
Prevention of Air & Water Infiltration

A Systems Approach

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FOREWARD

An average log home has nearly 1-1/2 feet of joint for every foot of log in the walls. If the wall is 12 log courses high, there may be a half-mile of joint to seal. Keeping those joints sealed from the elements is the major priority and challenge for every log home producer and builder. A well-sealed log wall minimizes air infiltration that can affect thermal performance as measured by higher energy costs. Protecting joints from water is the key to the endurance of the structure, and this protection includes windblown rain. The happiness and well being of the homeowner and the continued growth and success of the log home producer and builder will ultimately revolve around the design and quality control of the sealing system.

A properly sealed log home also makes surface maintenance much easier. When the seal is inadequate, moisture accumulates within the log seams. The moisture can migrate to the outer surrounding surface areas that are likely to have been treated with an exterior finish to protect the wood, resulting in an undesirable buildup of moisture under the finish. The consequence of moisture buildup beneath the finish is a common cause for failure of products intended to protect the wood.

The key to success can be found in the concept “system”. That’s because no one component alone can promise to deliver a successful seal between the log seams. Instead, a combination of these elements working together is necessary to achieve a consistent, reliable seal. The system components include caulk, foam gaskets, log shape, proper installation, and other elements that will be discussed in this paper.

The approaches to sealing a log home are as varied as the log home producers in existence today. The fact that there is not one universal log sealing design (i.e., triple, double, single tongue and groove; Swedish cope; spline and miter; chink; etc.) confirms that there is no single method of sealing. The single common denominator that delineates and distinguishes the quality manufacturer from the mediocre company is that the Quality Company always regards the seal at the log joint within the context of a “sealing system”.

The basic sealing system checklist should include the following considerations:

- The properties of the logs (section properties, stress grade, mechanical properties of the species used)*
- The moisture content of the logs*
- Accuracy & consistency in the milling process*
- Quality and type of sealant materials and fasteners*
- Log shape and sealant/fastener placement*
- Construction techniques and quality*
- Building design and location*
- Weather conditions during the building process*

Successful log building systems have considered all of the variables above. The log producer, the building designer, the sealant manufacturer, the fastener manufacturer, the construction crew, and the homeowner all play important interrelated roles in the sealing equation. The degree of sealing success with minimal field complaints will greatly depend on how critically each of the individual sealing elements are evaluated, managed, and coordinated by all concerned. The strength of the log sealing system will always rely on the integrity of the individual parts and their ability to work together.

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AIR & WATER INFILTRATION

While only 2% of the cost of building relate to air infiltration and waterproofing, 90% of the problems occur due to failures in these seals.

Building Code Requirements

Chapter 11 of the International Residential Code (2000) covers energy efficiency and addresses air leakage in paragraph N1102.1.10:

“All joints, seams, penetrations; site-built windows, doors, and skylights; openings between window and door assemblies and their respective jambs and framing; and other sources of air leakage (infiltration and exfiltration) through the building thermal envelope shall be caulked, gasketed, weatherstripped, wrapped, or otherwise sealed to limit uncontrolled air movement.”

The code further discusses protection against decay (Section R323; see Log Homes Council white paper *Preservation & Maintenance of Log Buildings*) and includes moisture vapor retarders in the previous section.

The 2000 International Energy Conservation Code speaks on the subject in three places, with the most pertinent section being 502.1.4.2 Caulking and Sealants:

“Exterior joints, seams or penetrations in the building envelope, that are sources of air leakage, shall be sealed with durable caulking materials, closed with gasketing systems, taped or covered with moisture vapor-permeable house-wrap. Sealing materials spanning joints between dissimilar construction materials shall allow for differential expansion and contraction of the construction materials.”

It is quite clear that the building codes reflect the research and studies performed over the last several decades and are requiring design and building professionals to pay attention to both the issue of energy conservation and of building durability.

Where Does Infiltration Occur?

Warm air leaking into your home during the summer and out of your home during the winter can waste a substantial portion of your energy dollars. One of the quickest dollar-saving tasks you can do is caulk, seal, and weatherstrip all seams, cracks, and openings to the outside. You can save 10% or more on your energy bill by reducing the air leaks in your home.¹

Air infiltration through of cracks, gaps, etc., can account for as much as half of the energy consumption of the building unless those areas have been sealed. Leading at nearly 25%, air infiltration at sole plates is the greatest, followed in decreasing order by wall outlets, exterior windows, vent hoods, fireplaces (dampers, chimney flashing), recessed lights, exterior doors, dryer vents, and duct systems to be the primary culprits. Add seams around pipes and other penetrations of the building envelope to arrive at over 200 square inches of leaks in an average home.

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How to Find the Air Leaks

Contractors have the option of using blower door tests, infrared scanners, and/or tracer gases to identify the source of air leaks and measure building tightness.

- ❑ **Blower Door** -- *This device includes a fan mounted on an insert that fits inside a doorway, allowing negative pressure to be generated inside a building to measure air leakage.*
- ❑ **Infrared Imaging** -- *Infrared photographs create a visual indication of heat leaks from a building.*
- ❑ **Duct Leakage Testing** -- *Most heating and cooling ducts leak energy. Technologies are available for testing ducts for leaks.*

Thermography uses special thermal infrared devices that measure the different levels of heat being radiated through a building envelope and show a color-coded thermogram image. The progression of colors from least heat loss to greatest is black, lavender, purple, blue, green, yellow, red, and white. Black areas indicate well-insulated or unheated areas.

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USING SEALING SYSTEMS TO CONTROL ENTRY

Managing air and water penetration of log buildings is similar to that described below for wood siding. This text is taken from *The Ins and Outs of Caulking*, published by the Forest Products Laboratory's Advanced Housing Research Center.

“Wood-based siding is expected to shed water, but it is usually not expected to act as a perfect barrier. Individual pieces of siding in good condition resist water penetration, but water can potentially enter between pieces, where siding meets trim or window or door casing, at penetrations through walls, and at intersections of walls with roofs and decks. In addition, when horizontal lap or shingle siding is exposed to rain, water can be expected to rise up the back of siding as a result of capillary flow and wind-driven rain. Water that is absorbed into siding or that wets the back of siding through capillary rise or minor leaks will eventually evaporate. However, evaporation is not immediate—the siding will retain the water temporarily.”

