

SOCIÉTÉ D'HABITATION DU QUÉBEC

HOUSING CONSTRUCTION IN NUNAVIK

GUIDE TO GOOD PRACTICES



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GLOSSARY

ACTIVE LAYER:

Surface layer of the soil subject to the annual freeze-thaw cycle.

AGGRADATIONAL ICE:

Ice that forms at the base of the active layer as a direct result of permafrost aggradation.

CRYOFACIES:

Assembly of cryostructures, a permafrost composition and structure formed of sediments and ice.

CRYOSTRATIGRAPHY:

Vertical succession of a sequence of cryofacies.

CRYOSTRUCTURE:

Geometric patterns created by the three-dimensional assembly of ice in various forms (lenses and veins of various thicknesses, ice coating stones, ice in voids, etc.) and by sediments in the permafrost.

CRYOSUCTION:

Suction process that occurs in freezing or partially frozen fine-grained soil. Interstitial water migrates by capillary action to the freezing front, where it forms ice lenses.

CRYOTURBATION:

Disturbance of soil caused by the formation of ice and the freeze and thaw processes.

DEGREE-DAY:

Units used to calculate heat accumulated (above 0°C) or lost (below 0°C). For example, the cumulative degree-days above 0°C for a given time period is called the thawing index. This index is simply the sum of the daily average temperatures for all days on which the temperature is above 0°C. The sum of degree-days below 0°C for a given time period is called the freezing index.

FROST HEAVING:

Uplift movement of the ground surface caused by the formation of ice in the soil.

FROST-SUSCEPTIBLE SOIL:

Soil in which ice segregation (lenses) forms, causing frost heaving when low temperatures and water inflow are sufficient and persistent.

GELIFLUCTION:

Downslope movement of unfrozen material on a frozen substrate. For example, the active layer that thaws in summer flows downhill by gravity over the underlying permafrost. This is a fairly slow movement (a few centimetres a year) and ends up forming geomorphological features such as gelifluction lobes on slopes.

ICE WEDGE:

Massive ice body, usually in the shape of a wedge, with the narrow edge facing down. It results from water freezing in thermal contraction cracks. Repeated annual contraction, cracking and freezing of the infilled water gradually increase the width of the ice wedge.

INTERSTITIAL ICE:

Ice contained in the pores (voids) between soil particles.

INTERSTITIAL WATER:

Water found in the pores (voids) between soil particles (grains of silt or sand, stones, etc.).

N FACTOR:

Ratio of the soil surface freezing or thawing index to the air freezing or thawing index.

PERMAFROST:

Soil (or rock) that remains at a temperature below 0°C for a period of at least two consecutive years.

PERMAFROST TABLE:

The upper boundary of permafrost, typically ice-rich in frost susceptible fine-grained material.

RETICULATE ICE:

Horizontal and vertical ice veins that create a three-dimensional rectangular or square network.

SEGREGATION ICE:

Ice lenses formed by cryosuction.

STRUCTURED SOIL:

General term to designate any soil with an orderly, fairly symmetrical morphological surface pattern (e.g. ice wedge polygons, mudboils).

SYNGENETIC PERMAFROST:

Permafrost formed by the rise of the permafrost table as a result of the deposition of additional material on the ground surface and the subsequent equilibrium of the ground thermal regime. Syngenetic permafrost is common in deposits on slopes, alluvium deposited by rivers, eolian sand or accumulations of peat.

TALIK:

Unfrozen layer or part of the soil that occurs in a permafrost area because of a local anomaly in thermal, hydrological, hydrogeological or hydrochemical conditions.

THERMISTOR CABLES:

Series of sensors (thermistors) inserted vertically into a borehole that measure the temperature at various depths. Thermistors are electric resistors that vary depending on temperature fluctuations and can be read manually with a voltmeter, or automatically using a datalogger.

THERMOKARST:

Process resulting in thawing of the permafrost and formation of an irregular topography (chaotic terrain) characterized by depressions due to loss of volume caused by melting ice. This thawing may be caused by climatic or anthropic factors.



PHOTOGRAPH: INUKJUAK (XAVIER DACHEZ)

BACKGROUND

Housing construction in Nunavik differs greatly from techniques in the rest of Quebec. The *Guide to Good Practices* was written to illustrate these differences and provide adapted performance criteria for architects, engineers, contractors, local administrators and anyone else involved in design and execution of this type of project. We encourage them to propose solutions that meet these criteria as fully as possible. Under no circumstances should the Guide act as an obstacle to development of innovations, but the suitability of innovations to the problems encountered in northern areas must be demonstrated (integration into the natural environment, enhanced energy efficiency, reduced costs, etc.).

The performance criteria set out here are not intended to replace the codes, standards and other applicable regulatory texts, but instead provide additional information. These basic regulations include the Building chapter of the Quebec Construction Code, although it has not been officially adopted by municipal authorities in Nunavik (those affected and with jurisdiction).

Over time, a certain number of products and methods that have worked well have been adopted by developers, designers and builders working in Nunavik. The Guide to Good Practices reviews the knowledge they have accumulated over the past 30 years building homes in Nunavik.

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NOTICE

This guide is the result of a process (currently being defined) for developing concepts and principles of sustainable development, applicable in the various phases of design, execution and operation of housing projects in Nunavik. This process specifically entails stages for review of the document's content using an adaptive evolutionary approach.

As it develops and future editions are published, it may address variations noted and observed with respect to the needs of occupants, imperatives of individual and community health, requirements dictated by environmental changes, financial constraints and other problems encountered. The Société d'habitation du Québec invites your comments and suggestions to help it revise and improve future editions of the guide to keep it current and relevant (see the Revision Proposal form).

INTRODUCTION

Growth is accelerating in the communities of Nunavik, as ever more developers and contractors enter the construction sector in the Far North. In addition, the Government of Quebec's plan to develop Northern Quebec's potential will draw more activities into this region.

However, the rules and regulations governing the northern construction industry are not always well known or followed. Lack of standardized written procedures has resulted in unnecessary conflicts between the communities, which seek compliance with municipal bylaws and construction rules, and developers or contractors, who feel they have not been clearly informed of the procedures they must follow and the permits they must obtain.

Furthermore, the housing stock in Kativik is overcrowded, with an estimated 30 percent of housing units having more occupants than the number of rooms, and a shortfall of about 1,000 units in 2015.

This guide was developed to:

- Create and institute a standardized procedure that applies to all construction projects in Nunavik;
- Facilitate the work of companies seeking to start construction projects in Nunavik;
- List all authorities that must be notified of projects to be built in their community;
- Promote compliance with rules and regulations (municipal bylaws, orders, occupancy permits for Class I lands, etc.);
- Improve knowledge of the specific of home construction in Nunavik.

Specifically, the Guide presents an overview of the procedures that must be followed for construction projects in Nunavik. In part, it explains the permits that must be obtained and the authority to which the application must be submitted. It specifies the design criteria that govern siting, exterior finish, architecture, foundations, building mechanics and, in a future edition, electrical systems, the environment and sustainable development.



1. LOCAL PROCEDURES AND AUTHORIZATIONS

1.1 GROUPS AND INDIVIDUALS INVOLVED

This guide is available to any organization or person planning to carry out or participate in a housing construction project in Nunavik, specifically:

- Northern villages;
- Landholding corporations;
- Housing project developers;
- Construction contractors;
- Design firms;
- Surveyors;
- Suppliers of construction products and materials;
- Any other person or organization involved in the construction of northern housing.

1.2 TYPES OF WORK

This guide provides information about the procedures, permits and performance criteria applicable to any housing construction project in Nunavik. This includes all types of housing, from single-family and semi-detached houses to multi-family buildings, whether new construction, additions or renovations.

For more information, contact municipal authorities (the northern village), the landholding corporation or Kativik Regional Government (KRG).

1.3 CONSTRUCTION PROJECTS

1.3.1 General organization

The construction season in Nunavik is shorter than in southern regions and this climate constraint is further complicated by lack of a highway connection to the rest of Quebec, which makes construction timelines dependent on shipping schedules for supply of materials and equipment. Due to high cost and limited space available for freight, aircraft are generally used only to bring in workers.

Shipping to communities in Nunavik is generally available from late June until October, depending on the ice pack. Calendars, rates and terms (reservation, packing, shipping of hazardous materials, etc.) can be viewed on the shipping companies' websites.

In winter, other constraints must be considered. The workday is shorter and granulates become virtually unusable. Moreover, removing material to construct granulate raft foundations is impractical because frozen soil is very difficult to excavate. In summer, when the surface soil thaws, it can be excavated and left for the heat to penetrate the substrate, before repeating the operation.

Contractors must ensure that construction sites and camps are kept clean and free of debris, and pose no risk of accident, over the full term of the construction project.

1.3.2 Administrative procedures

Procedures and the permits to be obtained differ slightly depending on the class of the land on which the project will be built (see sections 1.4, 1.6 and 1.7). The developer and contractor must obtain all necessary permits before work starts. The northern village and the landholding corporation in turn must ensure that permit requirements and conditions have been met.

Time must be allowed for issue of these permits. Developers should submit their applications as early as possible and allow at least 90 days before construction starts. Approval of major projects may take longer.

For construction camps, the northern village should be contacted (see Appendix I for contact information), because most villages have their own camps. Furthermore, equipment and materials may not be left in the community after construction is complete without first obtaining authorization from the municipal office and the landholding corporation (see Appendix I for contact information).

Landholding corporations may charge a fee for storing construction equipment in the community.

In communities where such bylaws are in force, northern villages may also charge fees if construction equipment or materials are left at the municipal dump, and penalties may be levied for failure to comply with certain municipal bylaws (governing materials sorting or the location where waste must be left in the dump, for example). Careful planning and organization of construction projects in Nunavik is important, because some logistical problems can cause serious delays.

The various procedures applicable to each land class in Nunavik are described below.

1.4 CLASS I LANDS

The land system under the James Bay and Northern Quebec Agreement (JBNQA) defines three land classes, ranked I, II and III. Class I lands are allocated to Aboriginal people for their exclusive use and are located in the usual locations where Aboriginal people live, as well as surrounding areas. On the following map, these are shown by the colours red (Crees), blue (Inuit) and purple (Naskapis):

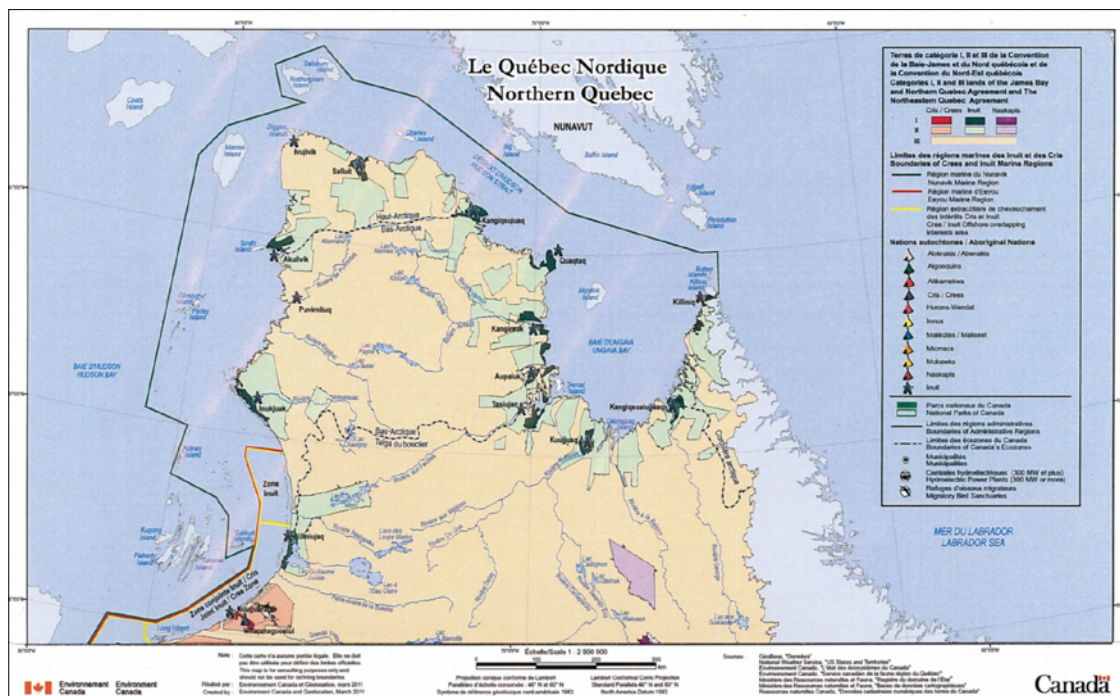


FIGURE 1.1: LAND CLASSES / SOURCE: ENVIRONNEMENT CANADA
<http://www.ceaa.gc.ca>

Construction projects within municipal boundaries or on Class I lands require formal permission for the project from the landholding corporation and the municipal council.

Here is the procedure.

First stage: Project proposal

The developer must submit an application to the northern village and the local landholding corporation at least 90 days before construction starts.

The following must be submitted: the permit application form filled out and signed, the non-refundable fees for the permit application and two copies of the site plan, location certificate, proposed building elevations and floor plans. The northern village also requires that an electronic copy of these documents be sent to the Kativik Regional Government landuse@krq.ca.

The form that must be submitted to the northern village can be obtained from the Kativik Regional Government development department at landuse@krq.ca, while that from the local landholding corporation is available on the Nunavik Landholding Corporations Association website at www.nlhca.strata360.com.

Second stage: Analysis of project proposal

The northern village and the landholding corporation review the project to ensure compliance with the municipality's master plan, zoning bylaws, any other applicable municipal bylaw and the community's general development objectives.

The landholding corporation authorizes occupancy of a plot of land. Developers should provide the northern village and the landholding corporation with thorough documentation during development of the project to avoid potential problems during the construction phase.

Third stage: Decision

The northern village and the landholding corporation send their written decision to the developer.

If the project is admissible, the northern village issues a development permit and the landholding corporation adopts a resolution confirming authorization to proceed with the project, by issuing a registration certificate to the developer. A land lease should then be drawn up between the developer and the landholding corporation. Note that the development permit must be issued and the resolution must be adopted before construction begins.

If the project is inadmissible, the developer must make the necessary changes or abandon it.

Fourth stage: Project approval

Once the project has been approved, the developer must notify the contractor selected for the project, to sign a memorandum of understanding with the landholding corporation on occupancy and use of the plot of land during the full term of the project, and to obtain a permit to operate a quarry, gravel pit, or both, for purposes of the project. Fees will be charged in both cases.

The contractor must then contact the northern village and the landholding corporation to make the necessary arrangements for the following aspects.

- Northern village: Discuss the municipal services that will be required during the project and the services the northern village can provide, such as human resources and heavy machinery rental, as well as the rental rates applicable.
- Landholding corporation: Sign a memorandum of understanding on occupancy and use of the plot of land throughout the project and obtain the rights to use natural construction materials (gravel and mineral materials). Some fees apply for occupancy and use of Class I lands; the rates vary depending on whether it is during construction season. Fees are also collected for extraction of natural materials. After signing the memorandum of understanding, the landholding corporation issues a termination of contract to the developer.

Fifth stage: Land surveyor

The land survey must be produced by a surveyor who is a member of the Ordre des arpenteurs-géomètres du Québec and must be submitted to and registered with the clerk of the Arpenteur général du Québec (GAGQ). Following this, GAGQ will send a copy of the document to the KRG land developer and to the appropriate landholding corporation. The permit holder has 12 months to submit a survey of the building and its siting on the lot to the landholding corporation, the northern village, the KRG land development department and the Minister of Energy and Natural Resources.

The surveyor retained for the project must ask the GAGQ for specific survey instructions, at least 30 days before performing the field work. For more information, additional instructions are provided in Appendix II of this Guide.

Appendix IV contains a table that reviews the permits required.

Additional requirements:

At all times during the term of the work, the developer must ensure that permits are visible from the street, and at the end of the contract, must ensure that the contractor removes from the area the supplies, items, equipment, materials, effects, etc. that were necessary to complete the project.

In some communities, the soil may be unstable and is not always suitable for construction. The developer is responsible for ensuring that all necessary soil studies have been performed. Université Laval's Centre d'études nordiques has produced maps of permafrost characteristics to guide development of the built environment in the 13 Nunavik communities in question. These maps are available in these communities and from the KRG.

Finally, some development projects may be subject to the "environmental and social impact assessment and review procedure" stipulated in chapter 23 of the JBNQA. It is recommended that developers check with the Makivik Corporation or the Kativik Environmental Quality Commission (KEQC) whether their project is subject to this process. The Commission is responsible for administering and monitoring the environmental and social impact assessment and review process in Nunavik. By way of information, Appendix III provides a description of projects that are automatically subject to this process and those that are exempt.

1.5 PUVIRNITUQ

For construction projects in the village of Puvirnituaq, where there is no landholding corporation, the developer must contact the Direction générale du Nord-du-Québec for the necessary land lease permits. A development permit must be obtained from the northern village in question and a land lease must be signed with the Ministère de l'Énergie et des Ressources naturelles (MERN) and with the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC). The procedures for obtaining the development permit and specific survey instructions are the same as those described in section 1.4.

1.6 CLASS II LANDS

Class II lands located in Nunavik and falling under the JBNQA are provincial public lands subject to the legislation and regulations of Quebec governing lands involving exclusive hunting, fishing and trapping rights for the Inuit that do not grant them special occupancy rights.

- The landholding corporation, which must ensure that the project does not infringe on Inuit user rights
- KRG, which must issue a certificate of authorization confirming that the project complies with the master land development plan for the Kativik region or any bylaw or order adopted by the KRG council—developers must contact the KRG land developer
- MERN, to sign a land lease
- MDDELCC, to obtain a certificate of authorization for drinking water and sewage treatment as well as waste disposal
- GAGQ, to obtain specific survey instructions

1.7 CLASS III LANDS

Finally, Class III lands are provincial public lands subject to the legislation and regulations of Quebec governing such lands, but on which Aboriginal people may continue their traditional activities year round, in addition to holding exclusive rights over certain animal species.

In Nunavik, Class III lands are all those not defined by the other classes.

The permits required for construction work on Class III lands are the same as those required for Class II lands (see section 1.6). However, formal authorization is not required from the landholding corporation.

1.8 NATURAL CONSTRUCTION MATERIALS

Most construction projects require gravel or other mineral materials. Before obtaining any mineral, a permit must be obtained from the authorities listed below and the applicable compensation must be paid.

1.9 EXTRACTION FROM CLASS I LANDS

Most communities already operate quarries or borrow pits. Some northern villages provide material extraction, crushing, cribbage and delivery services. The developer or contractor must contact the landholding corporation and municipal office for more information about the services available and rates charged. Under the JBNQA, landholding corporations may charge compensation fees for use and extraction of granulates. The landholding corporation is responsible for maintaining a register of all minerals extracted or removed from the quarry. This information may be forwarded to the northern village, which is responsible for transporting the material. This register must be signed jointly by the contractor, the northern village and the landholding corporation in question.

The developer or contractor may choose to extract minerals from a new site. Before extraction work starts, written authorization must be obtained from the following authorities.

- The northern village, which issues the permit confirming that the work does not violate any municipal bylaw
- The landholding corporation, which grants authorization to obtain and extract gravel or mineral materials
- The Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, which issues the certificate of authorization to operate a quarry or borrow pit

In all cases, the contractor must ensure that the site selected has been cleaned and graded at the end of the construction period.

1.10 EXTRACTION FROM CLASS II AND III LANDS

To extract natural materials from Class II and III lands, authorization must be obtained from the following authorities.

- The Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, for the certificate of authorization
- The Kativik Regional Government, for the certificate of authorization
- The Ministère de l'Énergie et des Ressources naturelles, for the mineral tenure and mine operating permit
- The clerk of the Arpenteur général du Québec, for specific survey instructions
- The Ministère de l'Énergie et des Ressources naturelles, to sign a land lease

The contact information for these authorities is provided in Appendix I.

1.11 OTHER CONSIDERATIONS

1.11.1 Electrical and telephone connections

When new construction must be connected to existing electrical and telephone systems, the developer or contractor must contact Hydro-Québec and Bell Canada to inform them of the exact location of the structure and the date on which the connection is required.

The applicant (developer or owner) may be required to pay costs if the structure is located beyond existing networks or in a location not appearing on the municipal master plan or zoning plan as an area for future development. In addition, if the building is erected at a distance that requires the installation of new posts specially intended for this building, the cost will be invoiced accordingly.

