are used as joists, carefully cut insulation to fit tightly around the irregular profile of the I-beam, eliminating voids.

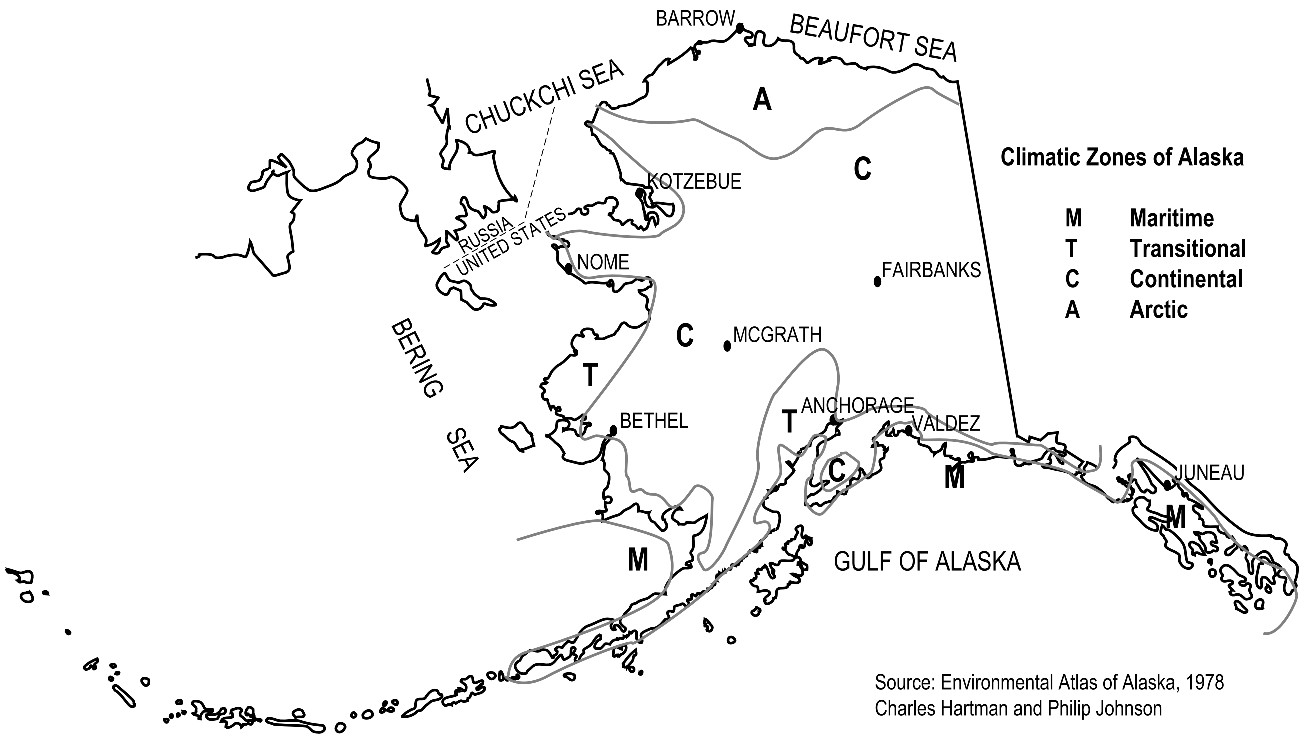
Expanded polystyrene foam core panels may not meet the standard; however, urethane-filled panels can easily. One of the problems with closed floor systems like foam panels is there is no room to easily run plumbing, heating, ventilation, and electrical systems. Some designers have gotten around this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

R-35 Walls

R-35 walls can be constructed using a single-wall stud system insulated with fiberglass batts and rigid foam applied to the exterior or interior of the studs. This can be expensive in both labor and materials. A double-stud wall insulated with fiberglass batts vertically between the studs and horizontally between the walls can reach insulation values of up to R-60, with the only extra materials cost being the price of the thicker fiberglass batts, plus labor. A double 2-by-4 stud wall with a 3 1/2-inch space between walls and insulated with R-11 fiberglass in both stud walls and R-13 high-density fiberglass in between the walls will meet the R-35 prescriptive standard for this region. Another good system to reach higher R-values is to fur in a foam panel wall system with horizontal strapping or vertical metal or wood studs to provide space for utilities on the warm side of the vapor retarder. This space can be insulated, provided the vapor retarder remains above the dew point temperature. This should be the case as long as no more than one-fourth (one-fifth is recommended) of the total R-value is on the warm side of the vapor retarder in region 5.

R-52 Ceilings

R-52 ceilings can be most easily constructed using energy heel trusses filled with 16 inches of blown fiberglass or cellulose. Foam core panels can also be used, but since the maximum depth of most expanded polystyrene panels only provides an insulation value of slightly over R-40, you will have to add furring either above or below to provide space for additional insulation. Urethane-filled panels framed with 2-by-10s will meet the required R-52 insulation value.


BARROW
BEAUFORT SEA
CHUCKCHI SEA
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C
KOTZEBUE
RUSSIA
UNITED STATES
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FAIRBANKS
BERING
SEA
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MCGRATH
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BETHEL
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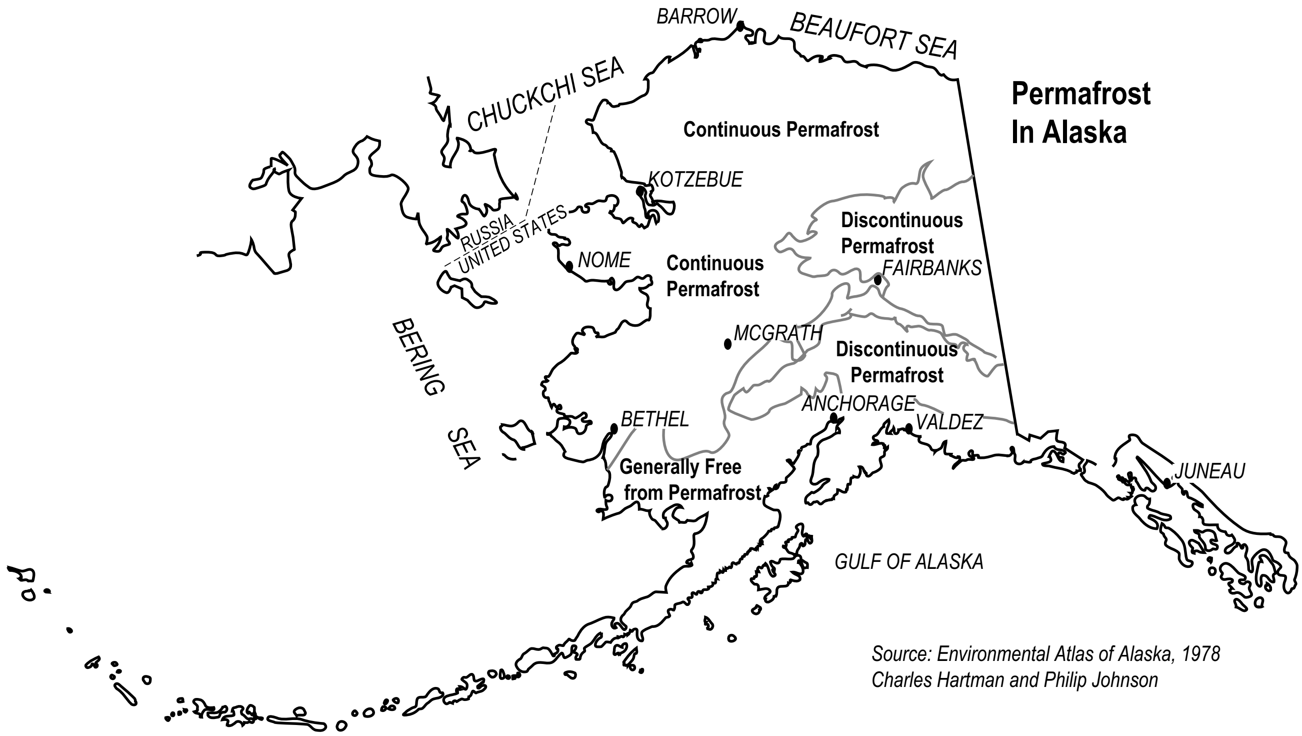
ANCHORAGE
VALDEZ
C
M
M
JUNEAU
M
GULF OF ALASKA
Climatic Zones of Alaska
M Maritime
T Transitional
C Continental
A Arctic
Source: Environmental Atlas of Alaska, 1978
Charles Hartman and Philip Johnson

4

Foundations, Floors, Basements, Crawlspaces

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

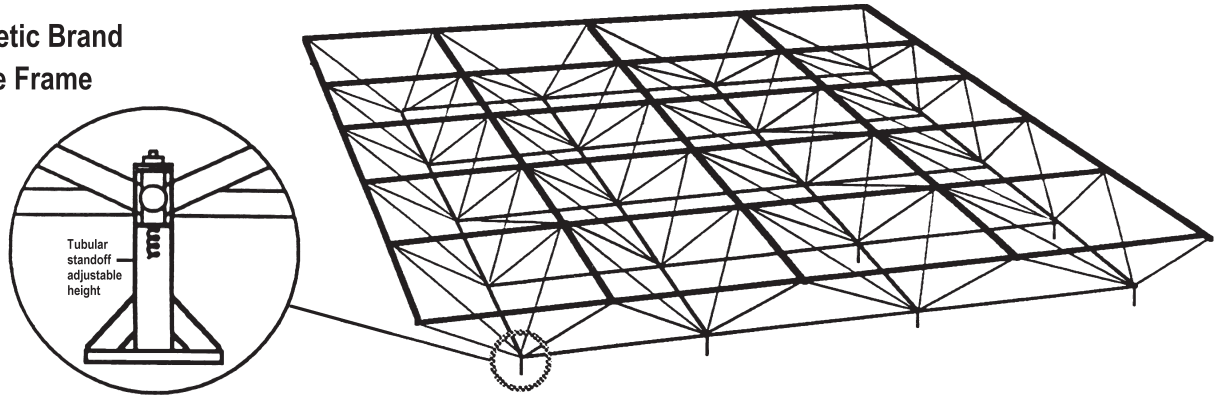
Soil conditions in Alaska vary from nearly bottomless muskeg bogs to permanently frozen ground; from ice-rich silts to solid bedrock. The only way to know for sure is to test. A preliminary soils test should be undertaken before designing the foundation. Test holes should be drilled within the footprint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



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

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

Triodetic Brand Space Frame

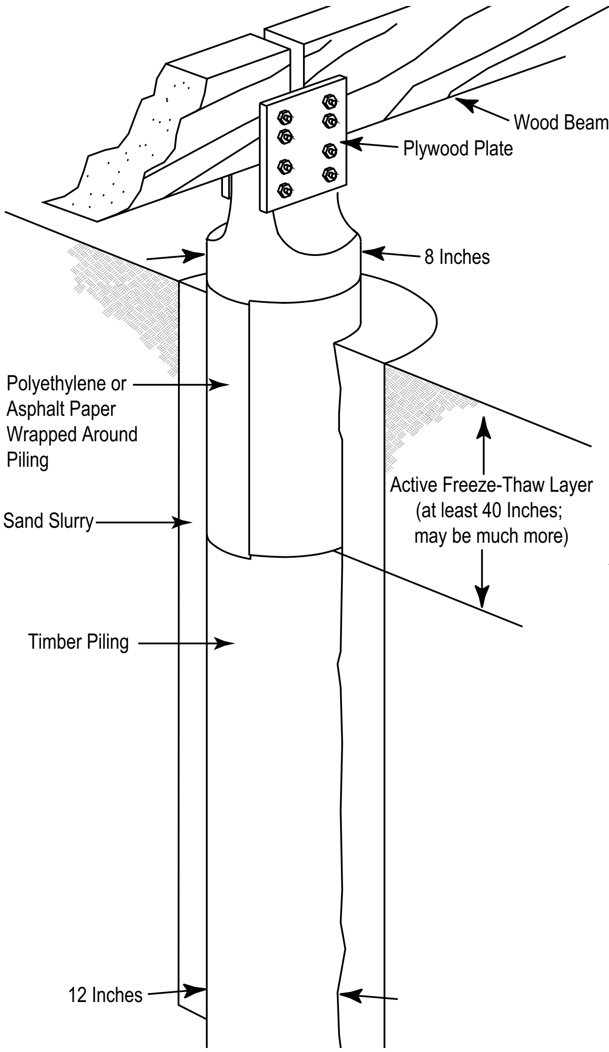


The foundation must be level and square—check the diagonal measurements from corner to corner. These measurements should differ by no more than 1/4". The accuracy and effectiveness of the foundation sets the tone for the rest of the structure. Good finish work begins with a good foundation.

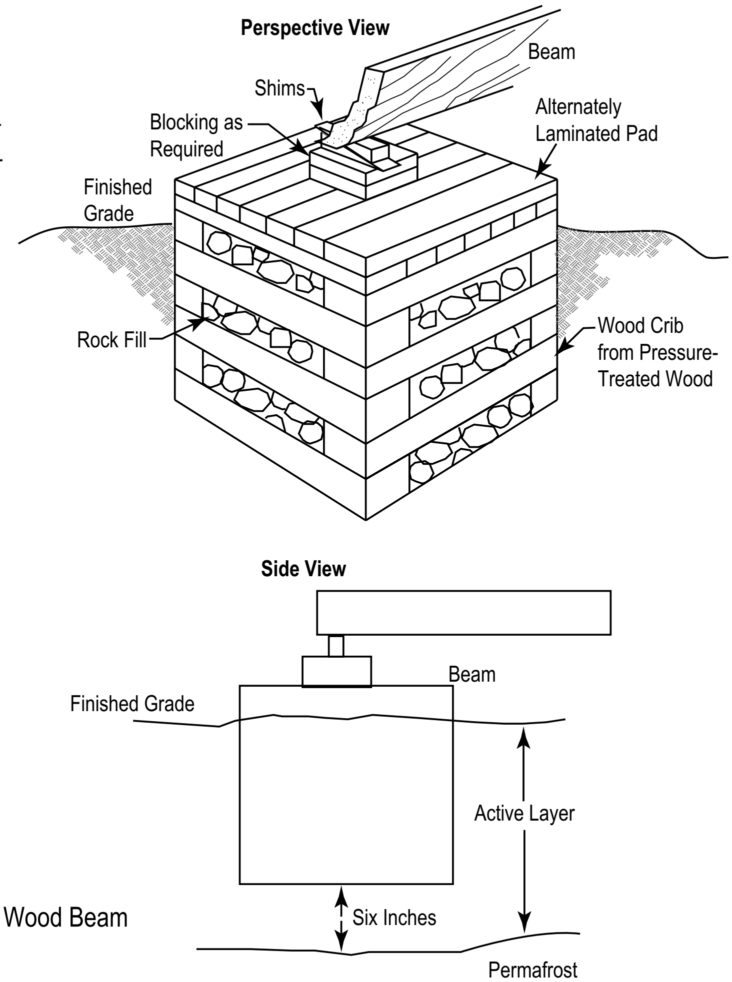
Regardless of the type of foundation (except open crawl spaces), the designer must include the foundation as part of the thermal envelope with appropriate measures specified to resist the flows of heat, air, and moisture. The plans must show how the insulation, vapor retarder, and air or weather retarder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

Design the Thermal Envelope

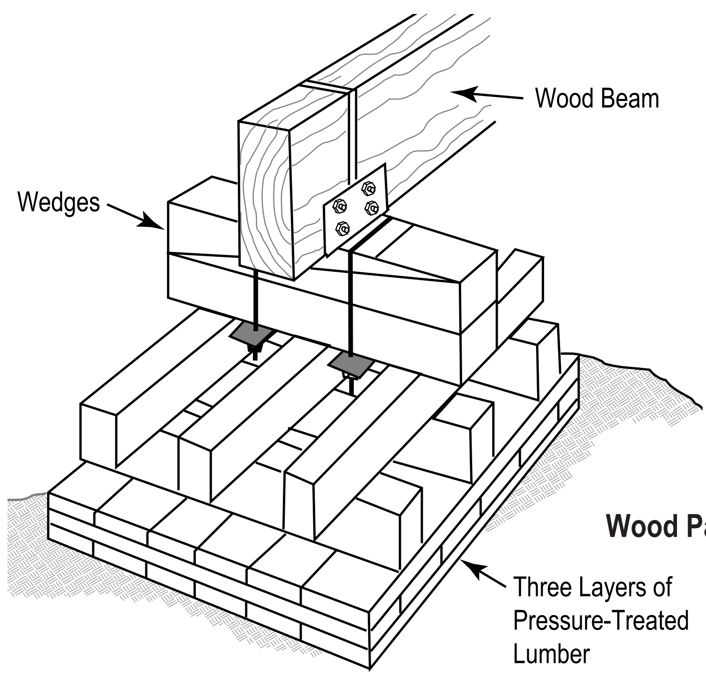
Now that you know what foundation you intend to use, next you must design the thermal envelope from the foundation through the floor, wall, and ceiling systems and back again to the foundation. You must be able to detail a truly continuous air/vapor retarder, insulation system, and weather retarder that meets all of the building science principles outlined earlier in this manual as well as meets the mandatory measures outlined in BEES. We urge you to use Hot 2000 or AkWarm energy analysis software. It will guide you in choosing optimal levels of insulation to meet an annual energy target. If you do not use Hot 2000 or AkWarm, then use Table 1 (on page 14).



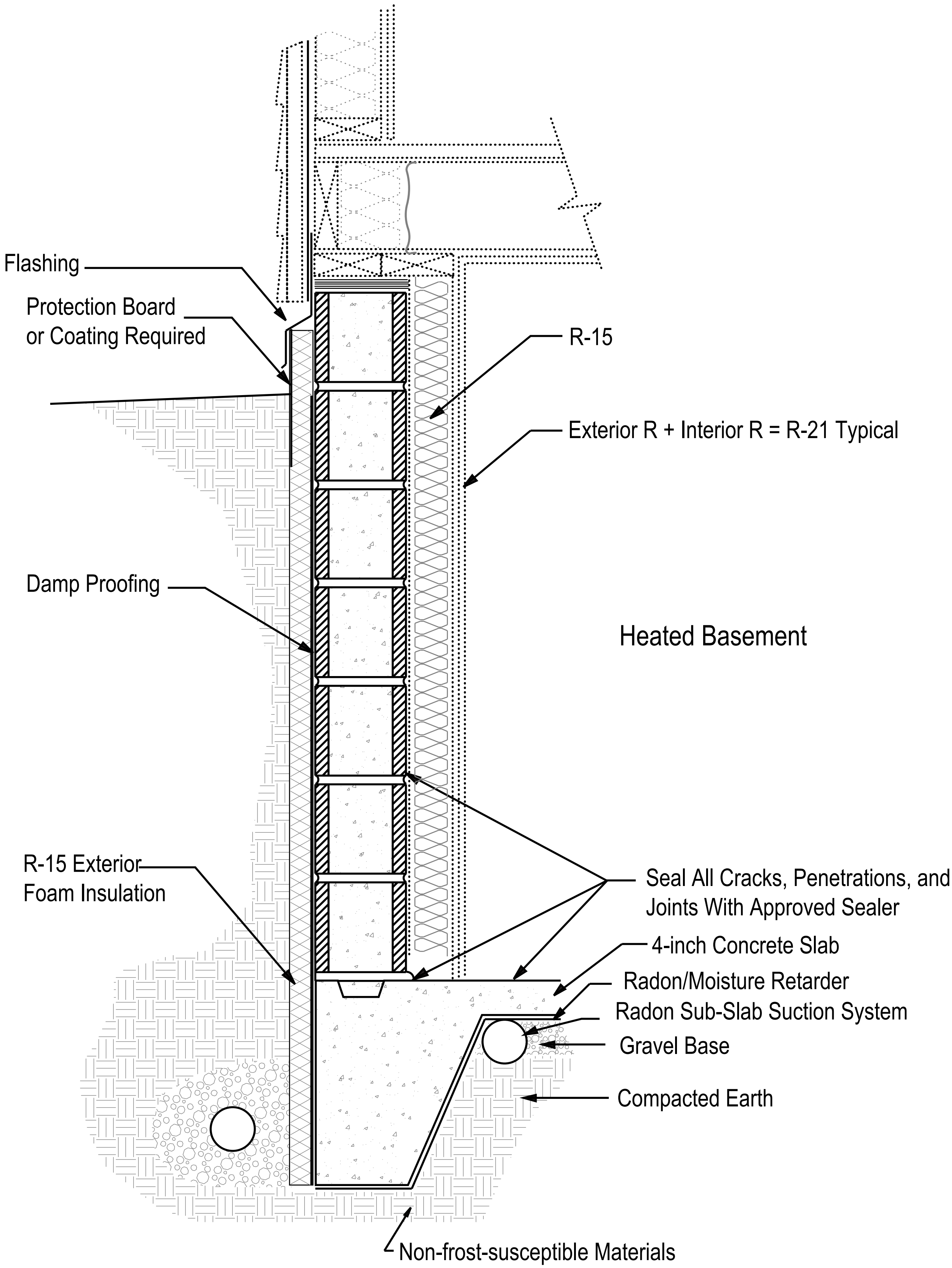
Pile Foundation



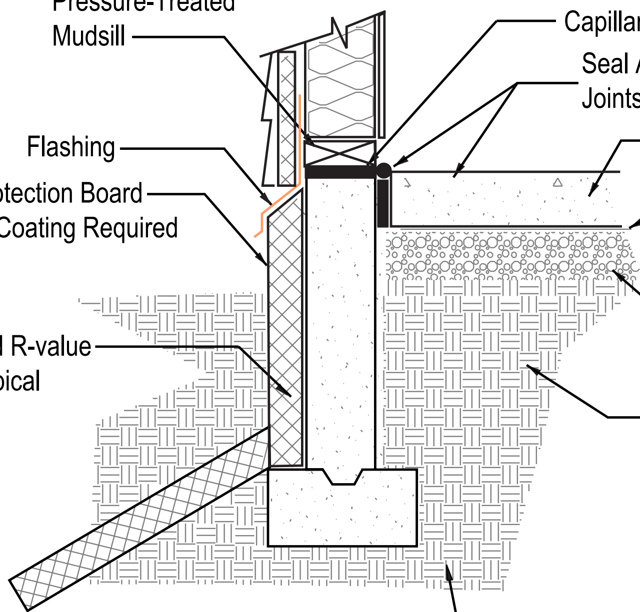
Crib Foundation



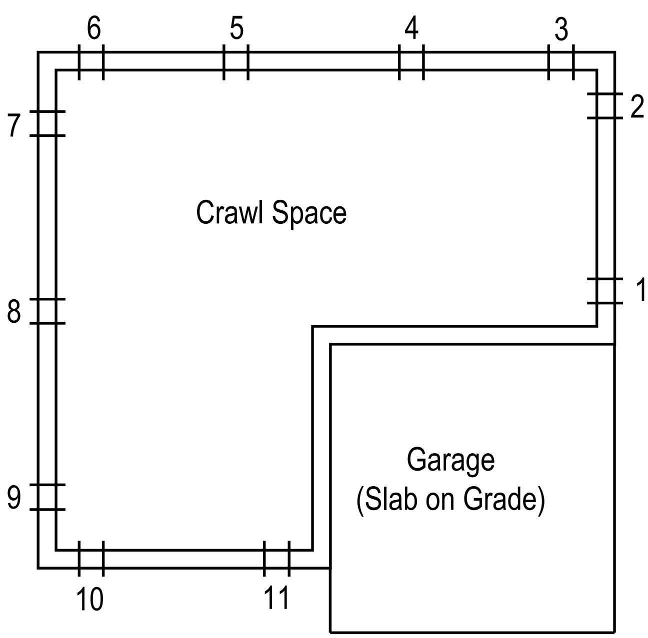
Wood Pad Foundation



Below Grade Wall with Exterior Insulation



Floating Slab on Grade with Exterior Perimeter Insulation



Crawl Space Ventilation Calculation

Sample Venting Calculation

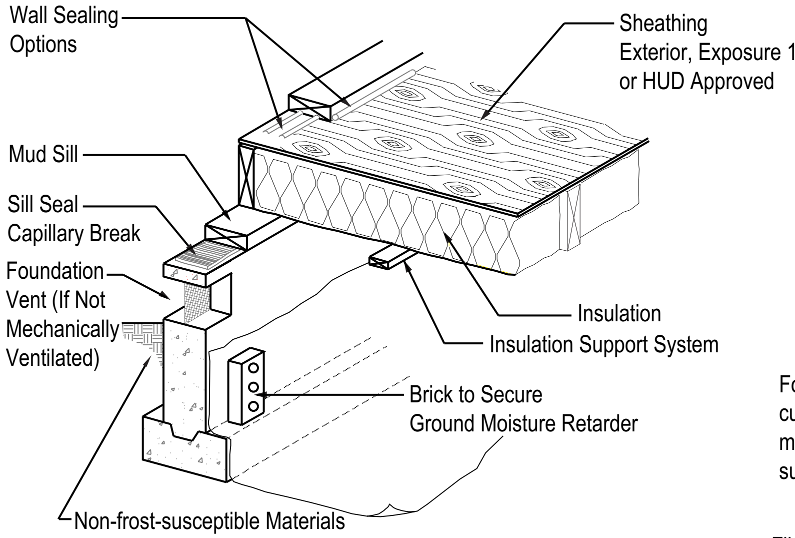
Per UBC Section 2516(c)6:
1 sq. ft. net free area/150 sq. ft. underfloor area