By contrast, the log wall *IS REQUIRED* to act as a perfect barrier.

When the log home industry talks about infiltration, they are clearly talking about limiting both air and water from entering the log wall. Since the log wall is the total defense against the weather, air and water have to be recognized as a dual entity and often as teammates.

A quality sealing system will be one that eliminates any surfaces on which water can collect or any channels that might allow water to move by capillary action to areas where drying (evaporation and/or drainage) is unlikely.

Keys to Log Home Suitability

Sealant products used in modern log homes should conform to several criteria:

- Flexible to maintain elasticity and resiliency necessary for log movement*
- Aesthetically pleasing, such as available in wood-tone colors*
- Easily tooled, applied, and cleaned-up*
- Available in user-friendly sizes and water-resistant containers*
- Strong enough to withstand the construction process*
- Stainable if designed to be used on exteriors*
- Cost efficient for the task with long shelf life*
- Durability – ability to withstand UV-radiation, ozone, freeze-thaw cycles, moisture and associated development of mold and mildew*
- Early weather resistance and minimal cure times*
- Impermeable to air flow and water (no absorption permitted)*
- Properly sized to the joint.*

Types of Joints

This paper is limited to the scope of joints or cracks in log walls that may permit air or water infiltration. Joints are termed by the extent of movement as working or non-working joints. Non-working joints are typically either static or rigid joints, while working joints are designed for movement (up to 12.5% or up to 25%). The type of joint and extent of movement are defined by the type of log building system used (see the discussion *Log Joint Design & Placement of Sealant/Fastener* later in this document).

They are sealed with materials that are intended to

- Protect against intrusion into the joint by any outside element*
- Prevent infiltration by air or water*
- Absorb movement (expansion or contraction)*

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Material Implications

Log grade and type, moisture content, milling accuracy and consistency, and choice of sealants, fasteners, and joinery are all factors that contribute to decisions regarding the sealing of logs. Milling accuracy and dimensional stability are critical in designing the tolerance and dimensions of the joint and sealant. If the placement of the sealant (in a groove, on a tongue, etc.) is not aligned with a corresponding groove, the best sealant will fail.

It is important to remember that movement and shrinkage occur to some extent in all log and heavy timber assemblies. Logs brought in from the environment and incorporated into a structure that is climate controlled will lose moisture and shrink in three dimensions; width, height, and length. This is true whether logs are air-dried, kiln-dried, standing dead, 6x 12, 6x8, or round. The sheer weight of building materials will also compress wood fibers. Equally important is the fact that unsealed or non-gasketed wood-on-wood will leak air or water to some extent. The key to building an air and watertight envelope is to build using a continuous sealing system designed to absorb the anticipated movement. Further challenges arise in making this sealing system palatable in conjunction with the design of the structure and mechanically compatible with the fastening system used in the log structure.

If a log producer could guarantee that each log would be perfectly straight, and that it was milled into its final form after it was dried to the equilibrium moisture content of the area in which it will ultimately be constructed, there will be few problems during the sealing and/or construction process. Ideally, this would result in minimal movement and tight joinery. Sealing logs under these conditions requires less material, and since movement is less, the sealant system is more likely to perform adequately.

Reality is that all logs adjust to the conditions at the building site first, and then adjust to the conditions imposed on them by the inhabitants when the heating and air conditioning systems are used. One can be assured that the part of the log that will move the least will be near the center, but this does not always mean it is strategically best for placement of sealant. If the log wall is designed so the center is sealed, will moisture entering the outside readily evaporate or drain to the outside? Is there certainty that the wood surfaces that can become exposed to the weather are adequately treated to resist nature?

Why Mud & Straw Isn't Used Anymore

Mud and straw were used because they were available. They are not used anymore because they do not work any better today than they did in the past. Today, there is a vast array of modern, ready to use sealant materials available to the log home manufacturer. These fall into three basic categories; chinking, caulking, and gasket.

Adhesives

For the purposes of this paper, adhesives are not practical options. While certain adhesives perform well with rigid frame construction, they are not conducive to log construction because the conditions typically found on the building site are counter to what is needed for consistent quality.

One note of interest is that many construction adhesives will create a wood-to-wood bond that is stronger than the bond between wood fibers themselves. Therefore, failure between the pieces of wood is almost always above or below the bond line.

Sheet Barriers

Sheet barriers are often used to seal the seams created between building assemblies. Larger sheets may be used for faster installation and offer few seams to tape. Smaller sheets of flashing are more appropriate for specific applications such as around chimneys where they penetrate the roof, between the roof and dormer walls, and around window and doors to seal the jamb to wall connection.

Polyethylene sheets have been used for vapor barriers for years, but the sheet can disintegrate over time if not properly protected. Newer house wrap products have been developed to provide barriers to air infiltration. Various flashing products (metal or vinyl) are providing quality seals under roofing, siding, and elsewhere to move air and water away from the joint.

Flashing may be used in combination with a caulking product to insure the seal. An example would be the use of a silicone caulk around the joint created by metal flashing and a masonry chimney.

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Joint Fillers

Joint fillers are used in deep joints where the depth of the joint must be controlled, where resilience is needed for working joints, or where a bond breaker is required.

Rigid Foam Insulation

Rigid foam insulation is the most effective product to seal very large openings where both insulation and air/vapor barrier properties are needed. Not appropriate around materials that will reach high temperatures, rigid foam is often used around plumbing chases, attic access covers, etc.

Backer Rod

Backer rod is used in several ways to seal against infiltration.

- ❑ *Crack filler – Use round, closed cell or bicellular foam, sized slightly larger than the crack it is to fill. Commonly available in 1/4" to 4" diameter and in coils and straight lengths, the foam can be pressed into the void. This is effective for long, narrow voids that may vary in width.*
- ❑ *Support filler – Trapezoid and convex shaped foam products are frequently used to support caulking to insure the shape of the caulking seal. Properly selected backer material will not allow the caulk to bond to it and will not affect the performance of the caulk as the joints moves.*

Caulk backer rod is a flexible, closed-cell or bicellular foam material that is formed into long, narrow lengths, generally of circular cross section. Backer rod is inserted into gaps, cracks, or joint reservoirs where seals are to be made; then the rod is sealed over.ⁱⁱ

Where depth of a crack is shallow and backer rod cannot be used, bond-breaker tape is sometimes used to prevent three-sided adhesion.ⁱⁱⁱ

Chinking

Chinking is a joint sealing option that is predominantly used in the log building industry. Only its relation to stucco and synthetic stucco systems bring it into the world of conventional construction.

