BOOKLET 8: WINDOWS AND DOORS

NORTHERN HOUSING TECHNICAL GUIDE

→ TAILORED FOR REMOTE NORTHERN ONTARIO COMMUNITIES

First Nations National Building Officers Association

Association nationale des agents du bâtiment des premières nations

DISCLAIMER

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The story of windows in the north

Windows are an essential element of a house. They maintain a connection with the outside natural world. When people are indoors they can still see what is happening outside (weather, animals, people passing). Natural outdoor light is able to enter the house during the day, influencing the circadian (natural sleep/wake) rhythm of the people inside. Operable windows can be used to allow fresh outdoor air to freely flow into the house when it is warm outside. Overall, windows provide an important physical and mental health benefit to the occupants of a home.

Evening view out a window in a house in northern Ontario

Unfortunately, windows can also be a source of technical issues. Windows can be where most heat is lost from a house. They are one of the more likely elements to suffer water penetration and cause mould and rot in the surrounding walls. Windows are also more likely to suffer from condensation formation on their surfaces than other elements in a house. These issues can be costly, but are avoidable if special care is taken during the planning and construction of a new house.

To manage these issues and receive the positive benefits that windows provide, an appropriate window for your northern region needs to be selected and installed properly. Even the best window product will suffer issues if it is installed poorly. Window installation is as important as window selection.

In general, the requirements and principles for windows also apply to doors. Additional door-specific guidance is also presented in this guide. There are two appendices at the end of this booklet: Appendix A presents sample window details and Appendix B provides an in-depth technical background on the standards that apply to windows and doors.

The story of windows in the north—continued

Several decades ago, traditional windows were relatively simple. They consisted of four main components:

- Wood frame (and wood muntins)
- Multiple lites of single-pane glass.
- Steel glazing points
- Glazing putty




An old traditional-style, wood-framed window with multiple small single panes of glass held in place with wood muntins, steel glazing points, and glazing putty

These traditional windows were very economical, straightforward to construct, and easy to maintain. The small single-pane lites of glass are much cheaper than modern insulated glazing units (IGUs), or larger pieces of glass, as they are more easily shipped and stored.

However, these traditional windows also had drawbacks. Wind-driven rain easily penetrates and leaks through these old-style windows and heat easily escapes through. This was tolerable in older-style log cabins or houses with uninsulated walls when a wood burning stove was used for heating, as the abundant heat and ventilation generated by the wood stove would help any window water leakage to dry up relatively quickly.

A reasonable argument could be made that these windows still have a place for specific applications, such as small open-format log cabins heated with a wood-burning stove in a location with an abundant, low-cost, and sustainable supply of firewood. Approval for a variance to the building code would be required to pursue this approach.

Old-style traditional windows with multiple single-pane lites of glass and framed in wood do not meet the thermal efficiency required for windows and doors in the *National Building Code* (specified thermal U-value). Frost or condensation will likely form on the single-pane glass during cold weather.

Modern windows with insulated glazing units (IGUs) that consist of multiple layers of glass are required to meet thermal-efficiency standards in the *National Building Code* (specified thermal U-value).

The story of windows in the north—continued

Over time, the technology, materials, and approaches that could be used for house construction advanced in all areas of performance, including heating, ventilation, and wall, floor, and roof construction. This has made houses much more energy-efficient and reduced heating costs. Modern windows were introduced to the housing construction industry as part of the overall greater trend to greater energy efficiency and lower heating costs.

As highly insulated houses are more vulnerable to water leaks, modern windows and doors are required to undergo water-penetration testing. Water is sprayed onto a window at a specified pressure corresponding to climate region. It is important to choose the window that was tested for your specific region.

All this advancement has led to modern windows with IGUs that are much more complex than those of traditional-style windows with a single pane of glass and framed in wood.

These advancements include:

- **Complex window frame sections that have multiple seal layers and allow for drainage to the exterior**.

A section of a modern vinyl casement window frame

- **Multiple layers of glass (double, triple and even quad-pane IGUs)**

Double-pane IGU in vinyl frame

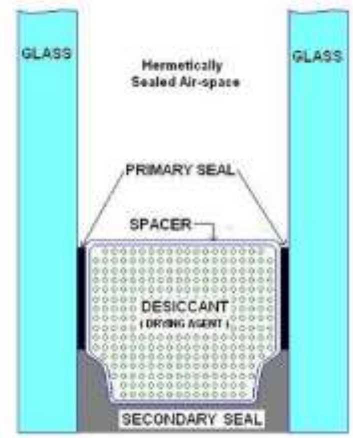
Triple pane IGU in a vinyl frame

Quadruple-pane IGU in a vinyl frame

The story of windows in the north—continued

Insulated Glass Unit (IGU) specific components/options:

- i) Air or argon gas, inserted in the space between layers of glass
- ii) Low-e coatings, various types and on more than one surface
- iii) Warm-edge spacer bars, material options
- iv) Desiccant
- v) Primary (interior) and secondary (exterior) seals



Section of a typical IGU with the components labeled

Window labeling with technical information:

- i) U-value (W/m^2-°K)
- ii) Energy Rating
- iii) Solar Heat Gain Coefficient
- iv) Visual Transmittance
- v) Air Leakage

A typical window label

Complex window installation details with embedded design information not obvious to non-architects or non-window experts:

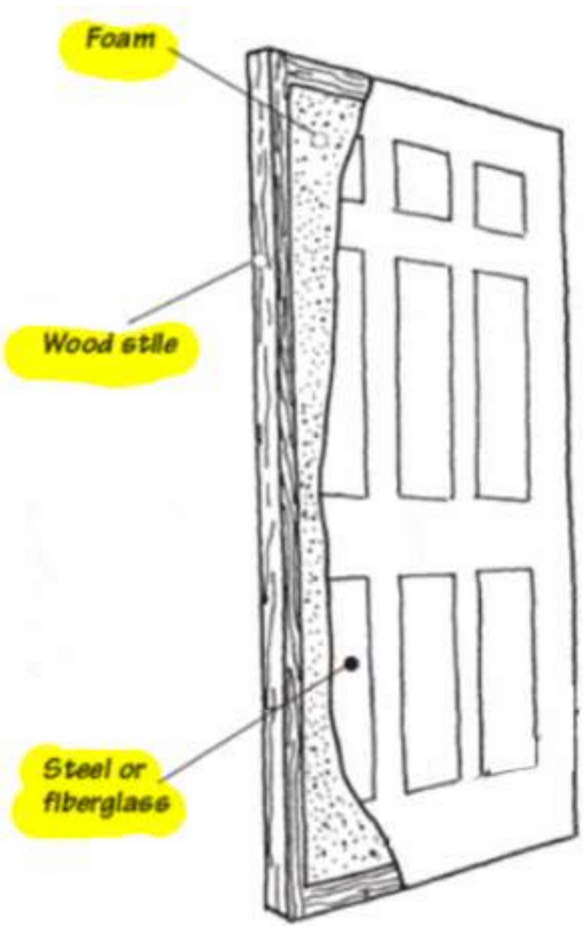
- i) Self-adhesive membrane pre-stripping of the rough opening in the wall
- ii) Shim/spacer placement to support the window
- iii) Appropriate gap between the window and the rough opening
- iv) Structural attachment of the window to resist wind loads and tolerate foundation settlement or wood-frame structure deflections or shrinkage
- v) Drainage of the gap around the window
- vi) Spray foam or sealant air-seal approach around the window perimeter
- vii) Flashings and exterior finishing

Architectural drawing section detail of a window sill

This booklet provides guidance on how to navigate all technical information and complexity related to windows, and focus on key items most likely to provide a long-lasting, high-performing window installation in a house in the north that meets building-code requirements.

DOORS

Historically, exterior doors where made of solid wood. Modern doors have a wood frame and are filled with foam insulation to make them more thermally efficient. The interior and exterior door faces typically come in painted steel or fibreglass. Higher end doors include a glass lite built into the door.



Basic elements of a basic modern door without a glass lite

Steel door with a half-size glass lite

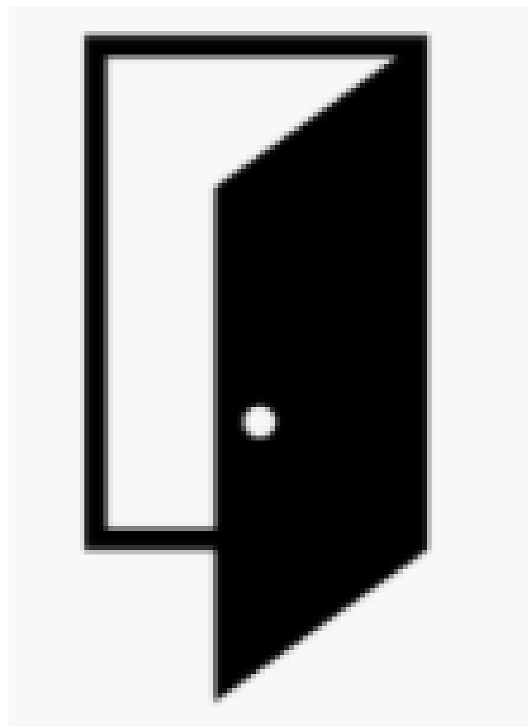
Most of the content in this booklet regarding windows also applies to exterior doors.

READ THIS BOOKLET IF YOU NEED TO:

1. **Buy new windows or exterior entrance doors for a new house in northern Ontario.**

2. **Know the key aspects of a proper window or door installation.**

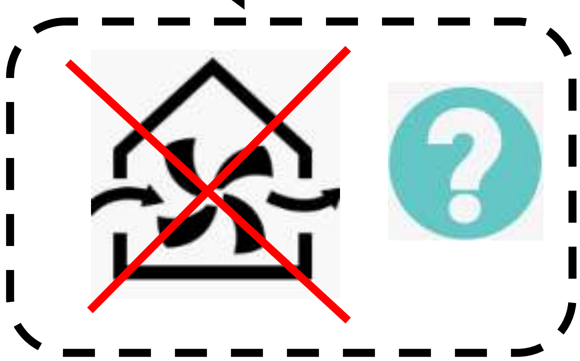
3. **Learn more about factors to consider when planning for *suitable* windows and doors for a new house.**



Suitable—The ultimate goal of this booklet is to improve the overall well-being and quality of life for community members, by advising on window and door selection most likely to uphold the energy efficiency of a house and to reduce risk of window and door failures (avoid excessive heat loss, moisture issues, condensation issues, and window frame or glass damage due to improper installation).

Is it a window failure, or a symptom of something else?

A window with condensation and mould growth



Caused by lack of ventilation?

Window failure, or a symptom of a separate house construction issue?

Some problems can be directly caused by window-specific issues or a different building deficiency, such as:

1) Foundation and/or structural problems: An inappropriate foundation or structural approach used in the construction of a house and/or construction defect in the foundation/structure often results in excessive foundation/structural movements that can easily cause glass to crack.

A crack in the glass of the window

A house in the north with a cracked window boarded over

See foundation and structure booklets for proper foundation and structural approaches for houses in the north that will not cause glass to crack.

**Note: Cracked windows can also occur from improper window installation (see installation section of this booklet).*

2) Poor Ventilation:

Condensation or frost/ice forming on the interior side of a window can be the result of poor ventilation in a house. Poor ventilation in a house with high occupancy will cause the air to become very moist (high relative humidity levels in the air). Even the best-performing windows can suffer from condensation issues if the moisture in the air builds up too much due to not enough ventilation or lack of use of exhaust fans in the bathroom and kitchen.

Condensation formation on the interior surface of a window with ice formation along the frame

See the ventilation booklet for proper ventilation approaches for houses in the north that will keep the moisture levels of the inside air from getting too high, and avoid condensation and frost/ice forming on windows and doors.

**Note: Condensation on windows can also be the result of using windows meant for a warmer climate. See the window-selection section of this booklet.*

Window failure, or a symptom of a separate house construction issue?

3) Heating issues:

A relatively common situation is windows needing to be left open during the cold winter months to manage overheating, especially when heating with a wood-burning stove.

A window left open through the winter to manage overheating

See the heating booklet for proper heating approaches for houses in the north that will help avoid overheating issues and the need to leave windows open during the cold winter months.

**Note: Overheating can also be an issue during warm weather months, if windows with a high solar heat gain coefficient (SHGC) are placed on a side of the house exposed to the sun. This is especially true for highly insulated airtight houses. Selecting windows with a lower SHGC can help avoid this situation (see the window-selection section of this booklet).*

Windows installed directly into a bare wood-framed wall

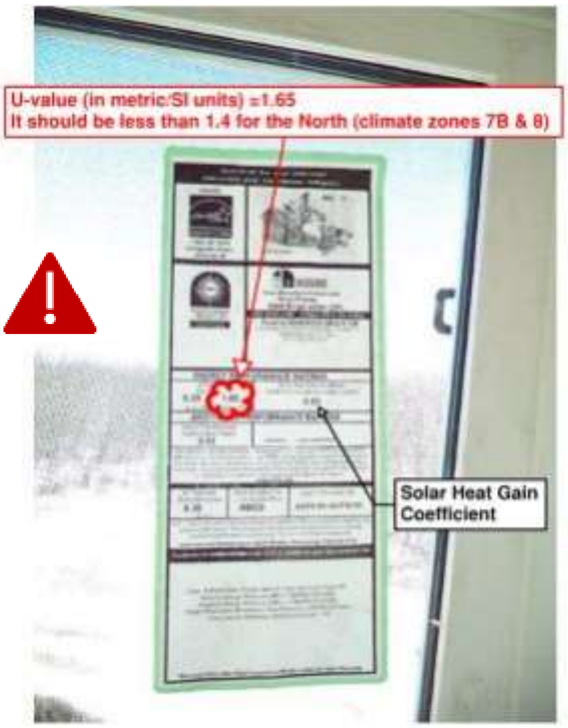
Typical pattern of rot deterioration of wood sheathing and stud framing in wall area below improperly installed windows

Common issues related to window or door purchase/selection

Window failures have been an ongoing and major issue with houses in northern communities. These issues include:

1) Windows and doors that allow too much heat loss:

Selecting or buying windows (or doors) from an big-box hardware store in the south that are rated for warmer climates in the south (having a U-value too high for the north) is a common issue. U-value is a measure of heat loss: the higher it is, the more heat loss. Using windows with high U-value results in excessive heat loss and condensation issues. These southern windows do not meet code if installed in colder climate regions.