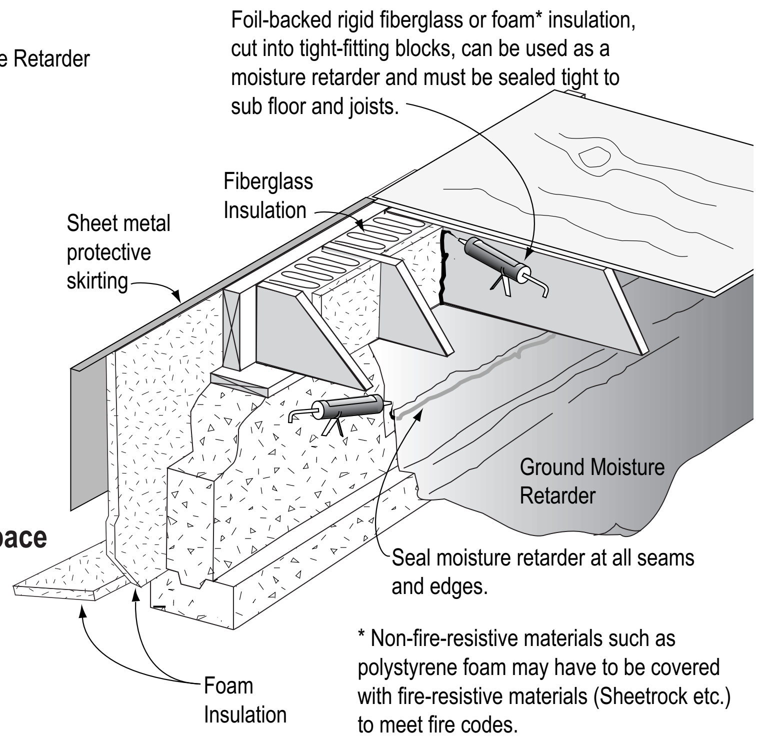
$$\frac{1400 \text{ (crawl area)}}{150} = 9 \text{ sq. ft. (total vent area required)}$$

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

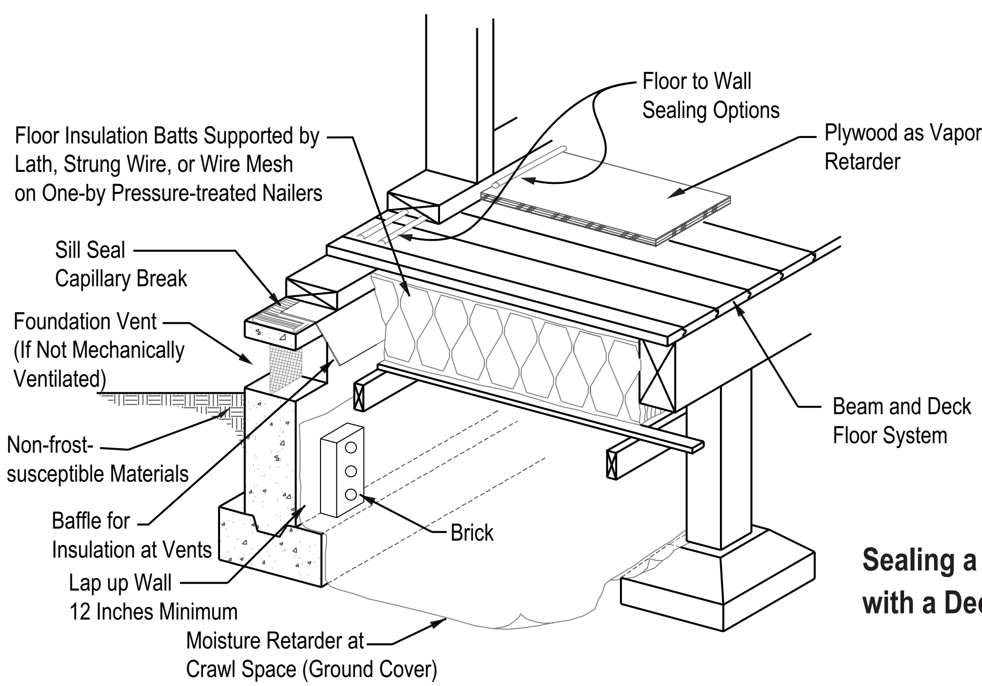
Note: In most of Alaska, temperatures are often well below freezing, and the crawl space is heated. We recommend that you ventilate a heated crawl space mechanically through the heat recovery ventilation system. One suppy and one exhaust, at opposite sides, will usually get the job done.

Sealing a Joisted Floor and Ventilating the Crawl Space





Sealing an insulated crawlspace

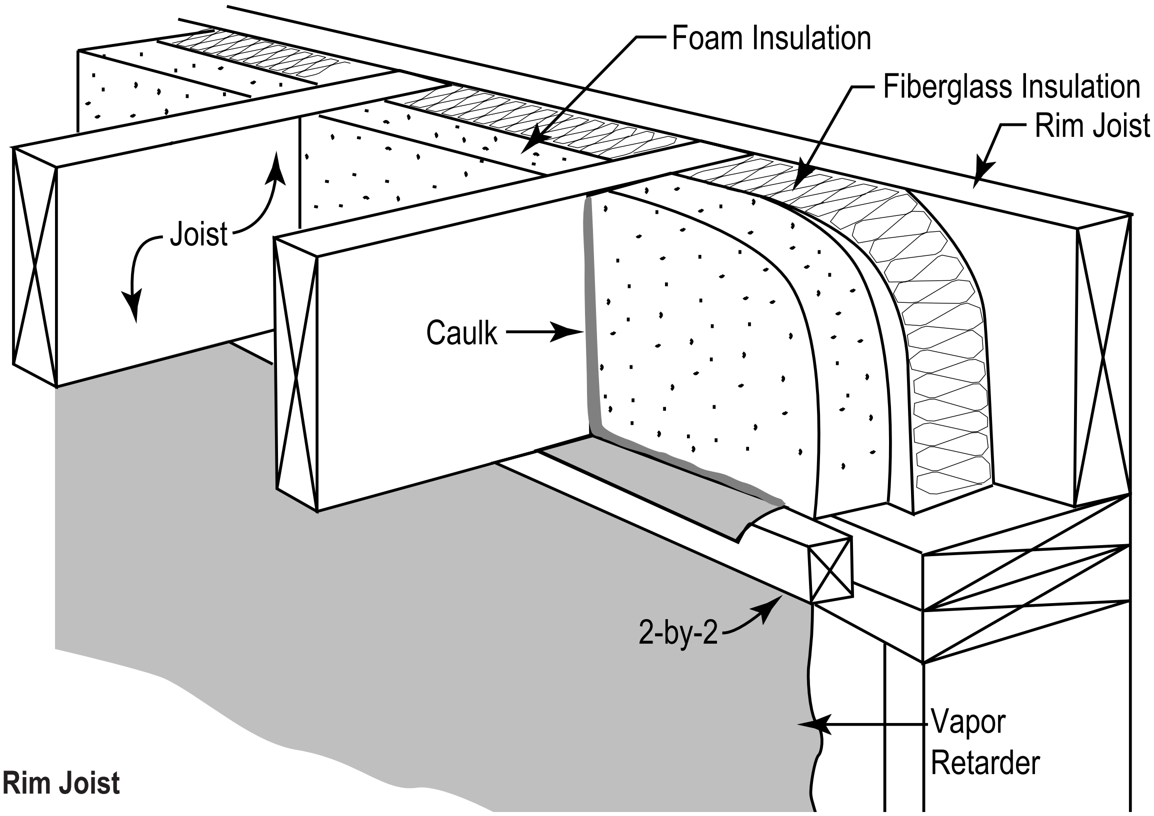


Sealing a Post and Beam Floor with a Decking Subfloor

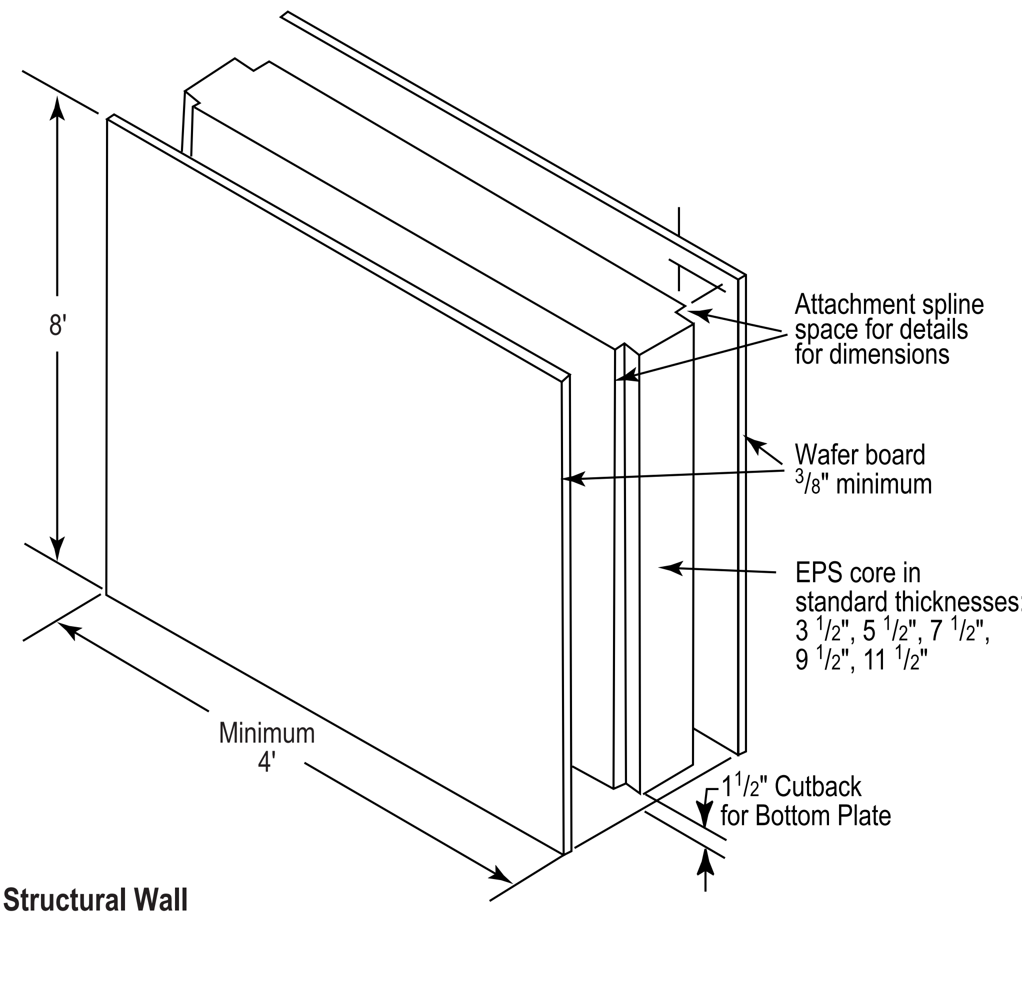
5
Walls

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

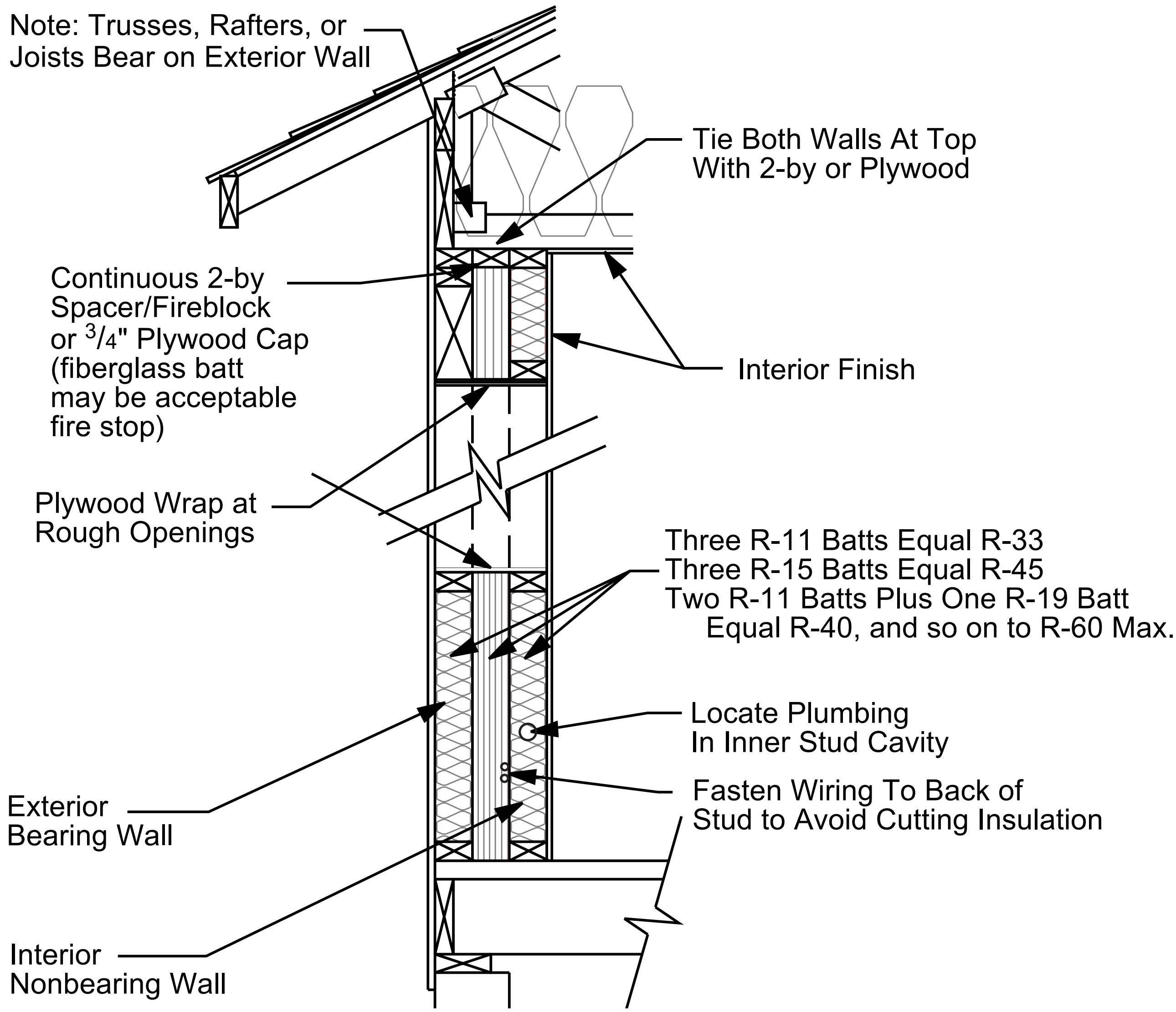
Full ceiling R-values should extend completely over the wall top plate, but not less than 80% of the R-value must be over the top plate. A continuous vapor retarder must extend over the entire ceiling and be sealed to the wall vapor retarder.



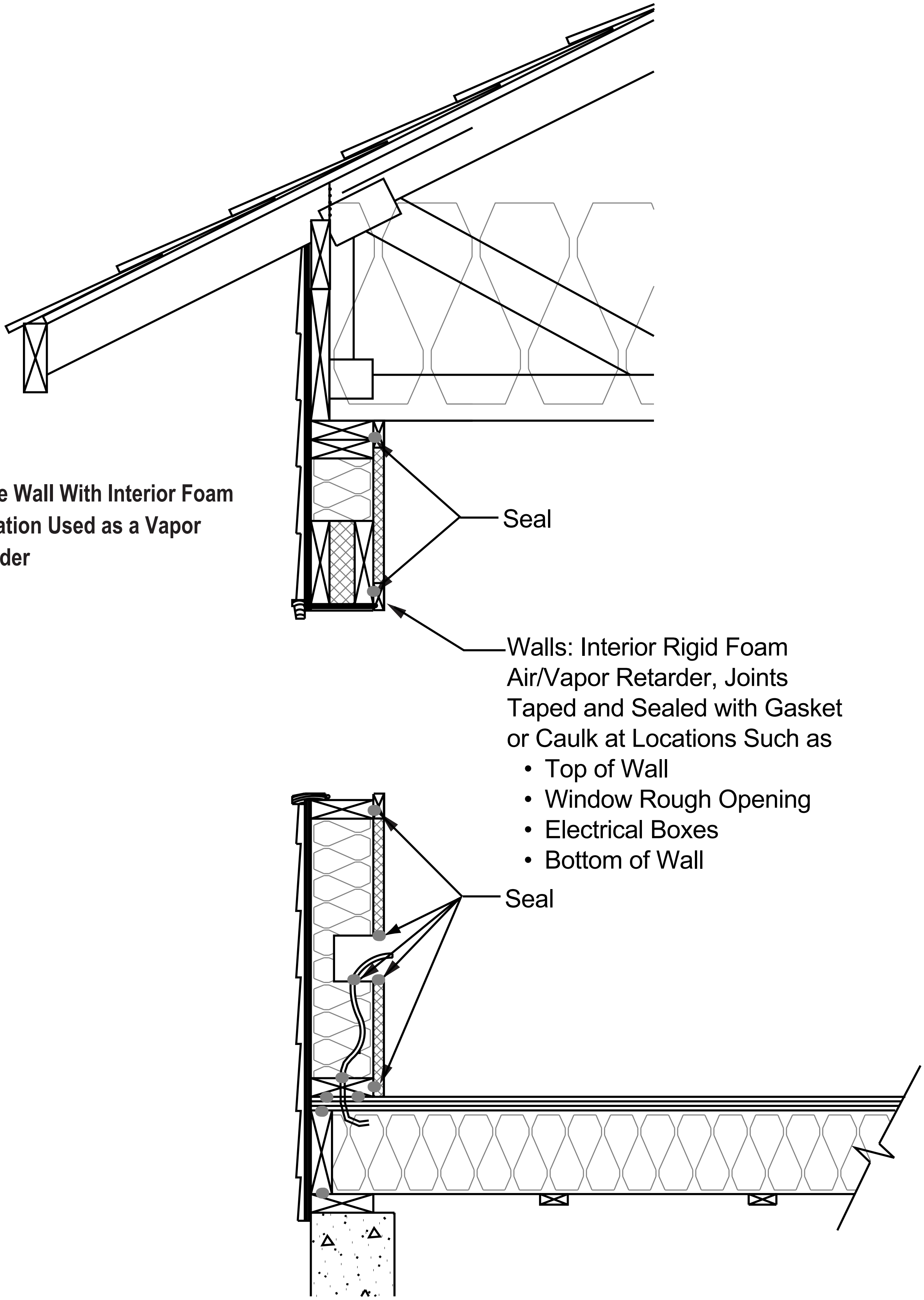
Sealing the Rim Joist



EPS Panel for Use as Structural Wall



Exterior Load Bearing Double Wall



Single Wall With Interior Foam Insulation Used as a Vapor Retarder

Log Buildings

Many communities in the forested areas of Alaska have an abundance of suitable timber growing near enough to make it cost effective to build log structures. With a thermal resistance value of R-1 to R-1.5 per inch, depending on species and moisture content, logs will obviously not meet the minimum prescriptive standards set forth in Table 1 of this manual.