Modern chinking is manufactured to mimic the old style mortar that was used in the infancy of the modern log home industry. Much like mud and straw, mortar-based materials did not work very well to seal out air and water. Mortar does not adhere to wood.

Like caulking products, modern chinking materials are specially formulated elastomeric materials, which adhere to wood, metals, and mortar. When used between logs and properly applied, chinking will stretch and absorb minor movement between logs, forming an air and watertight barrier, which is resistant to mold, mildew, ozone, extreme temperatures, and is aesthetically pleasing. Modern products come ready to use, are available in different colors, and are commonly available. All products on the market today are water clean up and must be applied to dry logs with a surface temperature of 40 degrees and rising. As most chink joints are fairly large in size, cure rates are fairly slow and freshly applied chinking should be protected from the elements and from physical damage until cured. As most chinking is applied after sealers or stains are applied to logs, compatibility with the chosen chinking is imperative as adhesion can be affected.

Chinking Joint Design

In order for any chinking material to properly perform in a log home, the joints must be properly designed and the chinking properly installed. Whether logs are round, square, milled or handcrafted, two-point adhesion is imperative. This means that the material is bonded only to the top and bottom log face in a joint reservoir and not to a third face.

Backer rods of various width, composition and design are commonly used as temporary filler between logs. Backer rods limit the depth of the applied sealant, resist the sealant to form the proper shape, and act as a bond breaker to prevent third-side adhesion.

Joint width should be a minimum of four times the anticipated movement of the logs.

- ❑ *For joints 1" in width or more, the depth should be 3/8" to 1/2". The depth of joints less than 1" wide should be half the width, but no less than 1/4".*

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- ❑ *One exception to this rule is the Appalachian style log, which commonly uses a Styrofoam backing material between the logs. These joints can be 4" or more in width. The chinking depth on this design can be ¼" in the body of the joint, but must be at least 3/8" at the point of log contact.*
- ❑ *Logs with a milled chink joint and log siding installed over OSB or plywood should incorporate a bond breaker tape to achieve two-point adhesion.*

Chinking Application

The vast majority of chinking is supplied in 5-gallon pails. The material can be applied to log walls via bulk caulking guns, common grout bags, by hand or with a commercial grade-chinking pump. However it is applied, all chinking material must be tooled to ensure proper adhesion to the logs and for appearance sake. Chinking is tooled by various methods, depending upon the style of the logs used. With round logs, the product is commonly tooled into place using small trowels, foam paintbrushes, and water that is sprayed on the surface to make tooling the product easier. With square logs, chinking is usually tooled into a flat joint using putty knives. Regardless of style, a good chinking job will be applied at the proper thickness, will be aesthetically pleasing, and will have a well designed joint incorporating two-point adhesion.

Wet Seal vs. Dry Seal vs. Hybrid

Caulk relies on adhesion while gasket relies on expansion or compression to seal the joint. Therefore, most log home manufacturers use a combination of all three methods. For instance, a company may use chinking on all of the horizontal joints, sealant or caulking on butt joints and corners and gaskets over windows and doors. Or they may employ a double tongue and groove log with caulking on the outside groove, gasket on the inside groove and chinking on a milled exterior chinking groove, or other combinations.

Which is best? While all properly designed and installed methods work, the most dependable method is the exterior one. This is due to the fact that an exterior seal is readily accessible and can be inspected and repaired if necessary. Interior methods rely on competent installation at time of log wall erection, and in case of later need of repair, accessibility will be a factor, forcing sealing to be accomplished from the exterior by caulk or other method. Some joints, such as over windows and doors, where movement can be extreme, clearly call for a large gasket with low compression and deflection value because movement can exceed the parameters of a wet seal.

Caulking

Caulking is used in both exterior and interior applications to seal between logs, in checks or cracks, around windows and doors, around corners, at log butt ends, between other joinery, on flashing, around wall penetrations, and in any number of other applications. Unlike chinking, caulking is usually used to cover gaps in wood or in transition from one material to another to make them appear to blend together and is usually available in a variety of colors. Modern caulking products are elastomeric, mold and mildew resistant, have excellent adhesive properties to a wide variety of substrates, and when properly applied can provide an excellent barrier to air, water and insect infiltration.

Caulking is also used to seal logs in tongue and groove style logs, usually by applying a bead of material to the tongue of the bottom log. Two-point adhesion can be achieved in this application by insuring that proper headspace is left between the tongue and the groove and the joint is not over-filled and the material is not simply squeezed out.

The design of the joint should ensure that the caulking material is placed as closely as possible to the exterior of the log to prevent water infiltration into checks or cracks. Caulk barriers whether internal or external should be continuous and extend through butt joints and corners and around windows and doors to provide a continuous seal throughout the structure.

The selection process must consider the type of joint, surface preparation at time of application, and compatibility of caulk and substrate. The key elements of a caulked joint are adhesion and cohesion.

- ❑ *Adhesion is the ability to stick to the surface of the materials creating the joint (substrates). Selection considerations include the compatibility of the caulk with the substrate, the conditions at time of application (e.g., temperature, presence of moisture, dirt, or other residue on the substrate), and any treatment.*

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- ❑ *Cohesion is the ability to hold together. Selection considerations include the type of sealant compared to the type of joint, the curing properties of the caulk, and the thickness and elasticity of the material being applied. Use caulk that will remain flexible enough throughout its service life to satisfy the application. ASTM Standard C920 identifies two weather-resistant caulk classes; Class 25 has high flexibility and Class 12-1/2 has lower flexibility.*

The National Bureau of Standards developed classifications for sealants to describe their purpose and usefulness:

- ❑ *Type I caulks – self-leveling; for horizontal, traffic-bearing joints*
- ❑ *Type II caulks – non-sag; for vertical or non-traffic-bearing horizontal joints*
- ❑ *TT-S-00230 caulks – pre-mixed, one-part, ready-to-use*
- ❑ *TT-S-00227 caulks – two-part caulks that must be mixed for each application; Class A caulks are for joint movement of up to 50% of the original size; Class B are for joint movement of up to 25%.*

Caulking products are commonly available, but most are designed for conventional housing and are not all compatible with log homes. As there are so many different applications, there are many different materials used in caulking. In the log home industry, these are usually acrylic, butyl, silicone, or urethane. Each of these materials has inherent pros and cons and the reader should refer to the chart below for caulking choices for specific applications. See Appendix, *Pros & Cons of the Typical Sealant Types Available* for more information.