For the fees applicable or more information on a Hydro-Québec connection, visit:

<http://www.hydroquebec.com/affaires/moyen/raccordement.html>

For a new telephone line installation, contact Bell Canada's new installations department at 310-2355.

1.11.2 Equipment rental in communities

The equipment and heavy machinery needed for construction is increasingly available locally. In most instances, it can be rented from the administrators of northern villages, landholding corporations or private owners. Where this is not possible, transportation must be arranged by ship.

Renting equipment in the community where construction work will be performed is encouraged. Contact the northern village in question for information about the equipment available (description, manufacturer, model) as well as the hourly or weekly rental rate.

1.11.3 Archeological sites

Known archaeological sites are usually shown on regional and local land use plans. Protective measures must be taken during construction work to avoid destruction or damage to these sites.

If relics or artefacts are discovered during work on a project, work must be stopped immediately and the Ministère de la Culture et des Communications du Québec as well as the Avataq Cultural Institute must be contacted to ensure appropriate conservation measures are instituted before work resumes.

2. SITING AND LANDSCAPING

2.1 BUILDING SITING

When building a structure in Nunavik, choice of the site is important and must consider several factors.

Since there is no storm sewer system in the villages, drainage is by surface runoff or percolation. The site therefore must have good drainage and must be outside periodic flood zones. However, the natural grade must not slope too steeply, and fill and grading must be used as sparingly as possible. The site must also be far enough away from unstable soil such as river banks and the foot of cliffs, where landslides and avalanches are a concern. The lot must also be large enough to accommodate the building and provide the necessary space for service vehicle movements and parking of occupants' vehicles. Finally, the chosen site must not disrupt community habits and activities nor hem in another property.

Snow drifts may also block access to building entrances and exits, overload roofs, block windows and give unauthorized persons access to roofs. Buildings therefore must be constructed and oriented to effectively control the distribution and density of snow cover. This avoids drifting around the perimeter of buildings, obstruction of entrances and exits, soil warming and potential thawing of permafrost (see Chapter 3 – Architecture). There are fairly effective devices for reducing or eliminating drifting, using the wind to scour away the snow, but these should be used as a last resort because of their high cost.

To facilitate snow clearance from laneways, sidewalks and parking lots, sufficient space must be provided for depositing snow away from buildings. Choice of these spaces must factor in the possibility of these piles of snow in turn causing drifting.

Consideration must also be given to service vehicle (delivery of drinking water and heating oil, sewage removal, etc.) and personal vehicle (automobile, truck, snowmobile, ATV, etc.) access to buildings. Service vehicles must be able to approach close enough to the building or connection points to facilitate the operator's work and must be located away from public thoroughfares wherever possible.

Buildings should be raised above ground level to avoid heat transfer to the soil. This reduces snow accumulation under or near the building in winter (through the passage and acceleration of wind between the soil and the building floor) and protects the underlying soil from direct solar radiation that triggers summer thawing of permafrost.

Buildings must be oriented to capitalize fully on passive solar energy to minimize energy use and maximize natural sunlight. The principle is simple: solar energy enters rooms by radiation and is absorbed by walls, floors and furniture, then is released as heat. This principle is even more effective when materials and objects receiving sunlight have high thermal storage capacity.

2.2 USE OF URBAN INFRASTRUCTURE AND UTILITIES

Use of the existing road system should be optimized to avoid urban sprawl and promote appropriate density. This reduces the cost of infrastructure as well as sewage removal and drinking water and heating oil delivery services, which use tank trucks in Nunavik villages, except Kuujjuarapik, which has municipal water and sewage systems.

Rear vision is often difficult in winter, so road design ideally should not require service vehicles to back up when making deliveries. Vehicle access lanes and parking areas used in the community, including those for fire trucks, must be designed to accommodate their turning radius.

2.3 LANDSCAPING

Exterior development should limit mineralized surfaces (asphalt and concrete) in favour of pale-coloured (or highly reflective) materials that absorb little solar energy, to avoid forming heat islands and transferring large amounts of heat to the soil, which could thaw the permafrost.

To limit the amount of mud and soil tracked into buildings by inhabitants in spring and fall, pedestrian walkways should be installed. Wood or stone edging should also be installed between earthworks, pedestrian walkways and parking lots that are resistant to heavy machinery used in snow clearance.

The location of access ramps and stairways leading to buildings should be optimized to facilitate snow clearance. These may be made of wood but steel or fibreglass slats are preferable as they are more durable. Steel components should be galvanized.

Wherever there are domestic service connections (delivery or drinking water or heating oil, removal of sewage, etc.), a stairway and a landing must be installed more than 1.5 metres above grade level. Ladders are not recommended due to the risk of injury and falls in winter.

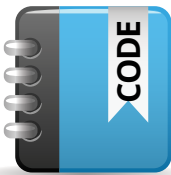
In Nunavik, snow and ice can melt suddenly. Care must be taken to ensure that meltwater runs far away from buildings and developed lands, to avoid flooding that might damage equipment, cause serious erosion and compromise the granular base's ability to support buildings.

Landscape planting should be encouraged. To extent the climate allows, well-designed plantings can play an important role in protecting soils from erosion caused by wind and runoff.

3. ARCHITECTURE

3.1 REGULATIONS AND RECOMMENDED APPLICATION

No construction regulations per se have been adopted by Nunavik authorities for design and construction of small residential buildings¹ and property developments. The Société d'habitation du Québec (SHQ) therefore recommends compliance with the regulatory provisions and techniques of the Régie du bâtiment du Québec (RBQ), mentioned below and designed to guarantee attainment of the minimum performance and quality levels it prescribes.



- Applicable **requirements** of the **Quebec Construction Code**², based on the most recent version legally in force in Quebec³
- Applicable **requirements** of the **Quebec Safety Code**, based on the most recent version legally in force in Quebec
- Applicable **requirements** of the Regulation respecting the professional qualifications of building contractors and owner-builders

The aforementioned regulatory texts also include all amendments published up to the deadline for acceptance of offers or bids. The transition periods stipulated in proposed regulations at the time of their adoption must also be taken into account. In the event of disagreement or contradiction in regulatory texts, the strictest requirements and criteria shall prevail.

In addition to the RBQ standards, there are other technical prescriptions under Quebec's jurisdiction that the SHQ deems relevant and recommends for all categories of residential construction in Quebec, such as the **technical requirements of version 2.0 of the Novoclimat Program, "home" and "small multi-unit residential buildings" components**, published by the Ministère de l'Énergie et des Ressources naturelles (MERN), as energy efficiency incentives (see Appendix V). Although compliance with the Novoclimat Program remains optional in Quebec, it is highly recommended, especially in northern areas with major energy efficiency stakes.

3.2 OPERATION AND MAINTENANCE – GENERAL

3.2.1 Mechanical and electrical equipment

Sufficient clearance and adequate access must be provided around and near mechanical and electrical devices and equipment for regular or sporadic inspection, adjustment, provisioning, maintenance, repair and replacement (see also section 4.1). Under no circumstances may this clearance be less than that required by Quebec regulations (see section 3.1) and stipulated in the manufacturer's recommendations. The design of work areas for maintenance personnel must also comply with the requirements of the Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST).

1. The Construction Code adopted by the Régie du bâtiment du Québec does, however, contain requirements that may apply to residential buildings, especially for plumbing, electricity, petroleum equipment and energy efficiency.

2. Use of the word "Code" in Part 3 below means the Quebec Construction Code.

3. The new section on energy efficiency (part 11) of the Building chapter of the Quebec Construction Code applies only to exclusively residential buildings (primary use: group C) with a built area of no more than 600 m² and a building height of no more than three storeys.

3.2.2 Finishing materials and products

The choice of materials and products, primarily those used for finish, should be based on their durability and ease of maintenance, repair or replacement.

The choice of materials and products should also be based on their availability, especially planned shipping dates, to avoid any additional costs and any work delays. Where delays are foreseeable, it is preferable to use substitute materials and products.

The choice of certified products is recommended. There must be assurance that the products and materials used meet the minimum quality standards set by recognized standardization bodies such as Underwriters' Laboratories of Canada (ULC) and the Canadian Standards Association (CSA).

Standardization of materials and products is also recommended. This means limiting the variety of materials used and the number of models of manufactured products for all projects or buildings, to reduce inventory of replacement materials and products. Ideally, materials and products of the same type should be sourced from a single manufacturer. This goal will be facilitated if consideration is given to materials already used in buildings in the same building stock. This approach should also promote a degree of esthetic uniformity in groups of buildings.

3.2.3 Inspection and maintenance planning

To optimize planning of inspection and maintenance operations for installed equipment, materials and products, a "building management manual" should always be provided by the contractor upon delivery, under a clause to this effect in the call for tenders documents.

This type of manual usually includes all useful information about components, such as the technical specifications of key materials, cleaning and maintenance instructions and frequencies, the list of spare parts and tools required, expiration or replacement dates, a description of applicable warranties, the full list of names, postal and email addresses, and telephone and fax numbers of suppliers and manufacturers. The manual also contains all methodology for checks, tests, settings and balancing of mechanical equipment, in electronic media, in a format accepted and approved by the owner's representative.

Under the same heading in call for tenders documents, training sessions for building maintenance personnel may be required.

3.2.4 Materials and product replacement

Based on personal experience and prior maintenance and repair operations, the owner's representative, in cooperation with the maintenance crew leaders, should determine the materials and equipment that require supply of replacement products, so specific requirements can be included in call for tenders documents and the construction contract. The owner's representative will also have to determine where these products must be delivered and stored. Replacement materials normally should be related to the following components.

- Interior finish materials and products for floor coverings, walls, partitions and ceilings, including paint in each colour used
- Exterior wall and roof cladding materials and products, including paint in each colour used
- All common hardware parts deemed necessary for doors, windows and indoor furniture fittings
- All glazing units deemed necessary for doors and windows

Provision must be made for reasonable quantities of materials such as insulation.

3.3 VOLUMETRICS

3.3.1 Aerodynamics of volumetrics

In Nunavik, sturdy foundations combined with architecture and materials designed to provide strong wind resistance are essential for building sustainable housing, as extreme weather conditions often produce gusts exceeding 100 km/h.

When strong winds are present, buildings raised above grade (approximately 0.6 to 1.2 m) and low roof pitches or flat roofs provide aerodynamic qualities that let the wind pass freely under and over the house, thereby reducing pressure on the constructed volume and vibrations during storms.



FIGURE 3.1: HOUSE CLEARANCE ABOVE GRADE / SOURCE: SHQ

A raised building also reduces snow accumulation around constructed volumes, which helps maintain the permafrost.

Figures 3.2 and 3.3 show the flows and wind effects above and below a typical house built on adjustable jacks that lift it off the soil, and their aerodynamic effect on snow accumulation on the ground.

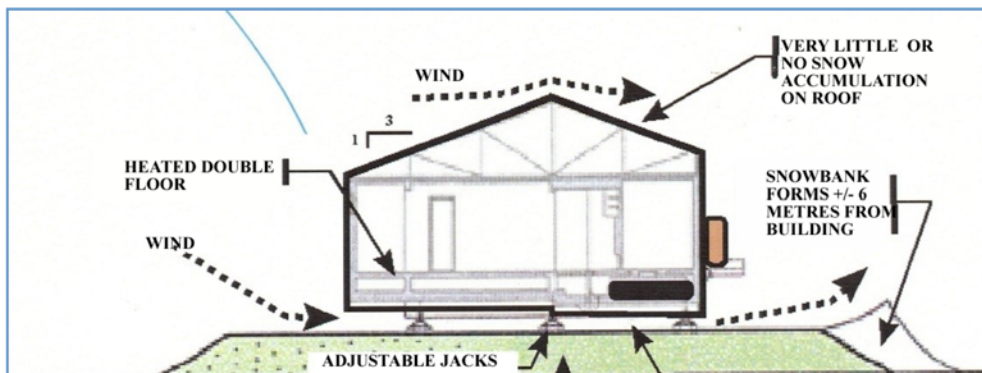


FIGURE 3.2: HOUSE AERODYNAMICS TO REDUCE SNOW ACCUMULATION
SOURCE: TOPOCLIMAT ET MICROCLIMATS DE LA VALLÉE DE SALLUIT (NUNAVIK), THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES, UNIVERSITÉ LAVAL



FIGURE 3.3: HOUSE AERODYNAMICS TO REDUCE SNOW ACCUMULATION
SOURCE: CENTRE D'ÉTUDES NORDIQUES, UNIVERSITÉ LAVAL

3.3.2 Rationalization of volumetrics

To maximize energy savings during the cold season, building designers should reduce the ratio of perimeter exterior wall area to indoor floor area as much as possible to reduce the area of insulated walls and thus the amount of thermal loss. For this reason, a square is the best configuration. This rationalization of volumetrics also achieves savings in building construction costs (time and materials) and throughout the structure's life cycle.

3.4 BUILDING ENVELOPE

A building's envelope separates outdoor and indoor conditions for the comfort of occupants. The Building Code refers to this function as "separation of different environments." The envelope design therefore must consider environmental parameters such as the site, orientation, climate and local geotechnical specifics.

The recommendations contained in this section strive for high-performance, sustainable design of the envelope in northern locations. They should also help clarify or complement the related requirements in the Building chapter of the Code, especially those in part 9, since these are designed for small-scale buildings. On this point, it should be noted that part 9 sets out very specific and relevant technical specifications to ensure that the building components covered in this chapter contribute to construction quality.

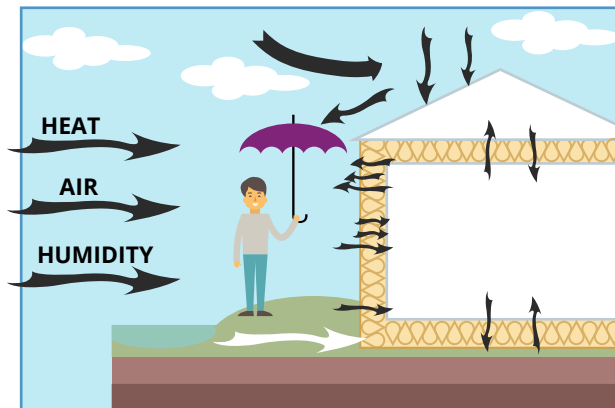


FIGURE 3.4: MOVEMENT OF HEAT, AIR AND HUMIDITY NEAR A BUILDING / SOURCE: SHQ

In the area of standards, also note that part 11 of the Building chapter of the Code covers energy efficiency of all new construction of three floors or less with total building area of no more than 600 m². These specifications apply to insulation and air and water seal of walls, roofs and floors, performance of doors and windows as well as indoor mechanical ventilation. Modelled on the Novoclimat Program of the Ministère de l'Énergie et des Ressources naturelles (MERN), these fairly recent requirements should achieve a 20 to 25 percent improvement in energy performance of new construction over the previous regulations, while maintaining and even improving occupant comfort.

Note that the following presentations include an instructional preamble for most of the concepts covered, to highlight the need for strict and reliable compliance with the installation of building envelopes in a northern climate.

3.4.1 Envelope seal

Since a building's envelope must separate indoor and outdoor conditions, the seal must be as tight as possible. Uncontrolled movement of air, humidity or water through the envelope can have negative repercussions (see Appendix VI), so it is appropriate to address sealing solutions through three factors.

- airtightness
- water vapour seal
- precipitation seal

Note that in part 5 of the Building chapter of the Code, the specifications on “separation of different environments” cover the envelope seal in terms of these same three factors.

3.4.1.1 Airtightness

General

All architectural components that ensure overall building resistance to air infiltration and exfiltration are called the “air barrier system” or “airtightness system.” This is considered a system because it encloses all insulated planes of the envelope: insulated walls, floors and ceilings as well as the points where these planes intersect. The system may be formed of a single continuous material or various overlapping materials (see Figure 3.5).

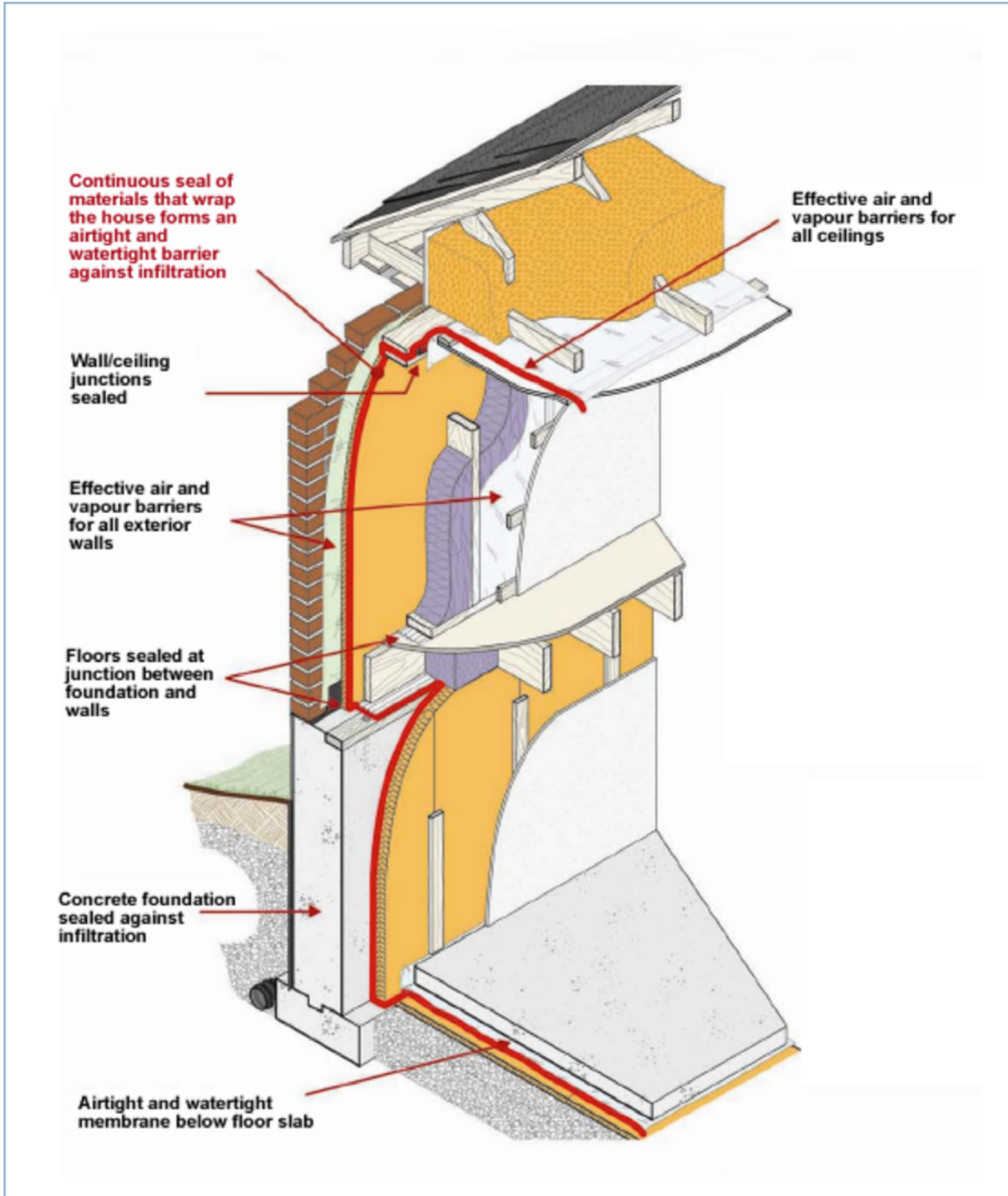


FIGURE 3.5: ILLUSTRATION OF AN AIR BARRIER SYSTEM BASED ON CONTINUITY (RED LINE) IN A STANDARD RESIDENTIAL BUILDING / SOURCE: MERN-NOVOCLIMAT

For the airtightness system to function effectively (see Appendix VII), good practices dictate that it possess at least the following properties.

- Continuity
- Structural strength
- Low air permeability
- High water vapour permeability
- Durability

Since air barrier quality is one of the keys to indoor comfort and energy savings in northern buildings, choice of a superior quality sealing system should be a priority. The air barrier system should consist of materials with above-average performance test values for common products in the market, rather than the minimum values dictated by the regulations.

It is difficult to predict the final airtightness of a specific construction assembly. Available data on the various systems used in construction are scarce and laboratory tests involve specialized facilities that are very expensive. For these reasons, an on-site infiltrometer test is highly recommended for all construction in Nunavik (see section 3.4.6).

General design

Two common design solutions are available for creating air barriers in northern applications.