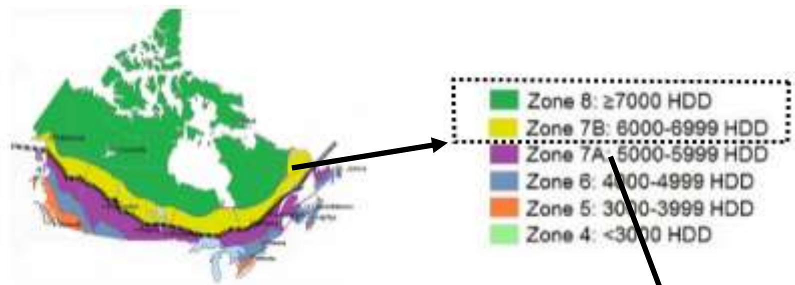


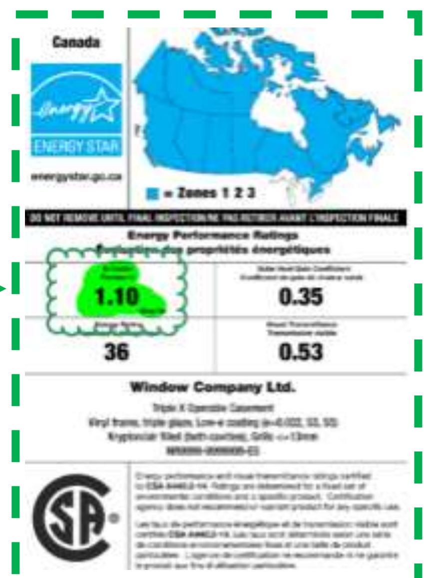
Table 9.36.2.7.-A
Required Thermal Characteristics of Fenestration and Doors
Forming Part of Sentence 9.36.2.7.(1)

Components	Thermal Characteristics[1]	Heating Degree-Days of Building Location,[2] in Celsius Degree-Days					
		Zone 4 < 3000	Zone 5 3000 to 3999	Zone 6 4000 to 4999	Zone 7A 5000 to 5999	Zone 7B 6000 to 6999	Zone 8 ≥ 7000
Fenestration[3] and doors	Max. U-value, W/(m²·K)	1.80	1.80	1.60	1.60	1.40	1.40
	Min. Energy Rating	21	21	25	25	29	29

A U-value as high as 1.60 is suitable for Ottawa; in Toronto, a U-value as high as 1.80 is acceptable, but windows with these U-values are not appropriate for the north.

Window installed in the north with a U-factor that is too high (suitable only for southern Ontario or southern BC)

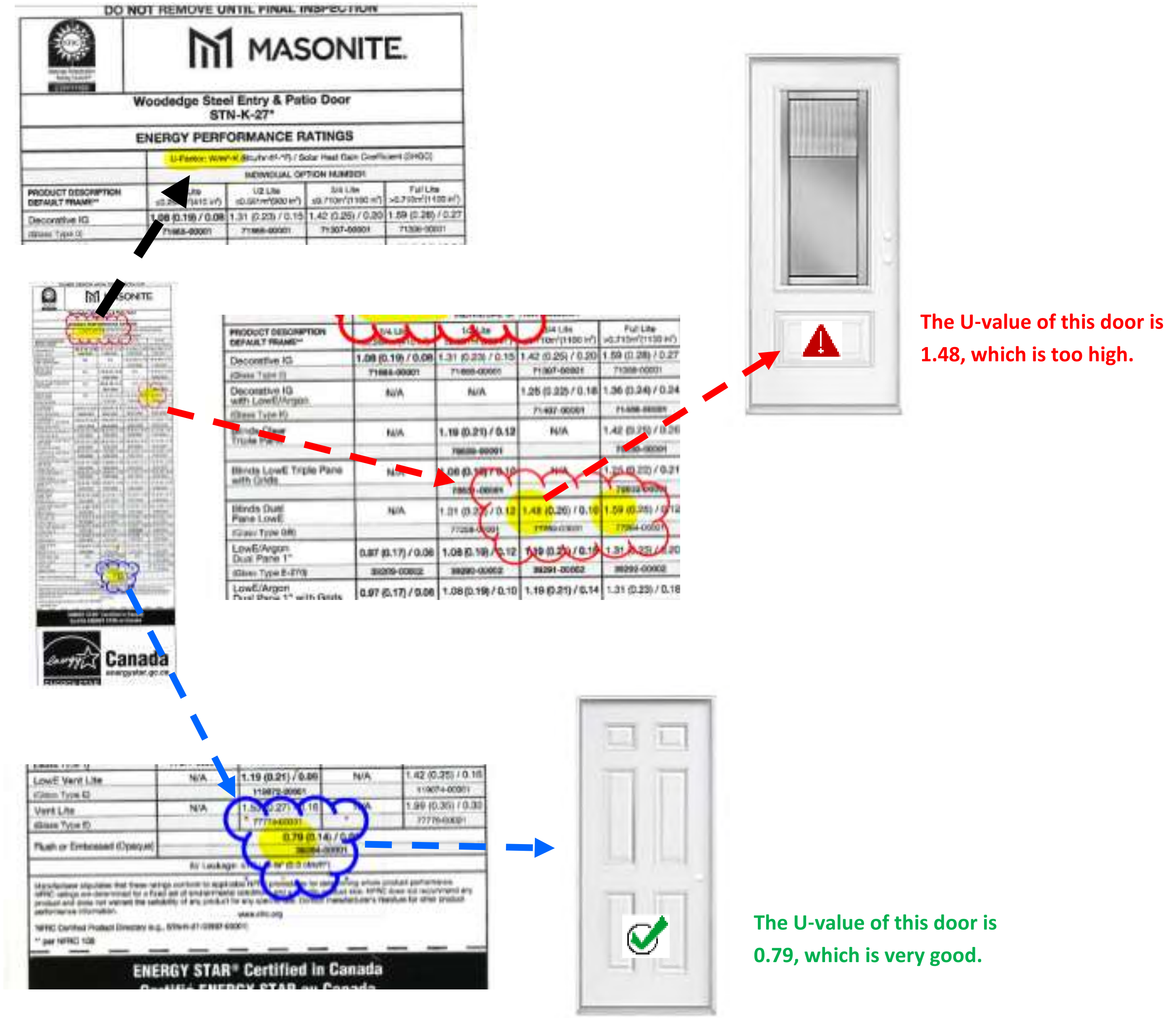
A window label with a suitable U-value of 1.10. Any U-value lower than 1.4 is code-compliant for the north.



Common issues related to window or door purchase/selection

Exterior Entry Doors:

The U-value of a exterior entry door should also be checked: Doors with a large glass "lite" typically have higher U-values that can exceed the 1.40 maximum requirement for northern regions.



A door label with different U-values listed for different lite configurations in a specific model of door. The version without a lite has a very low U-value (good). Some configurations with a large lite have a very high U-value (bad).

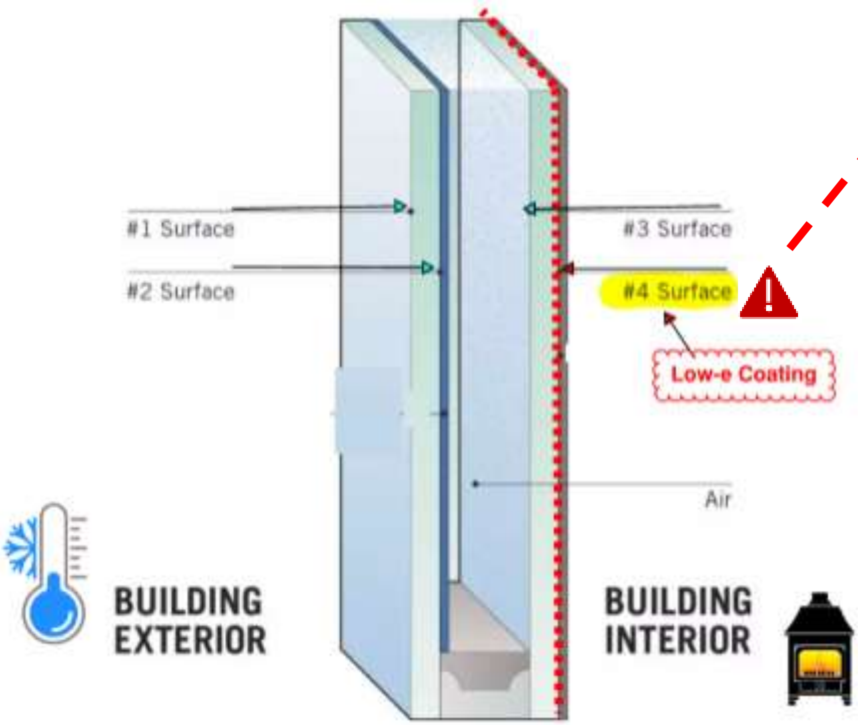
Select a door that has a U-value lower than 1.40. Avoid doors with a U-value higher than 1.40.

Common issues related to window or door purchase/selection

2) Windows with double-pane IGUs and a low-e coating on the #4 surface:

It is possible to purchase windows that meet the 1.40 maximum U-value requirement and have a double-pane IGU. However, to achieve this, a low emissivity (low-e) coating is applied to the interior surface of the glass (surface #4), which limits how much the window can be warmed by the inside of the house. As a result, the interior pane remains colder than if there was no low-e on surface #4. This significantly increases the risk of condensation/frost forming on the glass and is a window that should be avoided.

Frost on a window IGU



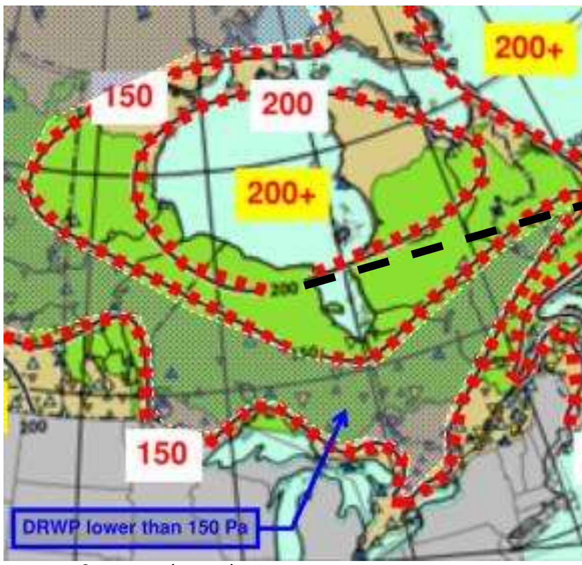
Location of low-e coating on surface #4 of an IGU

Windows with triple-pane or quad-pane IGUs with multiple low-e coatings on the #2 surface are recommended, to avoid condensation issues.

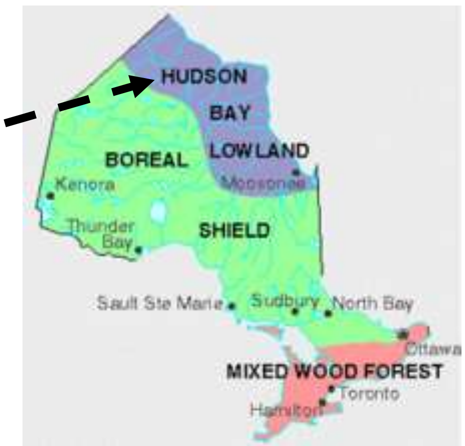
Common issues related to window or door purchase/selection

3) Windows and doors that may leak water too easily (for some regions):

The default Driving Rain Wind Pressure (DRWP) for residential windows is 140 Pa. A higher DRWP is required for houses near large bodies of water and the Hudson Bay Lowlands. For many regions in the boreal shield region, away from large bodies of water, the default 140 Pa is sufficient. Note: DRWP is not typically stated on the window label (the DRWP rating for a window or door must be requested from the supplier).



Map of DRWP (in Pa)



The Hudson Bay Lowlands have DRWP higher than 150 Pa.

If your house is near a large body of water, or in the Hudson Bar Lowlands: Request and obtain the DRWP rating of a window from the window supplier before purchasing the window or door. Check to make sure the DRWP is greater than what is shown on the map above.

For example, Fort Severn is on the Hudson Bay coast and requires a window with a DRWP of at least 200 Pa.

Fort Severn, ON

Equipment used to test DRWP

A window spray rack

Plastic chamber and vacuum on the interior

4) Missing Self-Adhesive-Membrane (SAM)

Installing windows (or doors) into the rough opening of wall framing, without a proper, self-adhesive membrane and housewrap pre-stripping of the rough opening is another common mistake. It results in moisture damage and mould in wall areas below windows. Note: Even high quality windows (or doors) can be expected to leak to some degree over their lifespan.

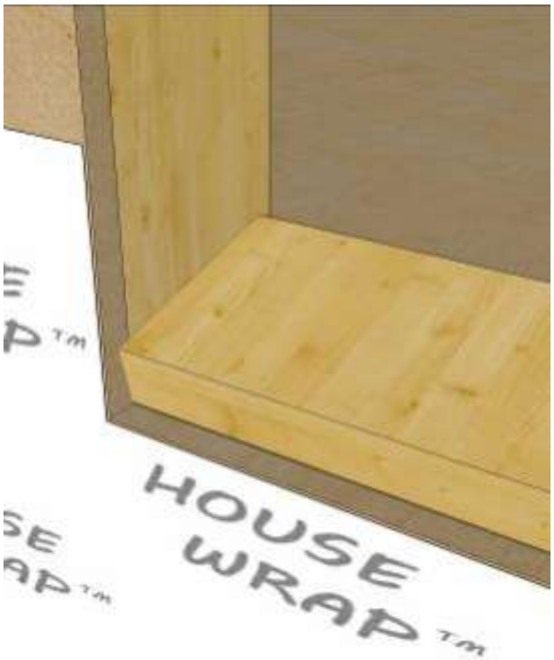
Windows installed directly into the wood framed wall without membrane wrap of the rough opening in the wall

The wood framing in the rough opening of a wall needs to be protected with self-adhesive membrane.