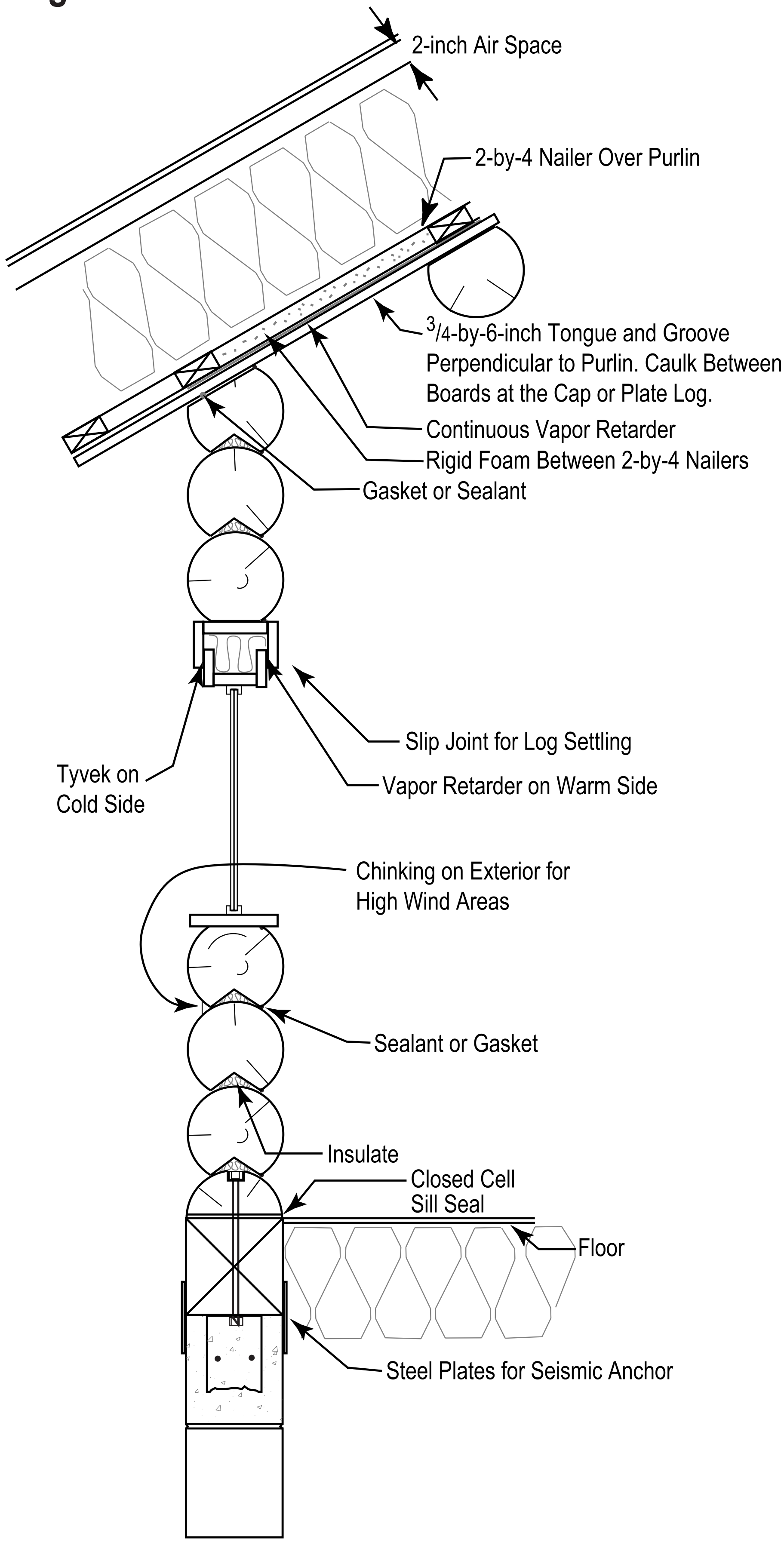
In the case of massive logs, R-value is not the only property relating to energy use. Logs act as a heat storage medium at certain times of the year. Log structures must be built to the highest possible standards of craftsmanship with strict attention to the 10 basic rules of building science introduced on page 6. A Hot 2000 or AkWarm analysis and air tightness testing should be done.

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

Log buildings are somewhat more forgiving than a typical frame or masonry structure in an earthquake because of the inherent flexibility of the connections between logs. The bottom round of log structures must be securely attached with long anchor bolts poured into the foundation wall. Log structures on post and pad or piling foundations must be through-bolted to support beams that are securely attached to the post or piling. Each succeeding course should be fastened to the course below with wooden pegs or dowels or with threaded rod or even rebar. Three-sided logs are often nailed together with countersunk 12-inch spikes or long lag screws. Door and window cutouts should be notched to accept wood or steel splines or both to keep the log wall aligned as it settles and shrinks about 1/2 inch to 3/4 inch per foot, depending on the water content of the wood.

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

Log Wall


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

retarder systems and airtight connections to the log walls must be part of the overall strategy.

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

Several excellent books on building with logs are noted in the bibliography. Also see the *Alaska Log Building Construction Guide,* available from Alaska Housing Finance Corporation.

Foam Panel Construction

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

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

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

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

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

Construction Sequencing

There are a few critical construction details that require a change in the way subcontractors do their jobs. With the exception of open crawl spaces, foundations are part of the thermal envelope and must provide for continuity of the vapor retarder and insulation. In some buildings, for example, rigid insulation and polyethylene are installed before any concrete is poured. If a concrete slab is being poured in an area known to have high levels of radon, a subslab ventilation system should be installed first.

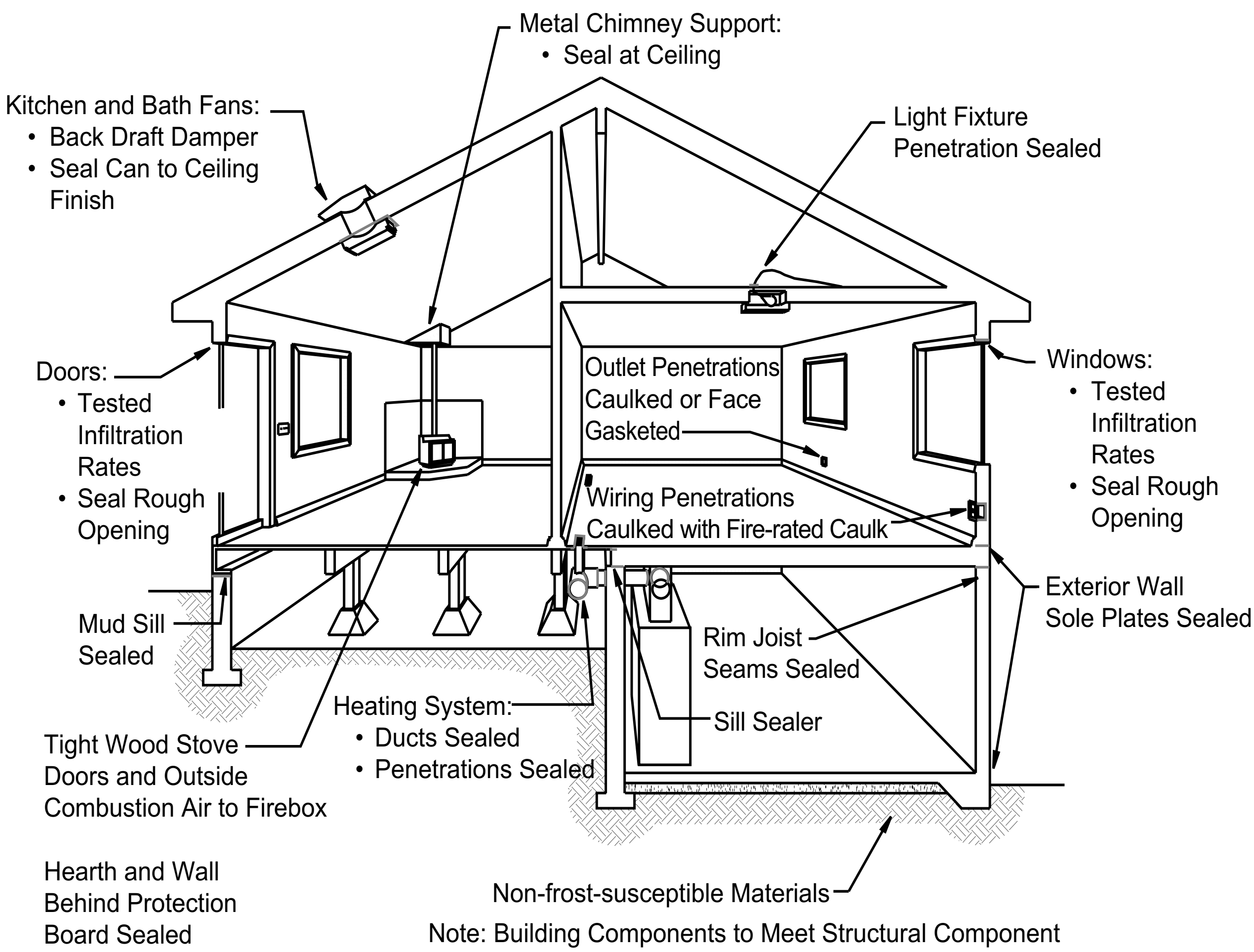
Extreme care must be taken to protect the vapor retarder from being penetrated by screed pins or with reinforcing mesh or rebar. One good way to accomplish this is to place the polyethylene down first, followed by a layer of rigid foam. Some concrete contractors have modified their screed pins by welding on a six-inch by six-inch plate that supports the pin on top of the polyethylene or foam to avoid puncturing the radon/moisture retarder. Some contractors use a laser to establish grade.

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

Vapor Retarder Installation

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

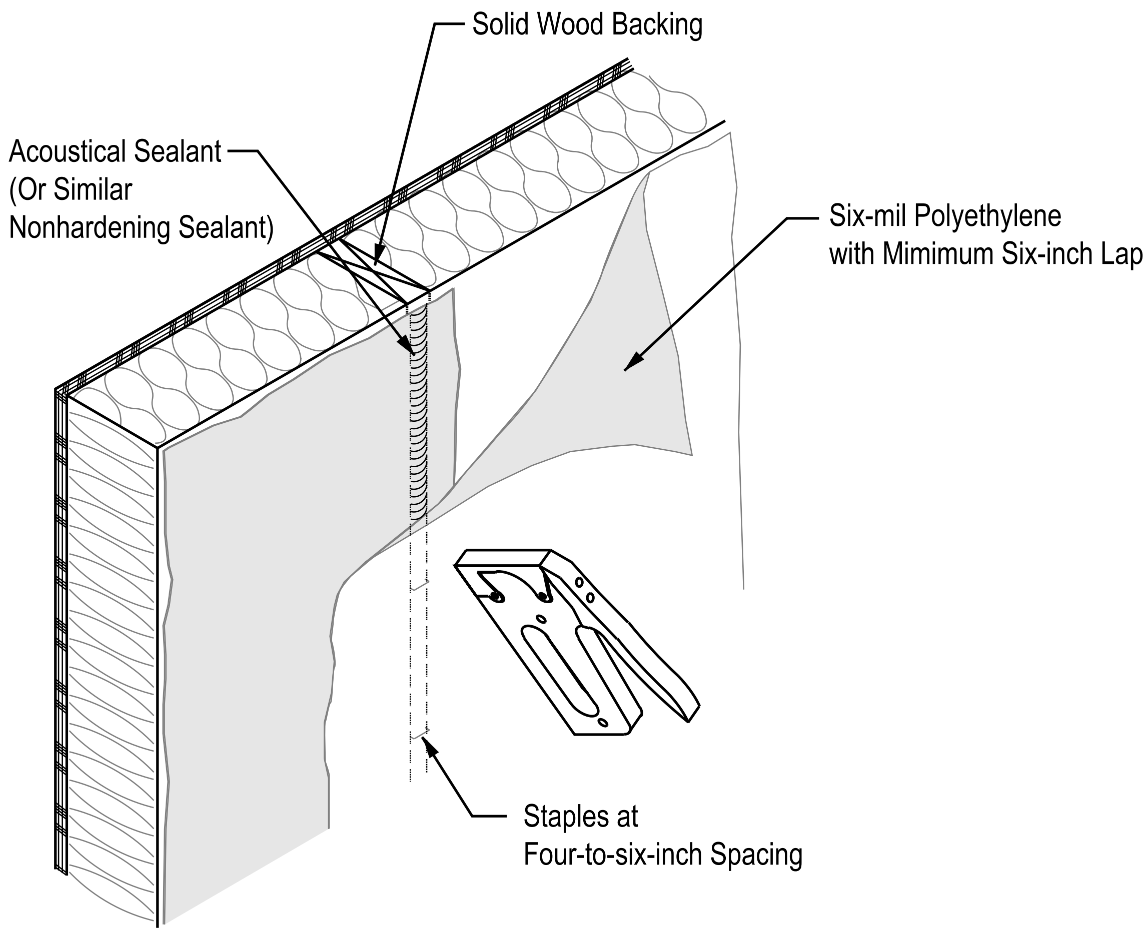
Air Leakage Control: Places to Seal



Note: Building Components to Meet Structural Component Formaldehyde Standards: “HUD Approved,” “Exterior,” or “Exposure 1”

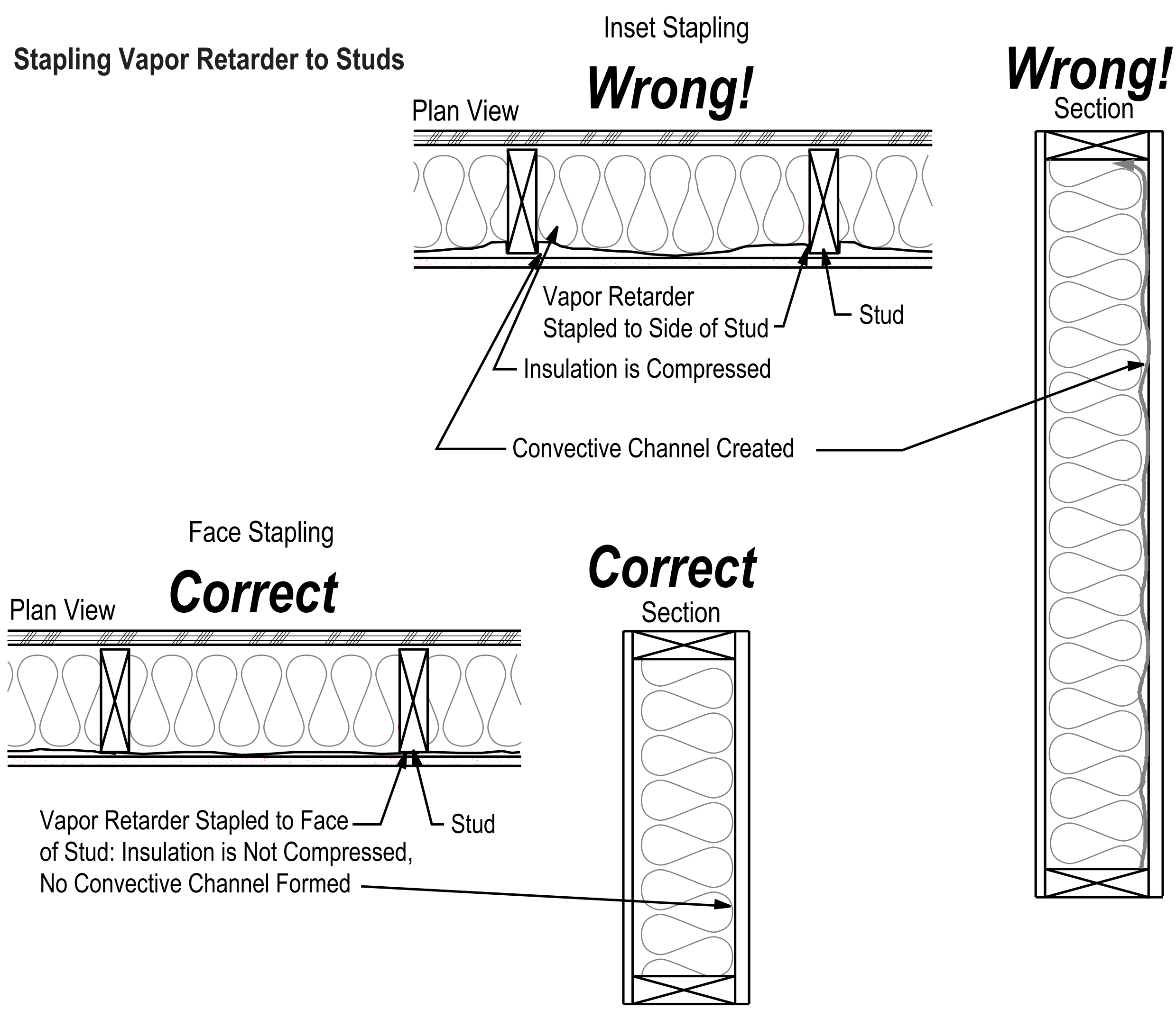
Some builders complete the entire shell, including insulation, vapor retarder, and ceiling drywall, before installing interior partitions. In Alaska where it is always a race to get heat in a building as quickly as possible, this actually makes sense. This will call for close coordination between all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

Installing the Air/Vapor Retarder



Installing a nearly airtight minimum six-mil polyethylene or cross-laminated vapor retarder (such as Visqueen, Ruffco, or Tutuf) is critical to the long-term success of a building. The most effective way to accomplish this is to plan ahead to provide for a continuous vapor retarder system. This means that strips of polyethylene must be in place over the top plates of interior partitions and behind partition wall junctions with the outside wall. Once the roof is on and all of the wiring and insulation are finished in a single-stud frame wall, it is time to install the vapor retarder in as large as possible sheets to reduce the need for lapping and sealing. Wall vapor retarder materials should be a few inches taller and longer than the wall so that even if the installation is not perfectly straight it can still be sealed to the floor and to the ceiling polyethylene, with the plates providing solid backing at top and bottom and the drywall nailer or last stud in a partition wall providing solid backing for the ends. The large sheets of polyethylene should be tacked in place with as few staples as possible, stopping just short of lapping another sheet of polyethylene. Now and only now should you take out the caulk gun to apply a continuous bead of acoustical sealant to the junction of the bottom plate and the floor and to the partition polyethylene tabs.

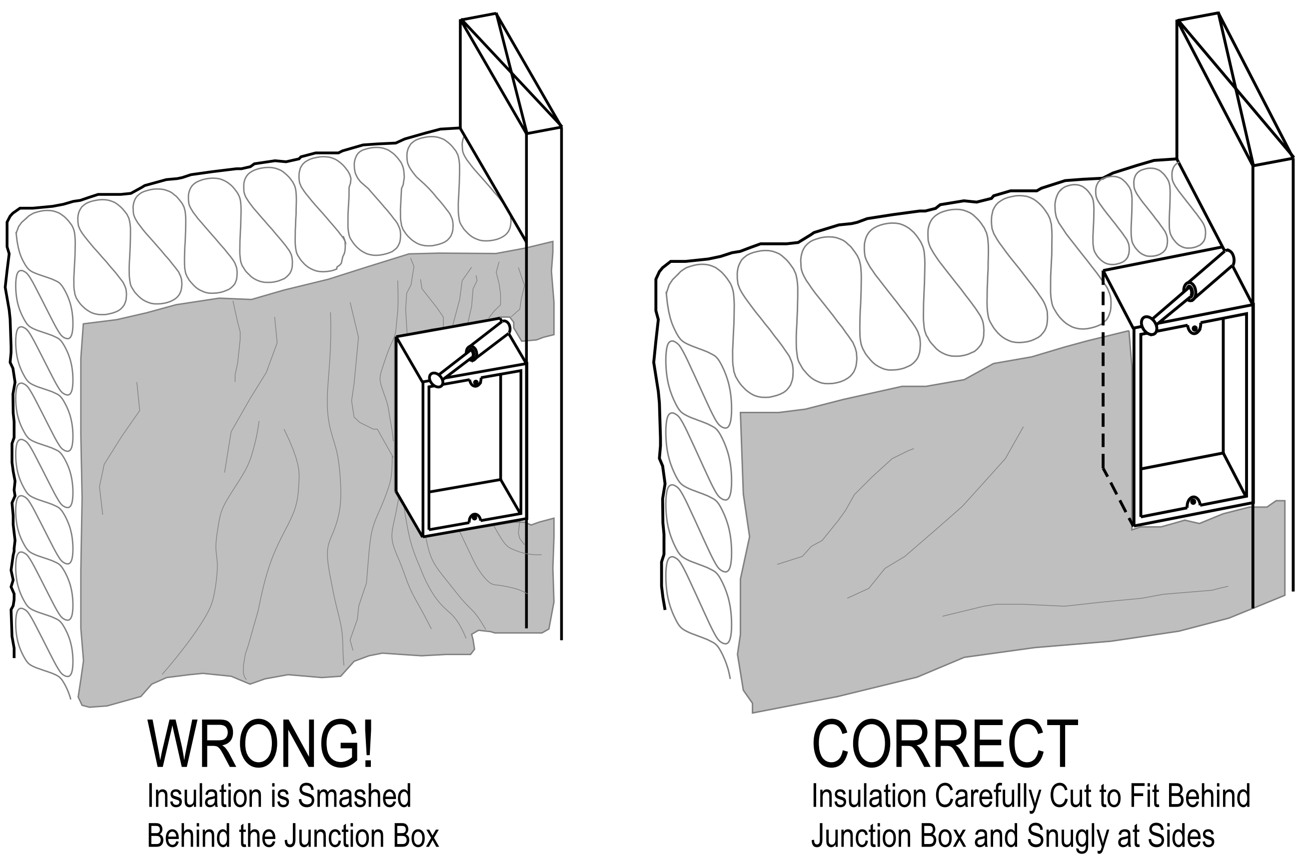
Now that we have the wall vapor retarder sealed on two ends and the bottom, it is time to put down the caulk guns and install the ceiling polyethylene. Once again, staple sparingly and stop just short of where you have to join the ceiling polyethylene to the wall polyethylene. Now take out the caulk gun and apply a continuous bead of acoustical sealant to the wall polyethylene, at least an inch down