- A so-called external membrane that combines the air barrier and rain screen functions is usually installed on the outside face of the insulation.
- A so-called “air barrier/vapour barrier” that combines these two functions must be placed on the inside face of the insulation.

Since uncompromised continuity is the essential quality of an air barrier system, the choice between these two systems will be specifically linked to obtaining the best possible continuity in system materials. For example, the air barrier in a ventilated attic must be formed by the vapour barrier sheet installed immediately behind the interior finish, since it is difficult to install a membrane on the cold side of flexible insulation in an attic obstructed with wood struts. In this specific case, the “air/vapour barrier” system must be chosen.

In the remainder of the air barrier system for the same building (in insulated walls, for example), it is quite feasible to switch to an “external” air barrier system, provided a sturdy, continuous connection is made between the wall and the attic.

To maintain total integrity of the building system, a sealed connection must be made between the wall air barrier and the foundation walls at the base of the building, or if the building is raised above grade, with the air barrier for the insulated floor.

Practical tips

Here is a series of practical tips about materials and design to install an effective, durable air barrier system in a northern building.

1. The air barrier membrane must be certified by the Canadian Construction Materials Centre (CCMC) not only in the “intermediate sheathing membrane” category but also the “air barrier” category, so it must have two certification numbers.
2. Regardless of the regulations, the “air permeability” value of the membrane used must be no more than 0.01 l/s/m² at 75 Pa.
3. Regardless of the regulations, the “water vapour permeability” value of the air barrier membrane must be at least 12 US perm if it is also used as an exterior rain screen.

4. The “water penetration resistance” value of the exterior membrane must be as high as possible to avoid water infiltration into the walls during construction. Under no circumstances should a membrane composed of microperforated polyethylene be used.
5. Selection of an exterior membrane should be based on its superior resistance to tearing and delamination, so as to maintain its integrity in frequently extreme conditions on construction sites.
6. To ensure the exterior membrane seal at rough openings for doors and windows, self-adhesive reinforcing membrane must be applied on all four edges of the opening and folded toward the interior and exterior of the wall in compliance with the CAN/CSA A440 standard on installation of doors and windows. Any extremity without an air barrier joining these openings must be sealed at the edge of the opening with a continuous double bead of compressed plastic sealant.
7. Airtightness of the exterior membrane where it meets architectural projections or electromechanical fixtures passing through the membrane must be ensured with plastic sealant for small wires and conduits, and with self-adhesive membrane for larger components.
8. Exterior membrane strips should always be sealed where they meet with the appropriate compatible tape, at a temperature of 5°C or more. Tape should only be applied in the same direction as furring for siding, by pressure and rubbing to optimize adhesion.
9. Mechanical securing—temporary or permanent—of exterior membranes that are not self-adhesive should be located beneath furring for siding or with screws through washers at least 25 mm in diameter. Use of a stapling hammer should be limited to nailing parallel to the furring for siding.
10. Exterior membranes should be backed by a rigid component such as sheathing or insulation panels to prevent potentially destructive vibrations in violent wind.
11. The new self-adhesive exterior membranes are an especially good choice because they require no mechanical anchors or backing panels for their protection and hermetically seal membranes between strips.
12. Exterior membranes composed of polyolefin fibres must not be left on the site, exposed to UV radiation longer than the time prescribed by the manufacturer, which is usually four months.
13. On walls of the exterior envelope, a single air barrier film should not be used as an “air barrier/vapour barrier” system because it does not provide the necessary structural resistance for lateral winds to which the wall envelope is exposed.
14. Choice of an air/vapour barrier system (installed on the interior face of the insulation) is acceptable provided the sheathing insulation protects it from any air convection that would cool it, otherwise damaging condensation points would form inside the system.
15. Any self-adhesive membrane used as a joining, reinforcing or transition material inside an air barrier system should be of the “winter” or “lt” (for low temperature) type, given the risks of low temperatures on the site during construction. These membranes should also be used only with a compatible primer applied to their substrate.

3.4.1.2 Water vapour seal

Figure 3.6 shows the interior face of a wall protected with a polyethylene sheet vapour barrier.

General

Remember that the purpose of a vapour barrier on an insulated wall is to minimize the migration and dispersal of water vapour from the indoor environment into the cold components of the building envelope, where this humidity would then condense and, over the long term, pose a risk of dampness and deterioration of materials. This risk of condensation is greater in a northern climate due to the very low outdoor temperatures to which buildings are subjected and their potentially higher level of humidity (especially in houses).



FIGURE 3.6: WATER VAPOUR SYSTEM ON INTERIOR WALL FACE
SOURCE: GOOGLE IMAGES

In addition to being required by good practices in the North American climate, water vapour protection is mandatory for all insulated wall, ceiling and floor surfaces under the Construction Code, which stipulates maximum water vapour permeability of $60 \text{ ng/Pa}\cdot\text{s}\cdot\text{m}^2$ (1.05 perm US) for the material used (see Appendix VIII).

General design

Interior water vapour barriers generally use plastic sheet (polyethylene 0.15 mm thick) or an aluminum film laminated to Kraft paper or a thin insulation batt. Products with an aluminum finish have three advantages: very low water vapour permeability, an additional insulating effect due to the ability of aluminum to reflect heat waves back to the building interior, and ease of sealing with tape.

Alternatively, if composition of the envelope allows, the designer may opt for the solution of an air and vapour barrier integrated into a single membrane, described previously in section 3.4.1.1.

Installation of a vapour barrier is subject to requirements of continuity and durability identical to those detailed for the air barrier in section 3.4.1.1, one of their shared functions being to form an airtight barrier. When correctly designed, the vapour barrier should form a genuine protection “system” that covers insulated walls, floors and ceilings like a shell, with no breaks.

Obtaining acceptable continuity requires solid sealing of all junction points in the vapour barrier, including where it meets any interior structural (floor joists) or electromechanical (wires, piping, etc.) projections.

Unless it is designed as an air and vapour barrier system, the vapour barrier is installed on the interior face of the building frame. The Code prescribes that it “[...] shall be installed sufficiently close to the warm side of insulation to prevent condensation at design conditions.” This criterion allows some latitude in the exact placement in relation to the insulation: for example, it could be placed between insulated framing and rigid insulation placed on the interior face. A recognized rule is to place at least two thirds of the insulation value on the exterior (cold) side of the wall, with the vapour barrier to be placed within the interior third.

Practical tips

Following are a series of practical tips on materials and design for installing an effective, durable vapour barrier system in a northern building.

1. The vapour barrier membrane should greatly exceed the standard of 60 ng/Pa.s.m² for required minimum permeability and should be type I. Note that use of only an interior rigid foam insulation panel as vapour barrier will not attain the type I class, even with sealed joints.
2. Avoid perforating the vapour barrier by separating electrical boxes and wiring from the interior finish with 38 mm thick furring so electrical fittings are entirely on the surface of the vapour barrier membrane.
3. Mechanical fastening of sheet membrane should be limited to a few temporary securing points, since the membrane ultimately will be held in place by the interior finish system.
4. Continuity of the vapour barrier should be assured by a 100 mm overlap between adjacent strips of the membrane or junctions, and by application of a continuous sealant joint in the overlap formed.
5. Acoustic sealant in tubes is the preferred compound for sealing vapour barrier sheets due to its high adhesion properties and permanent flexibility.
6. Joints between two membranes should be taped over on the surface in addition to the sealant applied in the overlap.
7. The preferred tape for double joint sealing is the same as the exterior tape used for air barriers.
8. Any mechanical fastener head, visible or not, should be taped over.
9. When erecting the building framing, remember to incorporate strips of membrane in preparation for sealing all junction points in the insulated envelope where vapour barrier continuity is required (e.g. at the top of an interior bearing wall or where an interior partition meets an exterior wall or insulated ceiling).
10. When erecting the building framing, make provision to include membrane strips on insulated ceilings for future connection of the ceiling vapour barrier with the exterior wall air barrier, to ensure its continuity.
11. Where the vapour barrier meets rough openings for doors and windows, a continuous connection on all four sides with the air barrier membrane that usually surrounds the framing of these openings is recommended. The most effective method is to lap the air barrier over the indoor vapour barrier with adhesive between the two.
12. At rough openings for doors and windows, once the air and vapour barrier junction has been sealed, the vapour barrier system and the door or window frame must be securely sealed on all four sides. Special tape, sealant in tubes applied to the base of the joint, or a strip of self-adhesive membrane are all acceptable solutions.
13. Avoid stretching the membrane, especially at interior corners, to avoid tearing when carpentry components force it into the wall or ceiling framing.

3.4.1.3 Precipitation seal

General

Protection from rain and snow is one of the main methods of “separating different environments” (interior and exterior) as required by the Code. This is shown as the basic function of the building envelope, to prevent:

- infiltration of water or snow into interior spaces;
- premature deterioration of envelope components, by minimizing infiltration into its exterior components (see Appendix IX).

General wall design

Based on the two fundamental objectives indicated above, in section 9.27, Cladding, the Building chapter of the Code presents a series of highly complex, sometimes limiting specifications and design choices adapted to various climate or other conditions.

Residential buildings as well as those constructed in humid and cold areas are subject to specifications on wall resistance to precipitation. In this building category, the Code specifies the use of two types of protection for exterior cladding: an initial external protection, formed by the wall siding, and a second layer of protection, placed immediately behind the siding, consisting of a flashing assembly and drainage system containing one or more so-called “intermediate sheathing” materials (intermediate sheathing panel or intermediate sheathing membrane) designed to intercept and dissipate water or snow that manages to penetrate the first payer of protection.

In brief, we can conclude that the Code requirement applicable to residential buildings in Nunavik allows a choice between two wall types: the “hidden protection” or “rain screen” wall type (see Appendix X).

Beyond the Code, we find that the specific challenges of structures erected in a climate such as that in Nunavik involve their resistance to wind loads, which are violent and sustained, and drive rain, snow, hail, sand and even dust into the smallest gaps in exterior siding and roofing. For example, the general dirtiness of air barriers in buildings under renovation has been noted in this region, on which wood siding has been removed 25 years after installation, a sign that foul weather manages at some point to work its way through joints in the wall siding. This dirt on an air barrier diminishes its effectiveness for humidity.

Under such severe conditions of exposure, adequate sealing of the external wall envelope is especially important, even for ventilated walls of the “open rain screen” type. The importance of ensuring effective drainage and aeration of the cavity behind the sliding remains essential on these structures.

General roof design

In Nunavik, there are two architectural solutions in roof design for residential buildings.

1. A roof with a vented attic.
2. A vented sandwich roof with cathedral ceiling.

The option of a mechanically drained flat roof must be automatically ruled out. In most cases, the drain could not be connected to a sewer or storm drain system, as the water would freeze once it entered the open space under the house, and such systems are normally not present in northern communities.



SOURCE: SHQ

While a pitched roof is preferable, the pitch must be fairly low, to reduce snow accumulation in winter, based on the aerodynamic principle that a flatter roof profile promotes natural shedding of snow. Wind strength and speed in Nunavik villages actually carry away the snow that falls on low-pitch roofs (see Figure 3.7). By contrast, snow and ice build-up on steep-pitch roofs pose a genuine hazard for people entering and leaving such houses.

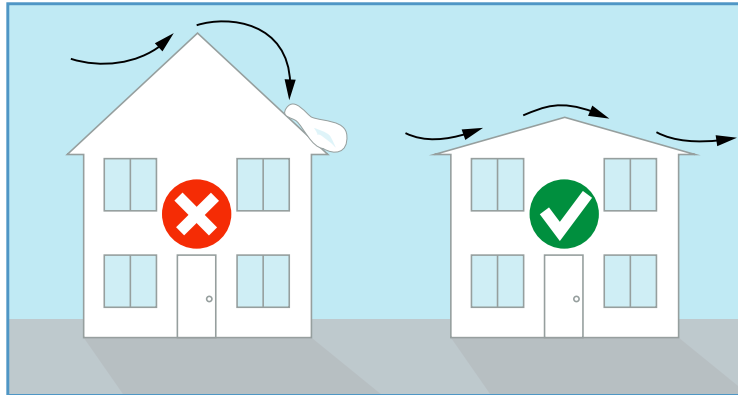


FIGURE 3.7: SNOW ACCUMULATION BASED ON ROOF PITCH
SOURCE: SHQ

Figure 3.7 shows the effect of wind on a steeply pitched roof where snow accumulates and on a gently pitched roof where it sweeps the snow away.

Between the two roof types mentioned earlier (ventilated attic or cathedral ceiling), the first is preferable in Nunavik based on two technical considerations, even though the second design may appear more architecturally interesting.

- An interior ceiling improves occupant comfort because there is less volume to heat in winter, which also saves energy.
- An accessible attic facilitates inspection of materials and maintenance, given that any open space under the roof is always subject to damage, often caused by condensation or water infiltration.

Regardless of which design is chosen, it is wise to remember that when storms rage in Nunavik, ventilated roofs are at risk of greater infiltration of light particles by the air currents to which attics are exposed. Two particular characteristics of northern regions combine here: wind strength and fine snow that, in certain weather conditions, takes the form of fog. Aeration of ventilated roofs must be designed to control these additional risks.

When roofs are exposed to rain, violent winds can sometimes drive the precipitation with incredible force and focused direction, forcing the designer to institute measures that increase roof strength and water-tightness. These measures include:

- Choosing cladding especially resistant to foul weather and the freeze-thaw cycle;
- Using extra-sturdy fasteners;
- Ensuring double water tightness.

Practical tips for walls and roofs

Following are a series of practical tips on materials and design to ensure that the exterior envelope of a northern building provides effective protection from precipitation.

1. Favour the “open type rain-screen” exterior wall design because it provides a barrier against very foul weather and the risk of water infiltration further into the wall envelope under the force of high winds.
2. It is wise to configure the ventilated cavity of “open type rain-screen” walls with the following design details.
 - Compartmentalize the cavity into sections no more than 6 m wide and one story high, closed at building corners, to balance pressure outside and beneath the siding.
 - Place siding furring vertically rather than horizontally to ensure drainage of water that might infiltrate behind the siding, and for siding requiring horizontal support, install a double row of cross-furring.
 - Install a filtering medium at the top and bottom of the cavity to block snow and dust particles.
 - Use an intermediate cladding membrane that complies with the CAN/CGSB-51.32 standard with a water penetration resistance of at least 200 cm based on AATCC (Association of Textile, Apparel & Materials Professionals) tests. This requirement to protect against water is generally easily met by the air barrier membrane required as part of the wall structure (see section 3.4.1.2).
 - Install a water cap board above door and window openings in compliance with the CAN/CSA A440 standard for fast drainage of water that may infiltrate behind the siding above these openings.
 - Install an exterior water table board at the bottom of door and window openings to carry runoff from water that may infiltrate behind the exterior siding.
3. Any roof covering should include a primary waterproofing system formed of a continuous bituminous membrane.
4. To ventilate voids under the roof, an extended access path must be provided between the void and the air intake, that includes a continuous filtering medium (or particle filter) at the entrance and exit of the ventilation circuit. The ventilated soffits used in southern latitudes are not recommended and preference should be given instead to the concept of a continuous horizontal air intake on the wall, integrated into the wall cladding 1.5 m or more below the level of the attic insulation (see Figure 3.8 below).

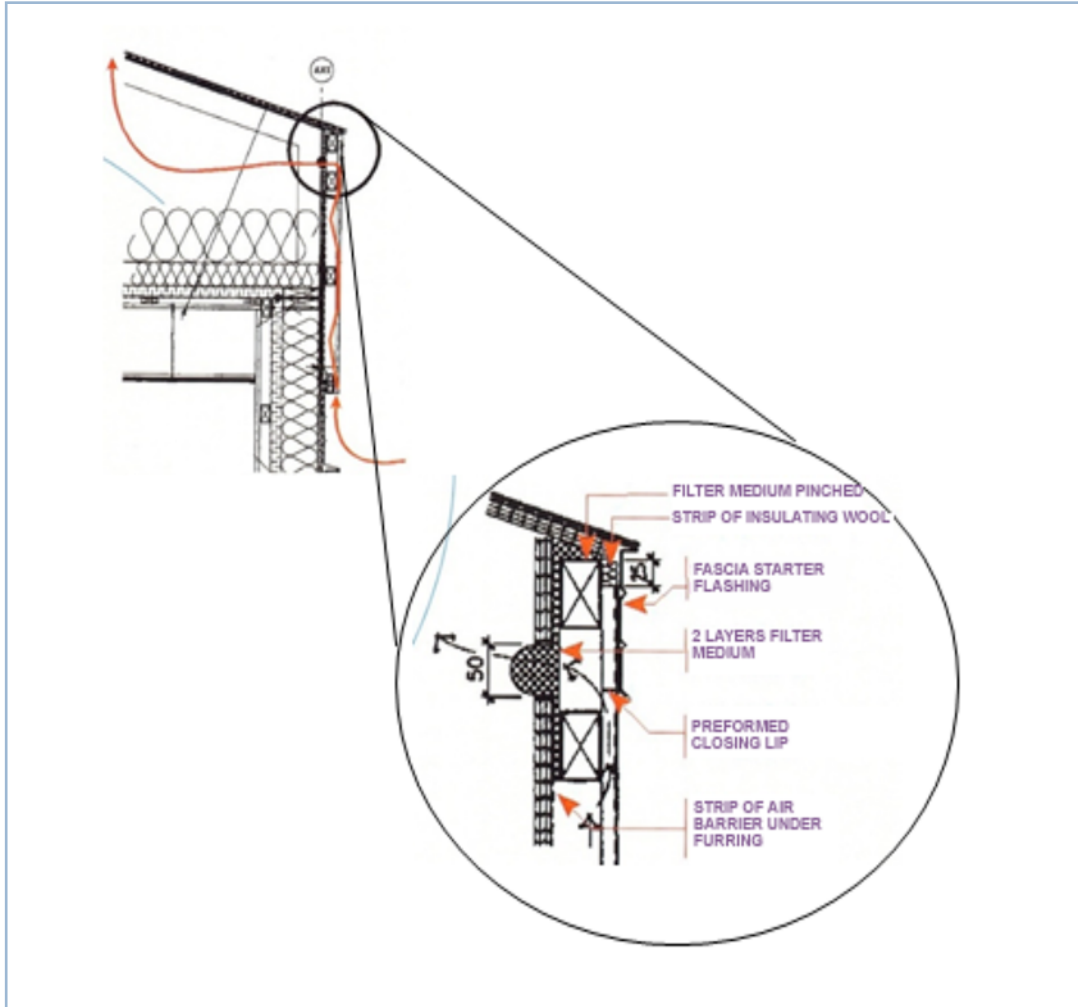


FIGURE 3.8: VENTING A VOID UNDER A ROOF / SOURCE: SHQ

Figure 3.8 shows how a void below a roof can be ventilated with additional protection against infiltration: air enters behind the exterior cladding where the upper section meets the lower section, and passes through a filtering medium before entering the attic.

3.4.2 Insulating the envelope

Insulation in the walls, raised floor or roof of buildings in a cold climate provides the envelope with thermal resistance and limits heat loss in winter. This is an overriding concern in building design in Nunavik, which has particularly cold, harsh winters.

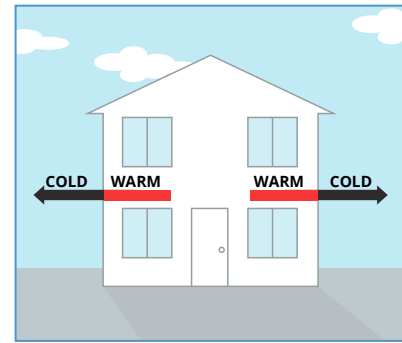
Many factors affect adequate insulation of building envelopes in northern regions, with the following goals.

- Ensure uniform indoor comfort for building occupants, regardless of the outdoor temperature, based on the principle that the better an exterior wall is insulated, the more uniform the interior comfort of the building. Conversely, insufficient insulation allows interior surfaces to cool due to excessive heat loss through thermal radiation, thereby making the building uncomfortable.
- Reduce energy consumption as heating oil is fairly expensive at this latitude.
- Extend the service life of building envelope components, given that insulation directly reduces the risks of condensation inside walls.
- Meet regulatory standards, which are quite strict in latitudes where heating degree days can reach 8,000 to 9,000, as in Nunavik (see Appendix XI).

Insulation specifications are found in two different sections of the Code's Building chapter: part 9.25, which applies generally, and part 11, which contains the mandatory minimum insulation requirements for new construction not exceeding three stories and with a floor area not exceeding 600 m².