Do not use caulk that has been stored for excessive periods or beyond the indicated shelf life. If it is difficult to force the caulk from the tube, the shelf life has probably been exceeded. However, the ease of dispensing caulk from the tube does not necessarily indicate freshness. Some caulks that have exceeded their shelf life may be pumped easily from the tube but fail to cure. Latex caulk that has been frozen in storage should be discarded.

Caulking Joint Design

Two-point adhesion is imperative for caulking material to properly perform in joints where movement is anticipated. Applying caulk in a joint that is too deep (depth cannot exceed width and is actually best when it is half the width) or one that allows the caulk to adhere to three surfaces will undoubtedly fail; it's just a matter of time. For both adhesion and cohesion in a moving joint, it is best to promote an hourglass shape using a backer rod.

For proper adhesion on both sides of the joint, make sure the surfaces are dry, free of frost, and clean (no dirt or loose materials). For wood that has been treated (especially with a water repellent), apply the caulk on a small piece of the treated wood to test its adhesion. A priming material can enhance caulk adhesion; information from the caulk vendor will indicate whether priming is necessary.

Caulking Application

The caulked joint can also be affected by how it is applied. Cut a 45-degree angle on the nozzle of the tube, beginning with a small tip. If it is too small, cut some more of the nozzle (the converse will not be a possibility). PUSH the gun along the crack with the angled nozzle running fairly flat along the surface. Do not let the bead get bigger than the nozzle tip. Remove the excess with solvent and a rag.

Tooling the caulk bead with a putty knife, spatula, bare finger, or rag provides a smooth, finished appearance and forces the caulk into the joint. Often, water or a combination of soap and water are used to help smooth and press the caulk into place.

Apply caulk within the range of acceptable application temperatures as indicated by the manufacturer. In some cases, the choice of caulk will be determined by temperature at application.^{iv} It is generally recommended that caulk be applied to the cool side of a building on a hot day and conversely to the warm side on a cold day.

Gaskets

Gaskets designed for uses in log building may come in rolls with an adhesive on one side. They are used most often between the log courses and around wall openings to seal the rough frame/buck. The adhesive is used to aid in placement during log stacking and not to seal the log.

The key elements for gasket use in the log wall are:

- ❑ *High performance products cost more than some sealants, but are a relatively small cost compared to the overall project. Yet, when low cost products fail, the cost to repair can be significant.*
- ❑ *The seal must be continuous. Ends of gasket tape need to be lapped (about 1 inch) to be sure the splice is sealed. Even transitions from horizontal to vertical need to be continuous.*

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- ❑ *Gaskets should be placed at the least vulnerable point on the bearing surfaces so that water drains away from the sealant*
- ❑ *Size the gasket to the joint size after settlement and shrinkage have opened the joint.*

Dry, preformed foam gasket is used instead of caulk because of ease of application, neatness, cleanliness, low cost, and uniformity of application (it cannot be squeezed out of the joint). The factors that should be considered when selecting a gasket are:

- ❑ *Compression – The force required to close the joint.*
- ❑ *Compression recovery – The ability to return to the original form after being compressed.*
- ❑ *Durability – Resistance to elements that will cause failure, such as the brittleness that can occur from UV-radiation or ozone exposure.*
- ❑ *Water absorption – Or lack of... the ability to stop moisture.*
- ❑ *Compatibility – How will it react with wood treatments, protective coating products, caulks, etc? Is it better to apply it to bare wood and treat around it, or treat first and apply sealant afterward?*
- ❑ *Ease of installation – Adhesive backed, .*

Density and cell structure are two of the key elements of selection. Product options include

- ❑ *Low Density Closed Cell - PVC, polyolefin, polyethylene*
- ❑ *High Density Closed Cell – neoprene, EPDM, polyurethane, polyolefin, polyethylene*
- ❑ *Open Cell – Made from polyurethane or polyester polyurethane, open cell urethane foam degrades rapidly from UV-radiation and ozone. Open cell foams are not appropriate in log walls unless they are impregnated with a sealant or sealed with an impermeable coating.*
- ❑ *Saturated Tape Products – In compression joints, saturated open cell gaskets out-perform caulks, mastics, and backer rod as the foam structure reinforces the impregnated sealant. The saturants range from asphaltic bitumen to petroleum-based liquid adhesive to neoprene rubber; some can make handling the gasket a bit unpleasant. The opposite of closed cell, these products are most effective when compressed 50% to 90%. Limitations include the need to keep the material warm in cold weather, but cool in hot weather.*
- ❑ *Butyl tape – Rather than relying on compression recovery to seal the joint, butyl relies on its adhesion and elastic qualities to maintain the seal.*

Low density closed cell foams have very poor recovery and do not provide an adequate seal in joints that move. Once compressed, the shape of the foam is set and over 50% compression can result in destruction of the cell structure.

Relying on their elasticity to recover and maintain a positive seal between surfaces, high density closed cell foams are designed for as little as 25% compression. They exhibit the highest level of recovery from compression, but are much more difficult to compress and are not very moldable. Their advantage is that they require less compression to perform well. The disadvantage may be that the density of the material makes it undesirable to compress it more than 50% to 60%, as it is likely to hold the joint apart.

EPDM (ethylene propylene diene monomer) is a synthetic rubber with exceptional resistance to UV-radiation, oxidation, air pollution, and extremes in temperature. It can be made into a hard, stiff, solid form, a bulb or hinge shape for better compression, or a skinned, closed cell extrusion.

Open cell products are sometimes useful to fill voids, but they require additional treatment to eliminate air and water passage. The advantage of open cell foam is that it can compress to a very small size. When fully wrapped with an impermeable plastic skin, open cell foam becomes an excellent product to fill a joint that will compress over time.