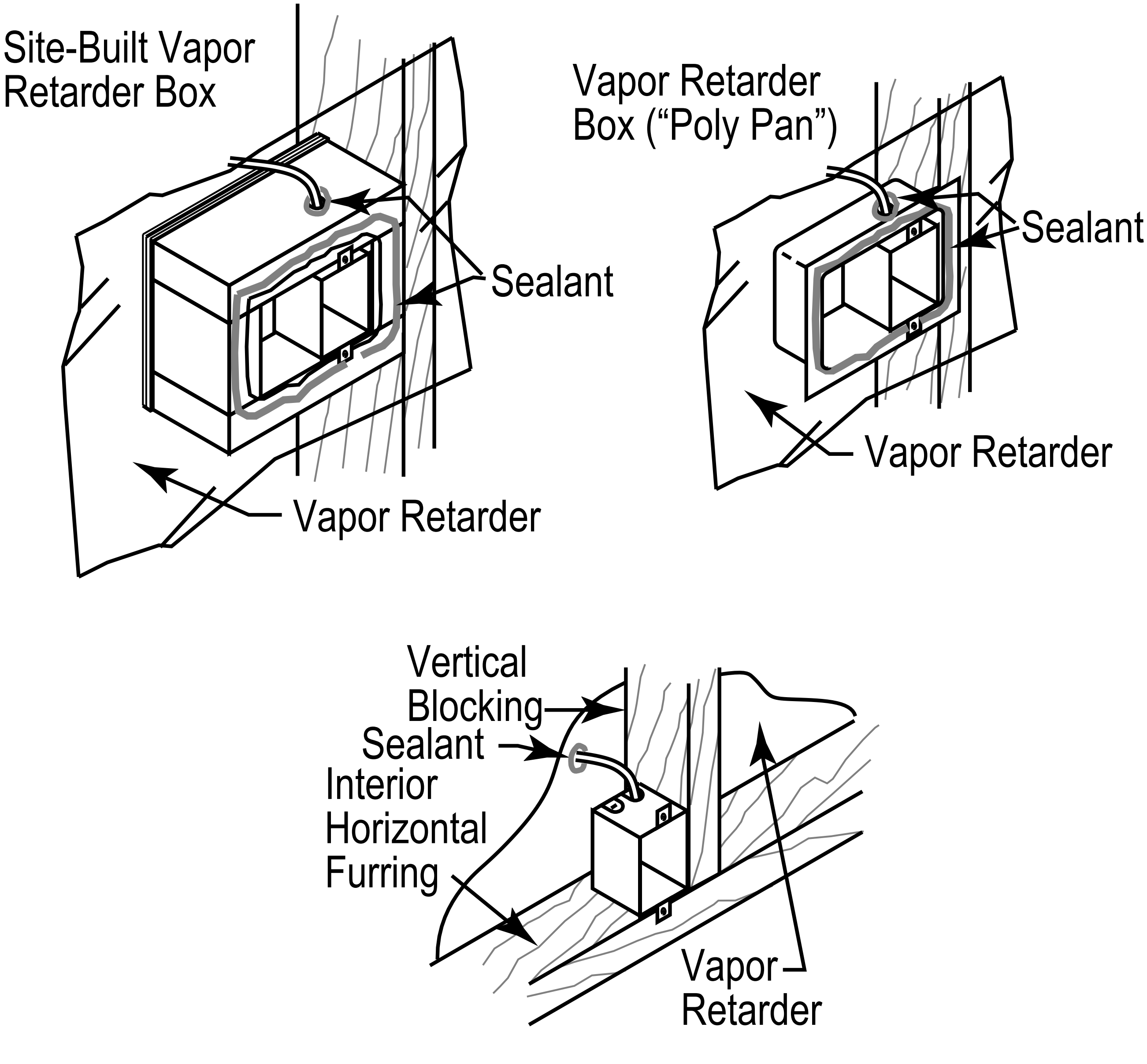
from the top so that when the wall drywall is installed it will compress the joint to provide an airtight seal. All vapor retarder lap joints must be made over solid backing so that a positive compression joint can be accomplished. Lap joints made without solid backing will come apart during the first wind storm or the first time someone slams a door in a tight structure. The sequencing of detailing the vapor retarder system will vary depending on the wall system used. For example, furred wall systems and double-stud walls require very few penetrations and are easier to make airtight than a single-stud wall.

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

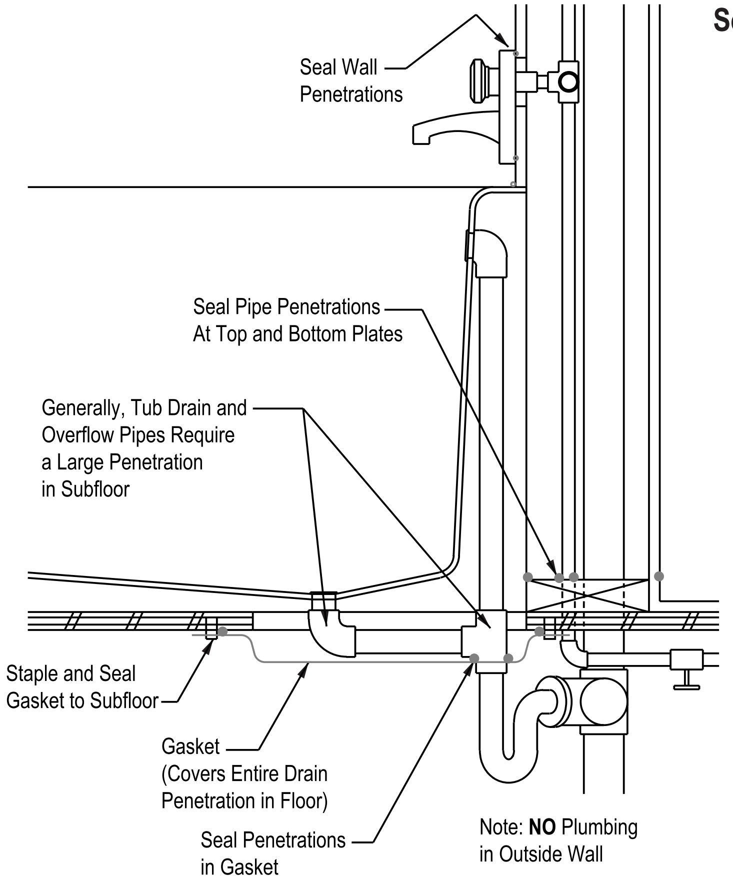
Installing Insulation Around Electrical Boxes



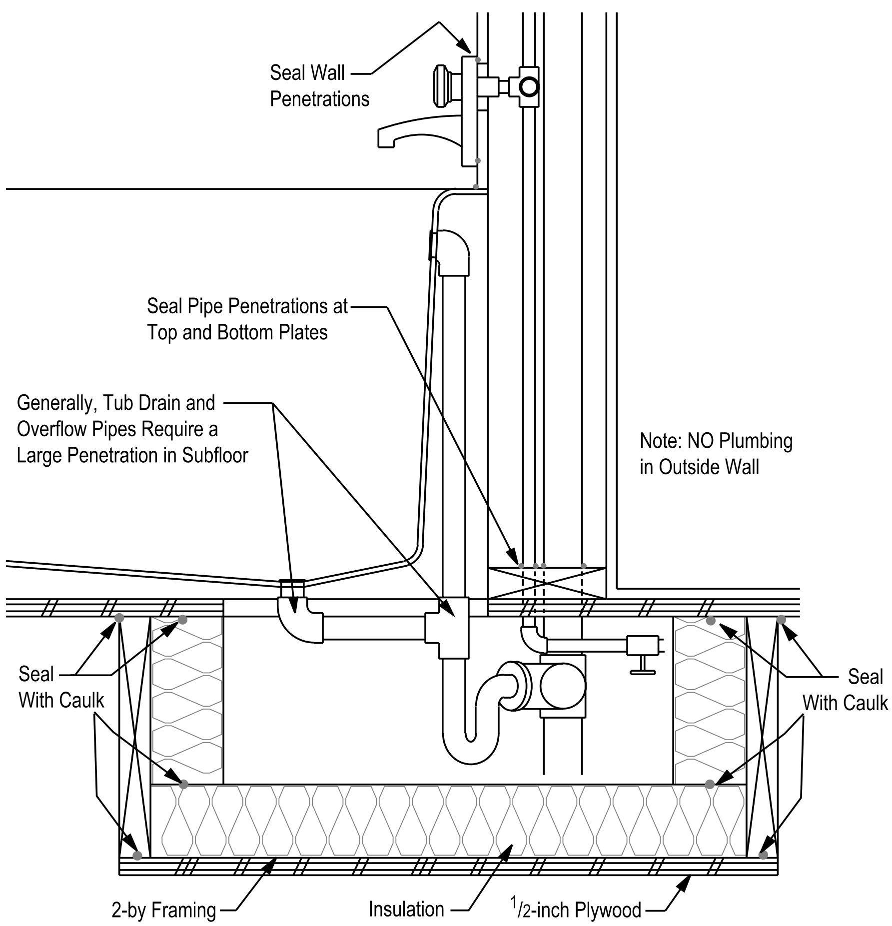
Sealing Electrical Penetrations



Sealing Plumbing Penetrations in the Floor

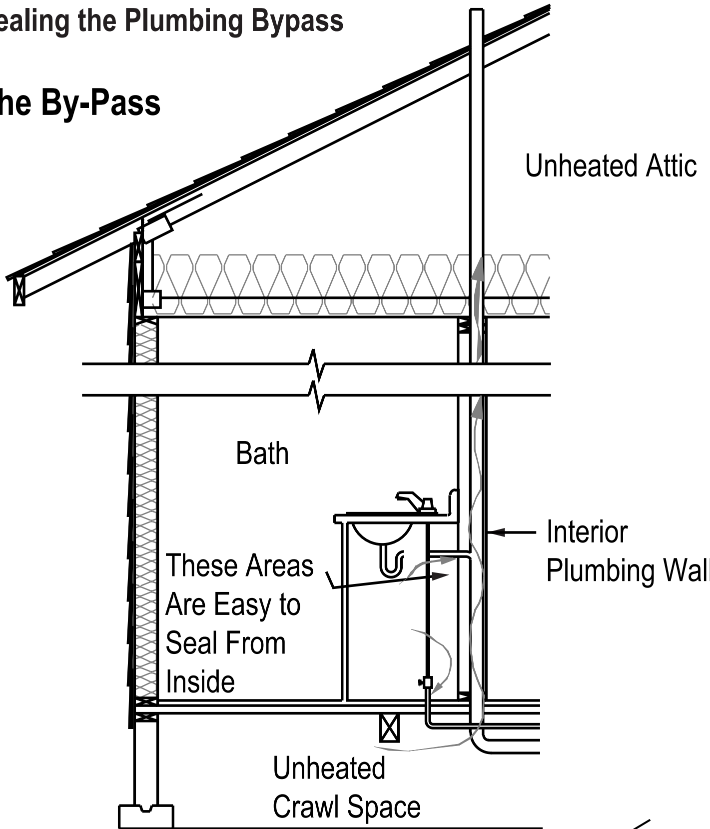


Sealing Plumbing Penetrations Over a Crawl Space

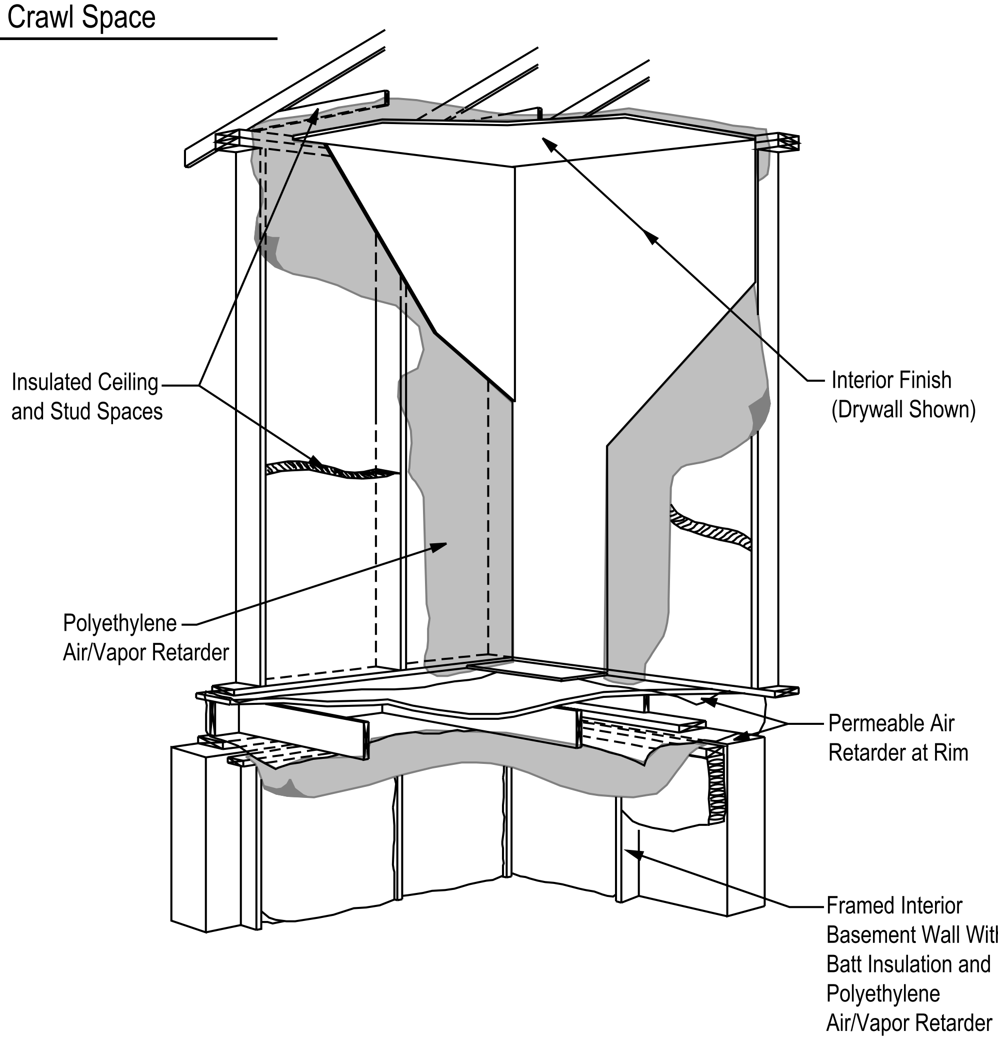


Sealing the Plumbing Bypass

The By-Pass



Detailing the Air/Vapor Retarder



6
Attics and Roofs

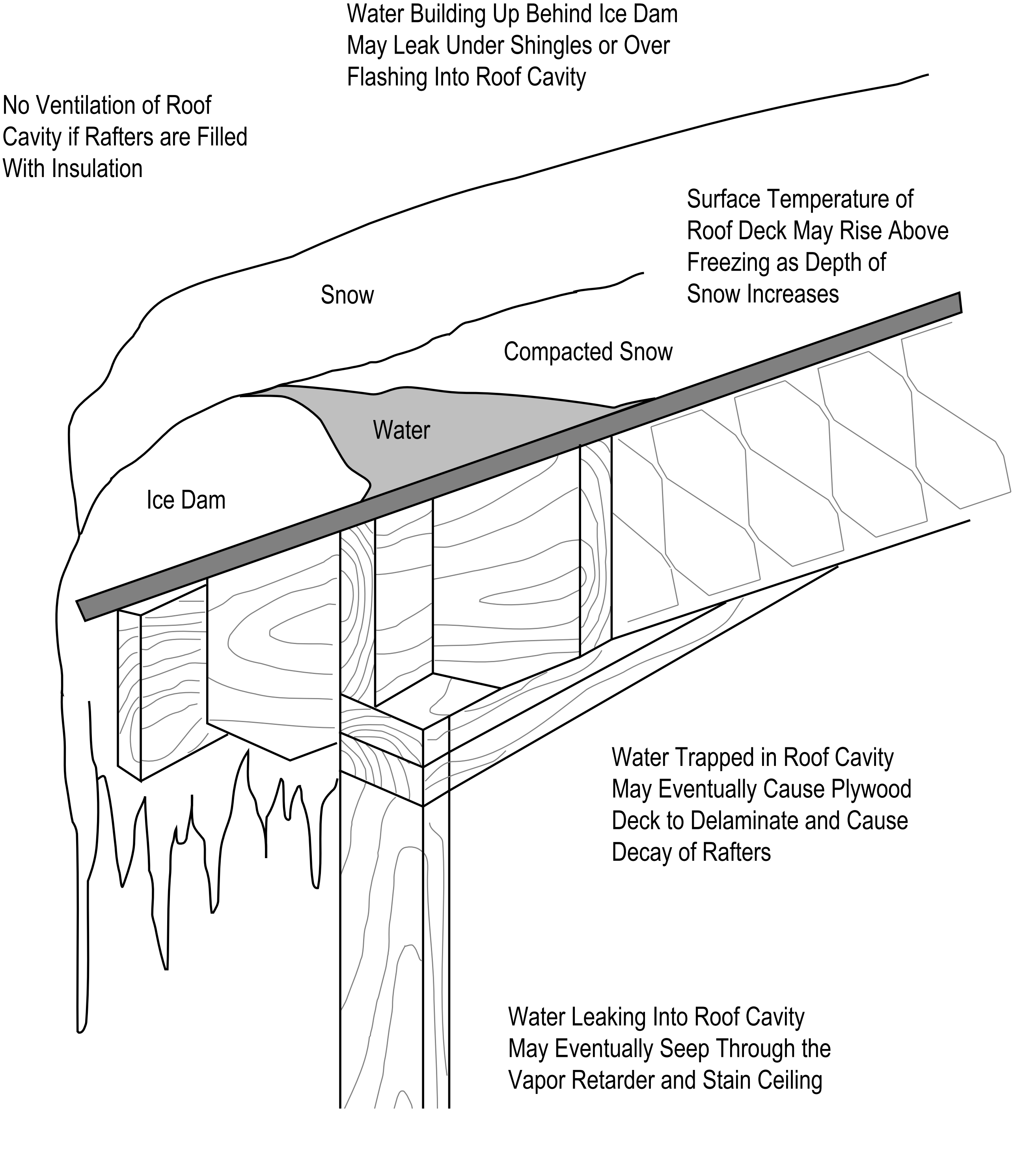
Hot Roof vs. Cold Roof

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 build-up insulates the roof, causing snow near the roof surface to melt from the heat of the building. This melted snow runs down the roof and refreezes at the edge, forming ice dams. These dams cause water to back up underneath the shingles. The solution is to provide ventilation in the attic, so heat from the building does not melt the snow.

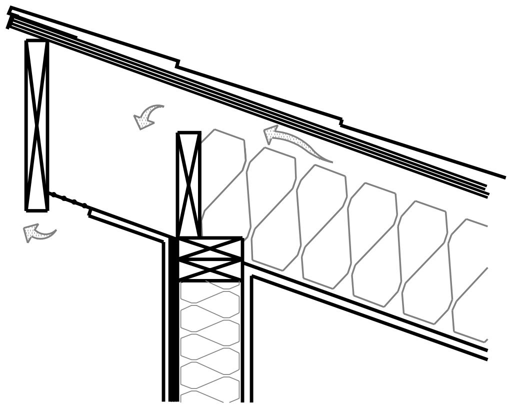
The decision to ventilate or not to ventilate the attic or roof must be based on which strategy is most likely to contribute to the longevity of the building. Once the air/vapor retarder on the warm side of the ceiling and insulation is so nearly perfect that heat, air, and moisture leaks from within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

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

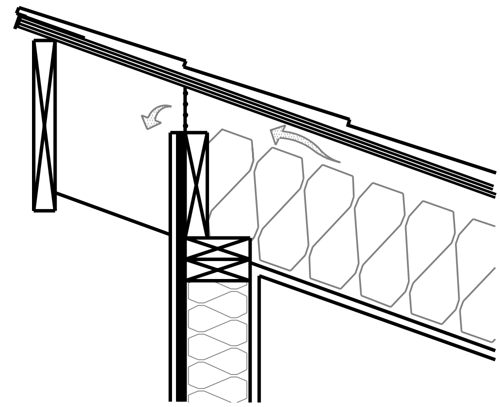
Formation of Ice Dams



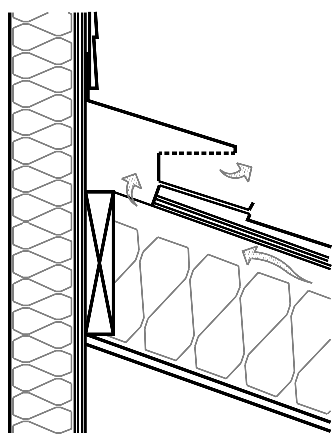
Providing Ventilation for a Cold Cathedral Ceiling Roof