Because it strives for high energy efficiency in all envelope components and contains a table of requirements specific to the coldest regions, where heating represents 6,000 degree days or more, part 11 of the Code's Building chapter constitutes a highly relevant reference for all residential buildings in Nunavik. The most useful requirements are the minimum insulation values in the form of thermal resistance coefficients expressed in RSI units for each building envelope component, as well as specifications on treatment of wood, steel or concrete thermal bridges (see Appendix XII).

To document the regulatory specifications on insulated walls, Table 3.1 reproduces Table 11.2.2.1-B of the Code's Building chapter with the minimum "total" thermal resistance values for primary exterior components of a building in Nunavik. "Total" resistance means that the insulating value is that required for the total composition of the wall, not that required strictly for the insulation, without allowing for thermal bridges created by framing.



SOURCE: SHQ

BUILDING COMPONENT	Total thermal resistance (TRSI)
Roof or ceiling separating a heated space from an unheated space or from the exterior air	9.00
Wall above grade except a foundation wall, separating a heated space from an unheated space or from the exterior air	5.11
Foundation wall separating a heated space from an unheated space, the exterior air or contiguous soil <i>NB: A foundation wall of which more than 50 percent of the surface is exposed to exterior air, as well as that part of a foundation wall framed in wood, must have a total thermal resistance equal to that required for an above-grade wall.</i>	2.99
Floor separating a heated space from an unheated space or exterior air	5.20

TABLE 3.1: TOTAL THERMAL RESISTANCE FOR BUILDINGS IN A LOCATION WHERE THE NUMBER OF DEGREE DAYS BELOW 18°C IS 6,000 OR MORE (TABLE 11.2.2.1-B FROM THE BUILDING CHAPTER OF THE QUEBEC CONSTRUCTION CODE)

On the regulatory provisions applicable to thermal bridges in walls, part 11 of the Code's Building chapter specifically stipulates that the insulation material must cover the building components that form a thermal bridge on the exterior or interior face or a combination of the two. Thus, wood or steel framing spaced less than 600 mm o.c., for example, must be covered by insulating material with a minimum thermal resistance of RSI 0.7 for wood and RSI 1.76 for steel. For thermal bridges in insulated floors, part 11 requires insulating covering with a minimum value of RSI 1.32.

It must be noted that to meet the regulatory requirement eliminating thermal bridges in wood frame construction, which includes the header and end joists, insulation is highly recommended on the exterior face of the framing for an effective solution. This design approach requires a break with current practice in Nunavik where, for a long time, thermal bridges were blocked on the interior side by adding insulating panels covering the walls and floor.

Adding insulation to the exterior of wall and floor framing under the specifications in part 11 of the Code's Building chapter on thermal bridges forces us to carefully consider the restrictions in other parts of the same chapter (section 9.25) on the placement of materials with low air and water vapour permeability within the building envelope. Popular rigid insulation panels such as extruded polystyrene have in fact been rated as vapour barriers: when placed on the warm side of insulated framing, this insulation will pose no risk of condensation, but if placed on the cold side, it must be thick enough for the dew point of the wall to be located within or on the cold side of the overlaid insulation panel. This highly important design aspect involves a calculation based on the table in the Code's Building chapter that specifically factors in the number of heating degree days in the region, which falls between 8,200 and 9,200 in Nunavik villages. Based on this table, in these villages, to place extruded polystyrene on the cold side, an insulation value of 50 to 55 percent of that for the insulation placed on the warm side must be provided.

The following three subsections propose certain measures applicable to floors, walls and roofs to ensure adequate insulation.

3.4.2.1 Floor insulation

In Nunavik, most buildings are raised above grade to prevent heat transfer to the underlying permafrost. The ground level floor therefore forms part of the building's exterior envelope. Insulating such a floor takes on special importance since 20 to 30 percent of heat loss in a northern climate is attributed to the raising of buildings.

In Table 11.2.2.1-A, the Code's Building chapter specifies a total thermal resistance of RSI 5.2 for an insulated floor raised above grade level. This requirement includes an insulating material of at least RSI 1.32 to block the thermal bridge formed by the framing. As stated earlier, the thermal bridge ideally should be broken on the exterior side of the framing so as to cover the header and end joists, the best solution for achieving continuity in wall-floor insulation (see Figure 3.9).

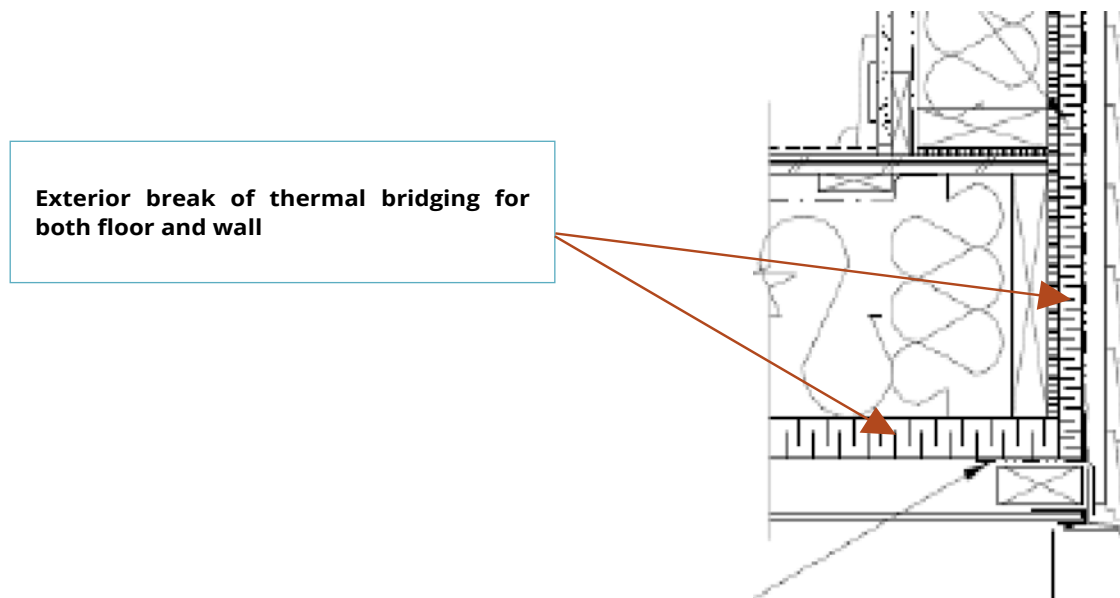


FIGURE 3.9: TYPICAL DETAIL OF WALL-FLOOR JUNCTION/ SOURCE: SHQ

Note that the exterior face of a floor raised above grade level rests at intervals on structural supports, usually steel beams, which also require minimum coverage with exterior insulation for a complete break of the thermal bridge.

A highly recommended construction concept for northern climates is a structural floor insulated to its full height, with a false floor above it, using the voids in the framing to run utility connections. This concept provides excellent continuity of insulation as well as an additional thermal break.

Use of structural framing consisting of wood I-beams or floor trusses rather than solid joists, insulated with blown glass wool, is also a wise choice because it further reduces thermal bridging in the floor.

In all cases, exterior insulation under the building must be protected by impact-resistant sheathing, since the open space between the ground and the floor rarely goes unused.

3.4.2.2 Wall insulation

Exterior wall insulation is dependent above all on the requirements of the Code's Building chapter, which specifies a total thermal resistance of RSI 5.11 for regions such as Nunavik, where heating represents 6,000 degree days or more.

This regulatory requirement includes installation of an insulating material as a thermal break for the wall framing consisting of studs, sills, plates and header and end joists that make up the exterior wall. Minimal resistance of the thermal break will vary from RSI 0.53 to RSI 1.76 depending on the type of framing (wood or steel) and the stud spacing. Under this heading, part 11 details the minimal RSI values for sheathing insulation as follows.

- a. requirement for wood framing
 - i. at least RSI 0.7 where wood framing is spaced less than 600 mm o.c.
 - ii. at least RSI 0.53 in other cases
- b. requirement for metal framing
 - iii. at least RSI 1.76 where framing is spaced less than 600 mm o.c.
 - iv. at least RSI 1.32 in other cases
- c. requirement for concrete construction
 - v. at least RSI 0.88 in all cases

Just as for wood floors, the thermal break should be located on the exterior side of wood framing so as to cover the header and end joists.

In this regard, since extruded polystyrene panels (blue or pink) are still widely used as exterior frame sheathing, it must be remembered that these constitute vapour barrier materials and that the Code governs their minimum thickness when installed on the cold side of framing. Thus, for a standard design wall with 2 x 6 insulated with 140 mm of RSI 3.34 glass wool (see Figure 3.10), calculation of the dew point under the Code will show that the insulating value of the polystyrene must be at least RSI 1.76, which means a panel at least 50 mm thick. We therefore can conclude that such a wall would produce a total insulation performance of RSI 5.91, which exceeds the required standard of RSI 5.11.

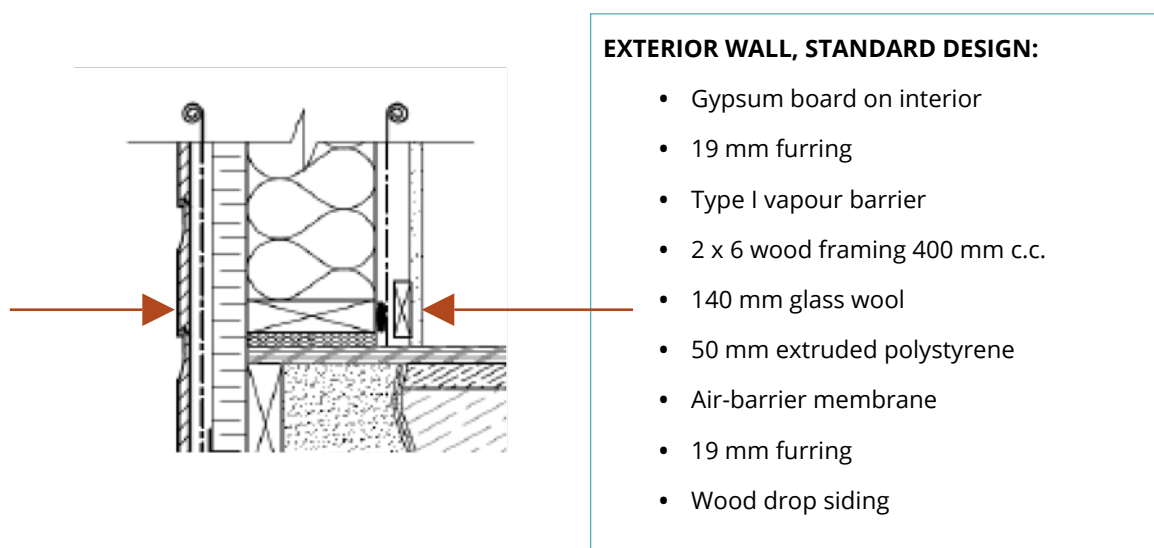


FIGURE 3.10: CROSS-SECTION OF STANDARD EXTERIOR WALL / SOURCE: SHQ

To create the thermal break required in part 11 of the Code's Building chapter on the exterior side, the solution to replace the vapour barrier insulation obviously is insulation that does not function as a vapour barrier, in this case, expanded polystyrene, a highly efficient material sold in high-density rigid panels with tongue-and-groove edges and with or without a laminated air barrier. Its insulating value is RSI 0.82 for a 25 mm thickness, which meets the Code's minimum requirement of RSI 0.7 for a thermal break on standard wood framing installed at 400 mm o.c.

Another solution in some Nunavik villages for obtaining a perfectly insulated wall envelope in northern areas is polyurethane foam sprayed in place for exterior coverage of framing. As an alternate solution instead of rigid exterior insulating panels, foam sprayed in place produces an effective air barrier containing no defects. Walls and floors insulated with this technique produce a building envelope of unmatched airtightness.

3.4.2.3 Roof insulation

Roof insulation value is dictated primarily by the requirements of the Code. As shown in Table 3.1, the required total thermal resistance for any "roof or ceiling separating a heated space from an unheated space or exterior air" is RSI 9.0 for regions where heating represents 6,000 degree days or more, as in Nunavik.

For a roof with a ventilated attic and a standard insulated ceiling finished with gypsum panels on furring, RSI 9.0 translates into a 460 mm depth of bulk mineral wool blown in between roof trusses, a substantial height.

Although the Code does not require a break in thermal bridges in insulated ceilings, the addition of insulating sheathing on the interior face of the roof trusses makes an attractive contribution to energy efficiency in a subarctic climate. As early as 1982, the SHQ introduced into its designs the installation of a 38 mm extruded polystyrene panel on the interior side of insulated ceilings. For a total performance of RSI 9.0 in the ceiling, this addition reduces the depth of bulk mineral wool blown into the attic to 385 mm.

The Code stipulates that the total thermal resistance of RSI 9.0 required for insulated ceilings below an attic may be reduced near the eaves where required by roof pitch and the necessary clearances for ventilation, provided, however, that the value is not less than that required for the wall. This solution must be combined with the installation of deflectors near the eaves to promote the free entry of airflows and ensure a minimum clearance of 25 mm below the roof decking (see Figure 3.11).

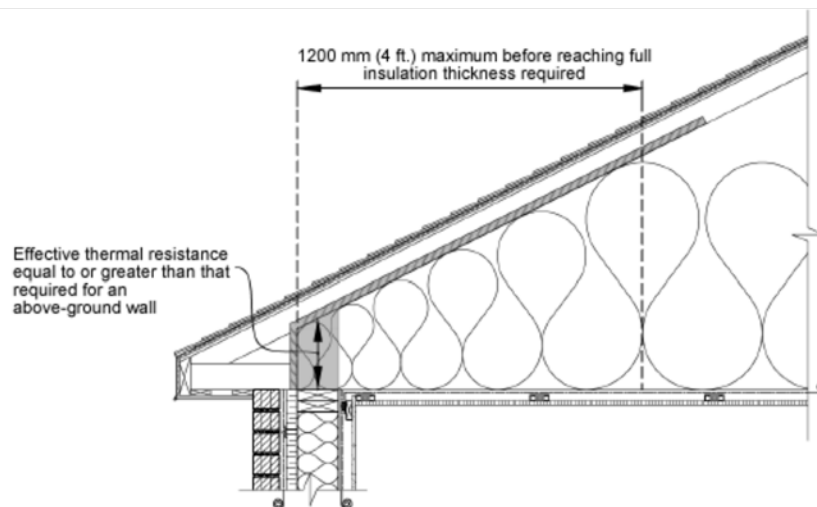


FIGURE 3.11: ROOF EDGE DETAIL / SOURCE: SHQ

A roof edge design with geometry that ensures full ceiling thermal resistance around the periphery, without reducing insulation depth, is the preferred solution. This design is found in the entire SHQ social housing stock allocated to the Inuit community (see Illustration 3.12).

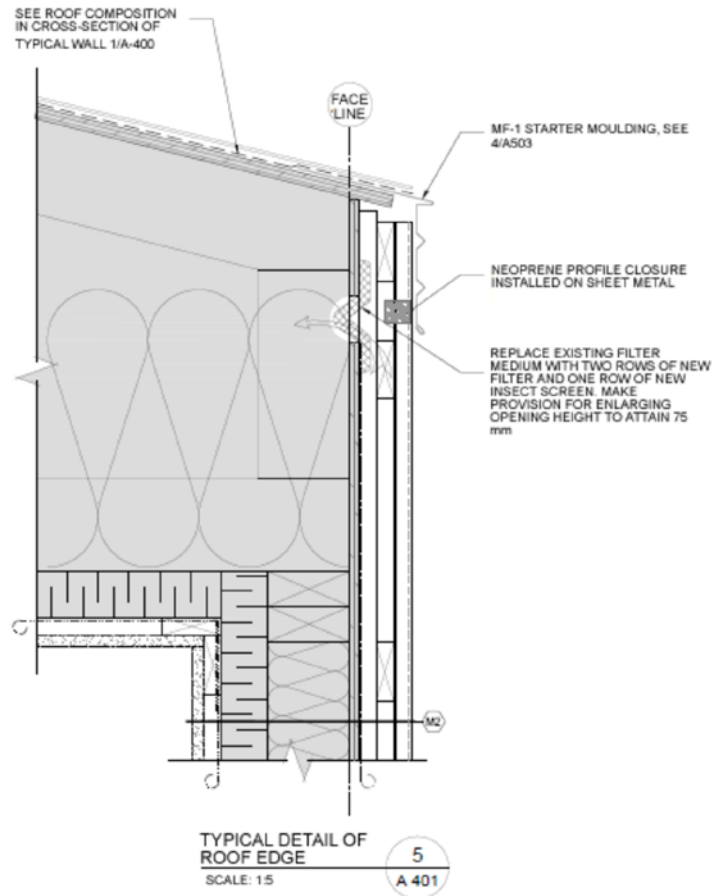
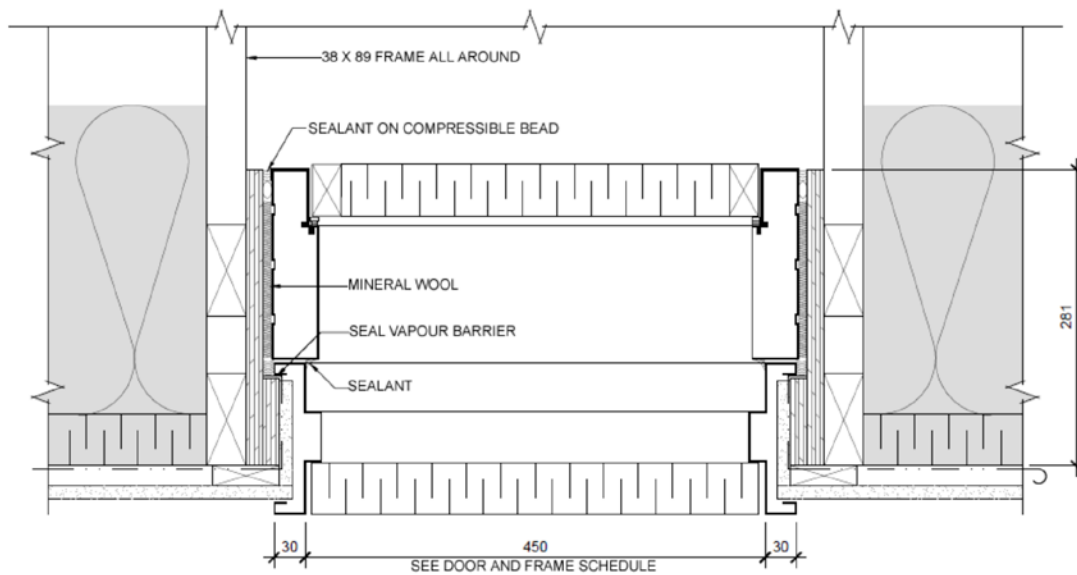


FIGURE 3.12: STANDARD DETAIL OF TYPICAL ROOF EDGE FOR LOW-COST HOUSING IN NUNAVIK / SOURCE: SHQ

The Code stipulates that there must be access to the insulated attic in each housing unit, in the form of an indoor access hatch at least 0.32 m² in area, one side of which must measure at least 545 mm. This hatch must be set in an insulated frame with double weather stripping and provide thermal resistance equal to that of the insulated ceiling. A design consisting of two superimposed hatches, such as those used by the SHQ in its major renovation projects, provides a more effective solution (see Figure 3.13).



DETAIL
ATTIC ACCESS HATCH
SCALE: 1:5

3
A 104

FIGURE 3.13: ATTIC ACCESS HATCH DETAIL
SOURCE: SHQ

No discussion on insulating voids under a roof is complete without addressing the quality of ventilation required for these spaces. Ventilation is required in all areas above ceiling insulation and is subject to strict standards set out in part 9.19 of the Code's Building chapter.

- The unobstructed area of all ventilation openings must be at least 1/300 the area of the insulated ceiling (1/150 if roof pitch is less than 1:6).
- At least 25 percent of the required flow must be located in the lower part of the void under the roof, with air intakes distributed to reach all parts of the insulation.
- At least 25 percent of the required flow must be located in the upper part. Note that the most efficient attic ventilation devices are the maximum type models, which must be located near the roof ridge. These ventilators must include a particle filtration medium as well as a drying pan at the base to capture condensation water.
- Ventilation must be distributed evenly between opposing sides of the building.

Insulated cathedral ceilings are subject to the same regulatory requirements as attics for insulation and ventilation. For optimal application, it is best to frame with roof trusses because their height can easily accommodate the necessary amount of mineral wool and still maintain the minimum required clearance of 63 mm between the top of the insulation and the underside of the roof deck.