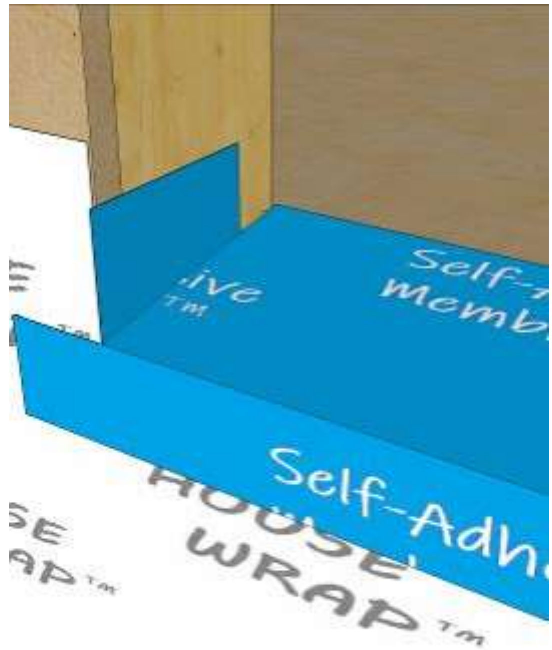
Proper installation sequence, with the housewrap and membrane installed in the rough opening before the window is installed

Common issues related to window or door installation

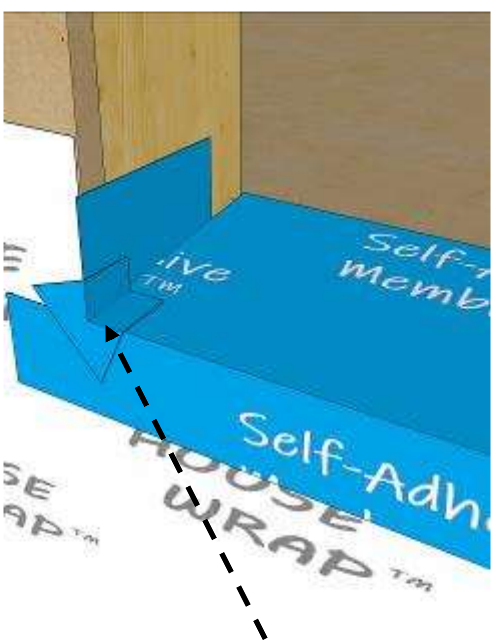
Proper sequence of housewrap and self-adhesive-membrane (SAM) installation on the wood-framed rough opening:



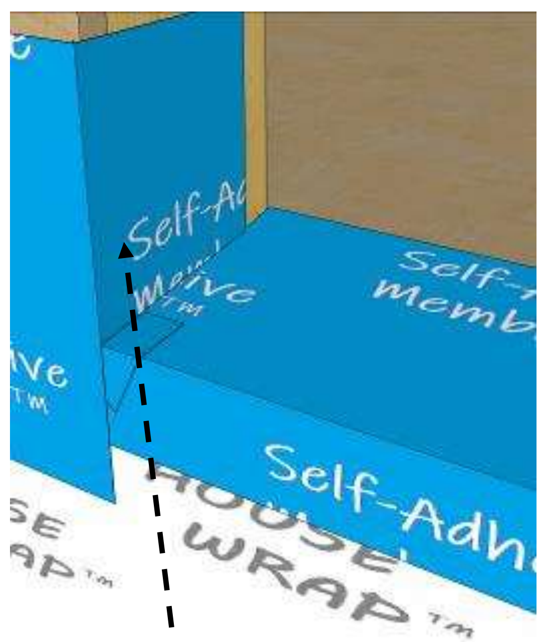
1) Housewrap "U" installed below sill



2) SAM installed on sill, lapped down over housewrap and up the jambs



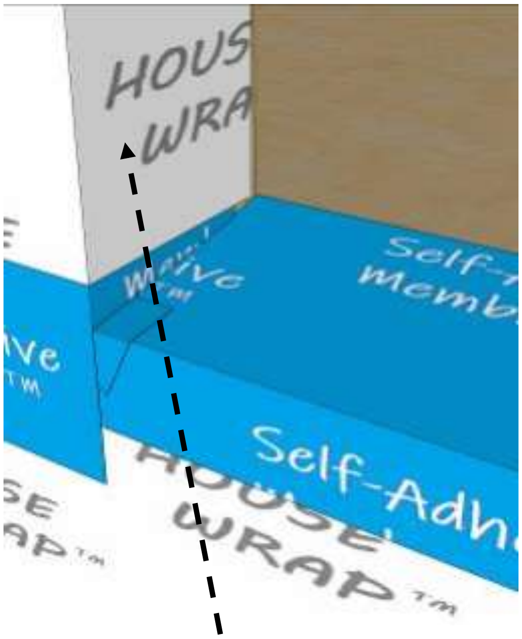
3) Install a SAM patch to prevent a pinhole at the corner.



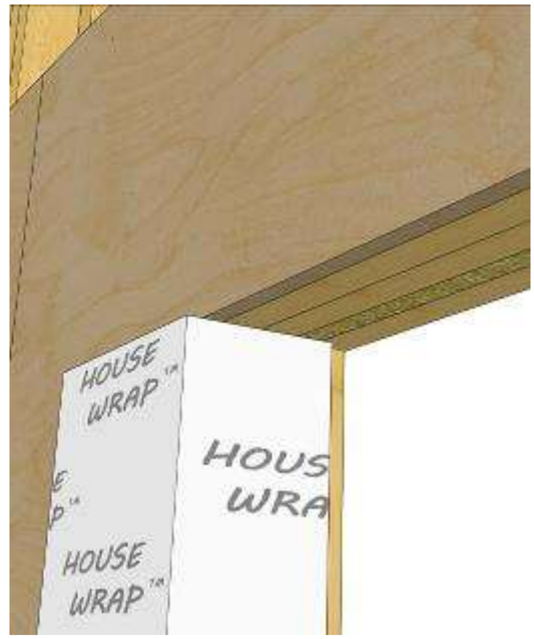
4) Install a strip of SAM that extends several inches up the jambs and is lapped over the patch and housewrap below.

Common issues related to window or door installation

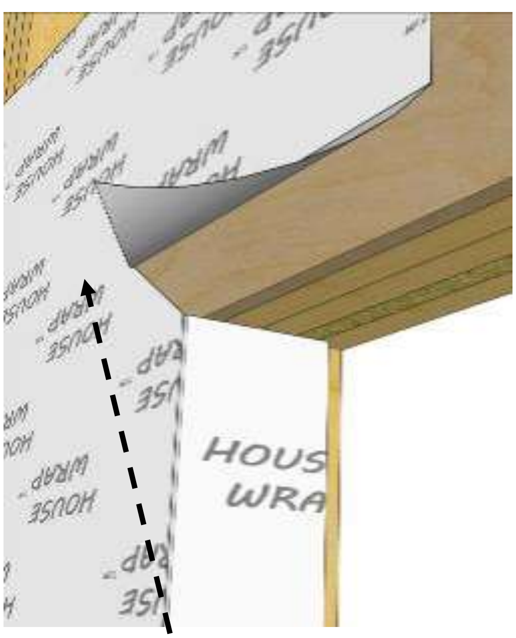
Proper sequence of housewrap and self-adhesive-membrane (SAM) installation on the wood-framed rough opening:



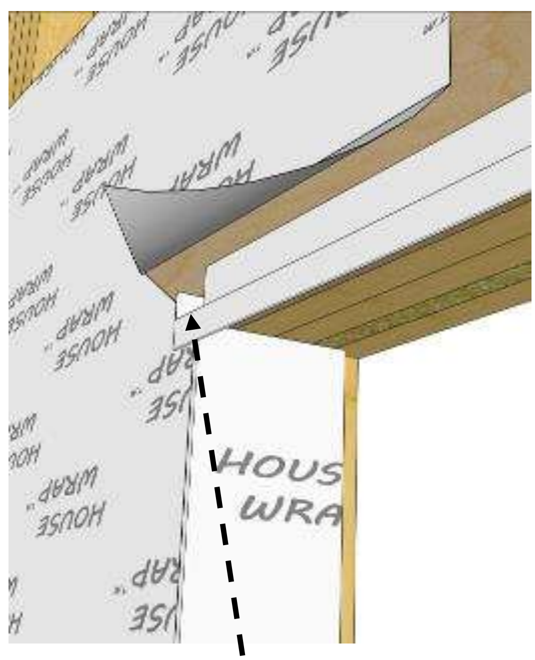
5) Install housewrap over the full height of jambs and lapped over the SAM.



6) Install housewrap to the top of the jambs.

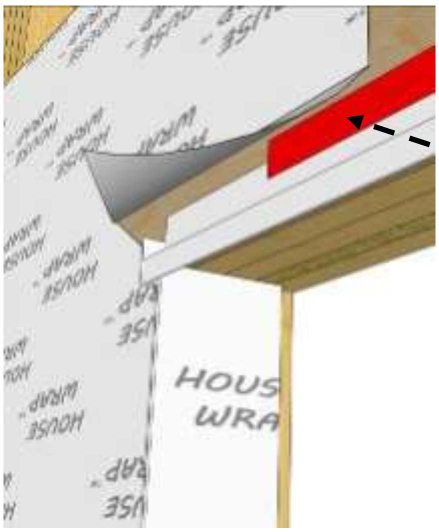


7) Install housewrap on wall around the window.

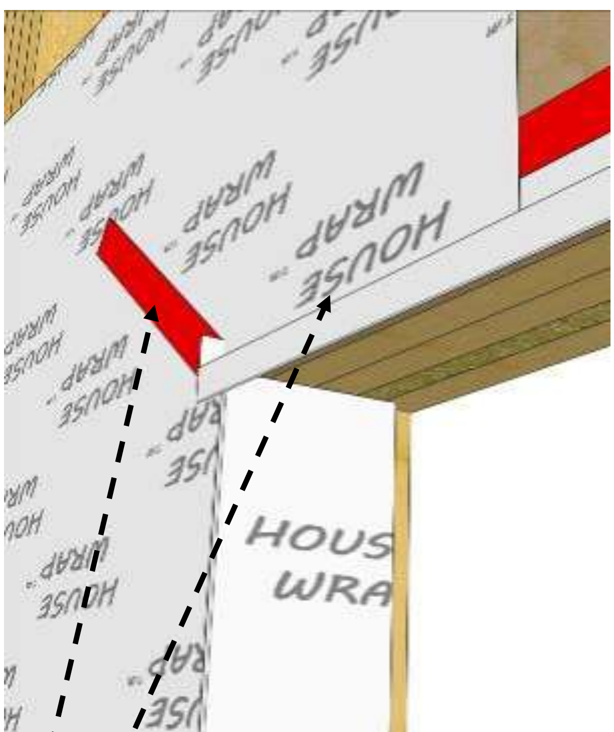


8) Install metal flashing with end-dams at the head of the window.

Proper sequence of housewrap and self-adhesive-membrane (SAM) installation on the wood framed rough opening:



9) Tape the top of the head flashing.



9) Lap the housewrap over the head flashing and tape the diagonal cut in the housewrap.

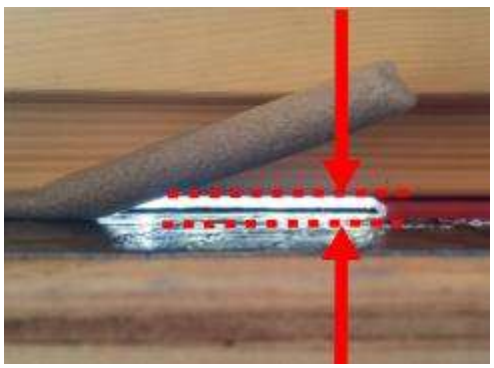
Common issues related to window or door installation

5) Rough Opening Gap—wrong size?

Windows and doors installed with too small or large a space with the rough opening:

Too Small? If the gap in between the window and the rough opening is too small, the window is exposed to a greater risk of being damaged from movements such as: wood frame shrinkage, foundation settlement, structural deflections, or expansion and contraction from temperature changes. The air/water seal will be more challenging to install and more likely to fail with any movements. Also, any water that penetrates the window will be less likely to drain to the exterior.

Too Big? If the gap is too big, excessive amounts of sealant or spray foam will be required to ensure airtightness, making installation more time-consuming and costly. A large gap also complicates fastening the window to the wood-framed wall.



A rough opening gap that is too small at the window sill (a small 1/4” gap)

A rough opening gap that is too big at the window head (a big 1” gap)

The gap serves several important functions:

- **Shrinkage:** Wood wall framing can dry and shrink without putting stress on the window.
- **House movements:** Small foundation settlements and/or structural deflections can occur without stressing the window.
- **Expansion and contraction**: Window frame can freely expand and contract as seasonal temperatures change, with minimal restraint stresses.
- **Air/water seal material compatibility:** Sealant and/or spray foam has enough space to stretch and compress with minimal force (if the gap is too small, there is not enough sealant or spray foam to stretch very much. Similar to pitching a rubber band with fingers close together, the rubber band can’t stretch nearly as far as if it is pinched at its ends).
- **Drainage:** Wind-driven rain or melting ice/snow that leaks into the joints of the window frame can drain to the exterior using the rough exit path created by the rough opening.

The gap between the window frame and the wood-framed wall’s rough opening (RO) generally should be 3/8” to 3/4” wide. A 1/2” gap is typically considered ideal for residential construction.

Common issues related to window or door installation

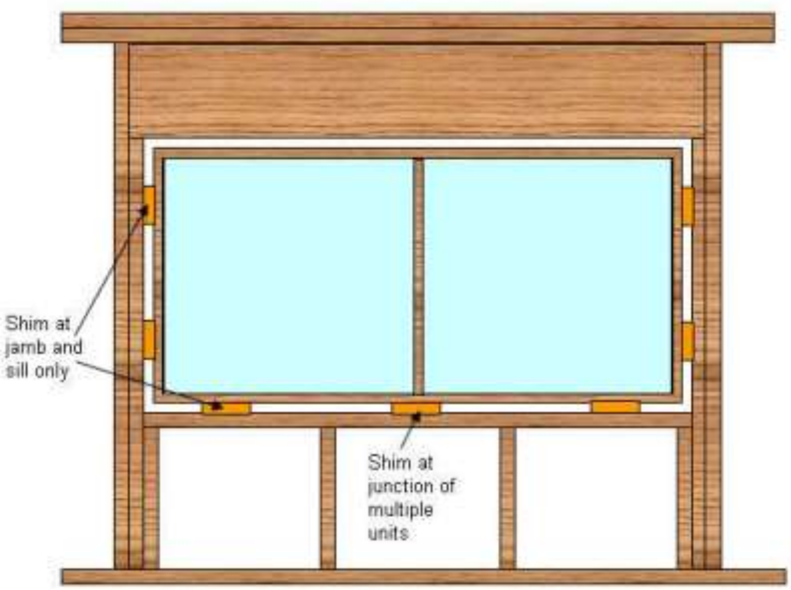
6) Incorrect shimming of the window:

As windows and doors “float” in the rough opening of the wood-framed wall, they need to be supported with shims at locations that can bear the weight of the window without stressing the window.

- Installing *too many* shims will cancel out the “floating” effect of the gap around the window.
- Installing *too few shims* or shims in the *incorrect location* will cause the window frame to deflect and increase the risk of window issues and failures.
- Installing shims *tight to the sill-jamb corner* will block drainage and interfere with the installation of a continuous airseal with spray foam or sealant.