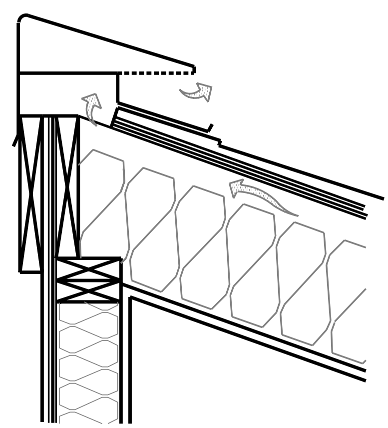
Shed Peak With Soffit



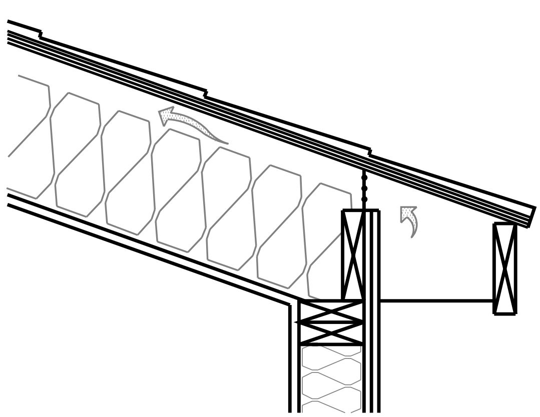
Shed Peak Without Soffit



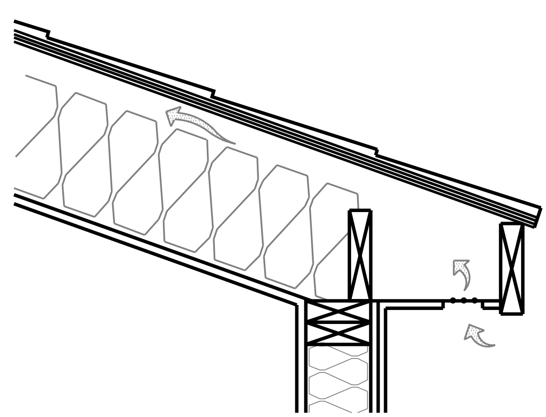
Shed Roof At Wall



Shed Peak: No Overhang



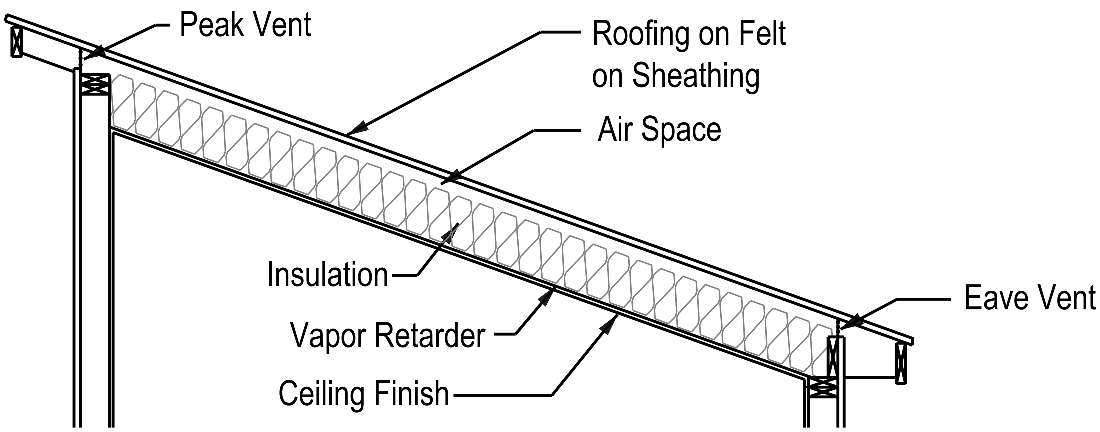
Eave Without Soffit



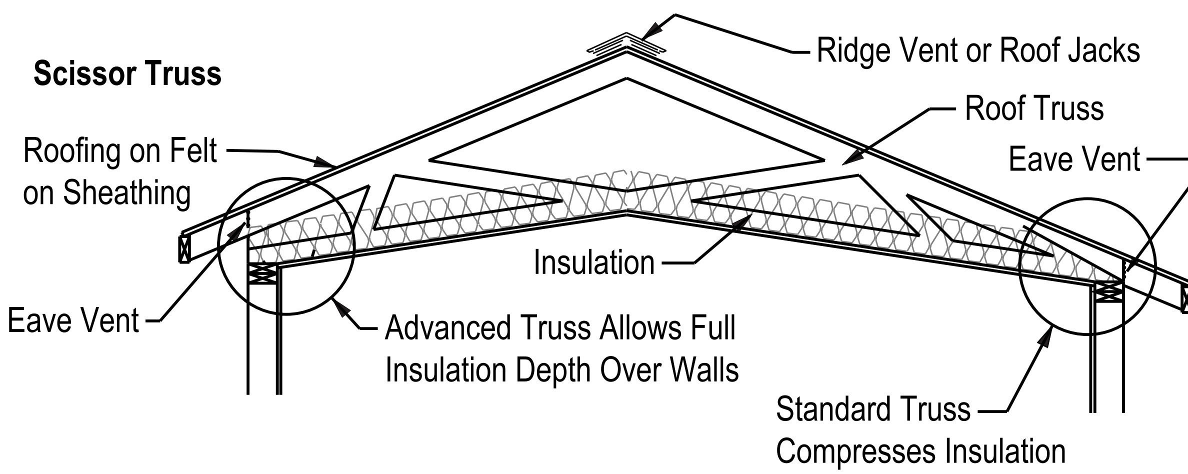
Eave With Soffit

Framing for Vaulted Ceilings

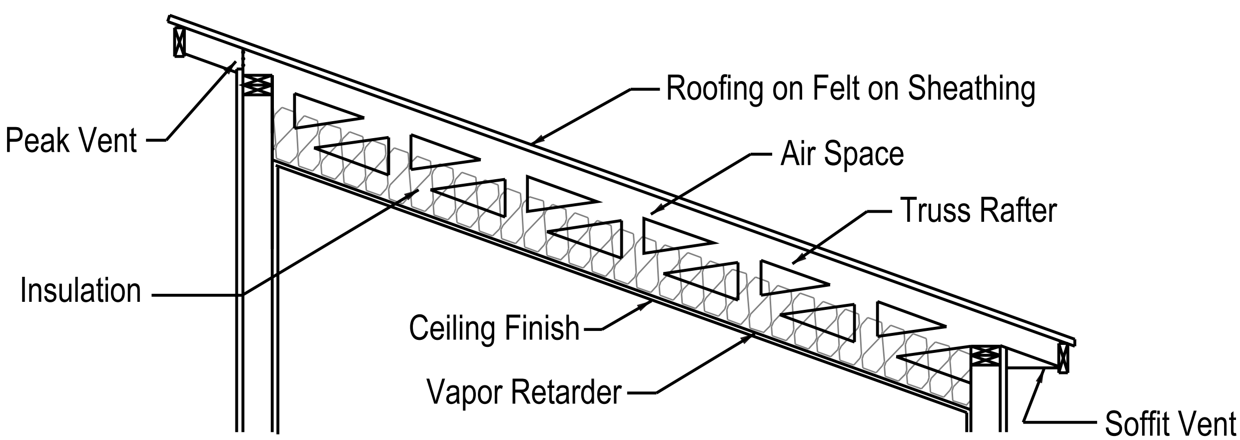
Single Rafter

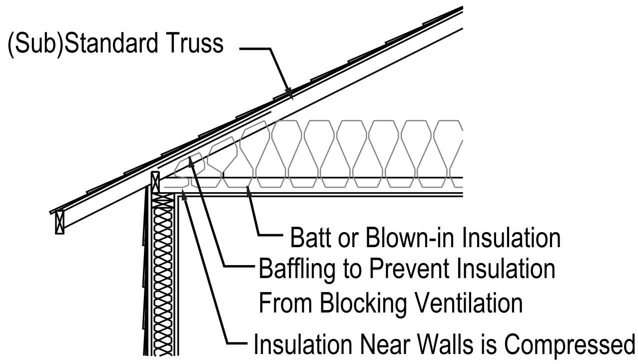


Scissor Truss



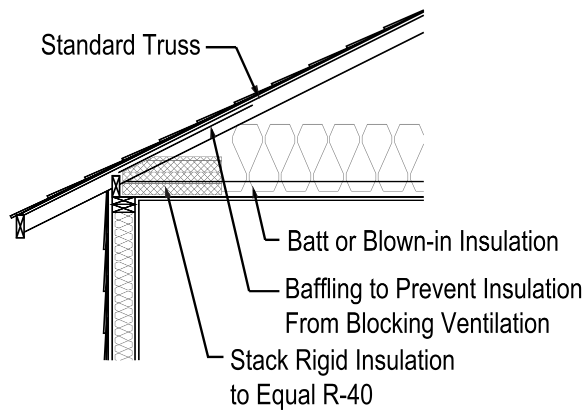
Flat Truss

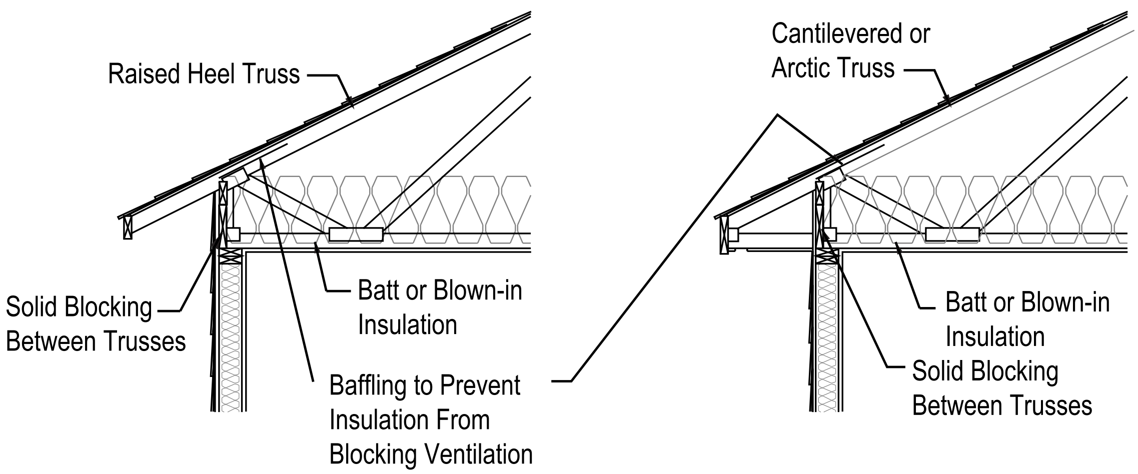




(Sub)Standard Framing

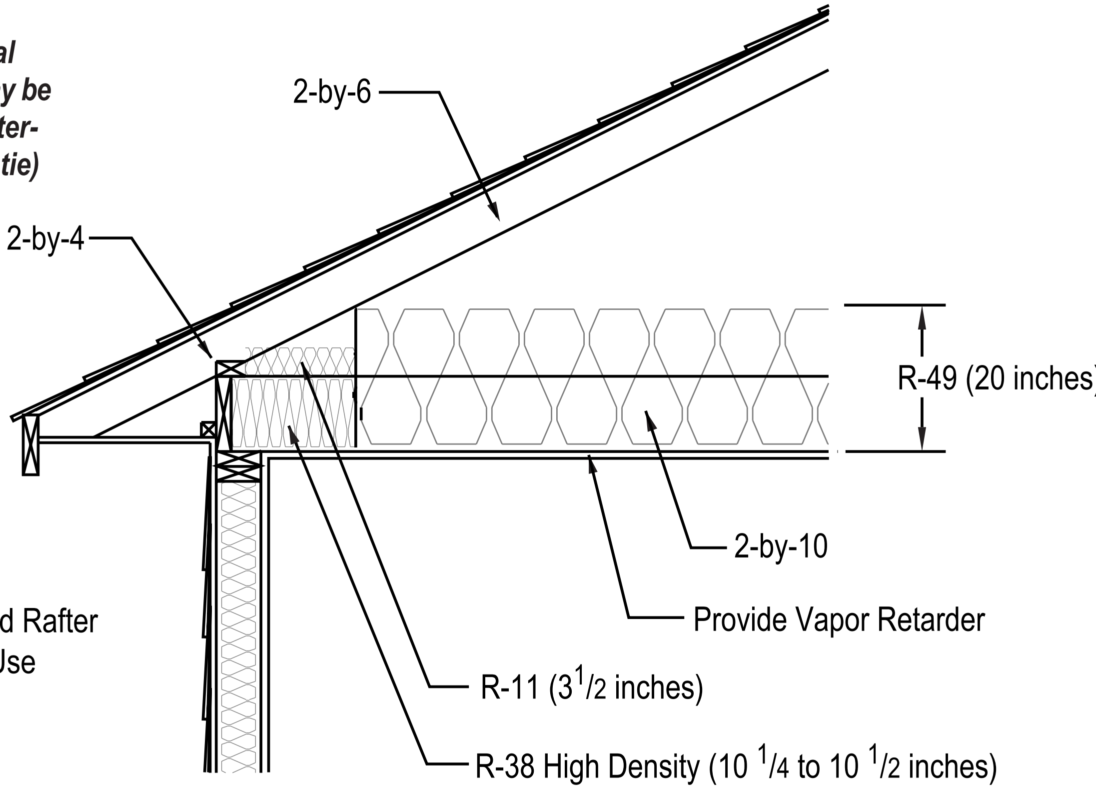
Advanced Framing





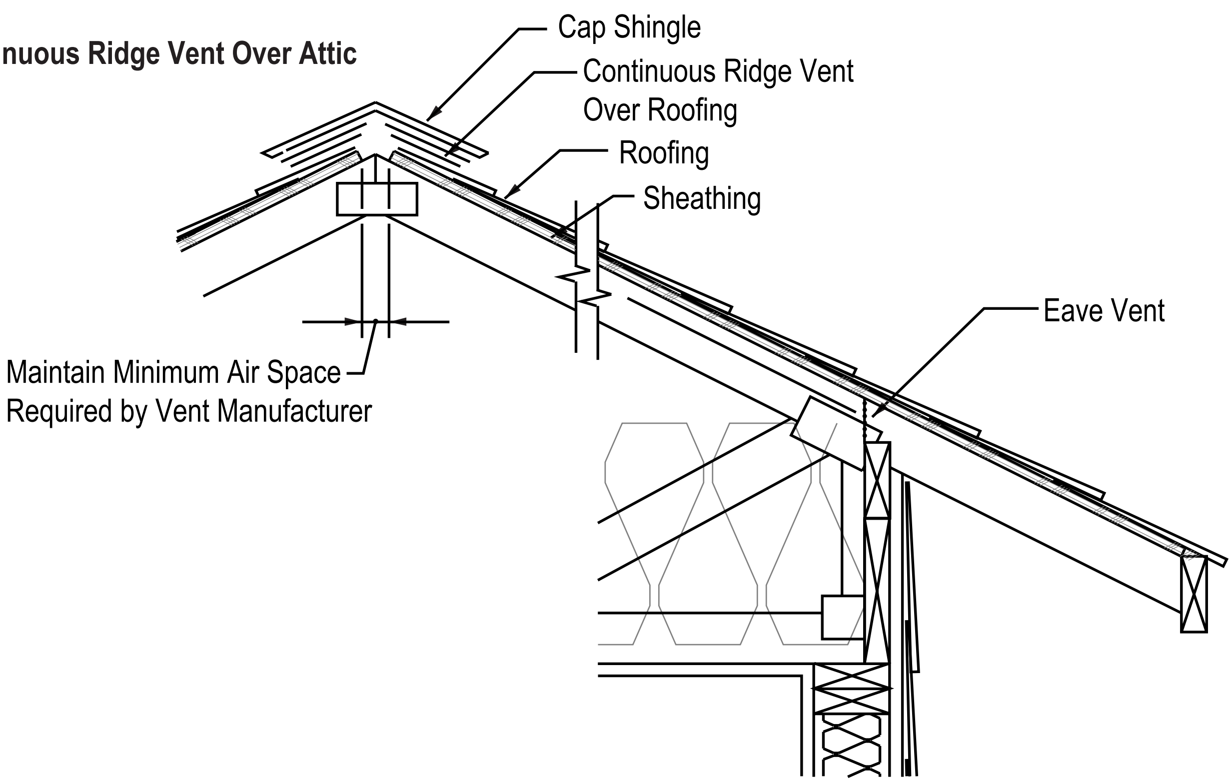
Advanced Framing Using Rafters

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



Note: Point Load Rafter Over Studs or Use Double Plates

Continuous Ridge Vent Over Attic



7
Windows and Doors

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

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

Installing Windows

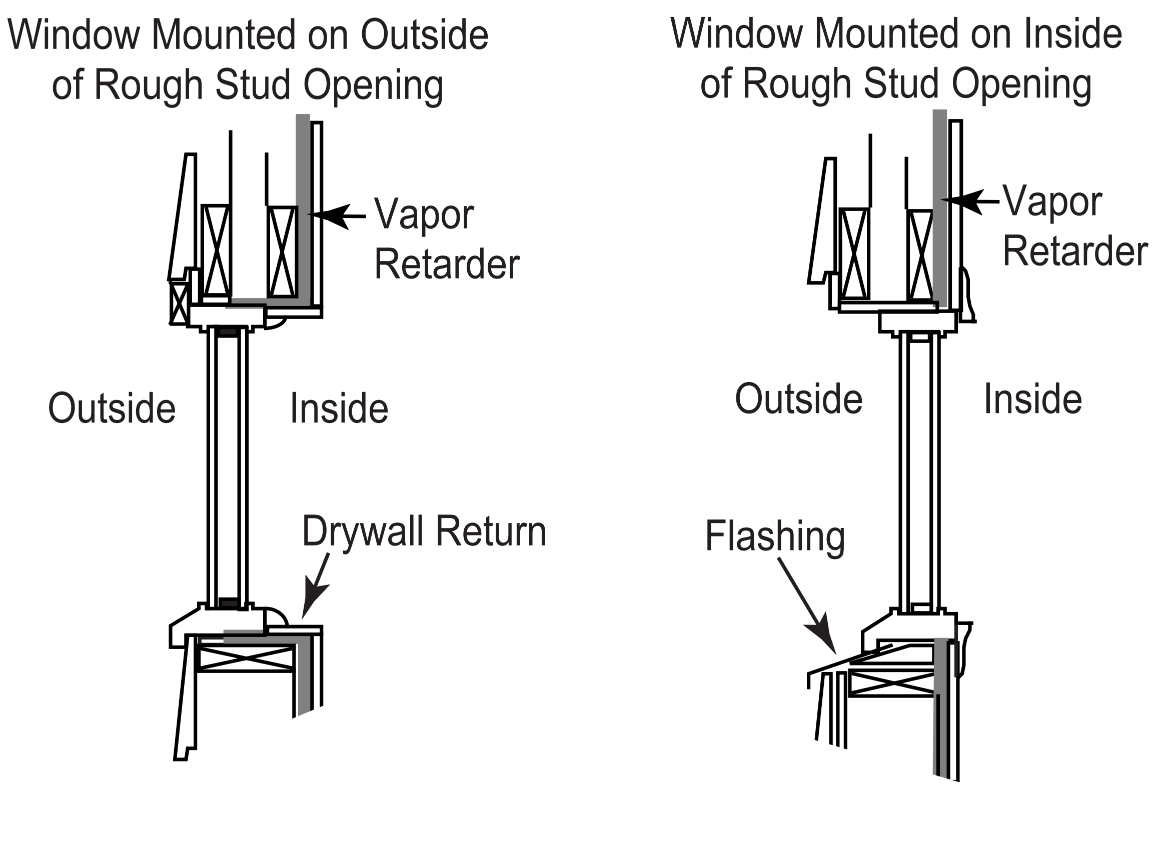
The walls of an energy-efficient house are generally thicker than those of a conventional house. This presents the choice of installing the window on the inside or outside face. The frames of most windows have the lowest R-value of any part of the thermal envelope. Mounting them on the inside of the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

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

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

To allow for expansion and contraction of the window frame, make the rough opening for a vinyl window about ½ inch larger than the window on all sides. Install shims on the sill under each corner and under each mullion or post in the window. Square up the window by shimming the sides, but keep the shims at least eight

Window Mounting Options



inches away from the corners. Install mounting clips on the window frame. Put the frame on the sill shims and make sure the window is level and plumb. Check that it is square by measuring across the inside of the frame diagonally in both directions (there may be welding burrs on the outside corners). If practical, it is easier to remove the glass and sash from large windows and install the frame first, then put the glass back in.

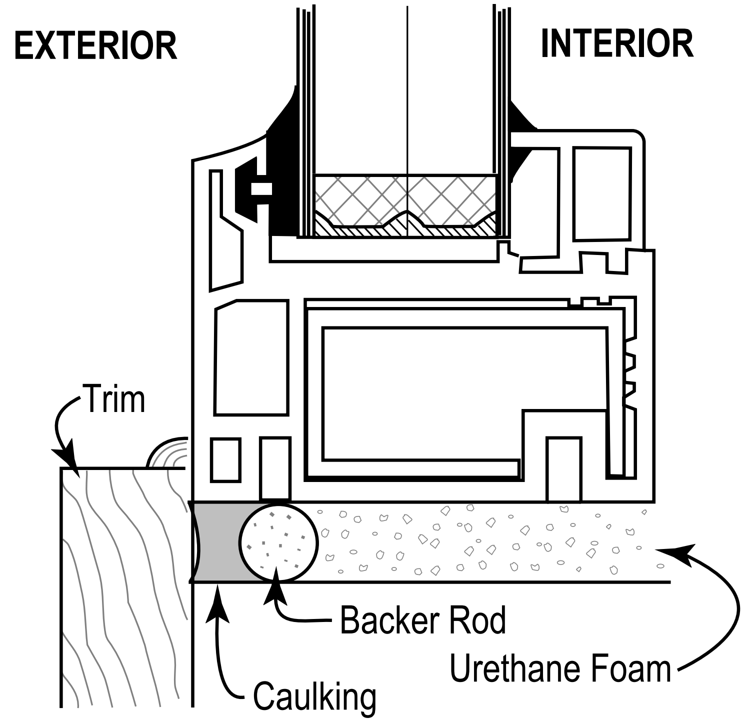
Making the window as energy-efficient as possible requires two separate jobs:

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

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

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

Clean vinyl window frames with denatured alcohol before applying the caulk. The caulked joint should be a two-to-one ratio; for example, ½-inch wide and ¼-inch deep. If a bead of caulk is too thick or is stuck on three sides, it cannot stretch as the window expands and contracts. The joint should be shaped like an hourglass (see drawing below). A closed-cell polyethylene rope (backer rod) helps make the caulk joint the proper size and shape and is a bond breaker so the caulk won’t tear.