3.4.3 Exterior cladding

As we have seen, building envelopes in Nunavik are exposed to extreme climatic conditions, so wall siding and cladding commonly used for residential construction in temperate climates is poorly adapted to this northern region, as their durability or performance is clearly inadequate.

3.4.3.1 Wall cladding

The architectural criteria for choosing exterior wall cladding in Nunavik have already been defined as follows.

- Proven resistance to impact in very cold weather
- Very low expansion coefficient
- Limited water absorption and good freeze-thaw resistance
- Resistance to abrasion by the “sandblasting” effect created by strong winds
- Modulation or installation promoting effective surface drainage
- Format that minimizes the number of surface joints
- Durable paint finish
- Ease of repair in the event of damage

The following cladding materials are deemed less suitable due to their disadvantages.

- Aluminum siding is extremely fragile to impacts and also subject to great thermal expansion and contraction during temperature changes.
- Vinyl clapboard expands and contracts during temperature changes and also becomes very brittle at low temperatures, and thus is subject to breakage from impacts.
- Wood composite drop siding (e.g. hardboard or “Masonite” panels) fades prematurely in Nunavik’s harsh climate and thus loses its water resistance.
- Prefinished engineered wood siding in boards or panels, where exposed, do not dry as effectively in northern climates, so damp engineered wood remains saturated with water, resulting in premature delamination at panel edges and board ends.
- Stucco is easily damaged and hard to repair.
- Reinforced fibrocement panels become brittle in cold weather.
- Reflective and pale-coloured cladding, especially on the southern face, reflects solar radiation, causing considerable build-up of energy (heat) in the soil around buildings, posing a risk of thawing and subsidence (see Figure 3.14).

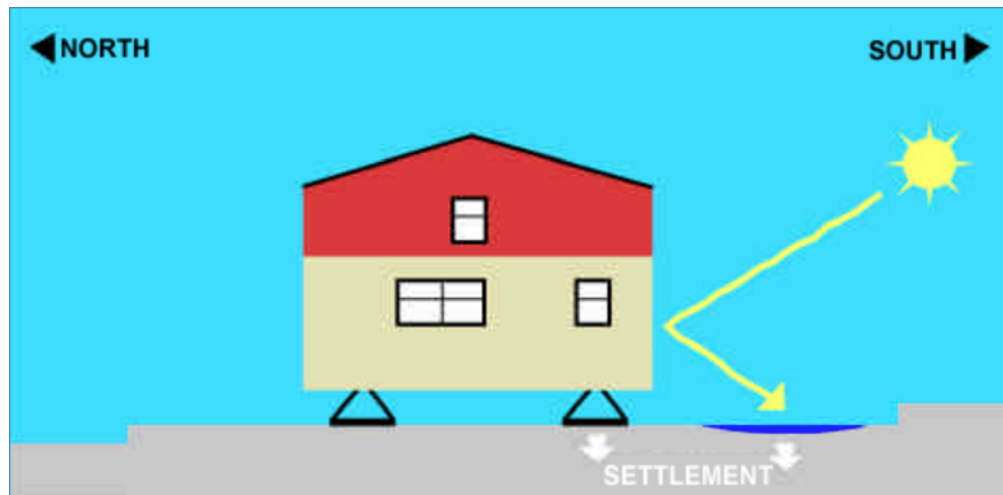


FIGURE 3.14: EFFECT OF PALE-COLOURED REFLECTIVE SIDING ON PERMAFROST
 SOURCE: TOPOCLIMAT ET MICROCLIMATS DE LA VALLÉE DE SALLUIT (NUNAVIK), THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES, UNIVERSITÉ LAVAL

In conclusion, solid wood siding or prefinished ribbed sheet steel are the two preferred materials in a northern climate.

Solid wood siding

- Solid wood drop siding is a preferred type of siding because its profile greatly facilitates repairs of breakage.
- Horizontal application is preferable because it reduces the risk of water infiltration between boards. In addition, porous cladding such as wood dries faster when placed over vertical furring.
- Pine is recommended as this species is recognized as very stable. For resistance to rotting, pressure-treated pine must be used, a raw pine from Western Canada, such as Lodgepole pine used by the manufacturer Goodfellow.
- This siding must be painted to avoid a gloomy appearance when the siding is wet. A factory-applied prepainted finish provides excellent protection and a warranty for up to 15 years against fading.
- Factory-painted trim is also recommended because the paint is much more durable than that applied on site during construction.

Factory-enamelled sheet metal panel siding

- When sold with an industrial-quality prepainted finish, this siding provides unparalleled durability.
- However, this material should not be used on the lower walls of a building, where it would be exposed to impact. Even minor impacts can cause irreversible denting.

The design and installation of wall siding supports on a rain-screen type of wall (wood furring system) are subject to the following standards under the Code.

- Siding must be fastened not only to the rough sheathing panel but also to the wall framing.
- Minimum profile of 19 x 64 mm or 19 x 89 mm, depending on whether it is fastened at 400 or 600 mm o.c.
- Maximum spacing of 600 mm o.c.

Caulking: all joints and intersections on an exterior wall where water might infiltrate must be sealed with caulking compound. This includes butt joints with door and window openings as well as with any projection where it pierces the siding.

3.4.3.2 Roof cladding

In Nunavik, the extreme pressure exerted by wind on roofing dictates use of the sturdiest cladding, a watertight system with a continuous sealed elastomeric bituminous membrane or asphalt shingle roofing laid over a membrane.

For pitched roofs, asphalt shingles are the preferred economical solution. Given the wind strength, however, certain precautions must be taken.

1. A shingle roof should include an underlying self-adhesive protective membrane covering the entire roof surface. In cold weather, primer must be applied under the membrane before it is installed.
2. Shingles must consist of a non-organic fibreglass fabric, which is highly resistant to freeze-thaw cycles. A product with a 25 year warranty is the basic standard.
3. To provide adequate resistance to tear-off, each shingle must be secured on two edges with continuous sealant in addition to mechanical fastening with at least six roofing nails, two for each tab.

3.4.4 Exterior doors

Exterior doors of a building, the same as any other opening in the envelope, are considered a potential source of air leaks and heat loss. Because it opens, a door will never achieve the same thermal resistance as the wall in which it is installed. However, there are some solutions available to maximize the efficiency of doors subject to the climatic constraints of Nunavik.

Design

Exterior doors must be made of steel cladding insulated with a polyurethane core, in compliance with the CAN/CGSB-82.5-M88 standard (16-gauge galvanized steel with a minimum of RSI 1.3). If a glass light is integrated into the door, it must be of insulating glass and if its area exceeds 0.46 m², it must incorporate the following minimum characteristics: sealed double glass, inert gas between the panes (e.g.: argon or krypton), low-emission glass (low-E), separated with an insulating spacer. It is preferable to install an insulated steel door in a frame that provides a thermal break, such as a wood frame, with a double high-performance perimeter weather stripping system, one strip being compression-type as specified in the manufacturer's engineering. The opening then becomes an integrated door and frame system similar to that of a window. Steel frames, even when equipped with a thermal break, are not a wise choice in terms of insulation, given the climate conditions in Nunavik.

In a northern climate, an integrated door and frame system should form part of the architectural entrance concept to establish an airlock, thereby maximizing protection from the cold. An airlock effect can be achieved in two ways: double doors installed in a single frame (one opening out and the other to the inside), or creating a vestibule with an exterior door on one side and an interior door on the other. This second solution is the best, because it reduces the amount of cold air entering the house each time the door is opened. The vestibule does not necessarily have to be heated, but may serve as a "cold porch," a very common design in Nunavik.

Part 9.6 of the Code's Building chapter sets out the intrusion resistance requirements for residential entry doors that are appropriate and should be applied during installation. In addition, for doors that open out and thus are exposed to extreme winds, a firmly secured chain or other retaining device to prevent the likelihood of tear-off.

Energy efficiency standards

Part 11 of the Code's Building chapter, on energy efficiency, includes a subsection on thermal performance of windows, doors and skylights that specifies minimum manufacturing requirements in compliance with the CAN/CSA A-440 standard for windows (see section 3.4.5 below). Note, however, that these are inadequate in a harsh climate such as that in Nunavik.

It is important to note that house doors are among the products certified by the North American ENERGY STAR program, which serves as a very relevant reference for selecting doors in a harsh northern climate. In that program, ratings assigned to products must be selected based on the climate zone where they will be installed, with zone D being specific to subarctic conditions (see Appendix XIII).

3.4.5 Windows

The same as doors, windows are the weakest link in a building envelope. Their thermal resistance and resistance to air infiltration are key factors in energy savings and comfort for the buildings in which they are installed.

Energy efficiency standards

The standards for this aspect of windows are found in the Code's Building chapter specifying a short list of design requirements in Part 11 on energy efficiency.

- Windows and skylights as well as glass lights installed in doors must achieve minimum airtightness of A2 under section 10.2 of the CAN/CSA A-440 standard for windows.
- The total area of rough openings in building components for windows, doors, skylights and other similar components must not exceed 30 percent of the above-ground wall area.
- The thermal characteristics of windows, doors and skylights must be determined in compliance with the CAN/CSA A440.2 standard on energy performance of window systems, as well as the user's guide, CSA A440.2-09 standard on energy performance of window systems, and must meet the values shown in Table 3.2.

Table 3.2 specifies the maximum U values and minimum EER values based on two geographic areas in Quebec: those requiring heating of fewer or more than 6,200 degree days.

BUILDING COMPONENT	Building located in municipality with no more than 6,200 degree days under 18°C	Building located in municipality with more than 6,200 degree days below 18°C
Maximum total thermal transmission coefficient (U) for doors without lights	0.9	0.8
Maximum total thermal transmission coefficient (U) / Minimum energy efficiency ratio (EER) of windows and doors with lights	2.0 / 21 or 1.8 / 13	2.0 / 25 or 1.6 / 17
Maximum total thermal transmission coefficient (U) for skylights	2.85	2.7

TABLE 3.2: MAXIMUM OVERALL HEAT TRANSFER COEFFICIENT (U) AND MINIMUM ENERGY EFFICIENCY RATIO (EER) FOR WINDOWS, DOORS AND SKYLIGHTS (TABLE 11.2.2. 4 TAKEN FROM THE QUEBEC CONSTRUCTION CODE)

The Code requirements are less than those of the North American ENERGY STAR program that provides certification for windows based on a division of the province into four climate zones, of which zone D fully reflects conditions in Nunavik (see Appendix XIII). The key ENERGY STAR requirement for windows certified by the program is the maximum U factor value of 1.2 (overall heat transfer coefficient). To achieve this value, however, does not require sealed triple-pane glass, a very high-performance component that is thick, heavy and expensive.

Quebec's Novoclimat energy efficiency program, which covers residential window performance, refers to the ENERGY STAR program. Novoclimat also provides a highly relevant diagram in the appendix illustrating the energy efficiency issues related to windows in a cold climate (see Figure 3.15) and explaining the benefits of a design based on the following technical characteristics.

- Frame manufactured to the CAN/CSA A440 standard for windows
- Low-E coating integrated into the sealed glass unit
- Insulating divider around the perimeter of the two panes in the sealed glass unit
- Argon gas between the two panes in the sealed glass unit

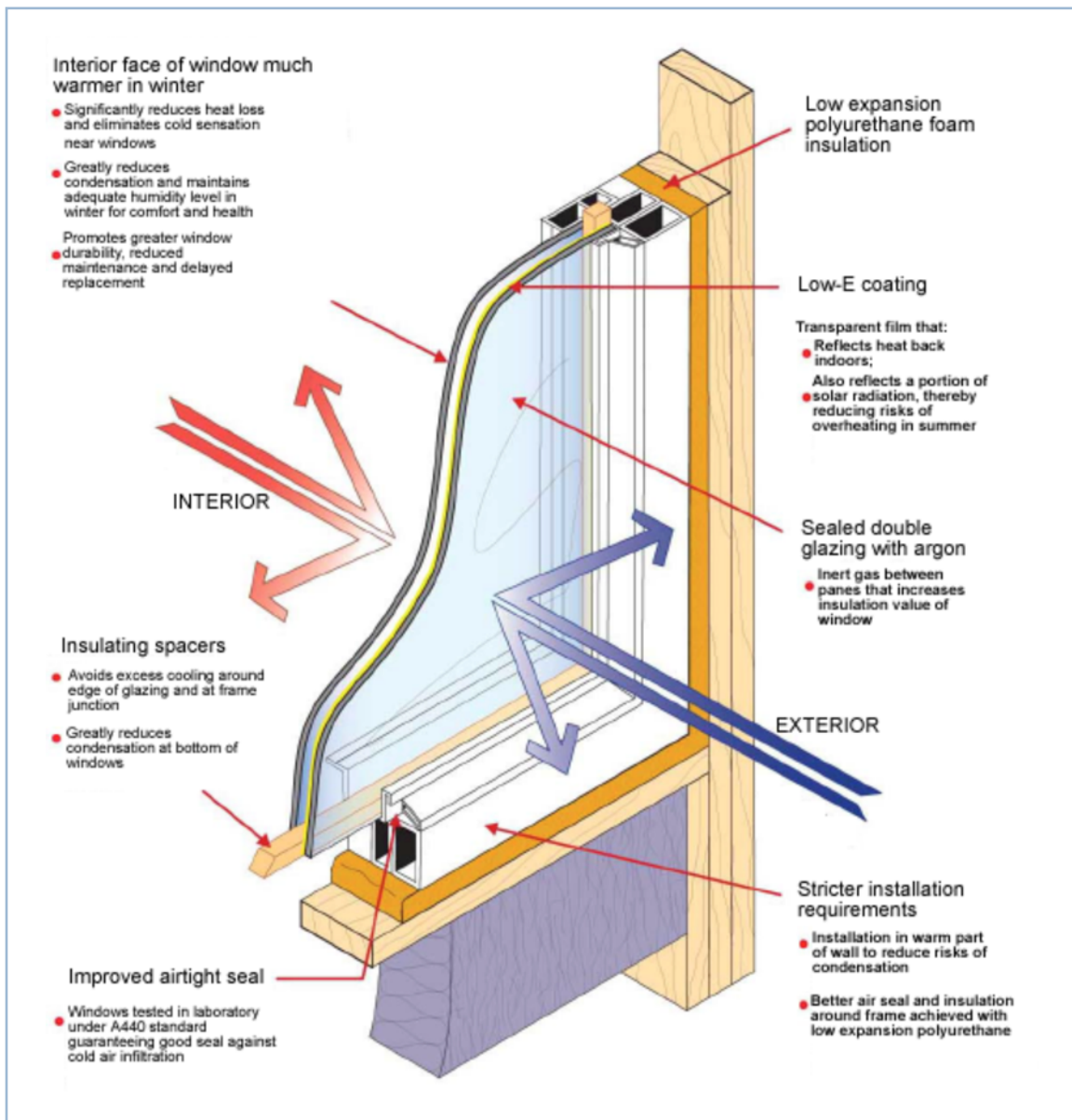


FIGURE 3.15: ILLUSTRATION SHOWING THE COMPONENTS OF A WINDOW WITH SUPERIOR CHARACTERISTICS (THOSE OF THE NOVOCLIMAT PROGRAM) / SOURCE: MERN-NOVOCLIMAT

Regulations

In addition to the energy efficiency requirements in Part 11, the Code's Building chapter stipulates other specifications in Part 9.7 on various design aspects that must be considered when selecting windows for residential construction.

Safety and protection: Bedroom windows must allow emergency egress with a minimum clear opening of 380 mm within a minimum clear area of 0.35 m². In addition, a window with a sill less than 900 mm from the floor must be equipped with a device to limit its opening to 100 mm and thus prevent falls by a young child. Finally, intrusion prevention requirements are included in the A-440 requirements for windows with a sill less than 2 m above the adjacent grade level. Under certain conditions, a guard rail may be required outside a window in areas common to several housing units.

Manufacture: All windows must be designed to comply with the CAN/CSA A-440-00 standard, which establishes performance classes for buildings based on their height and geographic location. All window products therefore must comply with this standard in a given class in laboratory tests.

Glass calculation: Window glass must be calculated in compliance with the CAN/CGSB-12.20-m standard, which specifies minimum thickness based on glass type, area and the wind pressure to which it is exposed.

Design aspects

Aside from the energy performance and regulatory aspects, window choice for residential construction is dependent on certain other design criteria appropriate for Nunavik, primarily involving material, opening method and strength.

Material: Windows may be of fibreglass, wood, aluminum, polyvinyl chloride (PVC) or composite materials.

- Aluminum is a preferred material in Nunavik due to its resistance to impact and its high strength. When used with a PVC thermal break, its insulating properties are positive, even in an extreme climate. However, its cost is high. For reasons of ease of sealing, if aluminum is chosen, a closed tubular profile is preferable to an open profile.
- PVC is a product well adapted to Nunavik's climate because the fact it is extruded and hollow gives it attractive insulating properties. Also, because the colour is incorporated into the product material, it requires no maintenance. The welded corner assemblies provide a good seal and the cost is very affordable for such a sturdy product. The material chosen must be at least 1 mm thick, however, as the thinner, less expensive versions do not provide the same performance.
- Fibreglass used in the manufacture of windows is the material that provides the highest quality, but is also the most expensive. There is a hybrid window, however, composed of PVC-fibreglass, in which the PVC is jointly extruded on the inside of the profiles as reinforcement.
- Because it requires high maintenance when used for windows, raw wood is not recommended for Nunavik, despite its excellent insulating properties. Its use a composite product with an exterior PVC or aluminum coating is also questionable given the thinness of these finishes, which provide little impact resistance.

Opening method: the various models of series windows available in the residential market are distinguished primarily by their opening method, which generally can be categorized as follows: casement (hinged on the side, opening out), awning (hinged on the top, opening out), hopper (hinged at the bottom, opening in), single or double hung (vertical sliding), hopper-casement (opening in both modes) and horizontal slider. Each model has benefits and drawbacks, which can be summarized as follows.

Casement and awning mode: these two opening methods are the only ones with an outward pivoting component and an insect screen on the inside, and they are equipped with a crank mechanism to control the infinitely variable degree of opening, which has great advantages. However, the hardware for these models is considered fragile and vulnerable to malfunction, generally resulting in high maintenance costs. Moreover, windows that open out are at risk of jamming in Nunavik under certain weather conditions, due to accumulation of hardened snow or ice.

- **Hopper mode:** the main disadvantage of this model is that it opens in and thus obstructs interior space. There are adjustable brake opening limiters to control the opening, however. The benefits are largely in the ease of operation and the very effective airtightness of the sashes, due to multipoint hardware that ensures even pressure on all four sides of the sash. This hardware is also considered extremely sturdy.
- **Hopper-casement mode:** this model has one sash that opens in, either in casement or hopper mode, thus constituting a sophisticated variant of the latter. The major drawback for use in Nunavik is the casement mode opening in, which exposes the sash to "banging in the wind," since no opening retaining device is available in casement mode.

- **Single or double hung and sliding mode:** sliding windows lack compression weather stripping on sash edges, using a friction fuzzy pile strip that limits their airtightness in strong winds. For this reason, they are poorly adapted to climate conditions in Nunavik. Double hung windows, however, with inner and outer sashes, provide the undeniable benefit of indirect and secure ventilation through alternate opening of the inner and outer sashes.

Sturdiness: the sturdiness provided by a window is measured by combining its resistance to wear of the hardware and weather stripping, deformation, impacts and air and water infiltration. There is one window superior to all others for Nunavik's climate: the PVC-fibreglass window with hopper opening. This model is also among the few that, with high efficiency glazing, can obtain the Passivhaus certification for construction materials.

Installation aspects

The presence of windows in a building envelope represents a potential breach of air and water tightness if not installed in compliance with a specific protocol that is specified in the CAN/CSA A440 standard, the main recommendations of which are listed below.

1. Centre the frame in the middle of the wall insulation or slightly to the interior, but not to the exterior.
2. Install the frame plumb, square and level, with shims at the bottom and on the sides.
3. Install the window in a rough wall opening that has previously been sealed with the air and vapour barriers folded into the opening and the joints sealed, to create an underlying membrane.
4. Apply a sturdy, continuous air/vapour barrier sealant all around the edge of the window. This sealant joins the frame to the underlying membrane with a highly adhesive and durable concealed product, such as a bead of tube sealant on a bead of foam, or a self-adhesive elastomeric membrane, or extra thick tape sold specifically for this purpose. It is preferable to make this seal on the interior side of the insulated wall to avoid trapping water if the window fails.
5. Apply insulating caulking in the open space around the frame, using injected foam or insulating wool.
6. Insert a metal sill under the air membrane at the top of the opening to drain away any water infiltration at this location, and seal it fully to the air barrier.