Unlike caulking (and chinking), dry preformed foam gaskets seal by expansion or compression to fill voids within a joint and rely on their “memory” to seal the space. Other gaskets are used over windows and doors to fill settling spaces. Various types of building gaskets have been used to seal between building assemblies or to block small openings. An example of the former would be gaskets used between the sole plate of the exterior wall and the subfloor. An example of the latter would be a gasket to seal an electrical outlet against air infiltration. Gaskets may also be effective in sealing the hole made to allow a pipe or vent to pass through the building envelope.

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Joinery Design Considerations

When sealing between logs with gaskets, joint design and proper gasket sizing is most important. The key to gasket joint design is to size it to fill the joint without excessive compression, yet with adequate recovery to fill the joint as it opens. Common considerations are compression recovery, compression force, water absorption, compatibility with substrates, and resistance to UV-radiation.

Correct headspace must exist between the tongue and groove to prevent crushing the gasket and to avoid having the gasket hinder log placement. The gasket must also be deep enough in its' expanded state to completely fill the voids in anticipated log movement. In sealing butt joints, a 'well' or groove should be routed to accommodate the gasket in its' compressed state, otherwise, logs will be held apart and gaskets will be over-compressed.

Gaskets are best for joints or small cracks with controllable or predictable movement. Tolerances in the joint will need to be compared to the allowable compression of the gasket and its ability to recover. Gaskets are available in an assortment of sizes to best suit the application. The size of the gasket in its compressed and expanded sizes determines the sizes of voids it can fill.

Some common uses for gaskets elsewhere in construction are

- Sill plate to foundation wall*
- Box sill to sill plate*
- Sub floor to box sill*
- Exterior wall to sub floor*
- Roof assembly to exterior wall*

Application

One advantage to gaskets and tapes is that they can be installed in most conditions. Adhesive-backed products may be difficult to work with on frozen or dirty surfaces, but a few well-place tacks will keep the material in place while the next piece is installed. Overlap ends to provide a continuous line of sealant. Cut the ends of the gasket using sharp shears or knife, wetting either with water or silicone spray to make cutting easier. Do not pull or stretch tape during installation as it may result in uneven thickness of the product.

Expanding Foam Sealants

Spray-on expansive foam products are typically polyurethane foams that are high- or low-pressure systems. They are available in cans or other larger metal pressurized containers and are dispensed into voids, cracks or joints where they expand and harden to a rigid mass.

Expanding foam sealants are an excellent means to increase the energy efficiency for most methods of construction. However all foams are not the same. Polyurethane foams come in many sizes and are intended for different construction and other applications.

- For smaller volume applications, one-component rigid polyurethane foam is appropriate.*
 - The size of the job should be less than 4 cubic inches of volume since these products are moisture-cured, and it takes atmospheric moisture to allow them to harden. If the job is larger than the size of a fist then the moisture cannot get to the center of the foam to allow it to properly cure.
 - One-component products are available in a single package where a straw is attached to the aerosol can. This is for the smallest applications.
- For higher usage applications, which are still small uses of rigid foam, "gun foam" is normally used where the aerosol is attached to a dispensing applicator.*
 - For maximal insulation value, make sure the foam is closed cell foam, which provides a range of an R-3 to R-5 per inch depending on the supplier and specific grade.
- For window and door applications, low-pressure foams are preferred to diminish the chance of bowing the window or door.*
 - Closed cell foam products are recommended over open cell foams. Open cell foams offer little insulation value or water resistance and do not stop air infiltration.
- For larger volume applications, two-component foam is recommended.*
 - It is a chemically cured material.
 - Disposable kits are available to the homeowner in sizes ranging from one cubic foot of rigid polyurethane foam up to fifty cubic feet of foam.
 - These materials typically have an R-value of R-7 to R-8 per inch of foam.

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- They have the ability to insulate, sound deaden, stop air and water infiltration, inhibit rodent infestation, and do not support mold growth.

Joinery Design Considerations

Newer, low-pressure foams can be effective in log home construction when applied with consideration to the following characteristics:

- *Best for sealing larger voids that are protected from sunlight and moisture*
- *Effective in static joints, but they lose effectiveness in high movement joints*
- *Generally a poor choice for log home sealants as most dry fairly hard and have poor or no elasticity*
- *Straw foam is difficult to control with a tendency to over-fill most joints and spill out onto logs where they are very difficult to remove. Gun foam is easier to control.*

The void should be contained such that the foam fills and seals cracks without oozing through them. They have been used as backing material for chinking with some degree of success, but blisters in synthetic chinking material have occurred due to out-gassing.

These products can be effective, but tend to be messy and some safety concerns arise. Expanding foams, similar to other adhesives and sealants, do not adhere well to frozen surfaces, oil-contaminated surfaces, or apply well or bond in cold climates because it will freeze. Most suppliers offer products with a shelf life between 9 – 18 months, so make sure to use the oldest product first for proper inventory rotation.

Log Joint Design & Placement of Sealant/Fastener

Horizontal Joint Design

Log on log joints come in many varieties. Manufacturers today use single tongue-and-groove, double tongue-and-groove, triple-tongue-and-groove, Swedish cope, full scribe, splined logs, and flat-to-flat. Variations on these systems include externally caulked or chinked joints, gasketed joints, and combinations of all three. All systems have advantages and drawbacks. Paramount is the consideration of how the chosen sealant system works.

Certain styles of log construction rely on the assembly and or seasoning of the logs to provide the seal. A coped log wall may be designed so that the points of the cope of the top log actually compress into the log below until the weight of the construction is fully supported by the bearing capacity of the log below. Some designs include a highly compressive sealant between the logs within the coped area while others do not. Another option is to provide a seasoning kerf in the top of the lower log such that the seasoning effect on the lower log places pressure on the cope of the top log.

Flat-on-Flat Bearing

No sealant should be placed on a load-bearing surface, as the compression will destroy the elastomeric properties of the sealant while the lateral movement of the two surfaces (during construction or after) will shear it. When the joining faces of the logs are flat (including splined log systems), the sealant should be placed in a “well” or groove system designed for it.