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

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

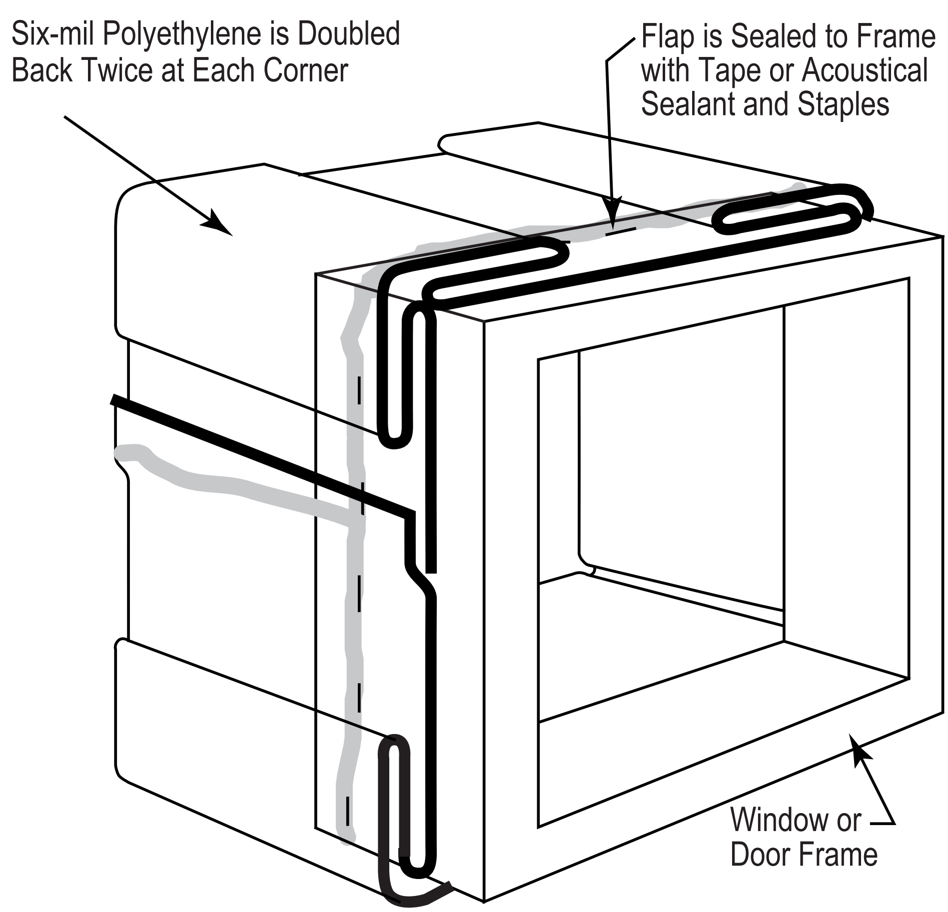
Polyethylene Wrap

To install polyethylene wrap:

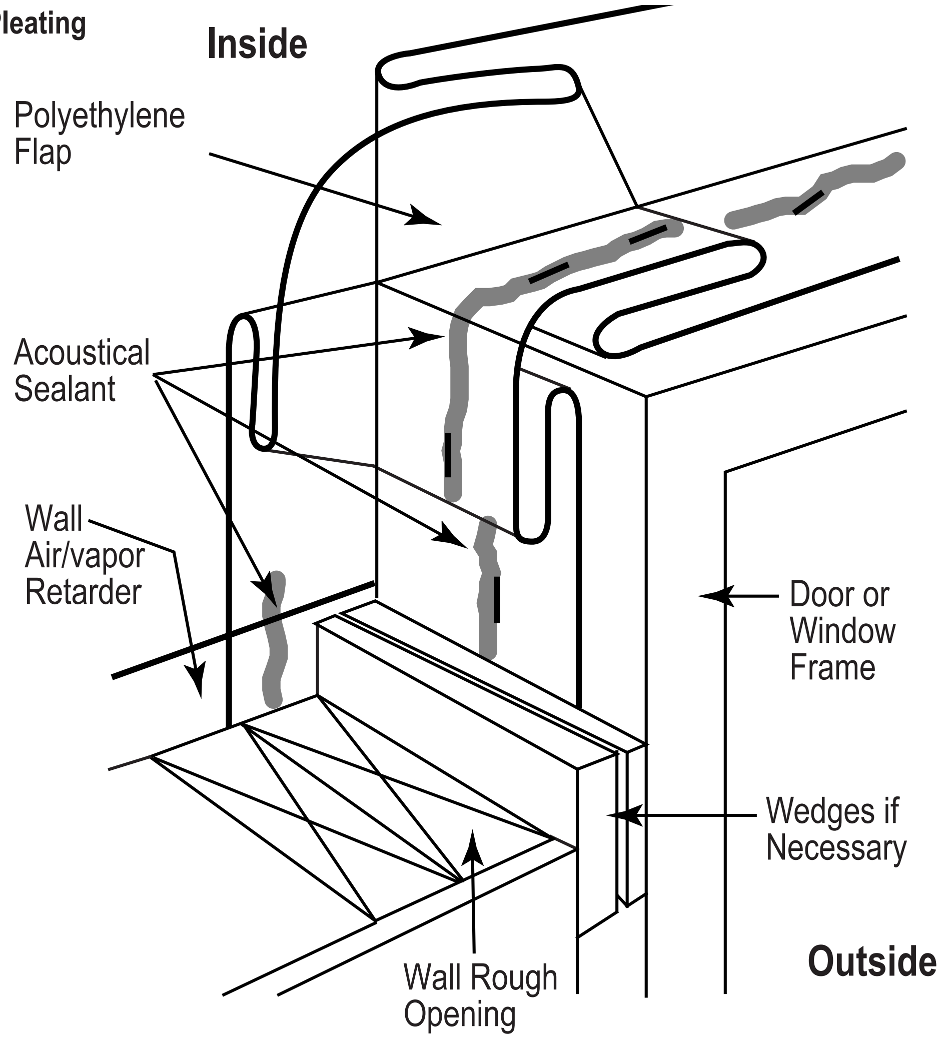
- Cut a 24-inch wide strip of six-mil polyethylene. It should be long enough to go around the window with about 20 inches extra.
- Apply a bead of acoustical sealant to one side of the wood window frame. The bead must be located toward the outside of the window frame to ensure that joints between the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

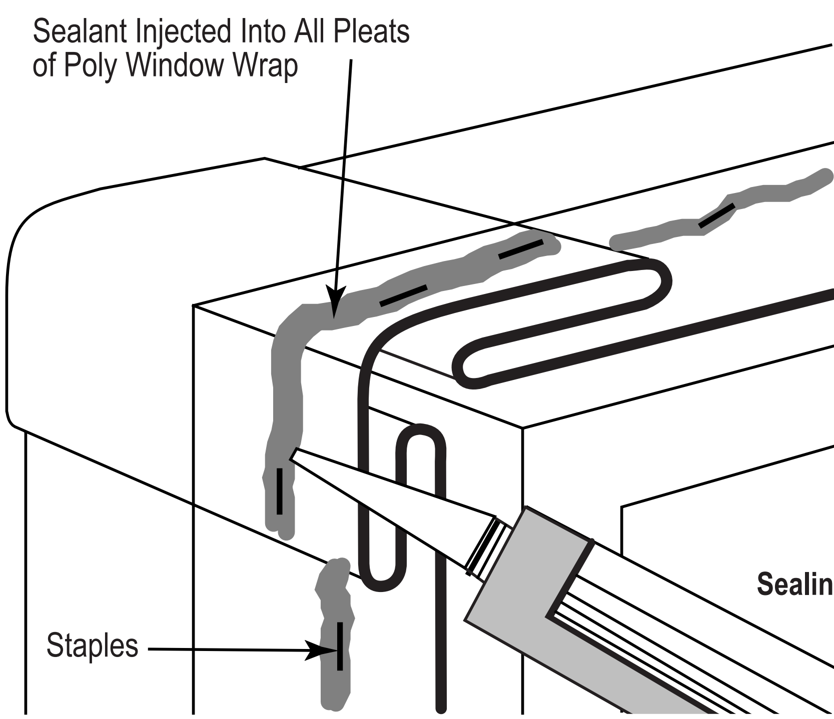
- At the corners place a pleat one inch wide in the polyethylene on both sides of the corner. Staple the pleats to the wood frame and inject acoustical sealant to seal the pleats. The pleats allow the polyethylene flap to fold back at the corners and seal against the wall air/vapor retarder. Continue this process around the frame and join the polyethylene strip to itself with a bead of acoustical sealant.
- Place a continuous piece of fiber-reinforced tape on the polyethylene above the bead of the acoustical sealant and staple through the tape, polyethylene, and acoustical sealant into the window frame (on wood frames) at intervals not greater than three inches. This ensures that the polyethylene will stay in place, as staples by themselves do not always have the holding power to keep the polyethylene in place.
- Insert the window frame in the rough opening and shim in place if necessary. When installing wedges, ensure that they go between the polyethylene flap and the rough opening and not between the polyethylene and the window frame.

Wrapping the Window Frame



Corner Pleating



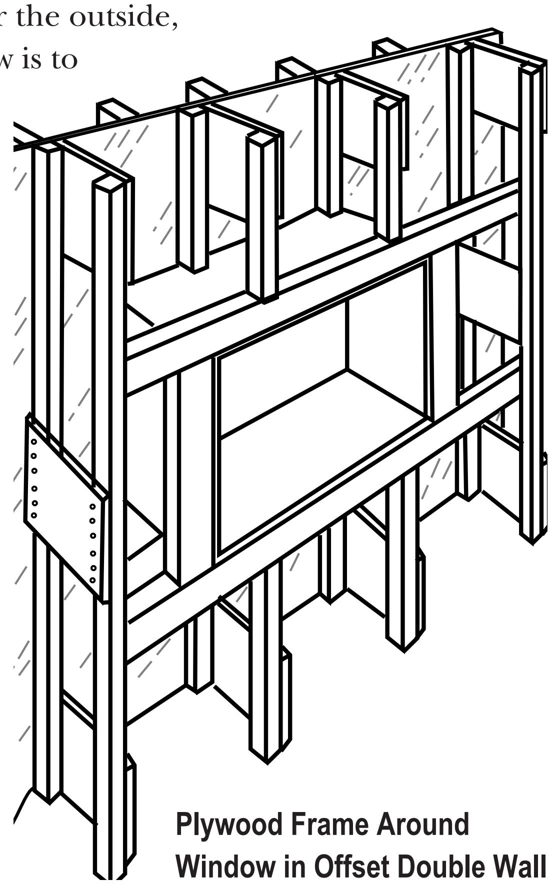


Sealing the Pleats

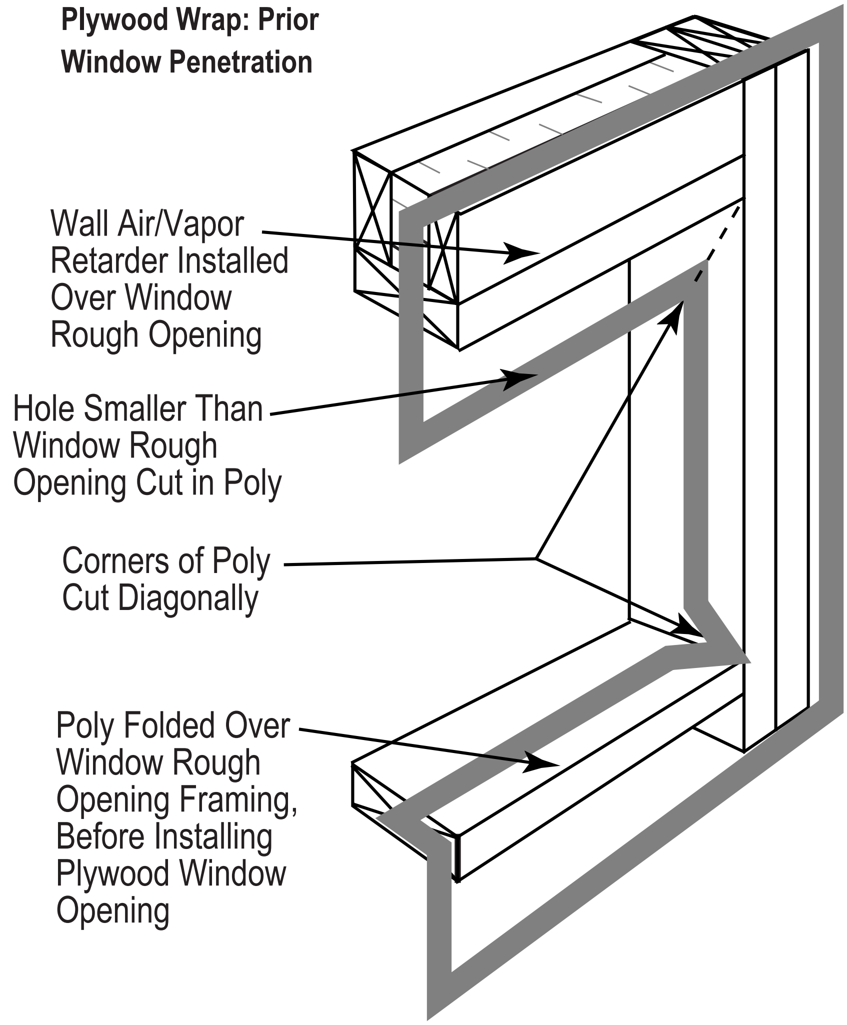
- Stuff the space between the window frame and opening with batt insulation or use backer rods.
- Staple the polyethylene flap to the rough opening.
- After the wall air/vapor retarder is applied, cut out around the window opening. Apply a bead of acoustical sealant between the window flap and wall air/vapor retarder and then staple them together.

Plywood Method

- The rough stud opening is framed to accommodate a ½-inch plywood liner covering the width of the opening. This will mean an increase in both height and width of one inch.
- Seal the air/vapor retarder from the house wall to the plywood liner with either polyethylene or drywall. In both cases, the seal can be to the edge of the plywood facing the room (see figure, next page).
- Nail the plywood liner into place flush with the interior finish and the exterior sheathing. The liner should be caulked to the rough stud on the interior.
- Install the window into the liner from the inside or the outside, depending on the intended location. If the window is to be located toward the interior of the assembly, install proper flashing on the sill before window installation.
- Insulate and seal the gap between the window and the plywood frame.



Plywood Frame Around Window in Offset Double Wall

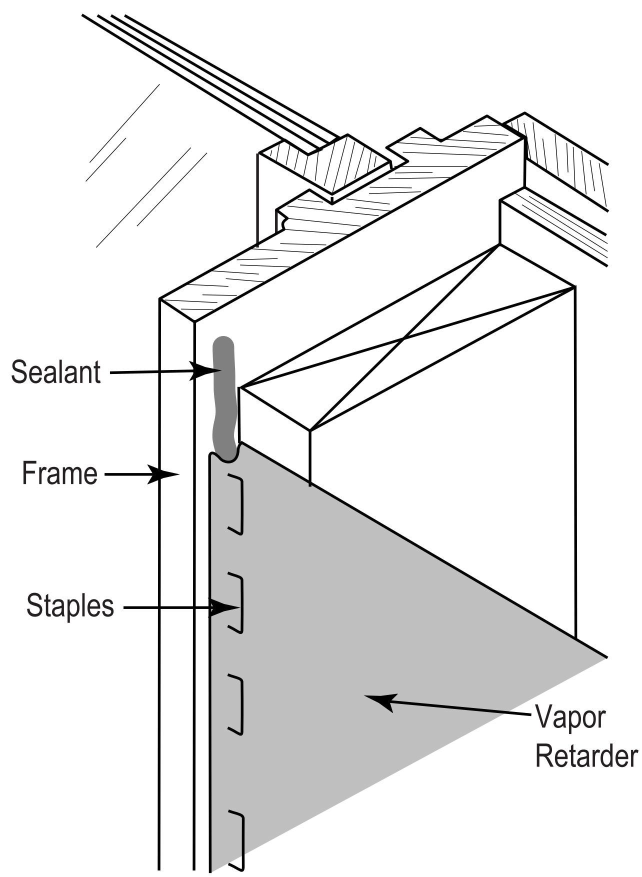


Drywall Method

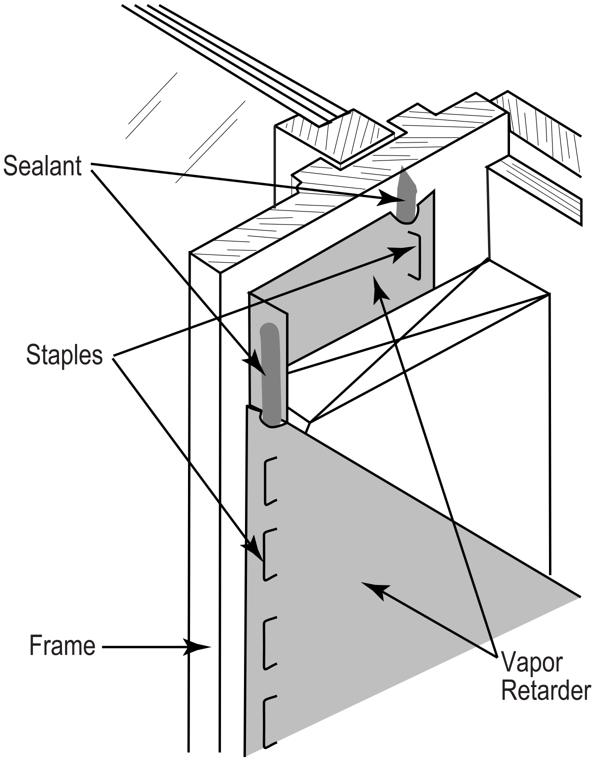
- After sealing, install drywall over the liner and install the finished sill.
- The rough stud framing and window installation follow conventional practice.
- The drywall interior finish is butted and sealed to the window frame to provide a continuous air retarder.
- Where the window is installed on the outside face of the wall, a drywall return will be required in the rough opening and it should butt onto the face edge of the window frame. Caulk this joint. Using a U-shaped drywall cap called a "mill core edge" to cover the cut edge of the drywall makes caulking this joint a simple matter.

- When the window is installed on the inside face of the wall it may be located so that the face edge of the frame is flush with the face of the drywall. This butt joint may be sealed with tape and covered with trim. Press the joint to provide an airtight seal. All vapor retarder lap joints must be made over solid backing so that a positive compression joint can be accomplished. Lap joints made without solid backing will come apart during the first wind storm or the first time someone slams a door in a tight structure. The sequencing of detailing the vapor retarder system will vary depending on the wall system used. For example, furred wall systems and double-stud walls require very few penetrations and are easier to make airtight than a single-stud wall.

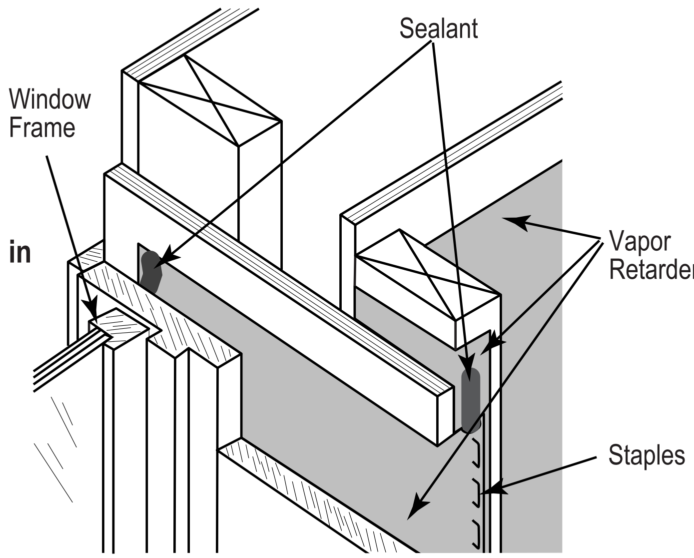
Vapor Retarder Sealed to Window Frame at Edge

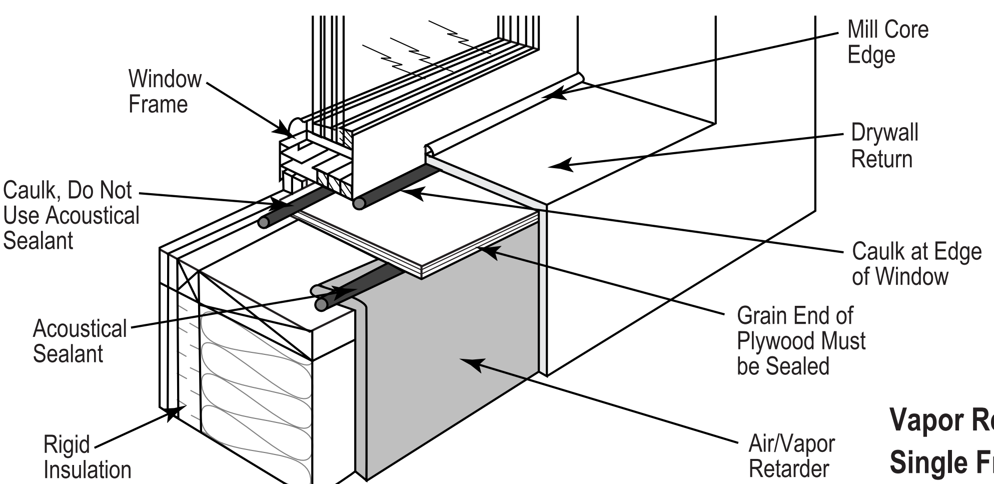


Vapor Retarder Sealed in Single Frame Wall



Vapor Retarder Sealed in "Saskatchewan" Type Double Wall





Vapor Retarder Sealed in Single Frame Wall

8
Mechanical Systems

Energy Efficient Lighting

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

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

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

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

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

Build Tight and Ventilate Right

A well-sealed outer shell and a properly working mechanical ventilation system are among the key components for any building that is designed and constructed to be healthy, safe, comfortable, and energy- efficient. These two components are essential to each other and to the building system as a whole. When the shell is carefully sealed to reduce drafts, maintain structural durability, and conserve energy, the fresh air exchange rate is reduced below the level needed to maintain good indoor air quality. A mechanical ventilation system must be designed and installed to provide enough air exchange. The ventilation system exhausts stale, moist air from the building and brings in fresh air from outside and distributes it evenly throughout the building. All buildings must comply with American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 62-1989, revised 1997.

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

Heating

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

1. Health and Safety

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

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

2. Durability and Maintenance

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

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

3. Comfort

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

4. Environmental Impact

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

5. Affordable and Efficient Operation

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

Appropriately sizing the heating system to the building and producing heat and hot water efficiently make operating such a building affordable.

Three Types of Efficiencies

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

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

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

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

Insulating Domestic Hot Water Pipes

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

Forced-air Distribution

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

Forced-air systems must be installed to provide a balanced air flow when interior doors are both closed and open. Grilles may be placed in doors or in walls between rooms. Doors may also be undercut 1" or more, although this may not always be effective. It is best to have both a supply and a return duct to each room.

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

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

Sealed Combustion Cabinet Type Heaters

Sealed combustion cabinet-type space heaters are widely used in Alaska and come in a variety of sizes, types, and heat outputs. Units such as Monitor, Toyostove, and Rinnai have computer boards, fans, and sophisticated set-back controls. These features, combined with sealed-combustion design, provide above-average heating efficiency and eliminate back-drafting problems. The heater uses a pipe-within-a-pipe forced venting system that doesn't require a conventional chimney. The unique intake and exhaust design usually requires that the units be placed against an outside wall, although extensions may be available for different placement or for clearance from drifting snow. The heaters can be installed in energy-efficient buildings, and several units may be used to provide zone control for larger buildings.