Refer to the window manufacturer’s installation instructions for appropriate shim placement.

- **The gap at the top of the window allows the window to “float” and accommodate structural movement, wood shrinkage, or foundation settlement without stressing the window.**
- **Shims located slightly away from the bottom corners help avoid air/water seal issues.**



Proper shim placement for a typical window. Note shims are offset from the bottom corners, placed directly under the middle vertical framing element, and are not installed at the window head.

7) Over-fastening a window or door to the surrounding wall framing:

Installing too many fasteners (nails, screws, etc.) around the full perimeter of a window or door is a common mistake that prevents windows from being able to “float” in the rough opening and accommodate movements. Over-fastened windows are much more susceptible to being damaged by foundation settlement, structural deflections, wood shrinkage, and expansion and contraction from seasonal temperature variations.

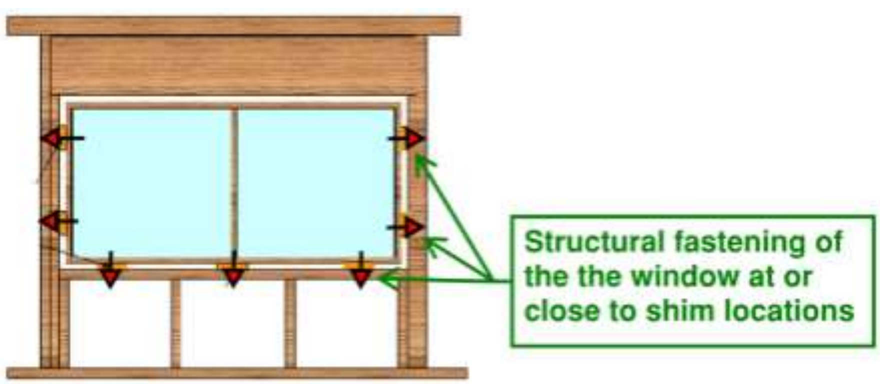
Adding too many nails to the nailing flanges is a common mistake.

Directly fastening through the window frame can also be overdone.

Refer to the window/door manufacturer’s installation instructions for appropriate fastening.

If fastening with nails in a nailing flange, or screws go directly through the window frame:

- **the fastening of the window should be similar to the shim locations. Fasteners should be located relatively close to the shim locations (within about 4”).**
- **avoid installing fasteners at/close to corners or at the head of a window.**



Fastening at shim locations

Common issues related to window or door installation

Window anchor-strap fastening:

Window with strap anchors built into the frame

Some high-quality windows have metal strap anchors built into the perimeter of the frame. These straps resist wind pressures from pulling or pushing the window out of the rough opening (horizontally), but still allow the window to vertically "float" in the rough opening and tolerate house movements.

Larger windows require more fasteners to resist wind pressures. The strap-anchor approach allows for numerous fastening points around the full perimeter of a window without the window losing its ability to "float" in the rough opening and accommodate house movements.

Built-in anchoring straps are recommended for large windows in high wind-pressure zones.

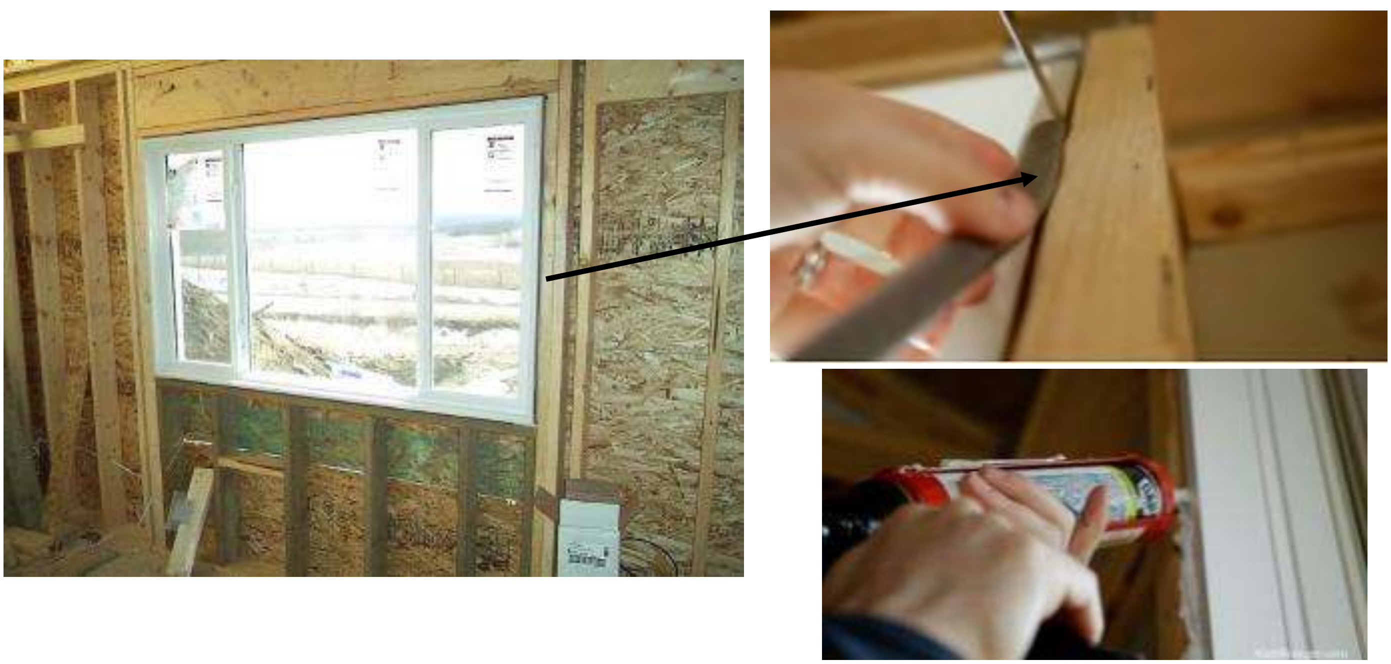
Window with strap anchors built into the frame installed in a rough opening

8) Poor airseal around windows and doors:

Lack of quality airtight seals around interior window or door perimeters is a common issue.

Window installation that fails to reliably connect the wall's air barrier (typically 6-mil poly sheet) to the window perimeter results in uncontrolled heat loss and condensation/moisture issues, including frost or ice buildup.

Ice formation from air leakage at the window header



The interior perimeter and rough opening gap being sealed with foam backer rod and sealant

Sealant supported with foam backer rod should be installed around the interior perimeter of windows, to ensure airtightness (even if the rough opening gap is filled with spray foam).

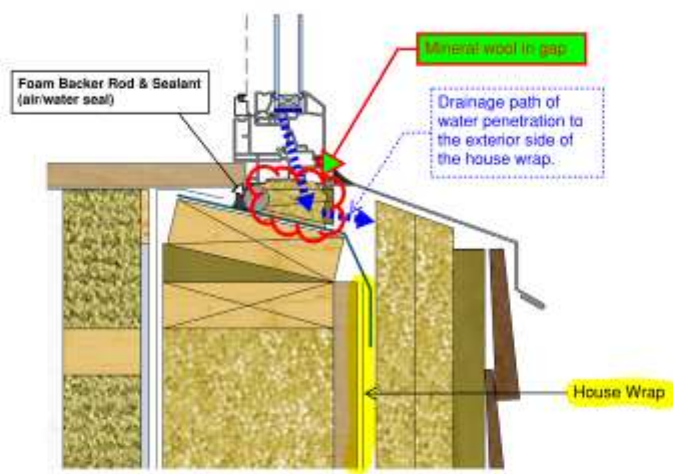
9) Over-reliance on spray foam:

Filling the rough opening gap with spray foam is the most common approach used by house builders to create an airtight seal between the window and the rough opening in the wall. However, a foam backer rod and sealant joint is known to create a more reliable seal against air and water leakage. The appeal of spray foam is that it is easier to install than a proper backer rod and sealant joint.

- High-expansion spray foam and/or firm spray foam can transfer damaging forces onto the window frame, preventing the window from being able to “float” in the rough opening and accommodate house movements.
- Spray foam also significantly reduces the ability for water that penetrates the window framing to drain to the exterior via the rough opening gap.

Spray foam being installed in the rough opening gap

If a house is in a region with a high Driving Rain Wind Pressure (DRWP higher than 140 Pa), it is recommended that the rough opening gap be left open to allow any water that penetrates sealant and backer rod to escape down the rough opening gap. If there is a desire to insulate the gap, mineral wool is preferred instead of spray foam, as it will still allow water to drain.



Rough opening gap at a window sill filled with mineral wool instead of spray foam, to allow water penetration to escape to the exterior side of the house wrap

Spray foam specific for window and door installation

If spray foam is being used, despite this guide's recommendations, a low-expansion soft spray foam specific to window and door installation must be used to avoid creating problems (i.e. expanding and bending window frames). It is also recommended that the spray foam be installed only at the jambs and head of the window, and the sill be filled with mineral wool insulation, to allow for drainage at the sill.

A spray-foam product specifically for window and door perimeters

This guide suggests that spray-foam installation around the perimeter of windows and doors is an acceptable approach for houses with a low risk of foundation settlement and/or structural deflections, in regions with low Driving Rain Wind Pressures (i.e. DRWP less than 140 Pa), away from large bodies of water.

CLOSING REMARKS

The total area of windows in the walls of a house should be no more than 25 per cent of the wall area.

When shopping for windows, look for windows that have:

- Triple-pane IGUs (quad-pane for high-efficiency homes)
- More than one low-e coating
- Argon gas between the panes of glass
- Warm-edge spacer (not aluminum)
- Frame made of a non-conductive material (wood, vinyl, or fibreglass): vinyl is the most common and cost-effective.

Air leakage: A2 is minimum for operable windows, but A3 rating is recommended for highly insulated homes heated by diesel furnace or electricity. A2-rated windows pair well with a house heated by burning wood (woodstove or wood-burning furnace) in communities with a large, low-cost supply of sustainable firewood. (Size matters*, and needs to be determined from the supplier/manufacturer, as this rating is typically not shown on the window label. Refer to Appendix B for more information).

Water penetration: The default 140 Pa DRWP rating for residential windows is not enough for many northern communities. For example, windows rated to 200 Pa DRWP are needed in Fort Severn, Ontario. (Size matters*, and needs to be determined from the supplier/manufacturer, as this rating is typically not shown on the window label. Refer to Appendix B for more information).

Design pressure: The default residential rating for window structural strength for high winds is 720 Pa, this is enough for most regions, except those that require higher wind-pressure ratings in the Eastern Arctic and as high as 1,000 Pa: Baffin Island, Nunavik, Labrador. However, all of Ontario has wind pressures less than 720 Pa. (Size matters*; the design pressure is shown in the window labeling as the primary designator in PSF. Refer to Appendix B for more information).

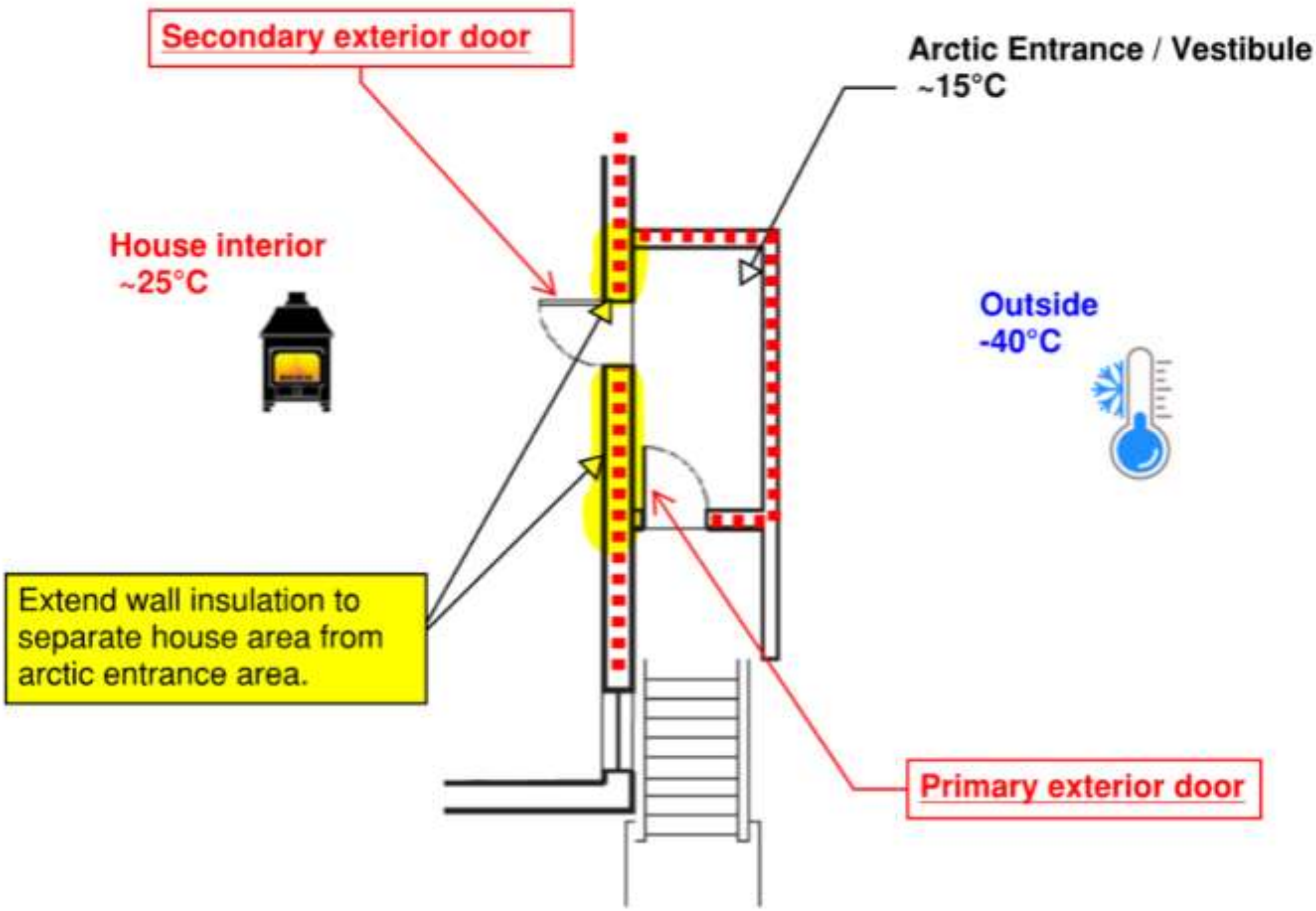
Energy Star is great, but beware of the solar heat gain coefficient (SHGC) and risk of overheating in spring/summer. Choose low-e with low solar heat gain coefficient.