2-Point Bearing Profiles

When a tongue-and-groove system is employed, headspace between the tongue and the groove must be maintained to ensure that gaskets are not compressed too tightly. Proper headspace is essential when using caulking to insure that product is not simply squeezed out and that a proper bead is left to absorb movement. Special care must be taken during construction to ensure that gaskets are not torn or caulking smeared during log wall erection or voids can be formed. Typically, the tongue and groove portion of the log is given the tolerance to make the joint seal properly while the other portion(s) of the log are in full contact to accommodate structural load bearing capacity.

Filling Voids of Non-Contact Systems

Non-contact systems or chink-style logs basically come in four varieties:

- *Appalachian or square logs style in both milled and un-milled varieties. Appalachian style logs generally have larger chinking joint filled with rigid insulation and/or backer rod and then chinked.*
- *Round logs in both milled and un-milled style. Round logs have smaller gaps usually filled with a backing material and then chinked or caulked.*

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In both cases, care must be taken that chinking or caulking materials are applied at the correct thickness throughout the joints. In general, most materials are applied at a rate of depth equaling one half the width, but no more than one half of an inch. Sealant manufacturers should be consulted for details and guidelines.

An externally caulked or chinked system must be designed and installed to insure proper depth, width and adhesion of the caulking material. Caulking material should be placed as close as possible to the outside of the joint to seal out wind driven rain, insects and air. Drip edges can serve to ward off moisture which runs down log walls and can serve to hide a caulk groove if aesthetically desirable. Drip edges are not a substitute for proper sealing.

Vertical Seams

Butt Joints

There are two types of butt joints – joints between log ends and joints between a log end and a log face. The principals governing these joints are similar to the horizontal seam between logs.

Care must be taken in the design of these joints to ensure log stability between log ends against lateral movement and twisting and prevention of air and water infiltration. This is best accomplished by using a combination of gaskets, caulking, splines, and proper positioning of fasteners. These joints must also provide spaces for caulking or gaskets to work.

- ❑ *Log ends simply caulked and fitted tightly together will result in caulking material being squeezed out, rendering it ineffective and unable to absorb movement.*
- ❑ *Conversely, logs fitted tightly together with gasket material will be held apart by the compressed gasket.*
- ❑ *Butt joints where logs are actually left apart 1/4", gasketed, splined in the middle and properly caulked are actually superior in eliminating air and water infiltration, but can be aesthetically displeasing.*

Wall Openings: Windows, Doors, Fireplaces

Regardless of type of construction, wall openings are the worst offenders as far as air and water infiltration are concerned. Again, as all logs settle to some extent, anticipated movement must be accommodated above these openings. Typical components of openings in log walls include:

- ❑ **Manufactured window and door units:** *Doors and windows and their sealing systems vary greatly, and manufacturers instructions must be followed.*
- ❑ **Rough frames or bucks:** *Joinery and mechanical connection of the buck to the log ends are often used to hold log ends in alignment. While this seam is often hidden by trim, a quality seal here will greatly improve the performance of the wall.*
- ❑ **Flashing:** *Flashing should always be provided where appropriate.*
- ❑ **Trim:** *Trim should be sealed to logs by means of caulk and gaskets to provide extra barriers to infiltration.*
- ❑ **Fill voids:** *The settlement space above window and door frames will only experience compression. Filling the original void should be done with a low-density foam or fiberglass insulation that will compress to a very small size. Most of the products of this type, however, also need to be wrapped in plastic or otherwise sealed to keep air and water from entering it.*
- ❑ **Seal:**
- ❑ *Fireplaces provide a separate challenge, as they are rigid, do not settle with the log structure, and are attached to a structure, which will settle. They also often span the entire height of a structure from foundation to roof. Consequently, several methods of weatherproofing must be employed.*
- ❑ *Chimneys must be flashed and counter-flashed to roofs.*
- ❑ *Logs should be caulked or chinked between masonry and log ends to prevent wicking of moisture into the logs. In situations such as these, it is important to understand and remember that the settling of a structure may warrant sealant maintenance down the road.*

The irregularities of log stress combined with climate, structure design, settling, and compression may very well exceed the physical limits of a sealant material. This is normal and in many cases likely.

Vertical Log Construction

It might be thought that vertical log construction would be easier from the standpoint of providing an effective seal. Actually, there is no difference in the need for a quality seal. In fact, although horizontal seams offer the potential of water sitting on a surface, water running down the face of the wall crosses over only the width of the seams. In vertical log construction, the water will run down the full length of the joint.

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Corner Joinery

Eliminating Water Traps

Some corner joinery can channel water into a trap where it can stand, soak into logs and eventually cause rot. These type joints should be avoided, or special care should be taken to caulk these spots externally so that the joint can be inspected periodically.

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COMPATIBILITY & DURABILITY OF PRODUCTS

Compatibility with Wood Treatments

There are many treatments used on logs from the time they are felled as trees to when they are actually incorporated into a structure as finished logs which are then stained, caulked, chinked, gasketed and sealed. These treatments vary from dipping or pressure treating logs in preservatives and/or biocides/fungicides prior to shipment to simple washing with bleaches or percarbonates after installation. Throughout these processes, each additional step or treatment must be compatible with the steps preceding.

Treatments and cleaners must be compatible with stains and preservatives, which in turn must be compatible with caulking and chinking.

- Bleach, commonly used to kill and remove mold, mildew and dirt accumulated during the construction process, can adversely affect some stain coatings.
- Some stain coatings contain wax or paraffinal oils that interfere with the adhesion of caulk and chinking.
- Conversely, some caulking products can interfere with the adhesion to ANY coating later applied.
- Oxalic acid is contained in many commercial wood cleaners and performs very well, but if not properly removed from cleaned logs can have adverse effects on some of the newer stain coatings on the market today.

If there is any doubt as to compatibility, the user should test the intended sealant with a sample of the treated material. If this is not convenient, consult with the log home manufacturer or the manufacturer of the product in question.

Moisture Content of Wood

In general, it is desirable to apply sealants to logs with the lowest moisture content possible. The laws of physics dictate that as moisture leaves a log, that log will shrink. Higher moisture content translates into greater log shrinkage, which can exceed the limitations of sealants. This is not to say that log homes can not be built from 'green' wood, only that allowances must be made for more movement in the design of the sealant systems employed to seal the structure. Gaskets must be larger and chinking and caulking joints must be made wider and deeper.