When selecting the heater, consider the fuel source. Some models need number one fuel oil or kerosene. Others require natural gas or propane. Most rural villages have supplies of number one heating oil, while kerosene is rarely used in Alaska. Some kerosene models may allow the use of number one fuel oil, but check with the manufacturer. Natural gas, when accessible, should be the least expensive fuel choice. Heating with propane is usually more expensive.

While these heaters can be more efficient and affordable than a furnace or boiler, they may have shorter warranty periods and cannot be used to heat domestic hot water. Install flue pipe and fuel lines using accepted airtight procedures for penetrations through exterior walls. Oil heaters have problems with fuel contamination, and a good filtering system should be installed. Always follow manufacturer's installation instructions and local building codes when installing any heating system.

Boilers

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

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

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

Solid Fuel Equipment

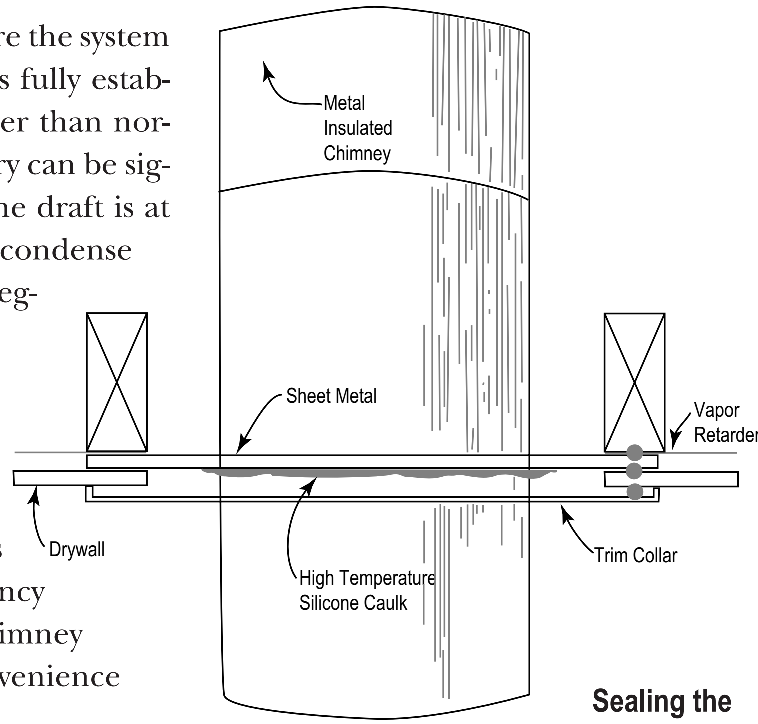
Heating appliances using solid fuel, usually wood or coal, are available today with efficiencies as high as 85 percent. The most efficient are direct vented, stoker-fired wood pellet units. Wood and coal appliances without automatic features have typical efficiencies of around 60 percent.

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

However, the airtight wood stove can be an excellent backup heating source when electricity is unreliable and for any and all emergencies. Wood, used efficiently and safely, is also a renewable fuel. All such installations must include outdoor combustion air ducting directly connected to the stove, and only the most airtight models should be considered. The manufacturer's minimum installation specifications should always be followed and exceeded whenever possible, since fire danger is always high in our long winters. See BEES, pages A-12 and A-43–46 for more requirements for fireplaces and wood stoves.

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

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



Sealing the Chimney Penetration

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

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

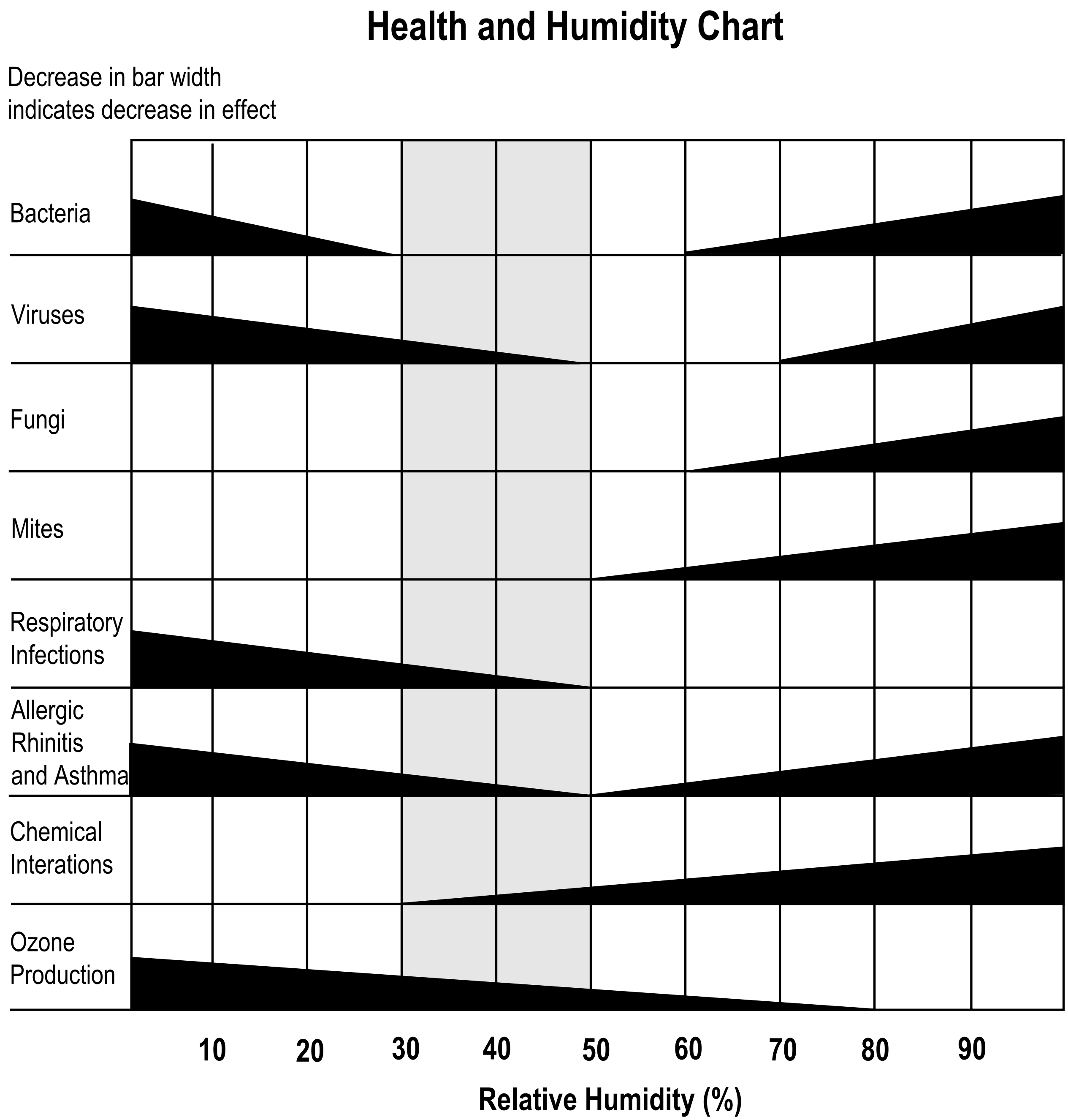
Ventilation

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

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

Ventilation System Types

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



Source: Sterling, Arundel, and Sterling. "Criteria for Human Exposure to Humidity in Occupied Buildings." ASHRAE Transactions, 1985, vo. 91, Part 1. **Note:** optimum zone moved 10% to left by the authors.

It is essential that the ventilation system is cost-effective not only to install but to operate. High energy costs in rural Alaska mandate a thorough review of local energy costs and appropriate ventilation strategies. This analysis may be performed using the Hot 2000 or AkWarm software.

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

Supply-only Systems

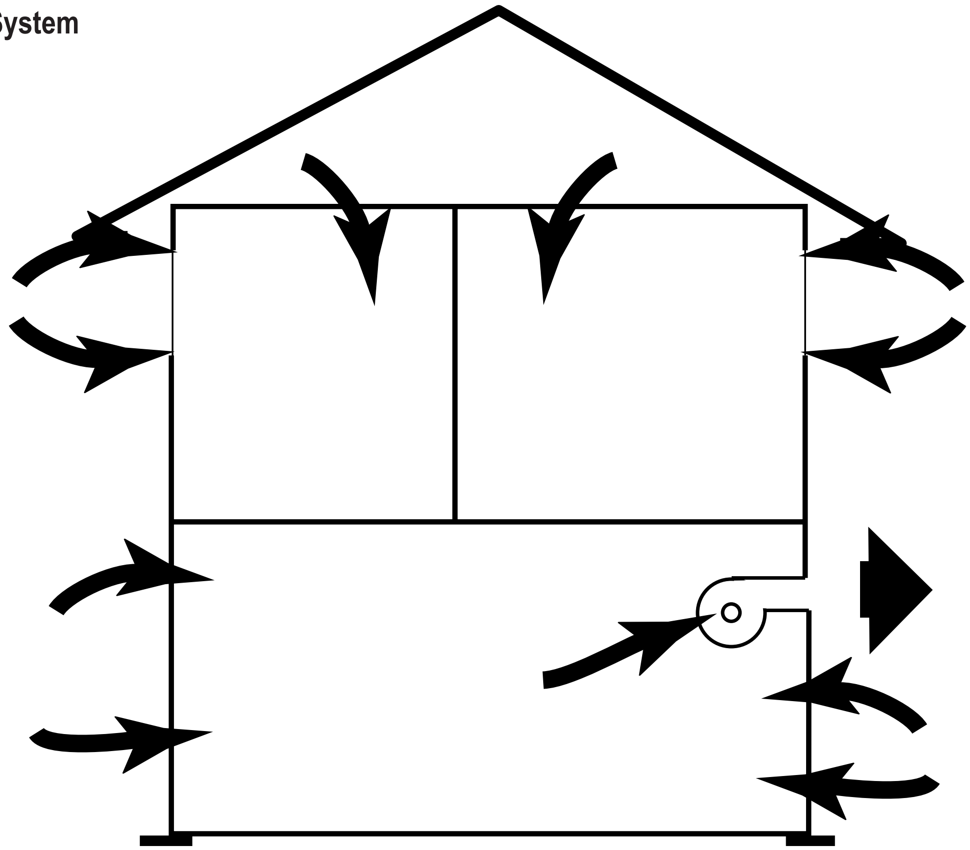
Supply-only systems typically consist of a fan that brings in outdoor air and discharges it in the building. This creates a higher pressure indoors relative to the outdoors. Air flow is always from areas of high pressure to areas of low pressure, so moisture-laden air will be forced out through any gaps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

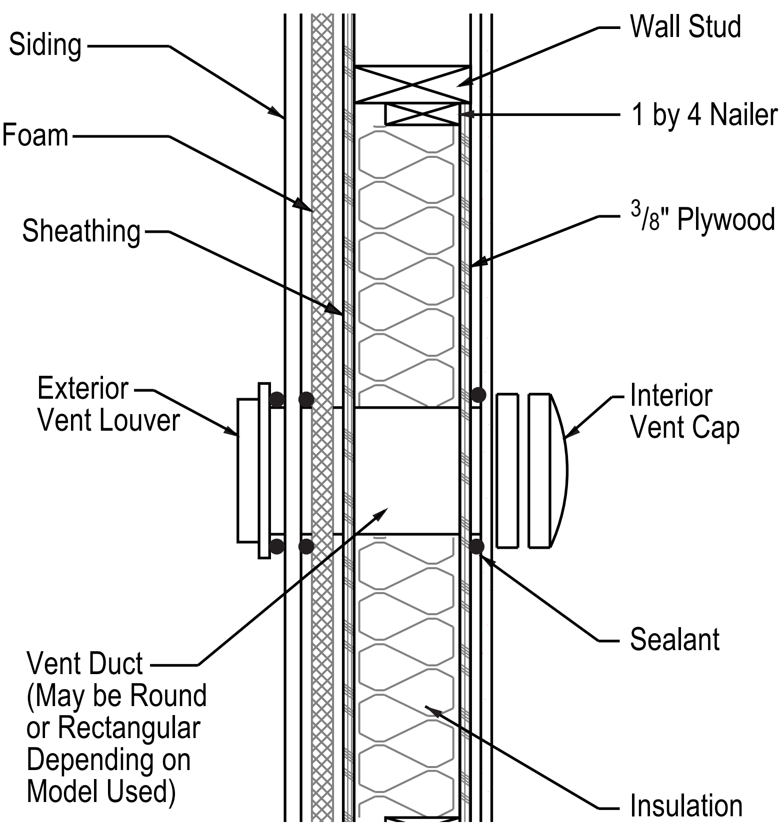
Exhaust-only Systems

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

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

Exhaust-only Ventilation System





"Fresh 80" Vent Installation

page A-43. This is a health and safety issue that must be addressed in the design, construction, and final testing of the building.

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

Balanced Ventilation System

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

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

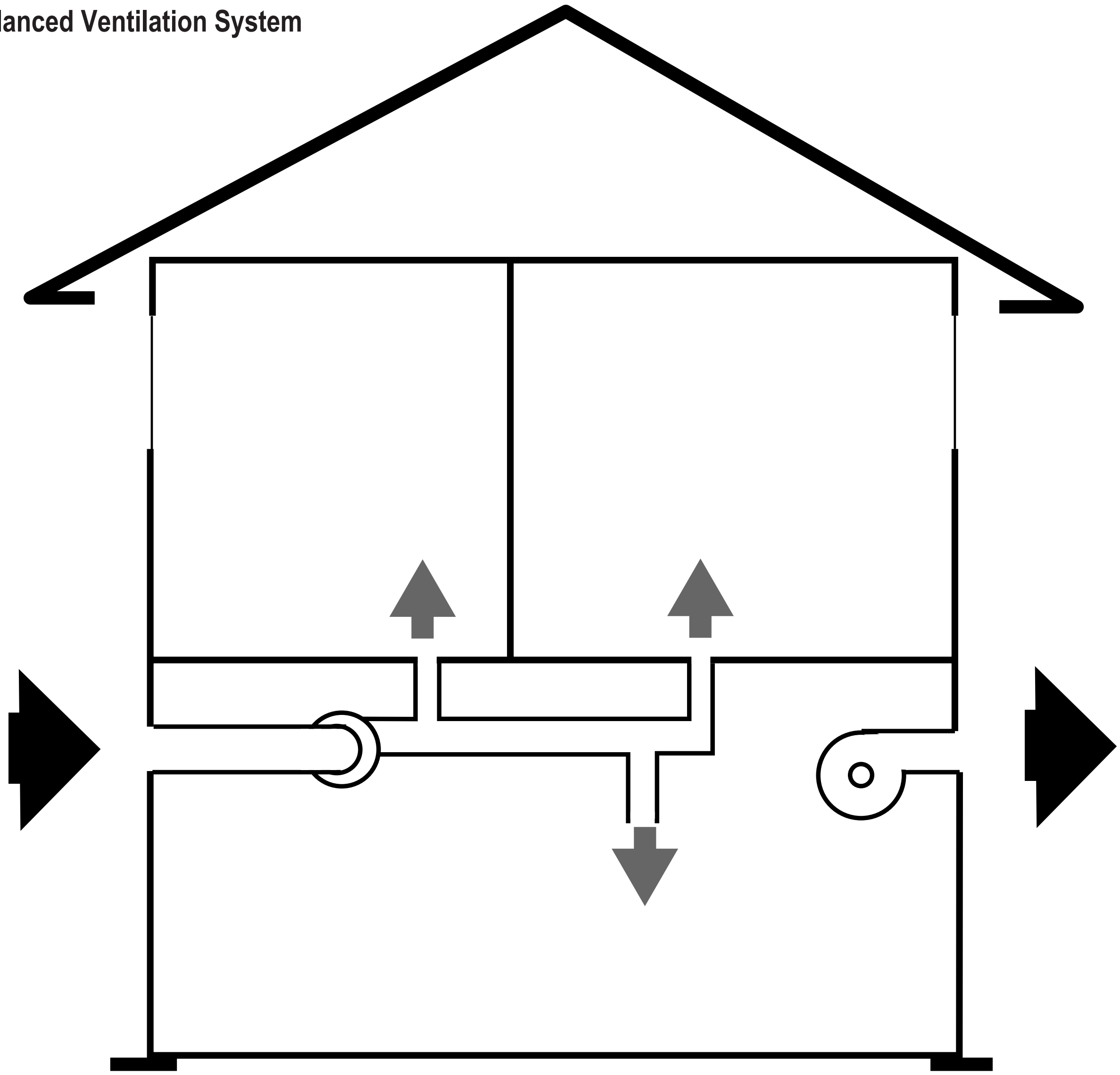
It will be necessary in most regions of the state to preheat or temper the incoming air for comfort reasons. A central balanced system affords the opportunity for exchanging heat from the exhaust air stream to the incoming air stream. The heat transfer provides tempered air to the building. This is called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

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

Heat Recovery Ventilators

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

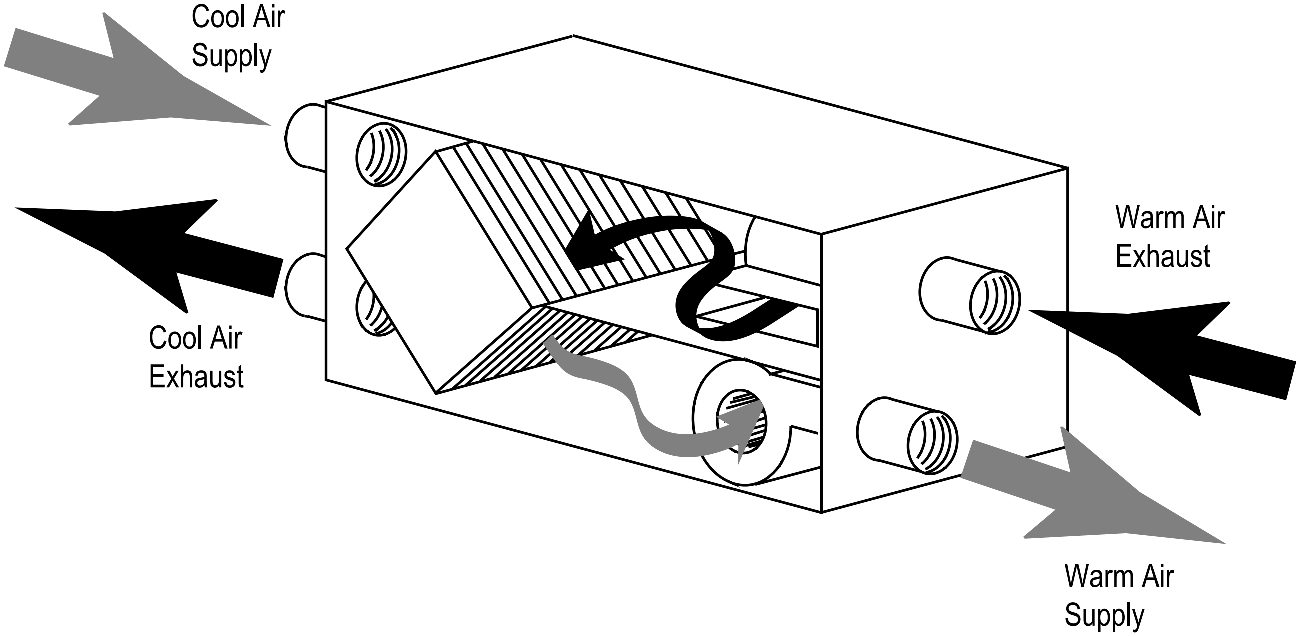
Balanced Ventilation System



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

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

Plate Type Heat Recovery Ventilator (HRV)