3.4.6 Infiltration tests

The air seal test, also called the infiltration test, is an excellent tool to ensure effective airtightness of a building envelope. This test measures air infiltration or the amount of air entering a building and locates air leaks.

This test can be performed on new or existing buildings. In a new building, it is highly recommended to conduct the test once all air seal components have been installed, before the interior finish is applied, so changes can be made before closing in the walls. However, the exterior wall insulation, vapour barrier, interior partitions, ceilings, electrical outlets and switches must all have been installed.

For new construction in Nunavik, it is highly recommended to schedule at least one infiltration session on the site to check the reliability of assemblies.

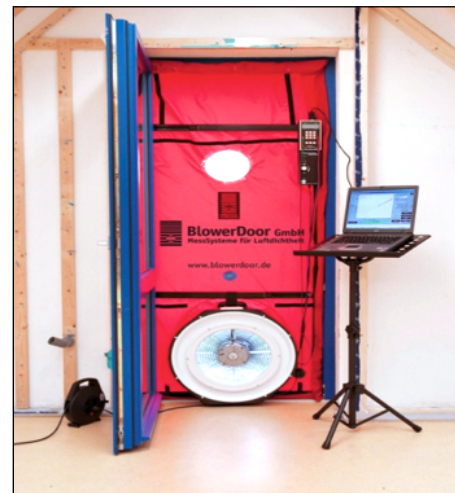


FIGURE 3.16: EQUIPMENT USED TO CONDUCT AN INFILTRATION TEST
SOURCE: GOOGLE IMAGES

Once construction has been completed. Airtightness can easily be measured by a second infiltration test, using the CAN/CSGB standard process. This can be combined with a thermographic analysis if the specific location of anomalies must be determined (see Appendix XIV).

3.5 INTERIOR FINISH

In Nunavik, due to the environment and active lifestyle of the local population, the use of resistant, low-maintenance interior finishes is indispensable for durable construction. The long-term availability of products used must also form part of the selection criteria with a view to future repairs.

3.5.1 Floors

Floor covering must be adapted to both Nunavik's climate and the use of the room in which it is installed. In a utility room, for example, painted plywood is deemed quite adequate.

Common residential floor coverings are reviewed below, with their respective benefits and drawbacks. The type of construction used should influence the choice of floor finish, since a raised building resting on a raft foundation cannot accommodate a rigid floor finish such as ceramic tile or solid hardwood due to the excessive risk of deformation; only flexible floor covering is appropriate.

3.5.1.1 Resilient flooring

Resilient flooring, also known as flexible floor covering, generally includes materials such as vinyl, vinyl composite, rubber and linoleum, sold in tiles or sheets. Tiles are easier to repair, but are subject to joint contamination if the floor covering is not meticulously maintained. For the same reasons, resilient sheet flooring must always favour a product that uses welded joints.

Following is an assessment of the main resilient floor coverings recommended.

- Linoleum: this totally natural product is not considered the most flexible of flexible finishes but is appropriate for all living and rest areas, with a minimum thickness of 2.5 mm. It should be avoided in high traffic areas of a building.
- Sheet vinyl: this product has properties very similar to linoleum but slightly more resistant.
- Sheet rubber: this flooring combines antiskid characteristics with the properties of vinyl. It should be chosen for high-traffic areas and entrance vestibules, in thicknesses of 1.8 or 2.5 mm. This is the only finish recommended for unheated spaces such as cold porches, where it acts as a waterproof membrane if applied in a single sheet and sealed around the edges.
- Vinyl tiles: this highly resistant non-porous material requires little maintenance but is not suited to unheated spaces.

3.5.1.2 Wood

Hardwood floors are not recommended in Nunavik, due to the cold, dry climate and the danger of water damage to joints between the individual boards.

3.5.1.3 Ceramic

Ceramic tile is durable and resistant, but its use must be limited to buildings with foundations resting on rock.

3.5.1.4 Carpet

Canada Mortgage and Housing Corporation recommends avoiding carpet in houses because it accumulates dust that is partly responsible for poor indoor air quality. Also, few Nunavik residents own a vacuum cleaner.

3.5.2 Partitions

Interior partitions must be strong enough to provide superior resistance to impact, as do reinforced gypsum panels. This is a recommended finish for all building partitions in Nunavik.

Non-bearing walls can be wood or steel framed.

Common walls between two units must have effective soundproofing and ideally should be double framed with studs extending below the floor.

If habitable rooms are adjacent to utility rooms, it is important to ensure that:

- Partitions have effective thermal and acoustic insulation;
- Continuous acoustic insulation extends down below the floor to limit transmission through the structure.

3.5.3 Interior doors

Interior doors are subject to wide variations in air humidity between winter and summer, and due to often intense indoor activities linked to the large number of residents in housing units. Use of solid wood core interior doors is highly recommended under these conditions for greater durability. Interior door frames may be of wood or heavy-gauge metal.

3.5.4 Ceilings

Gypsum panel is recommended as the finish material for ceilings due to its fire resistance and ease of repair.

Textured ceiling finishes are not recommended because dust and smoke soil and stain them.

3.6 OUTFITTING CONSIDERATIONS

3.6.1 Built-in furniture and equipment

Built-in furniture (lavatory cabinets, kitchen counters and cabinets, sinks and fixtures, vestibule and laundry shelves, etc.) as well as fixed equipment and devices (shower enclosures and fixtures, built-in medicine cabinets and mirrors, toilet paper holder, etc.) included in construction must be sturdy and resistant to damage, and where necessary, must be adapted to traditional Inuit activities (e.g. counter-tops of material that can withstand butchering of game and cleaning of fish). Post formed kitchen and bathroom counters must be avoided as they are often easily damaged, especially at the nosing and edges. All built-in furniture components should be prefabricated to accelerate and simplify installation on site.

For safety and maintenance reasons, glass and glazing should be avoided. If this type of material is absolutely necessary, choose resistant materials such as tempered glass.

3.6.2 Vestibules

Each single-family or semi-detached home should have an unheated entry vestibule known as a cold porch. This space should be large enough for occupants to safely store heavy equipment (boots, coats, fishing and hunting gear, etc.), ideally in a closet with shelves.

Ensure that the size and spacing of hooks for parkas and coats are adequate for the winter clothing used by the Inuit (recommended: 25 mm diameter with rounded ends and mechanical fastenings).

3.6.3 Kitchens

Here are a few recommendations for design of kitchens, based on Inuit culture.

- Adjust the room size to the number of occupants in the housing unit.
- Provide a central kitchen counter wide enough for butchering game.
- Install large stainless steel sinks so occupants can prepare large amounts of food.
- Adapt the ergonomics of work areas to Inuit customs.
- Provide extensive storage space.
- Install windows that open easily in the kitchen.
- Place the sink under the window to maximize contact with the outdoors when working in the kitchen.
- Preferably, install reduced-flow faucets in the kitchen (flow of 8.3 l/min or less at 413 kPa pressure).

3.6.4 Bathrooms

Bathrooms can easily cause problems if not correctly ventilated and with high humidity, so a good ventilation system must be installed as well as highly resistant accessories and finishes. Overcrowding in Nunavik homes means the single bathroom is very heavily used.

Simple, durable products must be selected in the design phase. For example, fibreglass shower stalls and bathtub profiles in fibreglass, polyethylene, reinforced acrylic or preformed PVC are highly recommended, as ceramic tile is unreliable due to constant shifting of buildings that are normally raised above grade level. Preformed finishes are also especially durable and easy to clean.

For plumbing, all bathrooms should be equipped with water-saving fixtures, such as toilets that use 6 litres or less per flush, a reduced-flow faucet of 8.3 l/min or less at a pressure of 413 kPa, and a water-saver shower head using 9.8 l/min or less at 551 kPa pressure.

Since the bathroom is used by a large number of occupants, the laundry should be located outside the bathroom, but could be placed in an adjacent area. For energy savings, it is also recommended that all plumbing be located in the same area of the home to shorten plumbing runs.

3.6.5 Utility rooms

Each single-family house must have a utility room for the central heating equipment, water heater, drinking water tank and pump system, as well as access to the holding tank. Semi-detached houses and multiple-unit residential buildings generally have only a single utility room. Utility rooms must be insulated and preferably accessible only from outdoors. Facilities must be maintained by qualified staff and occupants should not have free access.

3.6.6 Storage

Many large storage areas of various shapes must be provided in Inuit housing. Inclusion of the following specialized storage space is required: clothes closet in each bedroom; linen closet near the bathroom; pantry in the kitchen; general purpose storage near the entry door (of at least 3 m²).

4. MECHANICAL

4.1 MAINTENANCE DESIGN AND FUNCTION

The design of mechanical systems must allow for maintenance, verifications and test that must be performed after delivery of the building. Maintenance of facilities and equipment must be minimal and simple.

All ventilation ducts and other concealed mechanical equipment above ceilings or under floors must be accessible to facilitate maintenance.

Utility rooms and sanitary voids must be large enough for qualified staff to maintain and replace the equipment.

4.2 PLUMBING

4.2.1 Drinking water

Drinking water is delivered by truck to all buildings (except in Kuujjuarapik, where there is a water supply system).

4.2.1.1 Water supply system

Except in Kuujjuarapik, buildings have tanks and supply systems for drinking water. All plumbing fittings must be located inside the building's thermal envelope.

Water supply piping must be sloped to a low point, and a valve must be installed at each low point for drainage.

All plumbing equipment must be equipped with an easily accessible shutoff valve for maintenance.

4.2.1.2 Tank

The drinking water system must be located in a room where the temperature can be maintained between 5°C and 15°C to reduce the risk of bacteria growth in the tank.

The building structure must be designed to bear the weight of the water held in the tank.

Since there usually is no water delivery on weekends, water tank capacity must ensure independence for at least three days.

All water tanks must be built with non-corrosive material, equipped with a UV stabilizer and comply with a recognized standard for drinking water storage.

All tanks must have a drain that can empty the tank completely by gravity. There must be a cleaning and maintenance opening at least 500 mm in diameter with a safe, watertight cover. At least 1200 mm clearance must be provided above the access to the tank to facilitate maintenance.

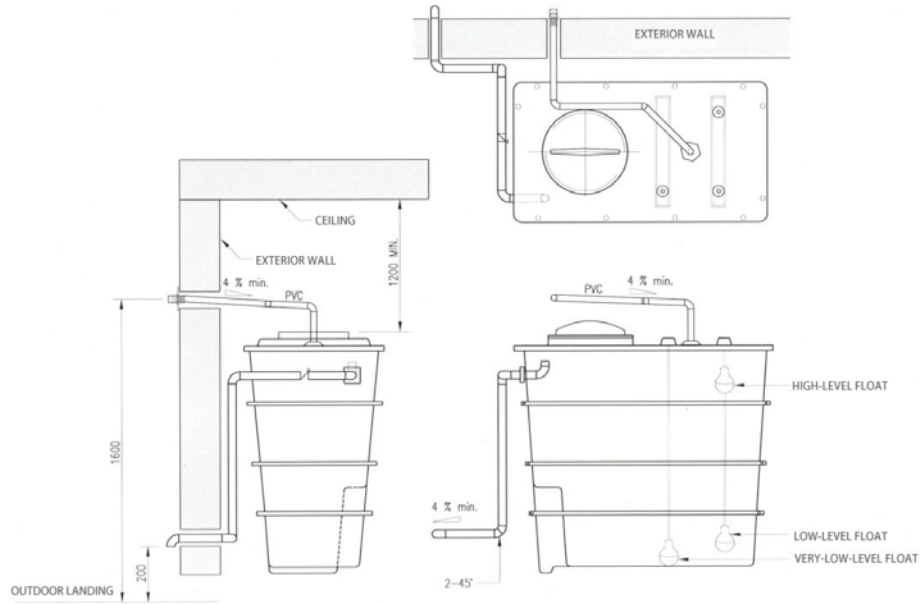


FIGURE 4.1: DRINKING WATER TANK / SOURCE: SHQ

A 75 mm diameter overflow pipe must be provided that drains to the outdoors, to avoid spills within the utility room. A check valve must be placed in the upper part of the overflow pipe to prevent cold air from entering the tank. The drinking water tank must have a PVC fill pipe inside the building and copper or brass pipe in the segment that extends through the exterior wall. This pipe must have a minimum slope of 4 percent toward the tank to avoid spilling outside. The exterior fill pipe connection must be compatible with the 38 mm rapid connection adapter on the delivery hose used in the village.

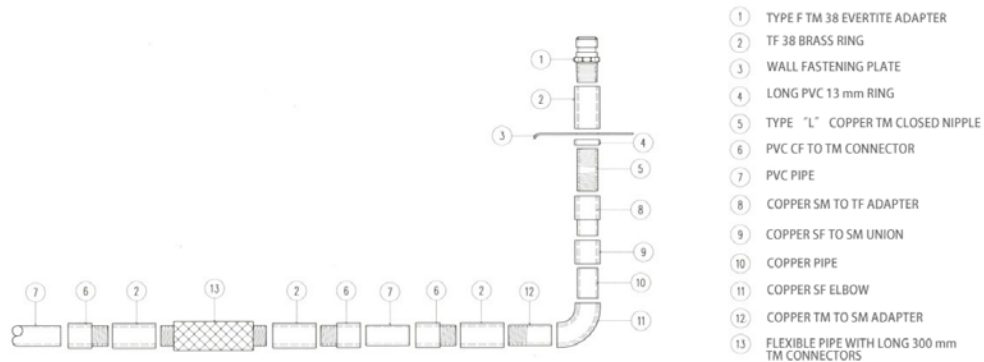


FIGURE 4.2: DRINKING WATER TANK FILL PIPE / SOURCE: SHQ

To prevent drinking water delivery equipment from resting on soil in a location where contaminants such as sewage might be present, the exterior drinking water filling connection must be located at least 1500 mm horizontally and at least 1000 mm vertically from the sewage pump-out connection (see Figure 4.3).

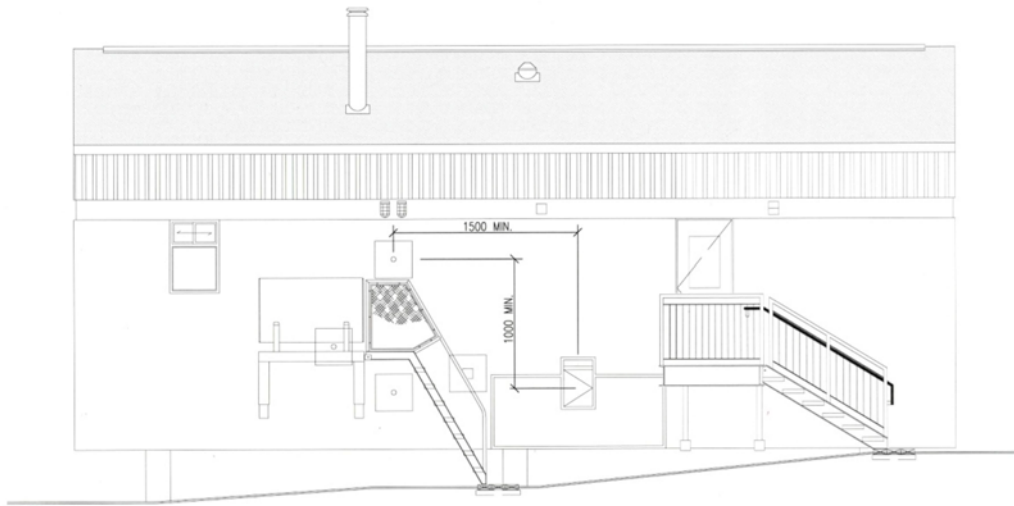


FIGURE 4.3: DRINKING WATER FILL PIPE CONNECTION / SOURCE: SHQ

The tank must be equipped with a system of level indicator floats and an electromechanical control system with the following components.

- A high-level indicator float that activates a blue lamp outside when the water level reaches 25 mm below the tank overflow, to notify the delivery technician that the tank is full
- A low-level indicator float that activates an amber lamp inside the house when the water level drops to 150 mm above the bottom of the tank
- A very-low-level indicator float that stops the pressure pump supplying the system and activates a red lamp inside the house when the water level drops to 25 mm above the bottom of the tank

4.2.1.3 Pressure pump

The use of stainless steel jet pumps is recommended for shallow tanks. Each pump must be installed with two shutoff valves for maintenance or replacement of the pump without having to empty the tank. A pressure gauge should be installed at the pump output.

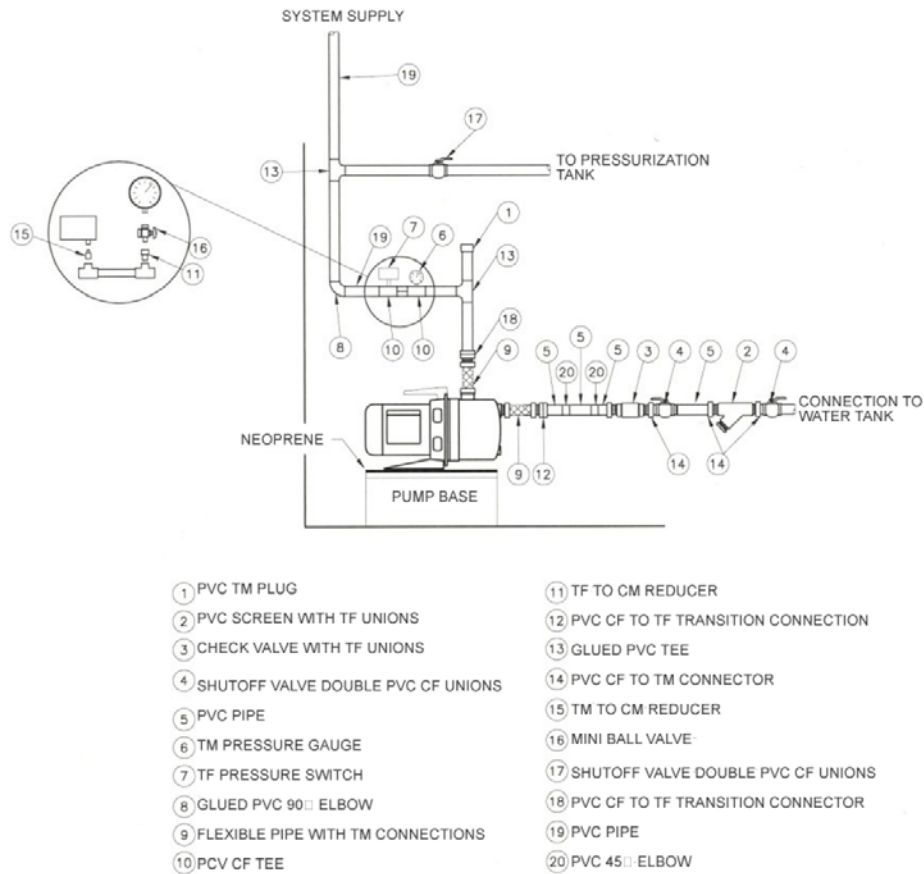


FIGURE 4.4: PRESSURE PUMP / SOURCE: SHQ

The system must be equipped with a pressurization tank downstream from the pressure pump.

4.2.2 Domestic hot water

Domestic hot water can be supplied by a direct or indirect water heater. The energy source used is heating oil, since electrical rates are very high when a home is electrically heated. Electric water heaters therefore are not a recommended solution in Nunavik. A floor drain must also be installed near water heaters.

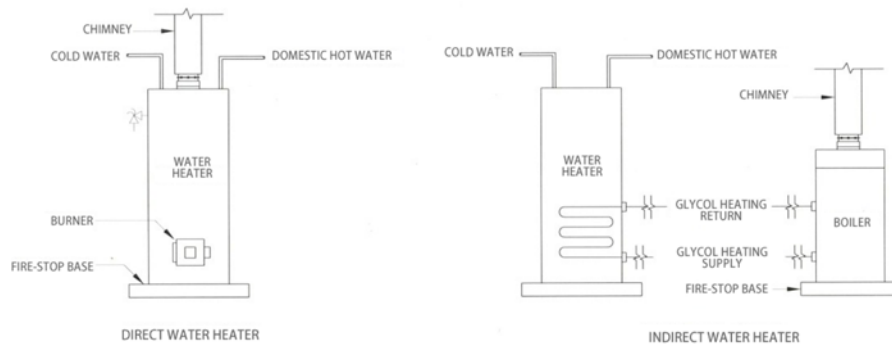


FIGURE 4.5: WATER HEATER / SOURCE: SHQ

4.2.3 Sewage system and holding tank

All housing units are equipped with a waste water holding tank, which must be located inside the building's thermal envelope in a location where waste water can drain by gravity. This tank may be installed in the lower part of the building and must be easily accessible for inspection and repair. Tanks buried in the ground are not recommended, for several reasons.