Temperature index: 77 or higher is recommended, but might not be available; ask for it, as not all manufacturers conduct this expensive testing.

**Size matters: A single window product is typically available in different sizes. The size tested for the rating matters, as small windows will perform better than large windows, in terms of air/water penetration and design pressure. If the window you want to use is larger than the size tested, it may not meet the minimum required performance for air/water penetration or design pressure.*

CLOSING REMARKS

An arctic entrance/vestibule configuration for the primary entrance to a house is recommended for all houses in the north, to minimize heat loss and issues with door perimeters icing up.



Architectural plan drawing of an arctic entrance configuration that uses two exterior doors

An exhaust fan in the arctic entrance vestibule is recommended, to expel moisture and odours from drying boots, snow suits, etc.

ADDITIONAL RESOURCES

OTHER RELATED GUIDES

- ***Housing Construction in Nunavik***, Société D'Habitation Du Québec (habitation.gouv.qc.ca)

- ***Keeping the Heat In***, Natural Resources Canada (www.nrcan.gc.ca)

- ***Illustrated Guide Achieving Airtight Buildings*** (www.bchousing.org)

- ***Canadian Wood-Frame House Construction***, Canada Mortgage and Housing Corporation (www.publications.gc.ca)

- ***Good Building Practices Guidelines***, Government of Nunavut (www.gov.nu.ca)

- ***Illustrated Guide for Northern Housing Retrofits*** (https://emrlibrary.gov.yk.ca/energy/illustrated-guide-for-northern-housing-retrofits-2016.pdf)

BUILDING CODES & STANDARDS

- ***National Building Code of Canada***, National Research Council Canada (www.nrc.canada.ca)

- ***CANADA BUILDING CODE FOR THE NORTH 1968***, National Research Council (www.nrc.canada.ca)

TECHNICAL INFORMATION

- ***Consumers Guide to Buying Energy-Efficient Windows and Doors*, ** Natural Recourses Canada (www.publications.gc.ca/site/eng/9.687692/publication.html)

- ***Canadian Building Digest***, National Research Council Publications Archive (https://nrc-publications.canada.ca/eng/search/)

- ***Building Science Articles*, ** Building Science Corporation (www.building science.com)

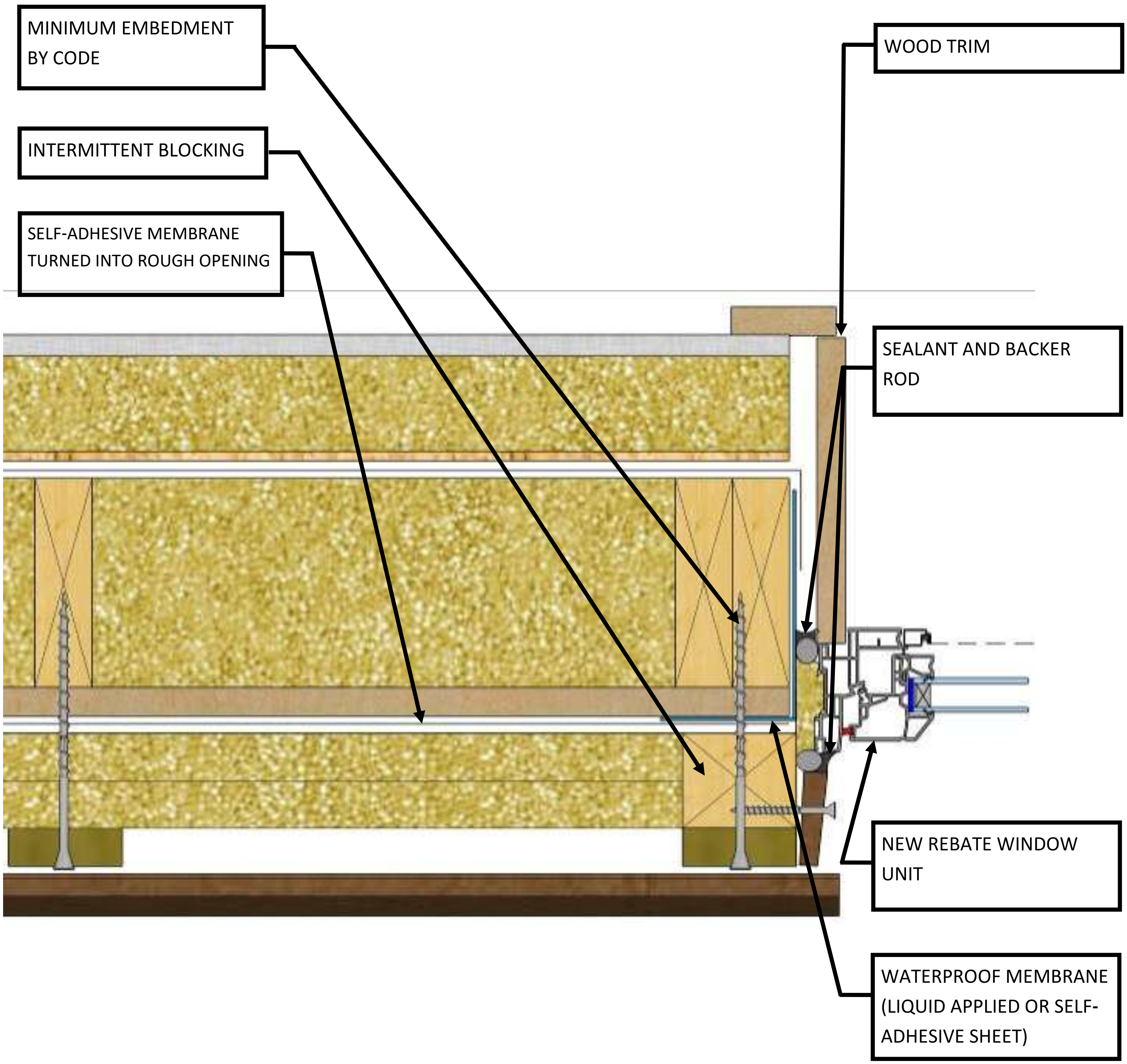
- ***Building Science Calculators***, Cold Climate Housing Research Center (www.cchrc.org)

APPENDIX A

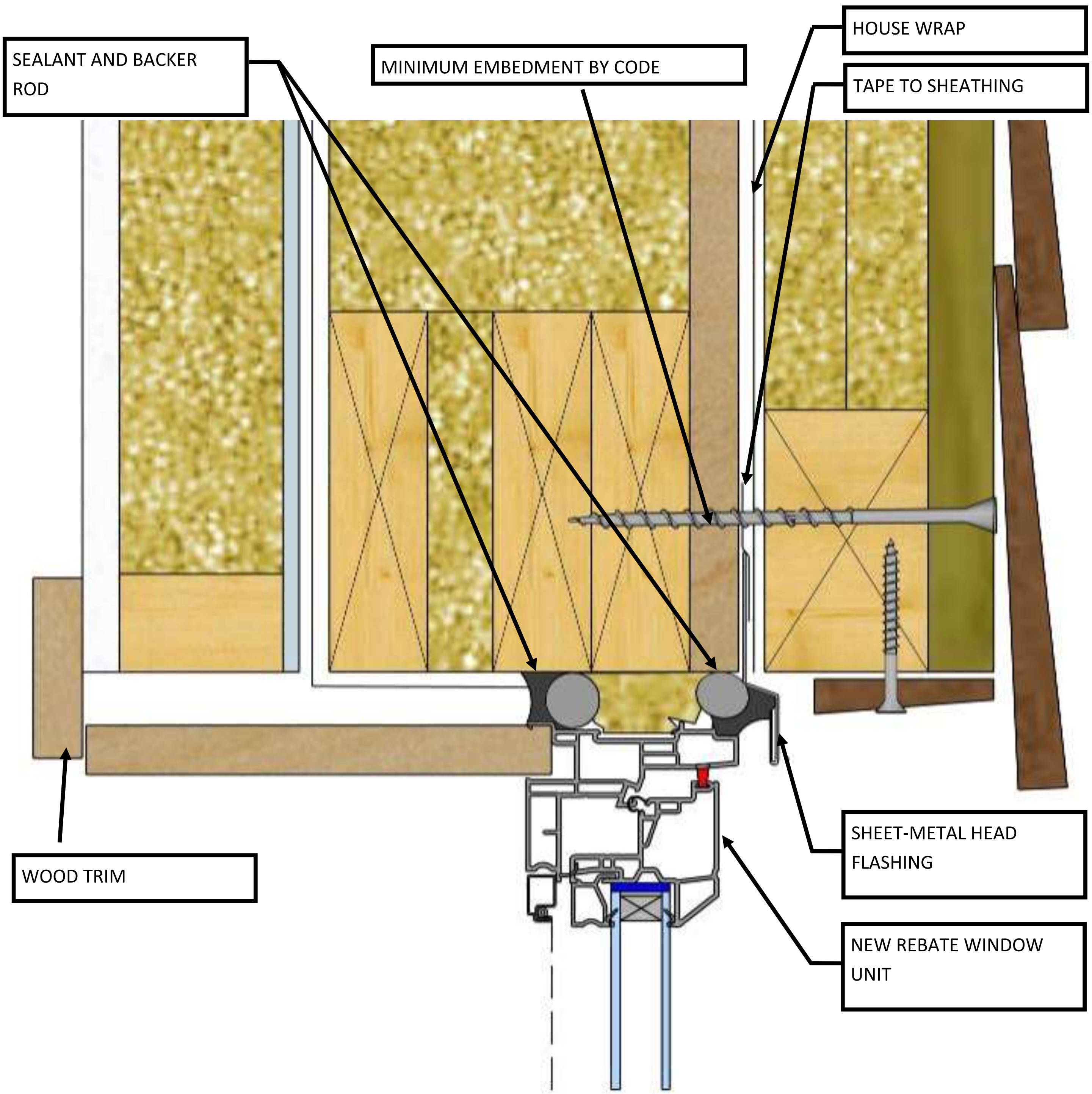
Example Window Details

The following pages present an example of architectural window detailing consistent with the overall design principles of the technical guide for northern housing and window and door-specific content in this booklet.

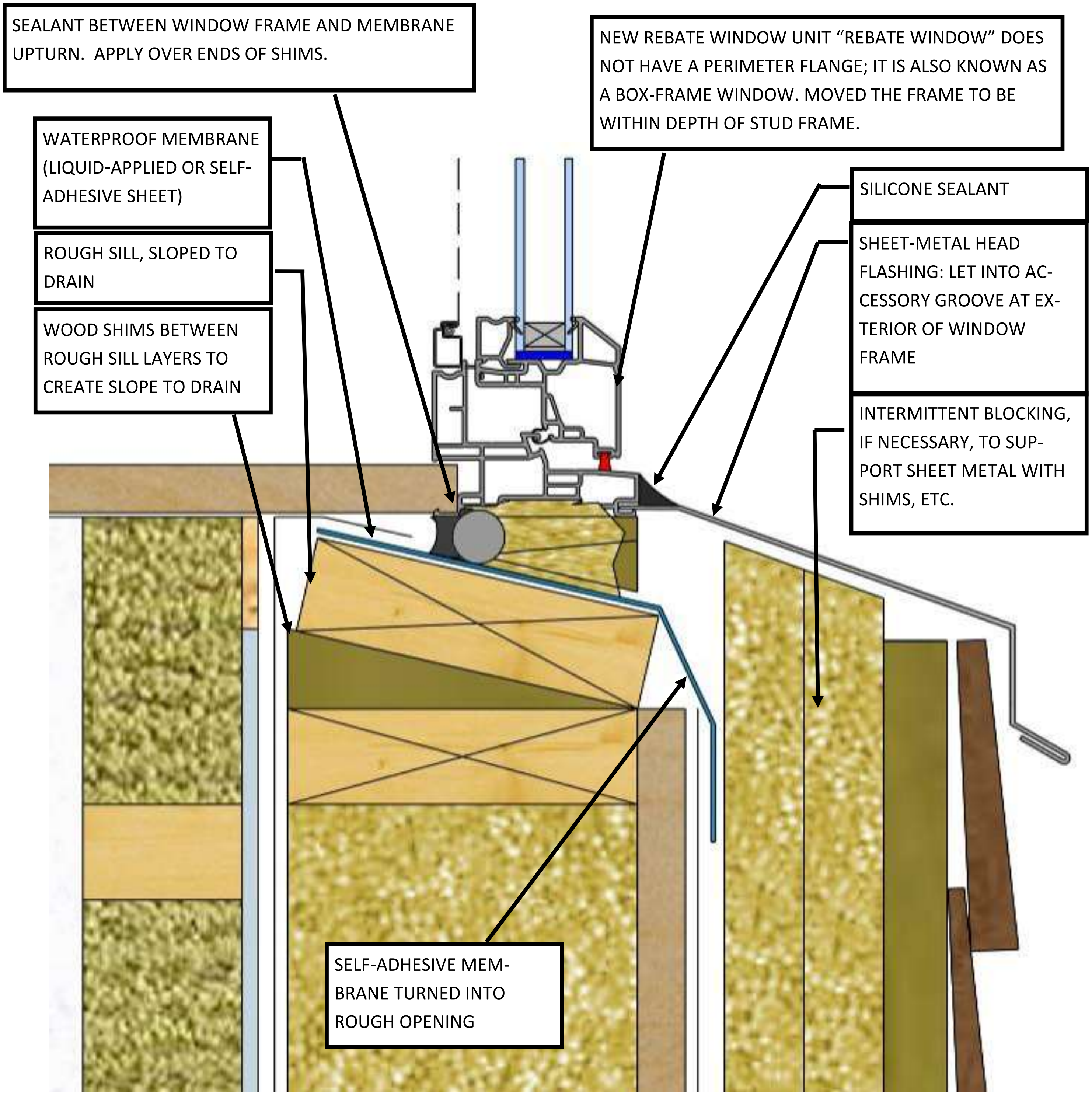
Fibreglass Rebate Mounted Window Jamb



Fibreglass Rebate Mounted Window Head



Fibreglass Rebate Mounted Window Sill



APPENDIX B

Background Technical Reading

The following pages offer a more in-depth read into the technical background behind the content of this booklet.