Maintenance of Sealants and Gaskets

Properly installed in well-designed joints, modern sealant and gasket products need little or no maintenance. Chinking or caulking installed on the exterior of a structure that has performed well through the initial drying-out period of the logs can be expected to last the life of the structure with only periodic washings to remove surface dirt.

Exterior caulking and chinking that has failed due to improper installation, poor joint design, or excessive, unanticipated log movement, is usually fairly easily repaired provided that products used subsequently are compatible. Sealants and gaskets installed inside logs are inaccessible and cannot be maintained if they fail.

Building Design and Construction

Perspective homeowners, with the aid of their log home manufacturer, begin the long-term maintenance of their log structure during the design phase. Log structures (and indeed all wood sided structures) should incorporate all means possible to minimize the effect of the elements on exposed wood. Large roof overhangs, proper guttering, drip edging on roof rakes, strategic placement of covered porches, placement and orientation of the structure on the building lot, elevation, and architectural features all contribute to the degree of maintenance the structure will require in the future.

As in all construction, the techniques and quality of construction are paramount. The construction manual of the log home manufacturer incorporates tried and proven methods for the construction of their log structures. These manuals cover techniques and methods for care of materials delivered to jobsites, building practices and methods, and rates of application and techniques for coatings, sealants, and preservatives.

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FINAL NOTES

Blower door tests performed on log homes over the years have shown superior performance as to air-tightness. Infiltration rates of less than 0.6 air changes per hour and less are not uncommon. More and more, log homebuilders are complying with the latest Energy Star programs.

The superior performance of log homes is due to the care and engineering that goes into the design, manufacturing, and construction. Even though the exterior of the log wall has several times as many feet of crack to seal than conventional construction, the same issues of penetrating assemblies create the biggest opportunities. Like frame construction, log walls must put up a defense on the exposed outside surfaces first. But, unlike framed walls, there is seldom a cavity to defend. Despite the several hundred feet of seams, log buildings, like quality wood windows and doors, rely on the performance of the sealing system. Each log home manufacturer has established its own approach based on a philosophy that has evolved with experience.

Supported by extremely qualified and knowledgeable suppliers, the modern log home is sealed with one or more of many excellent products and methods. The combination of products and expertise are used to assure our customers that their homes will be the best possible.

For more information, refer to

Publications

- ❑ *The Ins and Outs of Caulking, Forest Products Laboratory, Advanced Housing Research Center, Madison, WI*
- ❑ *Wood Handbook: Wood as an Engineering Material (FPL-GTR-113), Forest Products Laboratory, Madison, WI*
- ❑ *Consumer Guide to Home Energy Savings, American Council for an Energy-Efficient Economy, Washington, D.C. and Berkeley, CA; in cooperation with Home Energy magazine, Berkeley, CA.*
- ❑ *Construction Sealants and Adhesives, Panek, Julian R. and Cook, John Philip, John Wiley & Sons, NY, NY*

Web Sites

*American Forest and Paper Association
American Wood Council
American Plywood Association
Forest Products Laboratory, USDA
The Forest Products Society*

<http://www.afandpa.org/>
<http://www.awc.org/>
<http://www.apawood.org/>
<http://www.fpl.fs.fed.us/>
<http://www.forestprod.org/>

*Advanced Housing Research Center, FPL
Building Science Corporation
ENERGY STAR®, US Environmental Protection Agency
U.S. Department of Energy's Energy Efficiency and
Renewable Energy Clearinghouse (EREC) and
Network (EREN)*

<http://www.fpl.fs.fed.us/ahrc/welcome.htm>
<http://www.buildingscience.com/default.htm>
<http://www.energystar.gov/default.shtml>
http://www.eren.doe.gov/consumerinfo/energy_savers/index.html

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APPENDIX

Pros & Cons of the Typical Sealant Types Available

Acrylic Latex Sealants

Note: The following are generalizations and not universally true of all acrylic latex sealants. Some "acrylics" are based on low-quality acrylic polymers or are heavily blended with non-acrylic polymers -- which reduce the overall performance. Note: An acrylic latex product that is "siliconized" may or may not actually perform better than one not making such a claim -- sometimes such claims are merely marketing hype. Note: Virtually all chinking products are made from acrylic latex.

Pros	Cons
Water cleanup	Sensitive to water until cured -- can wash out before curing completed
Low odor	It it's cold, should be tented and initially kept warm (at least for short time)
Low toxicity	Can take several days (or even weeks) to fully cure, depending on bead size and weather (especially if cool/cold and humid)
Extremely easy to apply, tool and work with (overall, the best to work with)	Cures worst in cold/cool, wet/humid weather
Non-flammable	Lower-performing brands often cannot handle as much movement as most solvent-based or reactive types of sealants
Very good or excellent adhesion to wood and most common surfaces	Can freeze solid, and (if the particular product is freeze-thaw stable, which some brands are not) must be completely thawed out before being used.
Excellent resistance to weathering -- resists UV light and oxidation very well	Some types not freeze-thaw stable & can't be package-frozen before use
Almost always meets the environmental regulations in all areas -- nationwide	Some shrinkage, but not severe
Easily paintable/stainable with latex and oil-based coatings	
Excellent flexibility and elasticity	
Modest in cost, compared to other polymer systems	
Can be applied to damp surfaces -- but not if surfaces are actively wet	
Cures best in warm, dry weather	
Fresh material typically adheres well to old, dried material of the same kind -- making repair easy and relatively inexpensive	