- They are difficult, if not impossible, to inspect for water tightness of their exterior walls.
- They may contaminate the soil if a leak is not detected.
- They may cause heating of the permafrost due to release of the heat contained in waste water.
- Exterior piping connecting the building's drainage system to the outdoor tank must be heated.
- Exterior piping may crack or break due to freeze-thaw cycles and the associated movement of soils.

Exterior access must be provided for easy removal of the tank from the building.

The tank must be made of polyethylene, fibreglass or PVC to prevent corrosion, and must have been designed and manufactured to CSA standards. Concrete or steel tanks are not recommended due to the risk of cracking and corrosion.

Holding tanks must ensure at least three days' independence and be planned to hold at least double the capacity of the drinking water tank.

All tanks must have access at least 450 mm in diameter and a safe, watertight cover for inspection and repair. It is important to ensure that all connections and openings are air and water tight to avoid emission of foul odours.

The sewage pump-out connection must be far away from doors and windows. The connection must be compatible with the community's service equipment. A 75 mm fast connection adaptor should be compatible with the pump-out services, but it is preferable to check with the municipality. The pump-out pipe must be insulated in the exterior portion and for the first two metres on the interior.

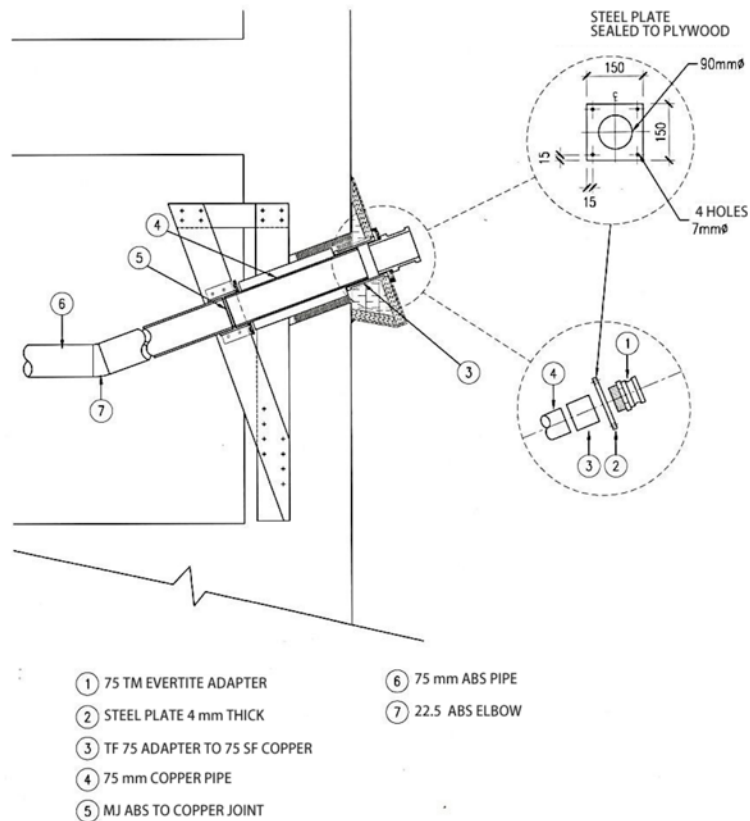


FIGURE 4.6: SEWAGE PUMP-OUT CONNECTION / SOURCE: SHQ

To ensure airtightness of the holding tank, an air pressure test must be performed.

1. The air test must be performed by closing all openings in the tank and filling it with air at a pressure of at least 35 kPa.
2. The test is deemed satisfactory when the pressure remains stable for 15 minutes without adding more air.
3. The pressure gauge must be graduated from 0 to 70 kPa.

After installation of all sanitary equipment and before commissioning any portion of the sewage or ventilation systems, a water pressure test is required.

1. Water must rise to a level at least three metres above all parts of the section being tested.
2. The water test must be conducted by closing all openings in the drainage system and the section to be tested, except the upper end where the water is fed in, until the system has been completely filled.
3. The test is deemed satisfactory if the water level remains stable for 15 minutes.

When the water level in the holding tank rises to 50 mm below the maximum level, a level indicator float must send an electrical signal to the electromechanical control system which must then activate a lamp inside the house to alert occupants to request sewer pump-out service.

When water level in the holding tank rises to 25 mm below the maximum level, a level indicator float must send an electrical signal to the electromechanical control system which will cut off electrical power to the building's drinking water pressure pump. At the same time, an exterior red indicator lamp must activate to indicate that the holding tank must be pumped out.

4.2.4 Exterior ventilation outlets

The sewage system stack vent on the roof must be insulated over its entire length when it is located outside the building's thermal envelope. The vent terminal on the roof must also be heated to avoid the formation of ice dams.



FIGURE 4.7: ICE FORMATION AT THE VENT STACK OUTLET
SOURCE: SHQ

Formation of an ice dam at the vent outlet can cause serious problems when the cleanout truck pumps out the holding tank. The truck's pump is actually powerful enough to empty all traps in the building's plumbing system, thereby allowing toxic gas contained in the holding tank to escape freely into the interior of the housing unit.

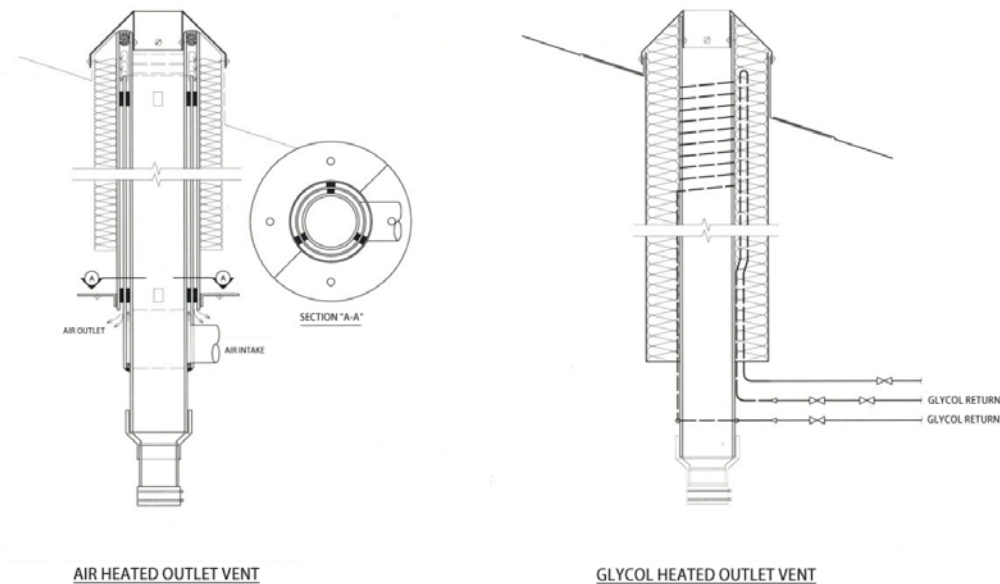


FIGURE 4.8: VENT STACK OUTLET HEATING SYSTEM / SOURCE: SHQ

4.3 HEATING

Light heating oil is the primary energy source for producing heat (space heating and domestic hot water) in Nunavik. The annual number of heating degree days⁴ below 18°C can reach about 9,000 in Salluit, compared with 4,500 in Montreal.

4.3.1 Heating oil storage tank

Each residential building must be equipped with a heating oil tank located outdoors and above the ground. The installation of oil tanks, piping and accessories must comply with the requirements of the Petroleum Equipment Installation chapter of the Quebec Construction Code.

Since that chapter's requirements applicable to this type of installation essentially involve the manufacturing standards for tanks and piping used for housing in Nunavik, we recommend referring to the latest version of the CSA-B139 standard, Installation Code for Oil-burning Equipment, for the other installation aspects.

Oil tank capacity must be calculated from the volume needed to operate the heating system at maximum capacity for at least two weeks.

Tanks must be located as far as possible from entrances to the building. The tank supporting structure must be made of non-combustible material and a safe ladder or staircase must be provided so the delivery technician can reach the fill pipe on the top of the tank. Necessary platforms, hand rails or guard rails must be provided to ensure the safety of the delivery technician. Ladders with one or two rungs may be used, but taller ladders must be avoided to facilitate the delivery technician's task of climbing up to the fill connection with the delivery hose. All metal works must be of hot-dipped galvanized steel.

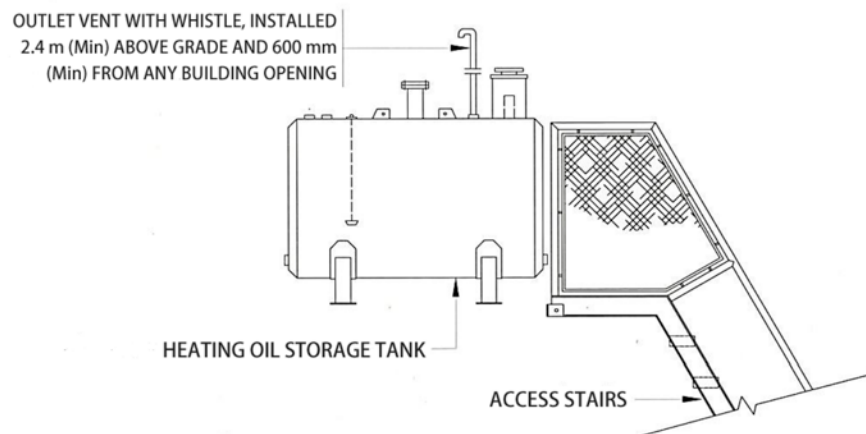


FIGURE 4.9: HEATING OIL TANK / SOURCE: SHQ

4. The number of heating degree days is obtained by adding all daily variances in a year between the daily average temperature and 18°C, when this average is less than 18°C.

4.3.2 Heating oil supply

Tanks must be installed above grade outside buildings, at a height sufficient to supply the burner or burners by gravity without need of a pump.

All equipment (piping, joints, valves, etc.) and all materials used for the heating oil must be compatible with petroleum products.

A small leak-proof steel drip pan must be solidly secured to the floor beneath each piping joint (burner, filter, etc.) inside the building to contain any minor leaks.

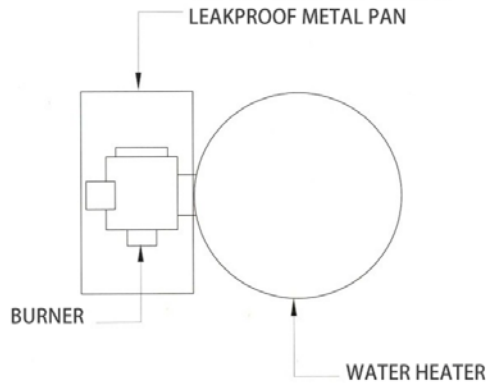


FIGURE 4.10: LEAKPROOF METAL DRIP PAN / SOURCE: SHQ

4.3.2.1 Heating oil temperature

Cold heating oil does not burn well. Before it reaches the burner, it must be preheated in a small auxiliary tank with a preheating oil pipe or serpentine supply tube inside the utility room near the burner.

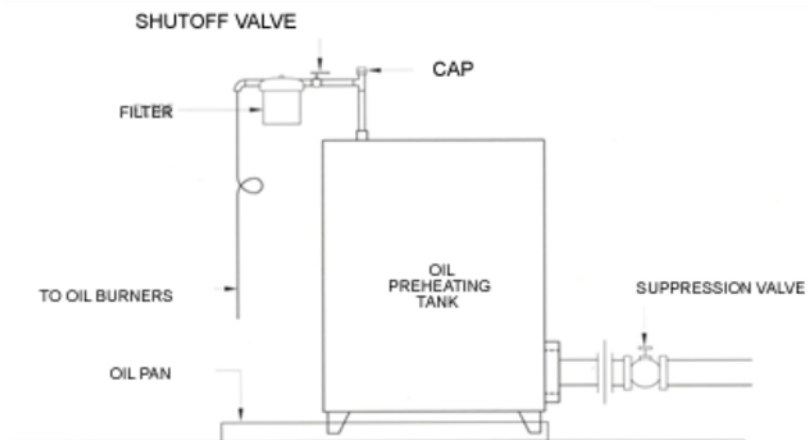


FIGURE 4.11: LEAKPROOF METAL DRIP PAN / SOURCE: SHQ

4.3.2.2 Piping

All exterior piping must be of hot dipped galvanized steel with series 40 threaded joints and a minimum diameter of 50 mm.

Supply piping must be equipped with a cleanout drain near the tank to trap water and sediment for removal. There must be a valve at tank outlet followed by a T with a branch at least 150 mm long running down and capped at the end.

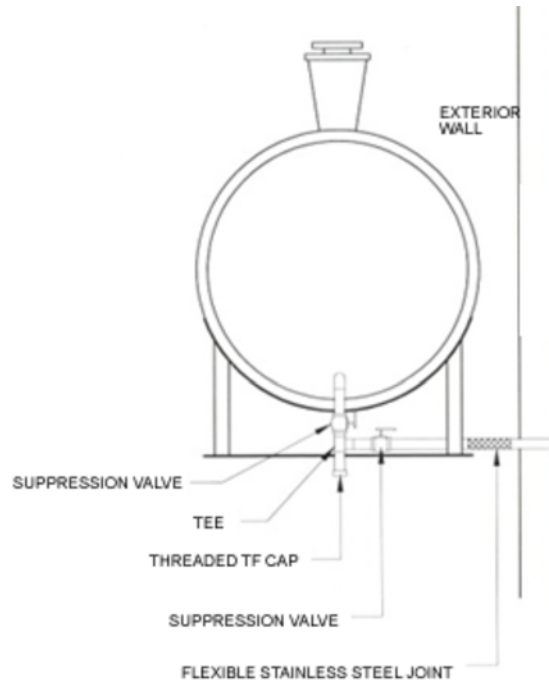


FIGURE 4.12: EXTERIOR PIPING FOR HEATING OIL SUPPLY LINE / SOURCE: SHQ

Piping connecting the tank outside the building must be equipped with a flexible joint in stainless steel mesh at least 600 mm long or a swivel joint⁵ near the exterior wall of the building. A flexible joint is preferable, especially where the tank and building are not resting on the same foundation.

The vent outlet must be equipped with a whistle and must be located at least 2.4 m above grade and 600 mm away from any opening in the building (see CSA-B139 standard for more details).

The burner must be connected with flexible pipe to facilitate maintenance and must be equipped with a leak-proof metal tray to capture any oil dripping off the bottom of the connections. Type K copper pipe or a flexible joint in stainless steel mesh may be used, the latter being preferable for maintenance.

4.3.2.3 Valves

A shutoff valve must be installed as close to the tank as possible (this valve may be similar to that used to purge the drip outlet) and another must be installed immediately next to where it enters the building. All equipment installed on the feed pipe that requires maintenance must be equipped with a valve at the entrance and exit (see Figure 4.12).

The feed pipe for each device must be equipped with a fuse valve installed at least one metre away from the burner, which shuts off in the event of fire.

5. A swivel joint consists of two 90° elbows separated by a length of pipe.

4.3.3 Combustion and ventilation air

The air needed for oil-burning devices must enter freely through a special duct installed for this purpose. The combustion air intake duct should enter through the floor of the utility room so as to draw air from beneath the building. The combustion and ventilation air section of the CSA-B139 standard, Installation Code for Oil-burning Devices, provides more details.

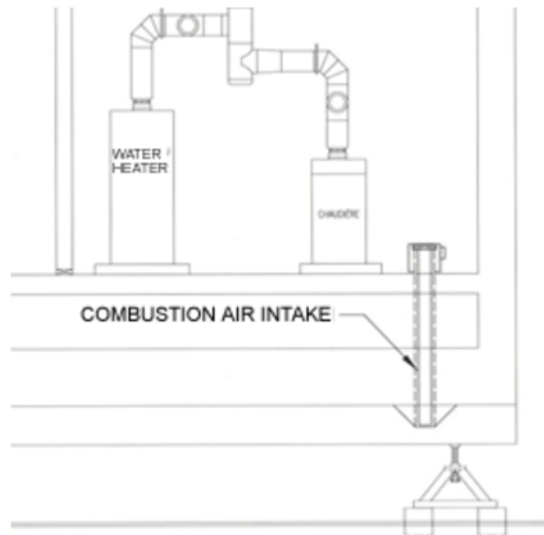


FIGURE 4.13: COMBUSTION AIR INTAKE / SOURCE: SHQ

Tightly sealed motorized dampers must be installed in combustion and ventilation air ducts.

The motorized damper in the combustion air duct must be synchronized with the combustion equipment so that it starts only when the damper is fully opened.

The ventilation opening in the utility room must be placed close to the ceiling. The size of air intakes and exhausts must be calculated based on section 4 of the CSA-B139 standard, Combustion Gas Exhaust and Air Supply.

Air intakes and outlets must be very carefully positioned to avoid freezing equipment in the utility room (water pipes and pumps, heating oil supply lines, etc.).

Air temperature in the utility room must be regulated by a thermostat. An electromechanical control system must allow simultaneous opening of the motorized damper in the combustion air intake and the motorized damper in the room ventilation system.

The utility room ventilator must be interlocked with the combustion air intake damper so that it operates only when the motorized dampers are fully open. This should be an exhaust ventilator to let air enter naturally through the combustion air intake.

4.3.4 Combustion gas exhaust

Installation must comply with section 4 of the latest version of the CSA-B139 standard, Combustion Gas Exhaust and Air Supply.

It is preferable to install a single chimney for all combustion equipment (domestic water heater, furnace, etc.).

The chimney must be securely anchored to the building structure (roof flange and brace, anchor plate, etc.).

All fire safety clearances must be observed. Where a chimney passes through a floor and ceiling, radiant fire breaks must be installed.

Where horizontal exhaust ducts are necessary, these must be securely fastened to the building structure using a trapeze support and threaded rod.

An insulated T must be installed at the base of the chimney for cleaning out solid particles resulting from chimney sweeping.

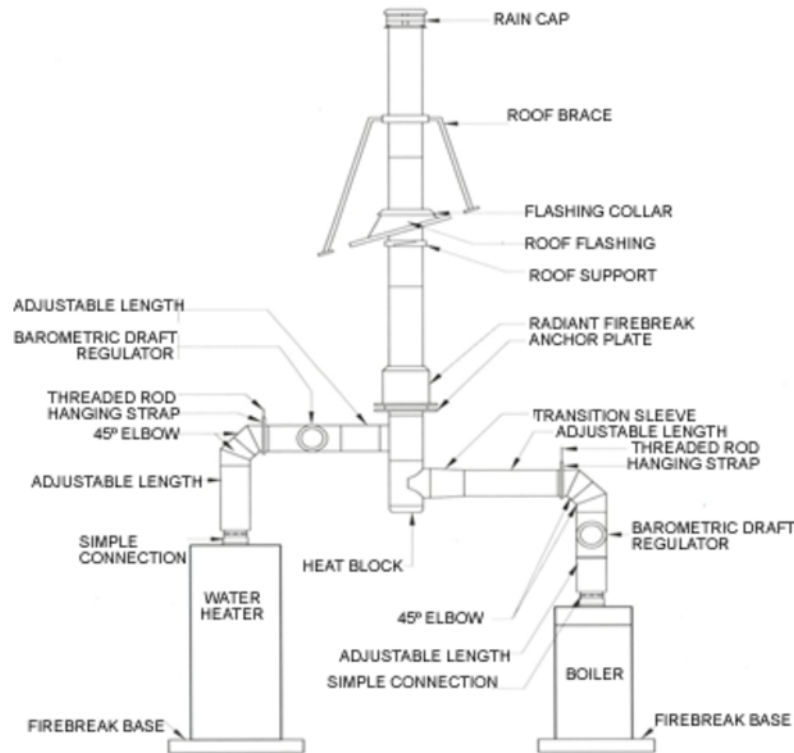


FIGURE 4.14: EXHAUST DUCTS AND CHIMNEY FOR COMBUSTION GAS / SOURCE: SHQ

4.3.5 Heating capacity

The heating system should be designed to produce no more than 100 percent of the maximum demand calculated from the applicable design parameters.