Performance Testing and Rating

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

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

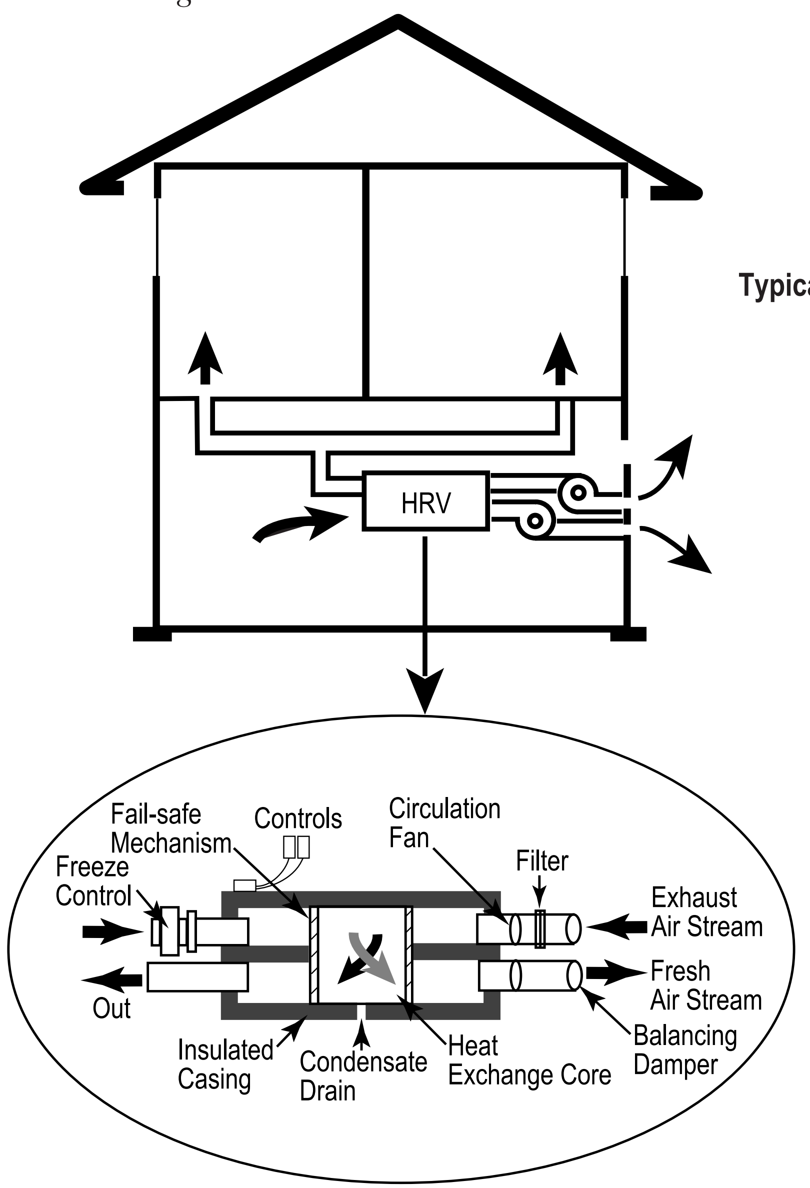
Selecting the Equipment

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

Locating theVentilator

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

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



Typical HRV system

Locating the Exterior Supply Inlet and Exhaust Outlet

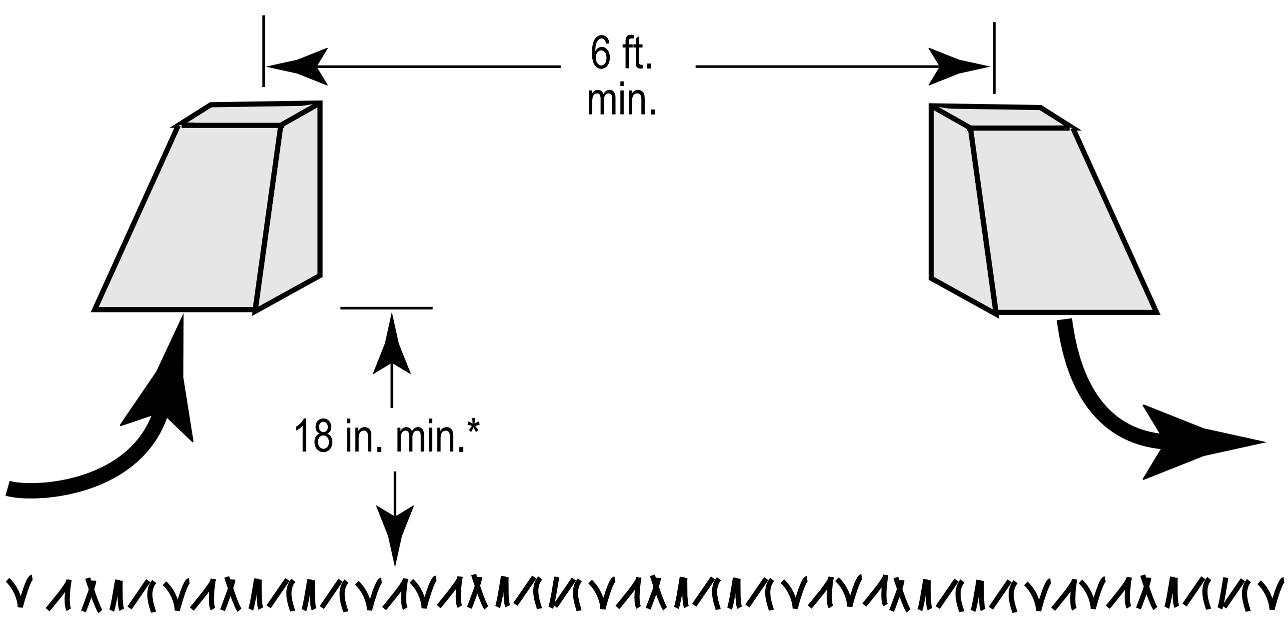
Supply air inlets and exhaust air outlets must be carefully located and installed to avoid contamination and other problems.

Supply Hoods

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

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

Location of Exterior Exhaust and Supply Air Hoods



* May need to be much higher in deep snow drift conditions

Exhaust Hoods

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

Fresh Air Distribution

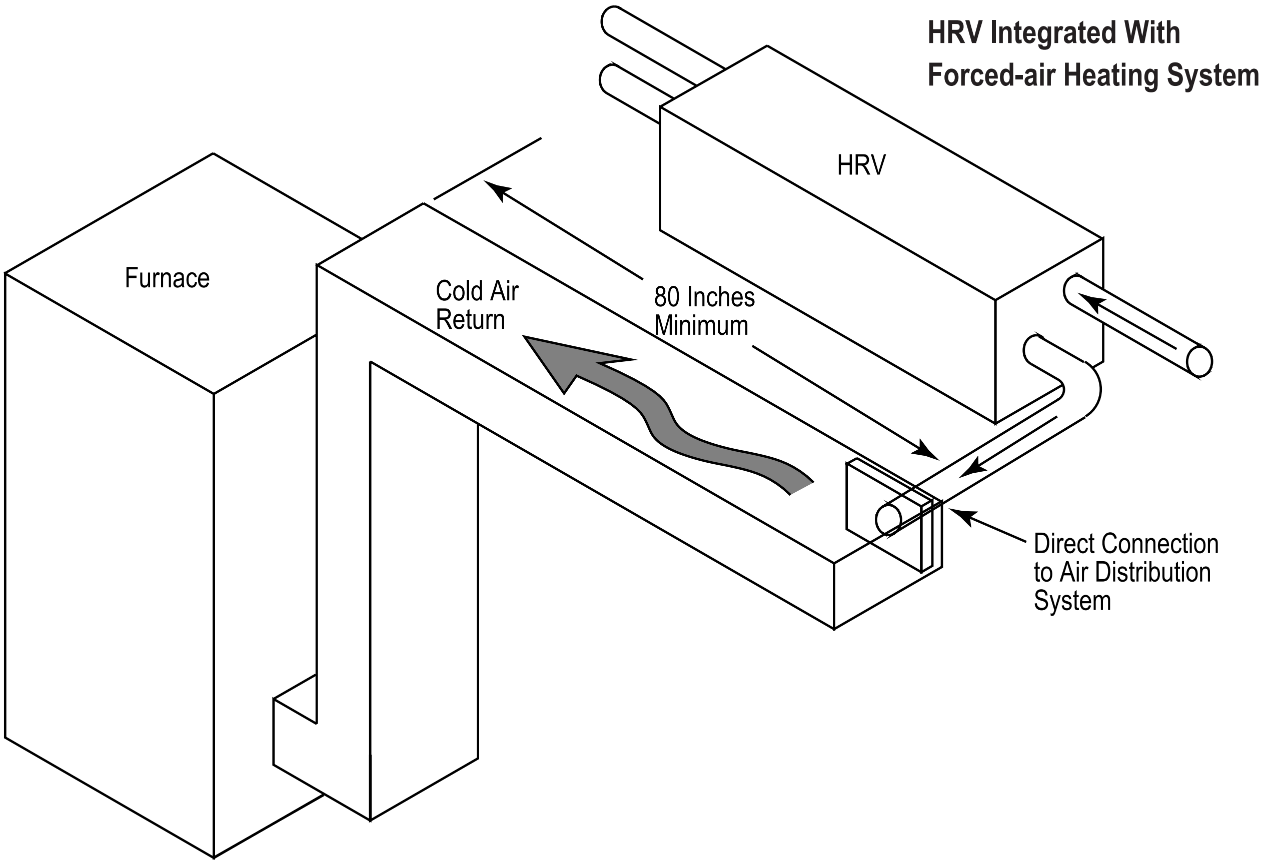
Outdoor supply air can either be distributed through an independent duct system or integrated with, and distributed through, the ductwork of a forced-air heating system.

Independent Systems

This approach is used in buildings that do not have a forced-air distribution system. In winter, the air supplied to each room may be below room temperature. The cooler supply air will behave like cool air supplied by an air conditioning system. The best way to supply cool air to a room is through a high interior wall or intermediate level ceiling diffuser. With this approach the incoming air has time and space to mix with the room air before dropping down to the occupied zone. This also helps to destratify and mix the air in the building (see graphic of grill locations).

Integrated Systems

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



Exhaust Locations

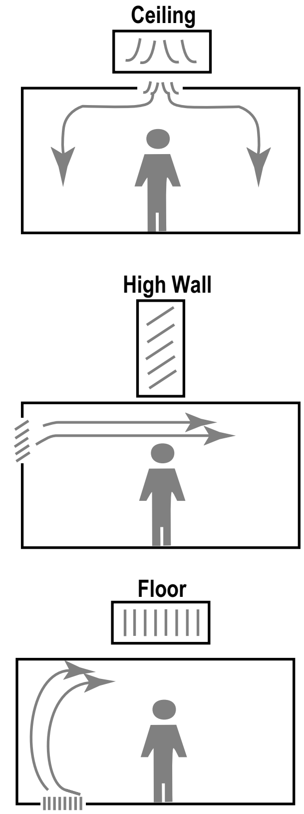
Exhaust air grilles should be located in the rooms where the most water vapor, odors, and contaminants are produced, such as kitchens, bathrooms, and workrooms. Rooms with only exhaust grilles will receive fresh air only indirectly, from other areas of the building. Undercut doors or install transfer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

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

Ductwork

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

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



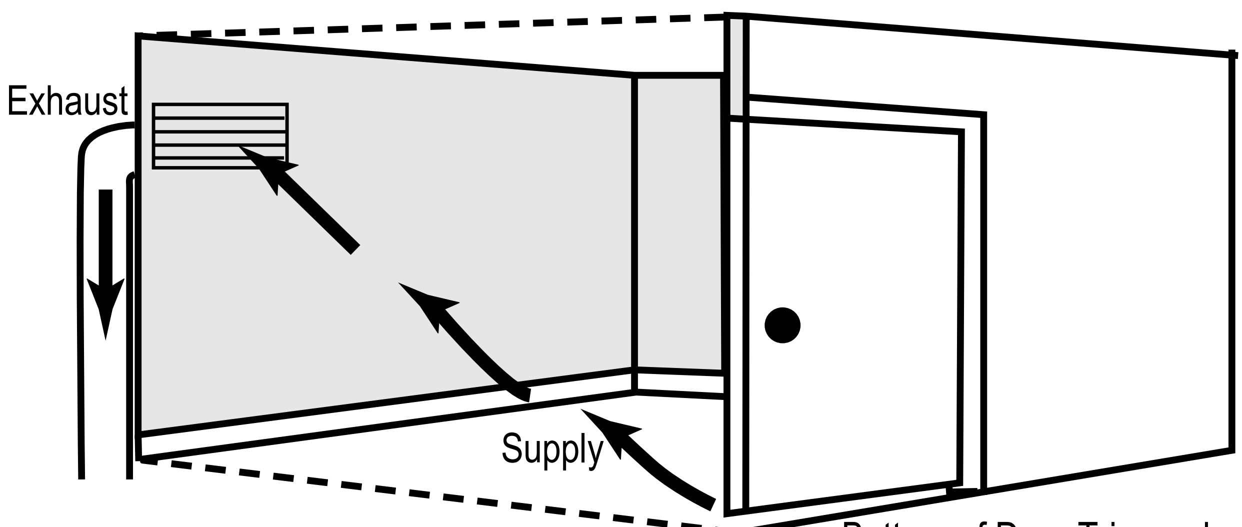
Grille Locations for Fresh Air Distribution

Controls

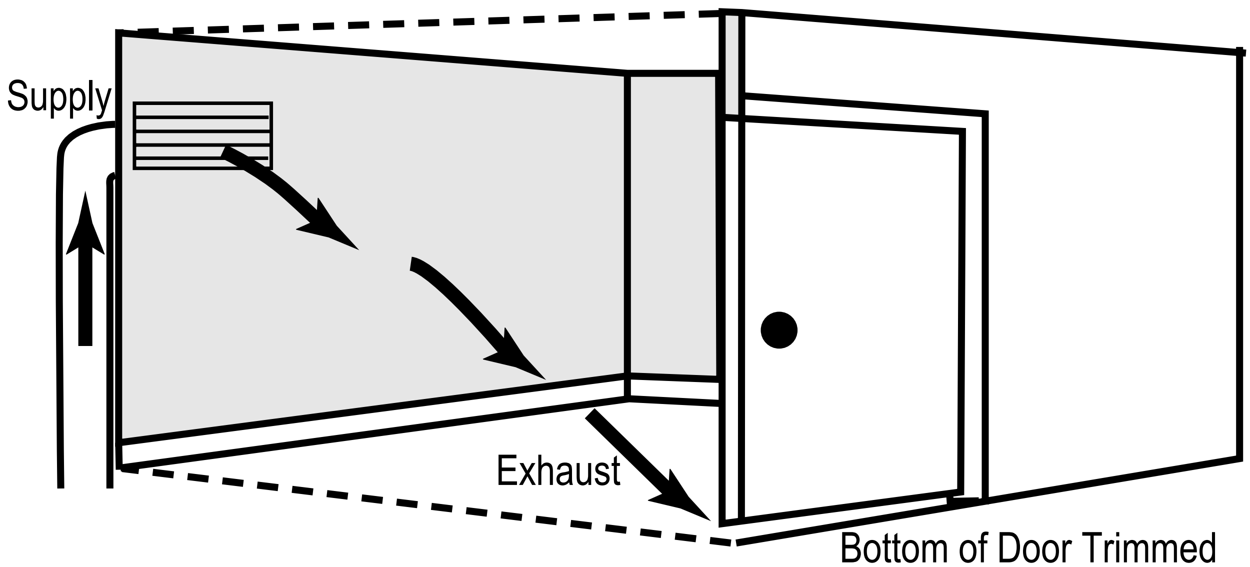
HRV systems are typically designed to operate at two speeds. On low speed, they provide the required base level of ventilation continuously. On high speed, they can handle additional occupant loads and contamination.

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

Typical Installation for Kitchen, Bathroom, or Laundry



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



Air Flow Measuring Stations

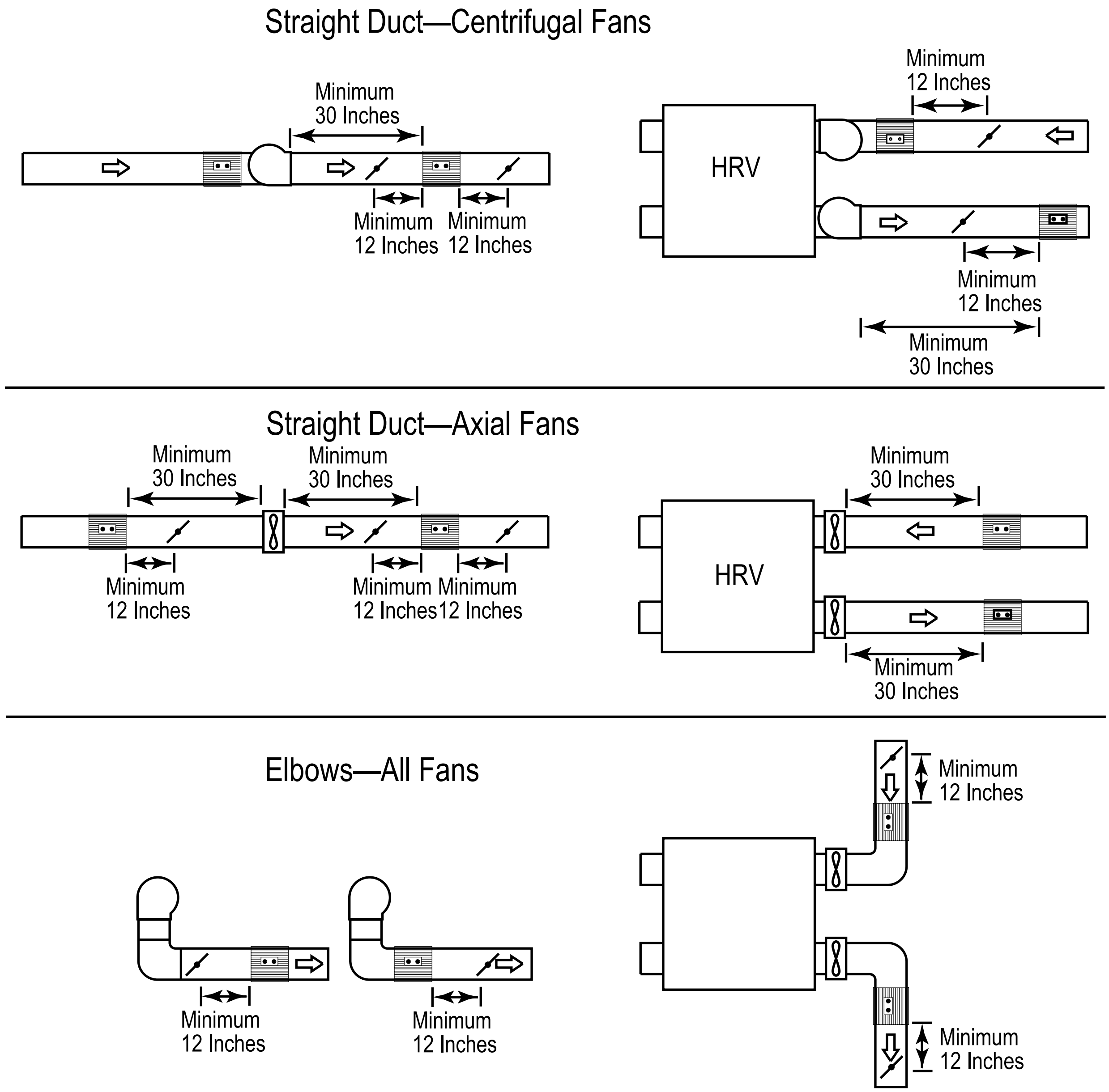
Air flow measuring stations should be installed in the warm side supply and exhaust ducts to enable the installer to balance the system. Dampers and flow measuring stations should be located in an accessible location near the ventilation system and in a position that will allow for accurate air flow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

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

System Installation

Once the system has been designed, ensure that the certified installer complies with all design and installation requirements, balances the system, and fills out any required installation reports. Any field deviations should be discussed with the designer before modification to ensure a properly operating ventilation system. The ventilation supply must bring in the same amount of fresh air into the

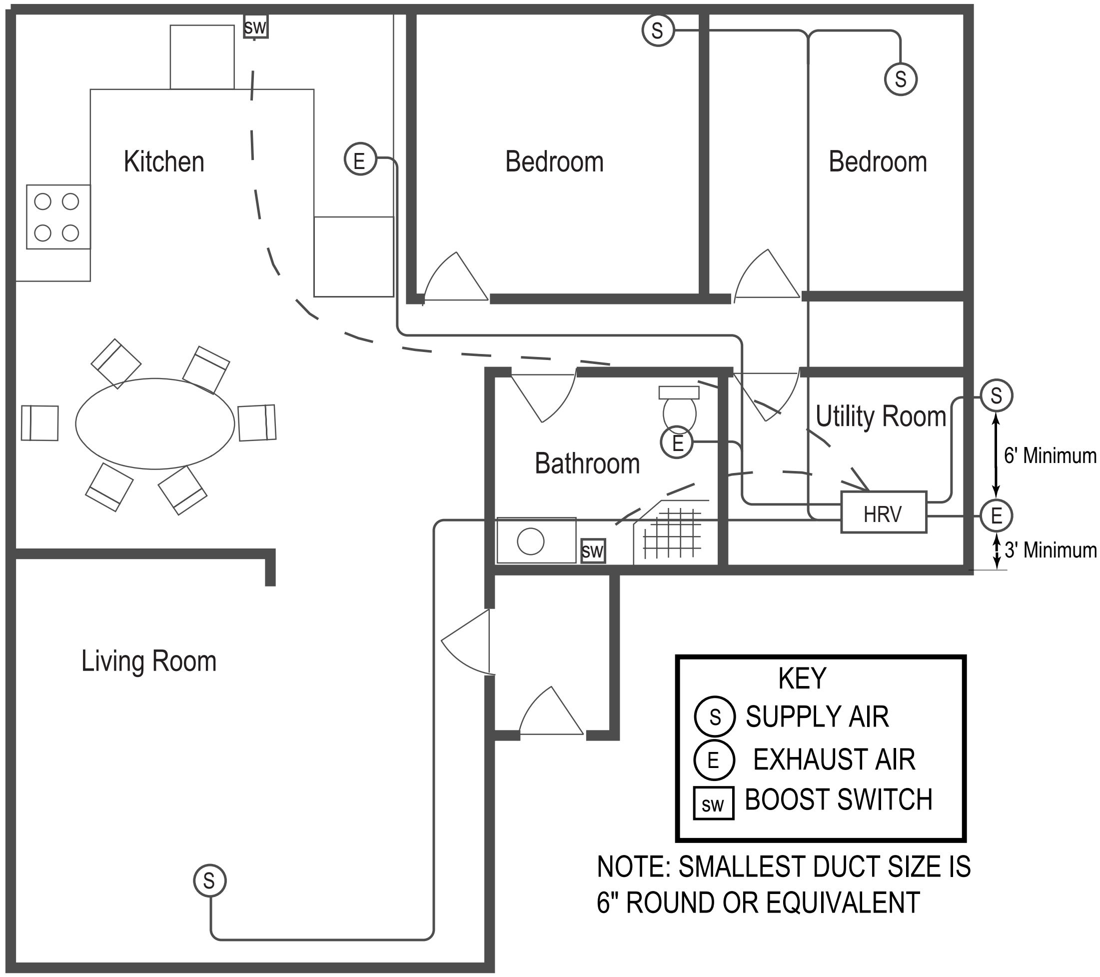
Locations of Airflow Measuring Stations



building as the exhaust fans are removing, plus or minus 10 percent. The system shall not cause a pressure imbalance greater than that allowed in BEES.

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

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



Water Conservation

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

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

Glossary

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

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

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

AkWarm is an energy use analysis software developed by the Alaska Housing Finance Corporation.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

R-value is a measure of the ability of a given material to resist heat flow. R is the numerical reciprocal of U. Thus, $R = {}^{1}/_{U}$. The higher the R, the higher the insulating value. All insulation products having the same R, regardless of material thickness, are equal in insulating value; expressed as ft-hr-°F/Btu. R-values for individual elements can be added to give a total R-value for an assembly.

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

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

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

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

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

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

U-value is the coefficient of heat transmission from an interior air film to an exterior air film. It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films, expressed as Btu/ft-hr-°F. U-value applies to the heat flow path through a single or combination of materials that comprise a building section. U-values can **not** be added to give a total U-value for an assembly.

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

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

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

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

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For access to these books and a host of other energy-efficient construction related publications, call the Alaska Housing Finance Corporation Research Information Center, (800) 478-INFO or (907) 330-8164.