The story of window selection

There are many window and door manufacturers in Canada. The Natural Resources Canada (NRCan) website includes about 320 manufacturers of ENERGY STAR-compliant windows and doors in Canada, offering more than 1.2 million window and door products, representing about 80 per cent of the Canadian market. Most manufacturers have a regional focus, designing and manufacturing products that reflect provincial and territorial building-code requirements, local building construction practices, specific climates, and other factors. Selecting a window or door is not just a matter of price—some thought needs to go into selecting a product that is suitable for the building location, and how the building and windows are oriented on site.

Windows for sale in a warehouse

APPENDIX B: Background Technical Reading

The story of window selection—continued

The window and door industry consists of system houses, dealers, and installers. System houses are companies that design windows and doors to suit a market. They arrange for testing to ensure products meet building codes and standards, then manufacture components for assembly into the finished product, either themselves or through dealers. Dealers make the sale to the consumer, usually directly by in-home consultation, and may place orders with system houses for manufacture, or do the manufacturing themselves, buying components and following detailed instructions provided by system houses. Dealers often also install the product, especially for replacement windows and doors in existing buildings. Dealers also include builder's supply and big-box do-it-yourself stores that take orders from builders and homeowners and arrange for manufacture by system houses, but leave installation to the builder or homeowner. It's a complex industry, with overlapping responsibilities for proper selection, manufacture, and installation. It becomes even more complex when design professionals—architects, engineers, or government agencies—are involved in selecting the product to be used, especially if they are not familiar with local supply chains.

In the north, it is likely that builders, renovators, and do-it-yourselfers have to deal with a builder's supply store far away in the south. The selection of windows and doors is limited to what the builder's supply has in stock from selected system houses. Side-hinged (swinging) doors and sliding patio doors are made to standard sizes and can be easily stocked. Windows are usually custom-ordered to the size needed, but some may be stocked in a limited range of sizes, with basic glazing, hardware, and finishes. Custom orders take time, and with limited shipping available to many remote communities, it is often necessary to order well in advance. The custom product you receive would still come from the manufacturer the builder's supply already has a relationship with. Arranging for a window or door product more suitable for your location and building from another manufacturer will be more complicated.

APPENDIX B: Background Technical Reading

Codes and Standards

Windows and doors must perform to standards set by building codes. We'll deal with requirements of the *National Building Code of Canada* (NBC) in this booklet, since it is used in Nunavut, Northwest Territories, and Yukon, Saskatchewan, and Manitoba. British Columbia, Alberta, Ontario, and Quebec issue their own building codes. Those codes are based on the NBC and have similar requirements. Along the way, we'll address other codes and standards referenced by the NBC, and some voluntary programs regarding energy efficiency, too.

Construction of houses and buildings is governed by the *NBC* in Division B, Part 9, Section 9.7 "Windows, Doors and Skylights."

Windows and doors are required to control:

- Air leakage
- Water (rain) penetration
- Wind pressure
- Insect and pest entry
- Forced entry (ie. break and enter)

Windows and doors must also be easy to operate.

Notice the word "control." Windows and doors are not airtight, waterproof, or break-and-enter proof. If the weather is bad enough, a window or door might leak. If someone tries hard enough to get in, they will. Manufacturers must test samples of windows and doors to standards referenced by the *NBC*. Many levels of performance are possible, so you need to choose carefully to match the performance of available products to the climate in your area. You also have to think about non-climate issues, such as the level of forced-entry protection you want.

The basics: air, water, and wind

North American Fenestration Standard (NAFS)

The *NBC* requires windows, doors, and skylights to comply with AAMA/WDMA/CSA 101/I.S.2/A440 North American Fenestration Standard/Specification (NAFS) for Windows, Doors and Skylights, with the year of issue of the standard given after, for instance, NAFS-11, for the 2011 edition. Standards are updated frequently, so it is important to know which edition is currently required by the NBC when choosing your windows and doors.

NAFS combines three previous, separate standards from the American Architectural Manufacturers Association (AAMA, standard 101), the Window and Door Manufacturers Association (WDMA, standard I.S.2) in the USA, and the Canadian Standards Association (CSA, standard A440) in Canada. Wind pressure and water penetration performance are calculated differently in the two countries, so a supplement was created for Canada, CSA-A440S1, Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440 North American Fenestration Standard/Specification for Windows, Doors and Skylights. This standard is usually referred to as CSA-A440S1, with the year of issue given after, for instance, CSA-A440S1-17. The NBC also requires compliance to that standard. As with NAFS, CSA-A440S1 is updated frequently, so it is important to make sure the correct edition is used. The correct editions can be found in the *NBC.*

NAFS is not user-friendly. It covers a lot of products (46 different varieties of windows, doors, and skylights), with an overlying classification system (four performance classes and up to 18 performance grades per class) to suit different building types (from low-rise, single-family houses to high-rise apartment buildings and office towers) and weather exposure (air leakage, rainwater penetration and structural loads). The standard is complex to understand and use, even for design professionals (architects and engineers).

In this section of the booklet, we'll take you through the basics of selecting windows and doors using the NAFS standard, simplified for buildings that fall under Part 9 of the NBC (three storeys or less in building height, less than 600 m2 in area, residential), and suitable for the Canadian boreal forest and arctic regions.

APPENDIX B: Background Technical Reading

The basics: air, water, and wind

NAFS Performance Class R: minimum protection

Part 9 of the *NBC* requires windows and doors for houses and small buildings to have been tested to pass at least NAFS Performance Class "R." That's the lowest of the four performance classes in the NAFS standard, but appropriate for houses and small buildings (R means "residential"). That means the following minimum levels for air leakage, rainwater penetration, and structural loads must be met:

Air leakage	Opening windows and doors, A2 level, 1.5 L/s/m^2 at 75 Pa
	Non-opening windows and doors, fixed level, 0.2 L/s/m^2 at 75 Pa
Rainwater penetration	140 Pa
Structural load	720 Pa

Air leakage is measured as the amount of air (L = litres) that in one second (s) passes through a window or door, on a unit area (square meter, m^2) basis. Air leakage is caused by wind blowing against, past, and away from buildings, forcing air inwards and outwards through cracks between window sashes and frame or door slabs and frame. Tests are usually made at a simulated wind pressure of 75 Pascals (Pa), the equivalent of a wind speed of about 40 kilometres per hour, which commonly occurs in winter months, especially north of the treeline. The minimum air-leakage rate for performance class R is 1.5 L/s/m^2 at 75 Pa for operable windows (sliding, casement, awning) and doors, and 0.2 L/s/m^2 at 75 Pa for fixed (picture) windows.

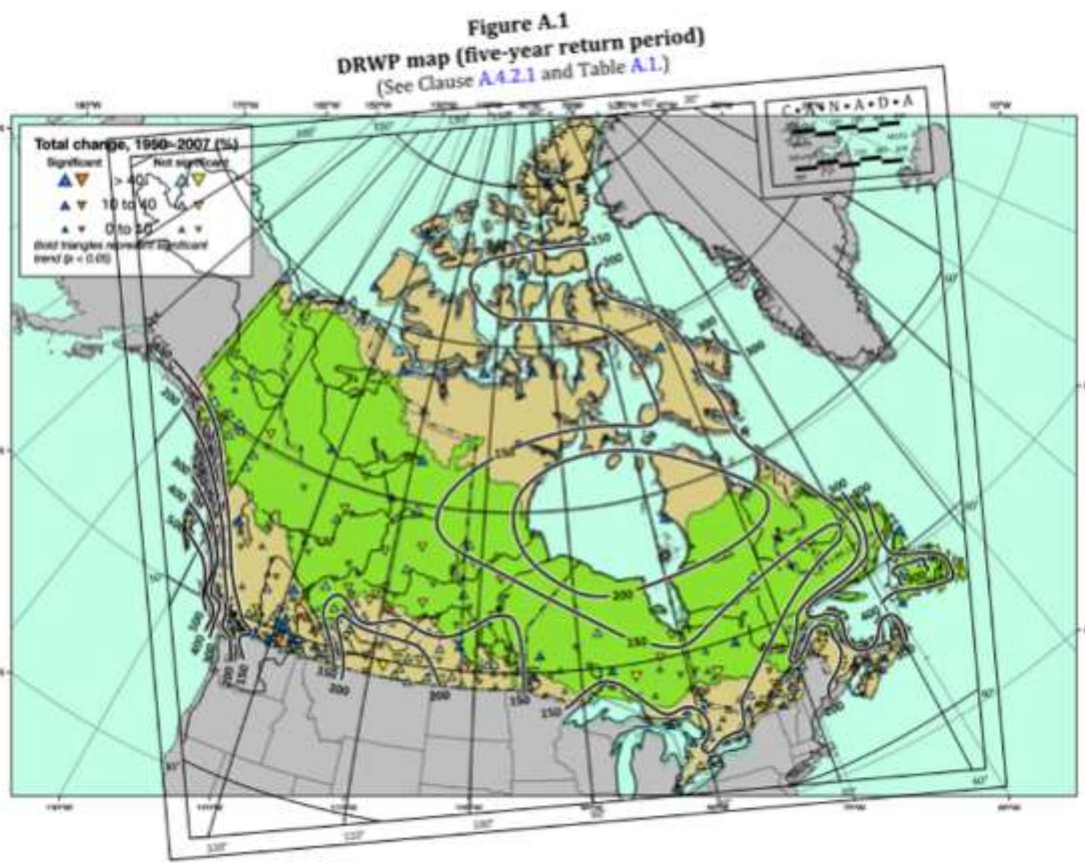
Rainwater penetration is measured as the Driving Rain Wind Pressure (DRWP) in Pascals (Pa). DRWP is strongly related to wind, which forces rainwater through joints and cracks in windows and doors, and between windows and doors and surrounding walls. As a result, very high DRWP values occur where it is windy. High rainfall can also result in high DRWP values. In the north, this occurs in coastal regions and the shorelines of large lakes. The minimum DRWP for performance class R is 140 Pa.

Structural load for windows and doors is directly related to wind pressure. For skylights, DP also includes the weight of snow and rain, but in this booklet we do not include skylights, because they allow too much heat loss in the winter. So DP is all about wind, and it is expressed as pressure on the exterior of a window or door in Pascals (Pa). The minimum DP for performance class R is 720 Pa.

The basics: air, water, and wind

Is the minimum good enough?

The *NBC* may require higher performance levels for DRWP and DP. To figure that out, you need to check the CSA-A440S1 standard. It includes a long list of communities in Table A.1 with DRWP and Hourly Wind Pressure, which is the same as DP. The standard tells you to choose your location from the table, and look up the DRWP and Hourly Wind Pressure (DP). If your location is not in the table, choose the value for a nearby location on the list. As you know, communities in the north are often spread far apart, so that may not be much help. For DRWP, CSA-A440S1 also includes a map you can use instead of Table A.1. In the figure below, we've reproduced the map overtop of a map of boreal and arctic regions and major communities. It looks like a topographical map, and you would use it the same way.



Map of DRWP contours and major communities in the boreal and arctic regions

APPENDIX B: Background Technical Reading

The basics: air, water, and wind

The contour lines on the map on the previous page connect locations with equal DRWP levels, from 150 Pa to 500 Pa. The higher the pressure, the more likely it is that rain will penetrate into a building through cracks and joints in a window or door, or between a window and door and the walls. In areas between the contour lines on the map, the DRWP value is between the nearest line values. So, if you're building in, for example, Baker Lake in Nunavut, the nearest DRWP contour line values are 150 and 200 Pa. A reasonable estimate would be to choose a value midway between 150 and 200 contour lines, 175 Pa. That's higher than the gateway DRWP of 140 Pa, which means you need a better than minimum window or door.

There isn't a similar contour map for Design Pressure (DP) (from wind speed) in CSA-A440S1, so instead use a map from another CSA standard that gives similar information. This map shows that for the boreal forest region, and much of the arctic, the minimum DP of 720 Pa should be fine, including our example location of Baker Lake, NU. However, coastal areas in Nunavut, northern Quebec, and Labrador require higher DP.

Wind Speed (MPH)	Pressure (psf)	Pressure (Pa)
52	6.9	331
56	8.0	384
62	9.8	471
68	11.8	567
75	14.4	689
81	16.8	804
87	19.4	928
90	20.7	993

Map of wind speed (mph) contours in light blue, pressures (Pa) in red where greater than 720 Pa.

So, for our example location of Baker Lake, NU, the DP meets the minimum requirement of NAFs, but we need a higher DRWP. Now what?

APPENDIX B: Background Technical Reading

The basics: air, water, and wind

Choosing the right product

Now that you know the performance levels needed, how do you know a window or door available at the builder's supply (or other source) is good enough?

Size Matters

Before you talk to the builder's supply, or begin surfing the web, you need one more important piece of information: the size of the window or door. That's because when wind blows on a window or door, it causes window glass and frames to bend. If the glass or frame is not strong enough, the glass might break and the frames bend permanently so the window or door does not work properly. You need to measure the size of the openings in the walls. Then you can contact the builder's supply or go online to search for products.

The Primary Designator

The NAFS standard requires all windows and doors to include a product label with a primary designator on it. Technical literature, web-based or other electronic publications, and advertising must also include a primary designator, so you should be able to find it online or in printed brochures. The primary designator is a three- or four-part code that looks something like this:

Class R—PG25: Size tested 760 × 1520 mm (~30 × 60 in)

How do air leakage, DRWP, and DP figure into this code?

The basics: air, water, and wind

Class R means the window meets the requirements of performance class R. That’s the minimum required by the *NBC*, so that’s good. The NAFS standard has four performance classes:

- **R** (residential): single-family houses
- **LC** (light commercial): low-rise and mid-rise multi-family buildings (townhouses, small apartment buildings) and other non-residential buildings (factories, retail plazas, small office buildings) where windows and doors are often larger, and weather exposure is higher.
- **CW** (commercial window): larger low-rise and mid-rise buildings with higher weather exposure (e.g. tall apartment buildings, office towers, schools, hospitals, and community centres).
- **AW** (architectural window): mid-rise and high-rise buildings with larger sizes and severe weather exposure (very tall apartment buildings and office towers).

For houses and small buildings, windows and doors are usually R and LC.

PG means the performance grade. The PG number equals the DP, after you convert from metric to imperial units of measurement; the designation system was originally developed for the U.S., where the imperial (or inch-pound) system is still used. The conversion factor is:

Metric DP x 0.02 = imperial DP

The basics: air, water, and wind

For our sample building in Baker Lake, NU, where we estimated the DP is 600 Pa:

600 Pa x 0.02 = 12 psf (pounds per square foot)

Performance grades start at 15 psf (equal to 720 Pa) and increase in steps of five psf. So, for the minimum performance grade of PG15, a window or door can resist a DP of: 15 psf / 0.02 = 750 Pa.