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Polyurethane Sealants	
Pros	Cons
Usable in most weather conditions -- usable when cool* and wet (but must be applied to dry surfaces) -- not rain damageable	Often contains low levels of isocyanates -- with toxicity and sensitizing effects -- which for some people can be severe
Excellent adhesion to wood and most surfaces	Typically a very bad odor -- best to be used only on the exterior
Good to excellent flexibility and elasticity; elongation can be up to 4x the original size	Often sticky and difficult to tool and work with
Accepts virtually all latex or oil-based coatings well	Cleans up only with solvents
Fresh material typically adheres well to old, dried material of the same kind -- making repair easy and relatively inexpensive	1-part types can take several days (or even weeks) to cure -- depending on bead size and weather (especially when cold and low humidity or dry)
2-part versions can completely cure in a matter of a few hours -- in virtually all weather conditions	Can be very hard to apply in cold weather because the product is thick and pasty when cold (should be kept warm until just prior to being used)
Good to excellent resistance to weathering	Often contains solvents -- with potential toxicity and flammability hazards
Cures best in warm, humid weather	*1-part versions (the most common type) cure worst in cold, dry weather
Overall, can be a good choice for log homes, but the precautions of this listing should be carefully taken into account	Occasionally, the adhesion can be so high and the modulus also so high that substrate failure occurs, which is the worst type of failure to repair
All types freeze-thaw stable in the package [Note: The overall, package stability of 1-part urethanes is not good -- often curing in the tube]	Have little ability to "stress relax" when under tension -- never lessening the force applied to the sealant or the bond-line when flexed
Minimal shrinkage	1-part types are packaged in non-plastic tubes, and therefore, not very rugged

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Silicone Sealants	
Pros	Cons
Most weather-resistant chemistry that is readily available (moisture, ozone, UV-radiation)	Typically, silicones have poor adhesion to wood (especially when wet)
Easily gunnable at virtually all temperatures -- even down to or below zero	Typically will not accept paint or stain (the "paintable" types often aren't very paintable/stainable & don't perform as well as the non-paintables)
Usable in most all kinds of weather -- with better curing properties than urethanes	The silicone oil plasticizers used in most sealants can migrate to adjoining surfaces and prevent those surfaces from being coatable
Relatively low in toxicity to work with -- much better than polyurethanes	Sometimes new silicone will not adhere to old, cured silicone, making repair difficult. [Note: Electrostatic charge on surface causes dirt pickup]
All types are freeze-thaw stable in the package	Many silicones are sticky and stringy to tool and work with
Minimal shrinkage	Many silicones have a strong acid odor (smelling like strong vinegar)
Long life	Overall, not a good choice for the log home industry
Chemically inert; no volatile off-gasing at high temperatures	Most types are fragile -- tearing easily ("unzipping") if slightly cut and stressed
	Little ability to "stress relax" -- never lessening the stress on the bond line/sealant
	Surface static electricity leads to much dust/dirt pickup over time.

Synthetic Rubber, Solvent-Based Sealants	
Pros	Cons
All weather application -- but should be kept warm until just prior to use for easiest gunning	Contains solvents that are hazardous and flammable -- however, usually a lower health risk than being exposed to isocyanates
Many are crystal clear -- the clearest sealants readily available	Sticky and difficult to tool
Excellent adhesion to wood and virtually all surfaces	Should be applied to dry surfaces
Very good weatherability	Bad odor -- best for the exterior (but odor typically dissipates quickly)
Readily accepts latex paints/stains right away and oil-based coatings within a week and, unlike silicones, does not cause adhesion problems of coatings on adjoining surfaces (because there is no plasticizer "bleed")	Cleans up only with solvents
Fresh material typically adheres well to old, dried material of the same kind -- making repair easy and relatively inexpensive	Significant shrinkage -- due to solvent evaporation
Readily cures in all types of weather -- no real limitations	
Good to excellent flexibility and elasticity	
Overall, a good choice for the log home industry when weather conditions require the use of an all-weather sealant	
Many or most brands have the ability to "stress relax" under tension	
All types are freeze-thaw stable in the package	

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Butyl Sealants	
Pros	Cons
Excellent adhesion to wood and all other substrates	Little or no elastic properties -- stretches like chewing gum, but has no elastic recovery (readily fails when used in expansion/contraction joints)
Once dried, accepts latex and oil-based stains and paints	Usable only where there is little or no movement of the joint
Very good to excellent weatherability	Extremely sticky and messy to apply and tool -- with "cob-webbing" a major problem (perhaps the messiest sealant there is to work with)
The most water repellent sealant known	Solvent cleanup
All weather application -- but guns easier if kept warm until just prior to use	Solvent odor
The best use is in "shear" joints -- like between sheet metal used in HVAC, gutters, roof flashing, etc. (in such uses, butyl is the best)	Overall, not appropriate for most applications on log homes
All types are freeze-thaw stable in the package	

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Oil-Based Sealants	
Pros	Cons
Excellent adhesion to wood and most all other substrates	Most versions ultimately cure hard as a rock, others stay "chewy" for a long period of time but have little or no elastic properties (unable to handle any significant expansion/contraction)
Immediately resistant to rain	Solvent cleanup required
All weather use -- but guns easier if kept warm until just prior to use	Some can contain enough solvent to be considered combustible
Moderate to good weatherability	Sticky to tool -- but not as bad as some other types of sealants
All types are freeze-thaw stable in the package	Overall, not a good choice for log homes, due to poor elasticity
Once dried, accepts latex and oil-based stains and paints	Can take several days or even weeks to cure (depending on bead size & weather)
Cheap -- generally, the cheapest available	

Polysulfide Sealants	
Polysulfide sealants are primarily used for commercial glazing, curtain walls, and solar collectors.	
Pros	Cons
All weather use -- but guns easier if kept warm until just prior to use	Not available through most channels of distribution, an industrial product
The best chemical resistance of all major types of sealants	Odor not very good (sulfur smell)-- should be used only on the exterior
Excellent adhesion to wood and most substrates -- including itself	Some contain solvents -- hazardous and combustible
2-part versions can completely cure in a few hours	Can be sticky and difficult to tool and work with
Immediately resistant to rain	1-part versions can take days or weeks to cure (in cold, dry weather)
Very good to excellent weatherability	Can be a bit more expensive than urethanes -- comparable to silicones
All types are freeze-thaw stable in the package	
Once dried, accepts latex and oil-based stains and paints	
Excellent elasticity and flexibility	
Overall, can perform well on log homes	
Minimal Shrinkage	

ⁱ Energy Savers – Tips on Saving Energy & Money at Home, a DOE publication at http://www.eren.doe.gov/consumerinfo/energy_savers/insulation.html

ⁱⁱ The Ins and Outs of Caulking, FPL Advanced Housing Research Center

ⁱⁱⁱ The Ins and Outs of Caulking, FPL Advanced Housing Research Center

^{iv} The Ins and Outs of Caulking, FPL Advanced Housing Research Center