That’s higher than the 600 Pa we estimated from the figure, so a window or door with a the performance grade of 15 should withstand normal wind forces in Baker Lake. That’s good.

What about DRWP? Remember that the designation system was developed in the U.S. There, the wind-driven rain performance of a window or door is calculated as 15 per cent of the DP. Once you’ve figured out the DP, calculate your wind-driven rain performance level. In Canada, we use the driving rain wind pressure, DRWP, which is independent of DP. The two approaches are often given different values, especially in coastal areas and in the north above the treeline. That can make it tricky to select the right window. To know you are getting the right window or door to deal with rain, you must ask for the secondary designator. We’ll get to that later.

What about air leakage? It isn’t shown in the primary designator either. The lowest allowable level in Canada is A2, but since Baker Lake is above the treeline, A3 is a good idea. That information is given in the secondary designator too.

Size Tested means the size a window or door was tested to in a laboratory, to determine its air leakage, DP and DRWP performance. You should compare the test size to the size you need. If the test size is equal to, or larger than, the size you need, that’s good. If the test size is smaller than what you need, that’s not good. You should look for another window or door with a test size equal to, or larger than, what you need.

The basics: air, water, and wind

The Secondary Designator

The secondary designator is optional and may not be included in a label or other material. You should ask for it if:

- You need an A3 air-leakage resistance
- You need a DP higher than the minimum level of 720 Pa
- You need a DRWP higher than the minimum level of 140 Pa

The secondary designator should be given with the primary designator on the window or door label, technical literature, web-based or other electronic publications, and advertising. It looks something like this:

Positive Design Pressure (DP) = 1920 Pa (40 psf)
Negative Design Pressure (DP) = 1920 Pa (40 psf)
Water Penetration Resistance Test Pressure = 290 Pa (6.06 psf)
Canadian Air Infiltration/Exfiltration = A2

Positive and negative design pressure should be equal to, or higher than, the DP you estimate from the figure on page 43. Positive design pressure means wind blowing against the outside of a window or door, and negative design pressure means wind sucking on the outside of the window or door. For windows and doors, the positive and negative pressures are usually the same. For skylights, the positive and negative pressures can be very different. Skylights are not often used in northern housing because they lose too much heat in the winter, so we won't discuss them in this booklet.

For our example building in Baker Lake, NU, we need the minimum value required by NAFS: 720 Pa. In the secondary designator example above, 1920 Pa was achieved in the test lab. That's good–as long as the size of the window or door tested given in the primary designator is equal to, or smaller than, what you need.

The basics: air, water, and wind

Water penetration resistance test pressure should be equal to, or higher than, the DRWP you estimated from the figure on page 42. For our example building in Baker Lake, NU, we estimated 175 Pa. The DRWP in the secondary designator in the example above is higher. That's good–as long as the size of the window or door given in the primary designator is equal to, or smaller than, the size you need.

Canadian Air Infiltration/Exfiltration should be at least A2 for windows that can open and for doors, and fixed for windows that do not open. It should be A3 if your building is in an exposed location, or above the treeline. For our example building in Baker Lake, NU, A3 is recommended–so this window or door would not be a good choice.

What's the answer?

The casement window in the builder's supply is not good enough. Design pressure (DP) and driving rain wind pressure (DRWP) are okay, but air leakage is low. You need to order another product.

APPENDIX B: Background Technical Reading

Energy Efficiency

Beyond NAFS: heat loss, condensation resistance, and solar heat gain

NAFS and CSA-A440S1 do not include requirements for thermal performance of windows and doors. You need to look to the NBC Part 9, Section 9.36 “Energy Efficiency,” the CSA-A440.2 standard “Fenestration Energy Performance,” and other programs such as ENERGY STAR for requirements and guidance.

Thermal performance means:

- Controlling heat loss
- Minimizing condensation
- Controlling solar heat gain

Just like the basics of air, water and wind protection, the goal is to “control,” not prevent, heat loss and condensation. Great advances have been made over the years to improve the energy efficiency of windows and doors. Still, heat loss is much greater through a window or door than through the surrounding walls. The goal is to manage heat loss so the effects–cold surfaces, condensation, uncomfortable conditions indoors–are reduced as much as possible.

The *NBC* Part 9, Section 9.36 regulates building energy efficiency. Compliance can be achieved by following specific requirements in Section 9.36 (“prescriptive path”), by computer modelling (“performance path”) or by following another code, the *National Energy Code for Buildings* (NECB path). The prescriptive path is the simplest approach. It applies if the total area of all windows and doors is less than or equal to 25 per cent of the total wall area. Windows and doors in northern housing tend to be modest in size because there is so much heat loss through them; it’s best to keep them small.

In this booklet, we will follow the “prescriptive path” requirements in Section 9.36 for control of heat loss.

Control of condensation is regulated by Section 9.7 of the *NBC*. We will describe those requirements in this section, too.

Fair warning: Energy performance requirements are changing quickly, as the federal and some provincial governments move to limit the effects of climate change driven by human activity. Check with the local building official to confirm that energy performance requirements described in here are still valid.

Energy Efficiency

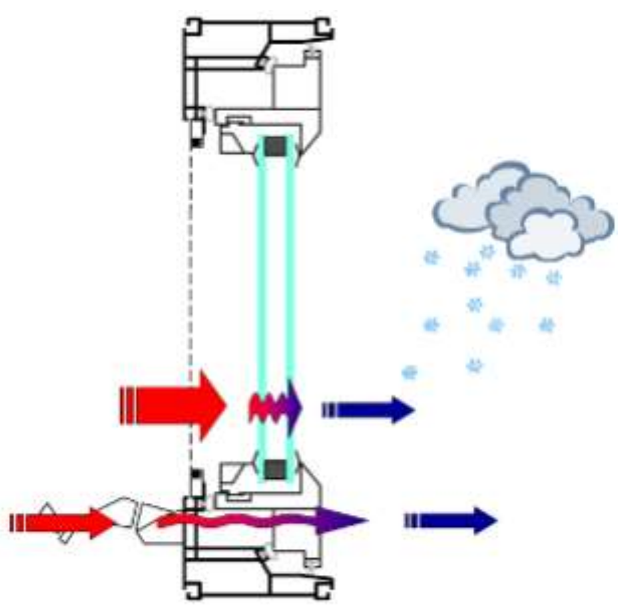
Controlling heat loss

The *NBC* requires windows and doors to have rates of heat loss, measured as U-value (also known as U-factor) and Energy Rating.

U-value is a combined measurement of three types of heat loss from inside the building to the outside:

- Conduction
- Convection
- Radiation

It is a single-number value for a window or door, including glass, door slabs and frames. Tests are made on standard-size doors and windows, the size varying by type (e.g. fixed window, casement window, entrance door, sliding door). U-value for the whole window or door is divided by the area of the window or door, to give heat loss on a unit-area basis. That makes it possible to compare the thermal performance of different types of windows and doors. U-value is calculated to CSA standard A440.2, Fenestration Energy Performance.



U-value representing heat loss through window's glass and frame

APPENDIX B: Background Technical Reading

Energy Efficiency

Conduction heat loss is direct transfer of heat through materials from the warm indoor air to cold outdoor air. When you put your hand on window glass on a cold winter day, the glass feels cold, and after a while, you feel your hand and maybe your arm get cold, too. Heat flows from your hand directly into the window glass. That's conduction.

Convection heat loss is circulation of indoor air caused by warm air contacting cold window- or door-frame surfaces, falling downwards and across the floor. As the cooled air falls down, warm air is drawn along the ceiling to the window where it, too, cools and fall down. As the warm air is cooled by the window it gives up heat energy which conduction takes away through the window to the outdoors. Convection also occurs in the air space within insulating glass units. Wind is part of a very large convection system, transferring heat energy from warmer to colder regions.

Radiation heat loss is invisible energy moving warm surfaces to cold surfaces. It's the same as holding your hands out to fire: Radiation from the fire travels through the air to warm your hands. Radiation energy does not pass through window glass, but instead warms the glass. The heat is transferred by conduction to the other side of the glass, and transferred by conduction, convection, and radiation to the next pane of glass in an insulating glass unit, where the process is repeated, transferring the heat to the cold outdoor air.

Conduction, convection, and radiation are combined in the U-value measurement of thermal performance.

U-value is the inverse of R-value, which is usually used to measure the thermal performance of walls, roofs, and foundations.

$$\frac{1}{\text{U-value}} = \text{R-value}$$

APPENDIX B: Background Technical Reading

Energy Efficiency

A low U-value (high R-value) is good. In Canada, units of measurement are Watts per square metre times Kelvin (temperature), or W/m2K. One Kelvin is equal to one degree Celsius, so you may see U-value expressed as W/m2°C. For products from the U.S., imperial units of measurement are used, Btu/h/ft2/°F.

To achieve a low U-value, windows and doors will include features such as:

- **Low conduction frames**: wood, fibreglass or vinyl, or combinations of these materials. Hollow chambers in fibreglass and vinyl frames may be filled with insulation.
- **Low-e coatings:** window and door glass coated with thin layers of metal to reduce radiation heat loss to the outdoors (low emissivity, or "low-e" coatings).
- **Low conduction gas fill:** the cavity between the panes of glass in insulating glass units may be filled with argon or krypton gas instead of plain air. Argon is used when the cavity is about 13 mm thick, typical for double-pane units. Krypton is used when the cavity is about 6 mm thick, common for triple-pane units.
- **Warm-edge spacers:** panes of glass are separated by a spacer around the perimeter of the unit. You can see the spacer looking through the glass. A "warm edge" spacer is any material other than aluminum, which was the standard spacer material before energy efficiency became a concern.

Many different frames, low-e coatings, and warm-edge spacers are available. The combinations are almost endless, but practically, most window manufacturers have a small selection available because equipment costs to manufacture frames and insulating glass units are high, and take many years of production to pay for. For the consumer, the important point is not so much the specific materials used but the performance achieved, that is, a low U-value, high Energy Rating (ER), and high condensation resistance (I value).

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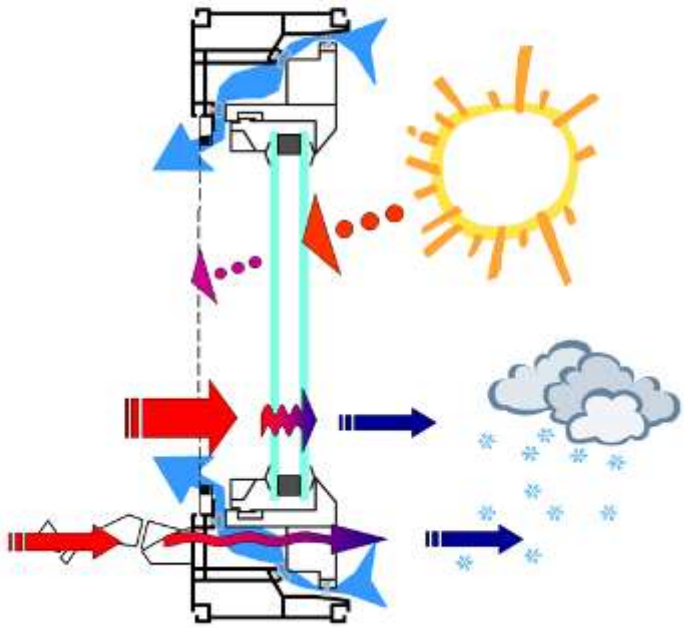
Energy Efficiency

Energy Rating (**ER**) combines heat loss measured in terms of U-value, air leakage (taken from measurements made during testing for NAFS compliance), and solar radiation. U-value measures heat loss to the exterior. Air leakage measures heat loss in terms of cold air entering a house through cracks and joints in windows and doors, and between windows and doors and the surrounding walls, which must be heated to keep comfortable conditions indoors. Solar radiation during daylight hours can bring “free” heat into a house through window glass (and to a much lesser extent, through frames), which reduces the need for heating. ER is also calculated to the CSA-A440.2 standard.



Energy Rating representing heat loss like U-value, but also includes solar heat gain and air leakage

Windows designed for high ER include features to maximize solar heat gain, such as glass low-e coatings designed to reduce heat loss, and also to allow high levels of solar heat to enter (high solar gain, low-e coatings), and narrower frames to maximize the amount of glass.

In general, a high ER is better than a low ER. The number is always greater than zero. There are no units of measurement.

ER is used only in Canada. Often, products made in the U.S. are rated only by U-factor.

Energy Efficiency

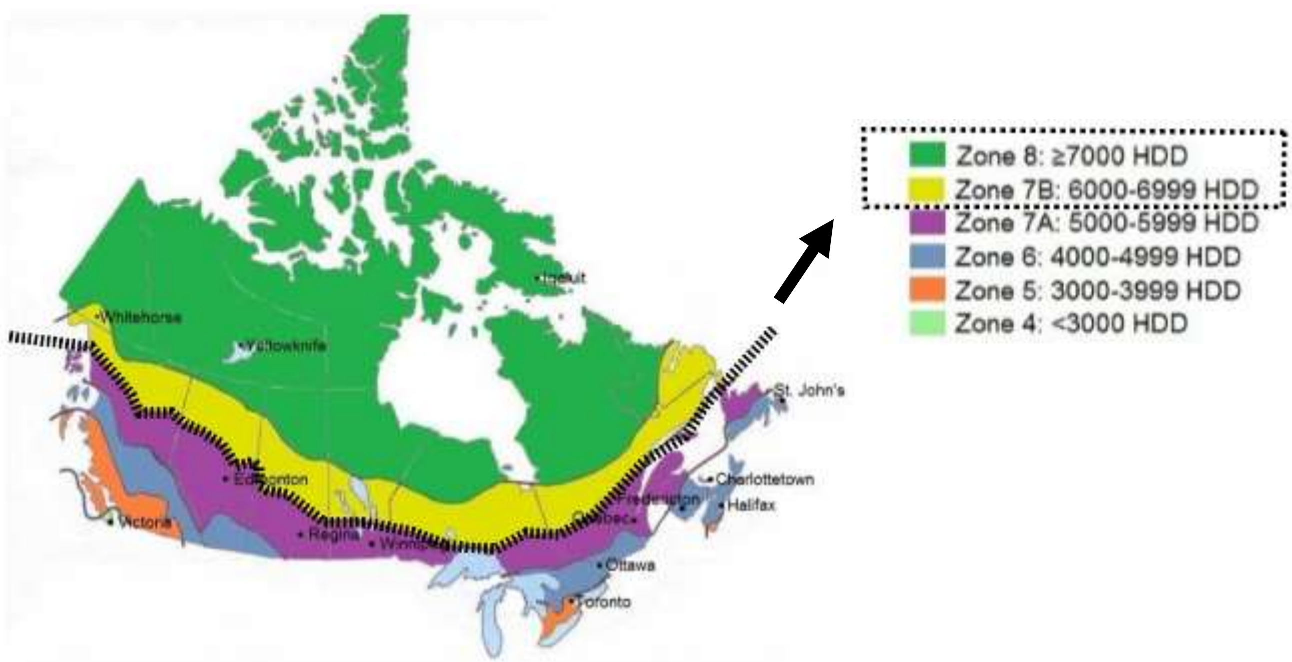
NBC Table 9.36.2.7-A gives the minimum U-value and ER rating required for windows and doors

Table 9.36.2.7.-A
Required Thermal Characteristics of Fenestration and Doors
Forming Part of Sentence 9.36.2.7.(1)

Components	Thermal Characteristics[1]	Heating Degree-Days of *Building* Location,[2] in Celsius Degree-Days					
		Zone 4 < 3000	Zone 5 3000 to 3999	Zone 6 4000 to 4999	Zone 7A 5000 to 5999	Zone 7B 6000 to 6999	Zone 8 ≥ 7000
Fenestration[3] and doors	Max. U-value, W/(m²·K)	1.80	1.80	1.60	1.60	1.40	1.40
	Min. Energy Rating	21	21	25	25	29	29

Table from the NBC with the required U-value and ER highlighted for northern climate zones

U-value and ER vary by heating degree day zones. “Heating degree days” are a way to estimate the heating requirements for a building. The higher the number of heating degree days, the colder the climate and the more heating energy (wood, diesel oil, propane) is required. As the number of heating degree days go up, U-factor goes down, and ER goes up. The map below shows the zones.



Map of climate zones

APPENDIX B: Background Technical Reading

Energy Efficiency

The southern boundary of the boreal forest roughly corresponds to the southern boundary of zone 7B. The treeline boundary between the boreal forest zone and the arctic is within Zone 8. Comparing this map to the *NBC* Table 9.3.6.2.7-A, we can see there is no change in U-value and ER requirements for these two zones.

- Maximum U-factor: 1.4 W/m2K.
- Minimum ER: 29.

Since the NAFS standard does not include thermal performance requirements, you will need to ask the builder's supply to provide this information, or try to get it from the manufacturer's website. For reference, the NBC appendix note to Table 9.36.2.7.-A gives some guidance on what to look for: insulating glass units with triple glazing and more than one low-e coating. The insulating glass units will also likely need to include argon or kypton gas fill instead of air, and a warm-edge spacer. The frames will need to have a low rate of heat loss (low conduction), such as wood, fibreglass, or vinyl.

Sunlight can be helpful…but not always

The ER method of rating thermal performance of windows and doors shows that solar heat gain can be helpful in reducing heating needs. However, large areas of south-facing windows and doors with glazing (sliding patio doors) can let in too much solar heat in the fall and spring, leading to overheating in some rooms while other rooms are cool enough to need heat. For northern housing, it is best to keep windows modest in size and avoid doors with glazing (sliding patio doors) to get the benefit, but not the harm, of solar heating.

The *NBC* does not include specific requirements for controlling solar heat gain. The ER calculation includes solar heat gain as an assumed benefit, but the calculation takes into account the window or door only, and not how the building as a whole responds to the added heat. If the heat isn't needed because the roof, walls, and floor are highly insulated, it can get uncomfortable inside. You might need to open windows and doors to get fresh air.

APPENDIX B: Background Technical Reading

Energy Efficiency

When is too much sun a problem?

- If there are a lot of windows or glazed doors facing southeast, south, or southwest
- If the windows or glazed doors have a clear exposure to the sky, such as in a town site, on the edge of a forest clearing or lake, or above the treeline
- If daylight hours are long, so there is a long time for solar heat to build up indoors

Solar heat gain is greatest when the height of the sun above the horizon (altitude) is low, and the horizontal angle of the sun (azimuth), measured from an imaginary line at right angles to the surface of a window or door, is also very low. The combination of these two values–the angle of incidence–changes from sunrise to sunset, and from winter to summer and back. Within a range of about 50 degrees, energy-efficient windows can let in a lot of solar heat, enough to make it uncomfortably hot inside a house with thick insulated walls, roof, and floor.

The amount of solar heat gain through windows and glazed doors can be controlled by:

- Turning the house on the site, or changing the design of the house, so fewer windows and glazed doors face southeast, south, and southwest
- Reducing size of windows and glazed doors facing southeast, south, and southwest
- Using a glazing with a low-solar-gain type of low-e coating

The amount of solar heat gain that enters through window or door glazing is measured by the solar heat gain coefficient (SHGC). This number ranges from 0 to 1. A double-pane insulating glass unit with no low-e coated glass has an SHGC of about 0.76, and a double pane insulating glass unit with one low-solar-gain low-e coating has an SHGC of about 0.4. Lower is better.

Energy Efficiency

Since there are no building-code requirements specifically limiting SHGC, you may have to ask the builder's supply to find out this number. It should be available through a window or door manufacturer's website. If a window or door is rated for the ENERGY STAR program (more about this later), the SHGC should be available in printed product literature and online, and on a temporary paper label on window or door glass when it is shipped to site.

An example of a temporary paper ENERGY STAR label

Caution: For programs such as ENERGY STAR, a window or door is rated for energy performance, including glass, frame, and sash frames for windows or door slabs for doors. That includes the SHGC. The frame, sash frames, or door slabs do not allow light through, so the combined SHGC will always be lower than the SHGC for the coated glazing only. That can lead you to thinking you are getting a low-solar-gain, low-e when you are not. You need to check specifically for the SHGC of the low-e coating.

Energy Efficiency

Minimizing Condensation

The NBC requires that condensation be minimized. That means any condensation that forms overnight should dry up on its own the following day, without causing damage to the window, door, or surrounding walls.

The NBC, Part 9, Section 9.7, Table 9.7.3.3 gives specific requirements for heat-loss control and condensation resistance:

Table 9.7.3.3.
Maximum U-value or Minimum Temperature Index (I) for Windows, Doors and Skylights(1)(2)
Forming Part of Sentence 9.7.3.3.(3)

Component	2.5% January Design Temperature					
	Warmer than −15°C		Between −15°C and −30°C		Colder than −30°C	
	max. U-value, W/(m²·K)	min. I	max. U-value, W/(m²·K)	min. I	max. U-value, W/(m²·K)	min. I
Windows and doors	2.5	54	2.0	68	1.7	77
Skylights	3.5	(2)	3.0	(2)	2.7	(2)

Notes to Table 9.7.3.3.:

(1) U-values for specific products can be determined according to measures referenced in AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights." Temperature index (I) is determined according to the physical test procedure given in CSA A440.2/A440.3, "Fenestration Energy Performance/User Guide to CSA A440.2-14, Fenestration Energy Performance."

(2) There is no appropriate test procedure available for testing the condensation resistance of sloped glazing.

Table of NBC requirements for U-factor or Condensation Resistance

Windows and doors are rated in terms of maximum U-value or minimum Temperature Index, (I). As the climate gets more severe, measured by heating degree days, the U-factor goes down and the Temperature Index goes up.

U-value considers the overall conduction heat loss of a window or door. Some parts of a window or door typically have higher U-values than others. Condensation will always show up on the weak spots first, and spread to better-performing areas as the temperature outdoors gets colder or the humidity indoors goes up. Temperature Index is calculated based on room-side surface temperatures, including specific locations known to be thermally weak, where condensation usually occurs.

APPENDIX B: Background Technical Reading

Energy Efficiency

Temperature Index is a better way to estimate the condensation risk of windows and doors. Unfortunately, it requires expensive testing in a laboratory. U-value factor can be simulated for less on a computer. U-value must be calculated anyway to ensure compliance to the NBC and for the ENERGY STAR program. Try to get the Temperature Index value for windows and doors you want for your building. If you can't, think about choosing another window or door, if an alternative is available.

Temperature Index is calculated to CSA standard A440.2, Fenestration Energy Performance. There are three other methods for measuring condensation resistance in the U.S.: "Condensation Resistance" (CR), "Condensation Index" (CI), and "Condensation Resistance Factor" (CRF). All four methods calculate condensation resistance differently, so the values are not equal and cannot be directly compared. You may see any one of the U.S. condensation resistance values reported in product brochures and online, especially if the product is manufactured in the U.S. Stick to the Canadian "I" value from the CSA-A440.2 standard, if you can get it.

In Table 9.7.3.3, maximum U-factor and minimum "I" values are given for three ranges of the 2.5 per cent January design temperature. At the design temperature, the windows, doors, walls, roofs, insulated floors, and the building heating system, working together, must keep you warm and comfortable indoors. It's not the coldest outdoor temperature that is possible, though–it could get colder, but for no more than 2.5 per cent of the hours in the month January (31 days x 24 hours/day = 744 hours x 2.5% = 18.6 hours). The intent is to strike a balance between being warm and comfortable indoors and the cost of construction. It would cost more to build a house to suit the coldest temperature on record, so instead we build to a higher temperature with the understanding that in the depths of winter, it might get a bit chilly indoors for a few nights.

Three ranges of 2.5 per cent of January design temperature are given in Table 9.7.3.3, with matching U-value and Temperature Index, to simplify the selection of windows and doors, instead of using the more detailed selection procedure in the CSA-A440.2 standard. The U-value and Temperature Index given for each range of the January 2.5 per cent design temperature is for the coldest end of the range (-15°C, -30°C and -50°C for colder than -30°C). Most locations in the boreal forest zone and arctic region fall into the colder than -30°C range, so to minimize condensation, you need to choose windows with a maximum U-factor of 1.7 W/m2K (or W/m2°C), or Temperature Index of 77.

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Energy Efficiency

Caution: The values given in Table 9.7.3.3 assume an indoor air temperature of 21C, and a relative humidity of 35 per cent. The indoor relative humidity level is a demanding target to hit, especially for the "colder-than-30°C" range required for most boreal forest and arctic housing. It is a reasonable one—Health Canada recommends a range of indoor relative humidity of 30 to 55 per cent in the winter—but many window manufacturers, component suppliers, and also the CSA-A440.2 standard recommend the indoor relative humidity should decrease as the January 2.5 per cent design temperature falls. For example, at -30C, CSA-A440.2 recommends an indoor relative humidity of 15 per cent or less. That is a considerable difference. Be careful when selecting windows and doors to make sure the windows and doors you select meet the U-value or Temperature Index required in Table 9.7.3.3.

Caution: The U-values required in Table 9.36.2.7.-A and the U-factors and Temperature Index values in Table 9.7.3.3 will require high-performance insulating glass units, usually triple pane, and often with more than one pane of glass having a low-e coating. Most low-e coatings must be included within the sealed cavities of the units to protect the coatings from damage. There is one type of low-e coating that can be exposed, applied to the room-side surface of insulating glass units, sometimes calls a room-side low-e, or "4th surface" low-e coating. This type of low-e coating can reduce the U-value of a double-pane insulating glass unit to about the same as a triple-pane unit. It allows manufacturers who have only double-pane units to supply windows and glazed doors to colder regions. However, it reflects radiation energy within a room away from the window glass, which means the glass becomes colder and condensation is more likely to occur. Be careful when choosing windows and glazed doors–if you are offered double-glazed products, check if a room-side or 4th surface low-e coated glass is included. If yes, consider selecting products without this coating.

ENERGY STAR

You may also hear about the ENERGY STAR program when you are searching for windows and doors. ENERGY STAR was started by the Environmental Protection Agency in the U.S. In Canada, it is run by Natural Resources Canada (NRCan). ENERGY STAR started in the 1990s for office products, including computers and monitors. It expanded to a wide variety of products, including windows, doors, and skylights in the U.S. in 1998, and in Canada in 2003. At first, the Canadian window, door, and skylight program had four zones, with increasing energy efficiency requirements from south (Zone A) to north (Zone D). Performance levels have been increased several times, essentially by pushing the lowest zones off the map, and moving the southern boundary of the northern zones southward. Today, ENERGY STAR Version 5.0 for windows, doors, and skylights requires the same performance levels across the country, from south to north.

Table 2: U-factor Criteria for Residential Windows and Doors

Product	Maximum U-factor $W/m^2 \cdot K$	Maximum U-factor $Btu/h \cdot ft^2 \cdot F$
Windows and Doors	1.22	0.21

Table 3: Alternate ER Criteria for Residential Windows and Doors

Product	Minimum ER (unitless)
Windows and Doors	34

NRCan ENERGY STAR requirements for U-factor or ER for windows and doors

ENERGY STAR products may comply either by U-value or ER. As discussed previously, ER includes the effects of air leakage and SHGC. ENERGY STAR products must have a temporary, removable label, and a smaller permanent label on the frame that includes U-value, SHGC and, if applicable, ER. There are several different versions of labels. One type of temporary, removable label is shown in figure on page 57. That's the kind of label most people look for. It should be visible on sample windows in a showroom, a builder's supply warehouse, or when the window is delivered to the job site.

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ENERGY STAR

ENERGY STAR compliance is not required by the *NBC*.

How does ENERGY STAR compare to the NBC?

The ENERGY STAR maximum U-value of 1.22 W/m2K (is W/m2°C) is lower than required in *NBC* Table 9.7.3.3 for condensation resistance and lower than Table 9.36.2.7-A for thermal performance, for locations in the boreal forest region and the arctic. Lower U-value is generally better (but see the caution below).

The ENERGY STAR minimum ER of 34 is higher than Table 9.36.2.7-A for thermal performance, for locations in boreal forest and arctic regions. Higher ER is generally better (but see the caution below).

So, if you buy ENERGY STAR-compliant windows and doors, you will also comply with the *NBC.*

Caution: ENERGY STAR addresses thermal performance only, measured as overall product U-factor or by Energy Rating (ER). Like the *NBC*, it considers SHGC assuming that solar heat gain is good. It does not consider the possibility of overheating due to the use of high solar-gain, low-e-coated glass in houses with large amounts of glazing facing southeast through southwest. However, it does allow windows, doors, and skylights to achieve compliance on the basis of U-value or a combination of U-value and ER. If overheating is a concern, products with low U-values should be selected. Unfortunately, that means little beneficial solar heating. A better solution (as mentioned before) is to orient the house on the building site or re-arrange the design of the house to avoid having windows and glazed doors with high solar exposure that could lead to overheating, or use modest sizes of windows and glazed doors to minimize solar gain.

This technical booklet was developed to help community decision makers and building officers choose among different technical options in the delivery of residential housing for First Nations communities in remote northern Ontario.

IMPORTANT NOTE

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