Heating systems perform best when running continuously. Oversized systems result in cycling (frequent stops and starts), which accelerates equipment wear and increases fuel consumption.

4.3.6 Heat-generating devices

The annual fuel usage efficiency (AFUE) of the heat-generating device determines which products perform best.

The higher the AFUE rating, the more efficient the device.

Some devices are rated at 85 percent or more. The energy performance rating must be certified by a recognized organization such as CSA International.

Even if not required by the manufacturer, a firebreak base of non-combustible materials must be installed below devices sitting on a combustible floor.

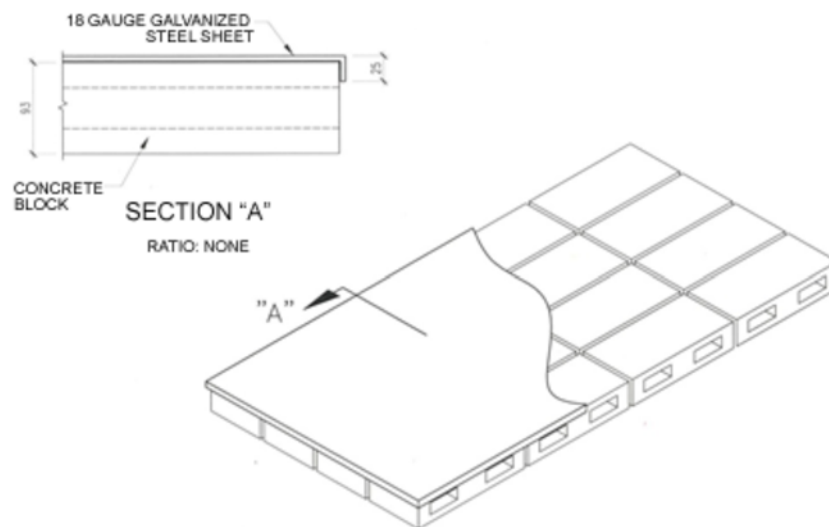


FIGURE 4.15: FIREBREAK BASE / SOURCE: SHQ

4.4 VENTILATION

4.4.1 General

Ventilation of residential buildings refers mainly to air exchange between indoor and outdoor, air distribution between rooms or air circulation within a given room (Institut national de santé publique du Québec [INSPQ], 2006). The introduction of fresh air indoors specifically helps dilute contaminants (White, 2003).

4.4.2 Natural ventilation

Natural ventilation primarily involves air movements resulting from opening doors and windows, all the small cracks and openings in the building envelope as well as the poorly sealed perimeter of doors and windows (INSPQ, 2006).

Natural ventilation occurs either through infiltration (passage of air from outdoors to indoors) or exfiltration (passage of air from indoors to outdoors). In a home, the movement of air (infiltration and exfiltration) is generated by a pressure differential between the interior and exterior. This pressure differential may be caused by a temperature difference (chimney effect) or wind action.

A house is deemed airtight when it has very little infiltration and exfiltration.

Natural ventilation is highly random and hard to control since it is affected by various factors such as airtightness of the envelope, temperature difference between outdoors and indoors, wind speed, etc. (Canada Mortgage and Housing Corporation [CMHC], 2004). Houses with a very high natural infiltration rate are also subject to large energy expenses (Efficiency and Renewable Energy Clearinghouse [EEREC], 2002).

4.4.3 Mechanical ventilation

Increased airtightness and insulation of houses have contributed to the development of mechanical ventilation (Environmental Protection Agency [EPA], South Dakota), which is an effective way to control air exchanges and thereby improve air quality and comfort inside buildings without sacrificing the benefits of a more airtight envelope (Reardon et al., 1990).

Mechanical ventilation refers to any motorized device that exhausts and takes in air to facilitate the aeration of rooms by exhausting stale air and replacing it with fresh air from outdoors (INSPQ, 2006). Mechanical ventilation systems are divided into three main categories.

- **Simple exhaust systems:** One or more ventilators expel air, while replacement air enters by infiltrations.
- **Simple air intake systems:** One or more ventilators draw outdoor air into the building while existing indoor air is expelled through openings in the envelope.
- **Balanced systems:** One or more ventilators expel stale air and draw in fresh air.

4.4.3.1 Primary ventilation system

Installation must comply with section 9.32, Ventilation, and part 11, Energy Efficiency, of Chapter 1, Building, Quebec Construction Code, current edition.

The primary ventilation system must:

- Have an extraction capacity consistent with the following table.

NUMBER OF BEDROOMS IN THE HOUSING UNIT	PRIMARY VENTILATOR'S EXTRACTION CAPACITY IN NORMAL OPERATION, L/S	
	MINIMUM	MAXIMUM
1	16	24
2	18	28
3	22	32
4	26	38
5	30	45
More than 5	Installation must comply with the CAN/CSA F326-M91 standard.	

TABLE 4.1: EXTRACTION CAPACITY

- Include a heat recovery ventilator (HRV) for which:

- Heat recovery efficiency (HRE) is certified by the Home Ventilating Institute (HVI) under the CAN/CSA C439 standard, Standard laboratory methods of testing for rating the performance of heat/energy- recovery ventilators;
- Heat recovery efficiency (HRE) is at least 60 percent and determined at a dry thermometer temperature of -25°C;

Each dwelling unit therefore must be equipped with its own heat recovery ventilator (HRV). The HRV should be located in the utility room, to mitigate noise and facilitate maintenance by qualified staff.

- Ensure minimum fresh air flow equal to the total needs of each room as in the following table.

USE OF ROOM	MINIMUM FLOW (L/S)
Master bedroom	10
Single bedroom	5
Living room	5
Dining room	5
Family room	5
Kitchen	5
Bathroom	5
Laundry room	5

TABLE 4.2: REQUIRED FRESH AIR FLOW

NOTE: ROOMS USED ONLY AS AN ENTRANCE, EXIT OR STORAGE AREA, SUCH AS VESTIBULES, HALLS, LANDINGS, SERVICE CLOSETS AND HEATING AREAS DO NOT REQUIRE INTAKE OF FRESH AIR.

d. Replace air in the dwelling unit at a renewal rate of 0.3 air volume per hour (CMHC – technical series 08-100);

e. Include a defrost cycle through air recirculation to avoid depressurization of the dwelling unit.

The HRV control device should be easy to use and located in the living room. The control device should include the following functions.

- i. Turn off the HRV.
- ii. Operate the HRV continuously in outdoor exchange mode.
- iii. Operate the HRV in exchange in scheduled mode (e.g. 20 minutes in exchange mode and 40 minutes in recirculation mode).
- iv. Operate the HRV in exchange mode when relative humidity exceeds the set point.

During the heating season, relative humidity inside a housing unit should not exceed 50 percent. In periods of extreme cold, relative humidity should be close to 30 percent to prevent condensation on windows (CMHC, *Moisture and Air – A Guide for Understanding and Fixing Interior Moisture Problems in Housing*, 2012).

4.4.3.2 HRV fresh air intake

The fresh air intake must be designed and installed to avoid obstruction by aspirated snow, through the use of a downward opening duct. The intake opening must be at least 600 mm above grade and the section must be large enough to attain an air intake speed of less than 1.5 m/s.

The fresh air intake must be placed where it cannot be blocked by accumulated snow, and on the opposite side of the building from potential sources of contamination such as sewage pump-out connections, heating oil fill pipes, etc. The placement of fresh air intakes must also consider factors such as prevailing winds, parking areas for automobiles, all-terrain vehicles, snowmobiles, etc. If not located on the opposite side from sources of contamination, fresh intakes must be at least two metres away from these points.

Fresh air intakes should be located underneath the building. If snow does accumulate in the air intake duct, the water from melting snow and ice can drain directly to the outdoors by gravity with no risk of serious damage to the thermal envelope due to infiltration.

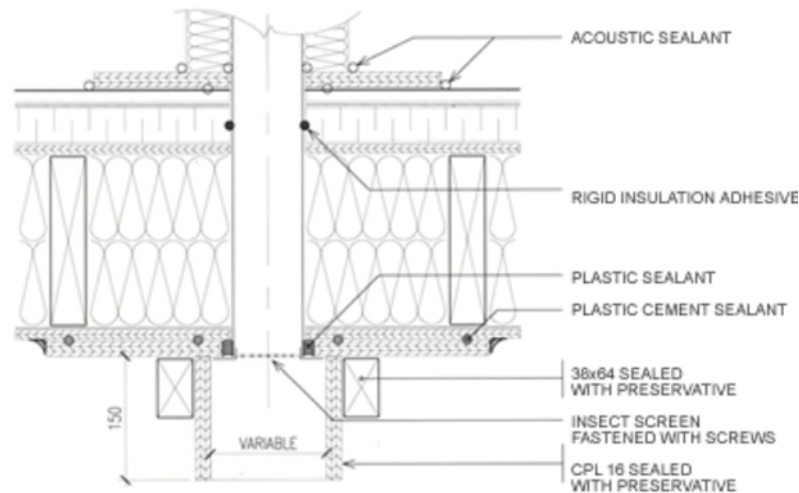


FIGURE 4.16: FRESH AIR INTAKE / SOURCE: SHQ

A removable insect screen should prevent the intake of insects in summer and can be removed in winter if air intake might be blocked by snow.

When the building's central ventilation system is not operating or is in recirculation mode, a tightly sealed device must prevent fresh air from infiltrating into the building.

4.4.3.3 HRV stale air exhaust

The heat recovery ventilator (HRV) stale air exhaust must not be located where snow might accumulate and where it would be exposed to prevailing winds.

Snow accumulation can prevent the system from effectively exhausting stale air from the building.

4.4.3.4 Kitchen range hood

The range hood must exhaust stale air directly out of the building. The extraction ventilator must have a nominal capacity of at least 50 l/s.

The range exhaust outlet should be located beneath the building so that water generated by condensation can drain directly outdoors.

A gravity check valve should be installed at the end of a horizontal duct upstream from the vertical segment that passes through the thermal envelope.

Installing the check valve in the heated portion of the building avoids problems associated with ice blocking the valve. When it does become blocked, the range cannot effectively exhaust the excess humidity generated by cooking food.

4.4.3.5 Bathroom

The primary ventilation exhaust intake should be located in the bathroom. The HRV thus can recover a significant portion of the energy contained in the air while also supplying replacement air in the dwelling unit. A manual control in the bathroom should place the HRV in exchange mode for a limited time (e.g. 20 minutes), after which the HRV will resume normal operating mode. Nominal exhaust capacity must be **at least 25 l/s**.

If the exhaust air intake is not located in the bathroom or toilet room, an additional exhaust device must be installed. This device must be controlled by a wall switch and have a nominal capacity of **at least 25 l/s**.

4.5 HYDRONIC HEATING SYSTEM

4.5.1 General

Hydronic heating systems use a heat transfer fluid to carry heat to the various rooms in the house.

4.5.2 Operation

A boiler equipped with an oil burner heats the water-glycol (heat transfer) mix and a pump circulates this mix through a closed loop of radiators in the rooms of the house before it returns to the boiler. Each radiator (or group of radiators) can be controlled by a valve and a thermostat to maintain the desired temperature in a specific zone.

In other words, each heating zone can be controlled by a thermostat that activates the valves near the radiators to heat this zone.

The thermostats in a zone open or close the valves for the zones they control to start or stop circulation of the hot water-glycol mix in the radiators.

The burner is activated by a control that maintains the temperature of the water-glycol mix in the boiler within the selected set points. This boiler can also heat domestic hot water. A separate hot water loop connects to the water heater tank and is controlled by the thermostat on that tank.

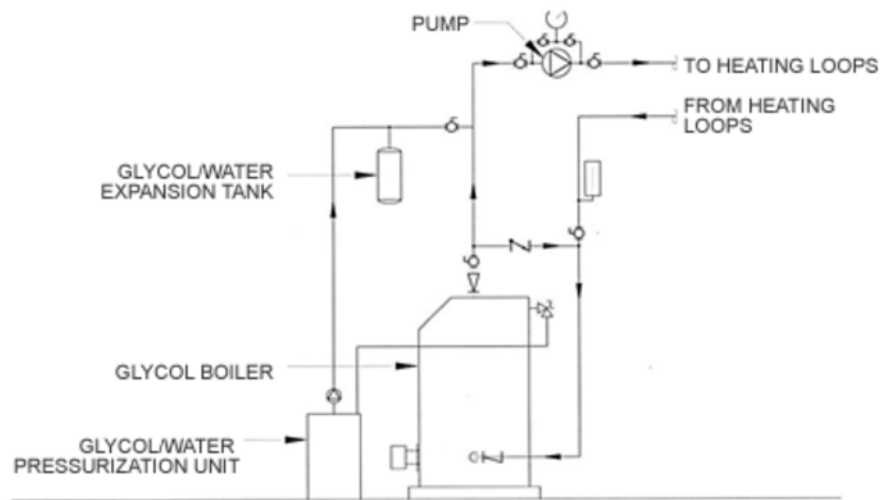


FIGURE 4.17: HYDRONIC HEATING LOOP FLOW DIAGRAM / SOURCE: SHQ

4.5.3 Components

Hydronic heating in Nunavik uses a heat transfer fluid composed of equal parts water and propylene glycol (by volume). The glycol prevents freezing and damage caused by ruptured pipes in the event of an extended outage.

The expansion tank absorbs dilation of the heat transfer fluid volume and must be large enough to handle the expansion coefficient of the mix.

The boiler's safety release valve must be connected to the pressure unit tank so the water-glycol mix can be recovered if the valve is opened.

A pump circulates the water-glycol mix through the piping loop to move the heat to the radiators. This loop must be equipped with drainage valves at the low points and air purgers at the high points in the loop.

4.6 FIRE SAFETY

4.6.1 Smoke detector

One of the most important principles of fire safety is speed of fire detection. Smoke detectors must be installed in the following locations in all dwelling units.

- On each floor
- In the hall close to bedrooms
- In each bedroom where someone sleeps with the door closed
- Close to stairways

The goal is to ensure that occupants can hear the alarm regardless of what they are doing.

Installation of smoke alarms is discouraged, however, in certain locations close to doors into the kitchen or bathroom, ventilation duct outlets, curtains, peaks of vaulted ceilings, wall corners, etc.

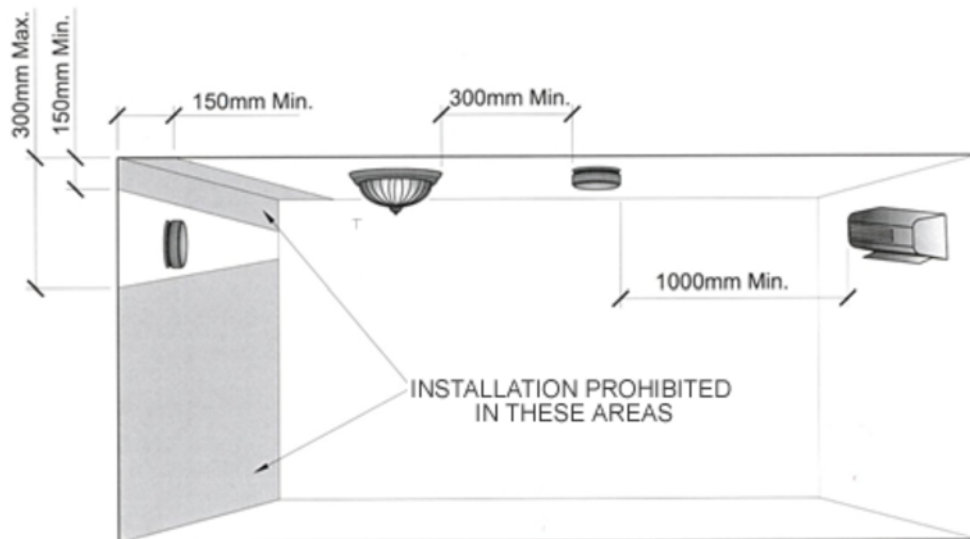


FIGURE 4.18: SMOKE DETECTOR PLACEMENT/ SOURCE: SHQ

4.6.2 Portable extinguishers

Portable extinguishers may be used by occupants when their safety is not compromised and the fire is small, to avoid serious consequences.

Class A, B and C extinguishers approved by Underwriters Laboratories Canada (ULC) are recommended. Extinguishers must be designed for the conditions in which they will be stored, especially where the temperature is below freezing.

4.6.3 Fire stops

Air within a building must not be able to move from one dwelling unit to another through ventilation ducts, heating ducts or a joint utility room.

In the event of fire, smoke generated in one dwelling unit must not spread to other units.

Fire stop registers must be installed in ventilation ducts where smoke might spread from one unit to another.

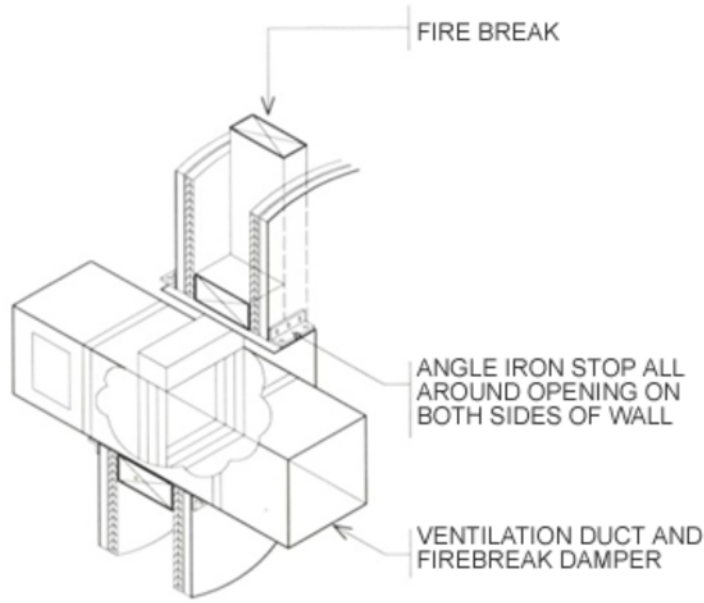


FIGURE 4.19: FIRE STOP REGISTER / SOURCE: SHQ

Fire stop registers must be accessible, through a hatch or other type of opening, for maintenance, inspection and resetting.

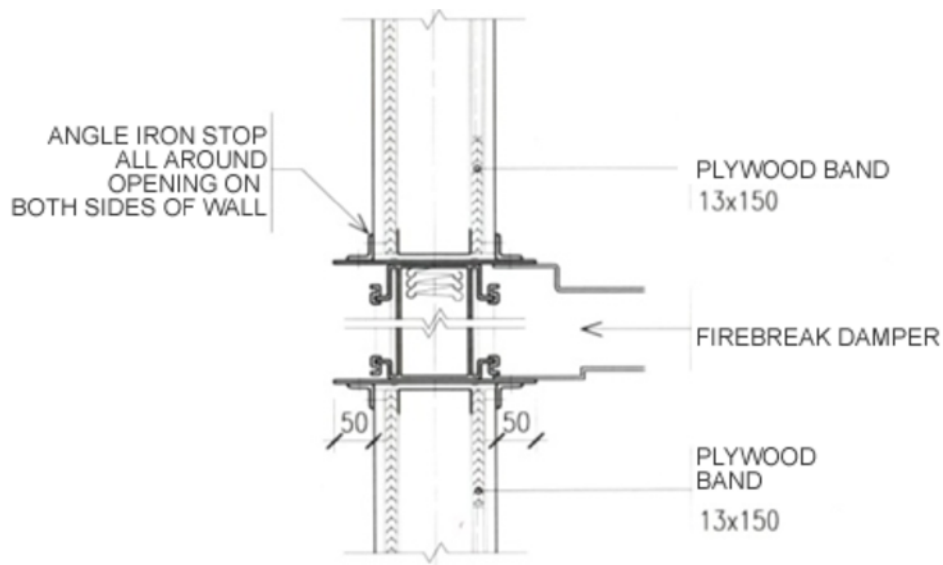


FIGURE 4.20: FIRE STOP REGISTER / SOURCE: SHQ

4.7 COMMISSIONING AND MAINTENANCE (PLUMBING – HEATING – VENTILATION)

4.7.1 Replacement parts and equipment

Maintaining an inventory of replacement parts and equipment is recommended for the most important components (drinking water pressure pumps, heating water circulation pumps, burners, burner sprinklers, fuses, etc.) to ensure the safety of occupants despite delivery delays, which can be very long.

4.7.2 Testing and maintenance

Operational and commissioning testing for heating and plumbing systems must be conducted to ensure their proper operation.

Before delivery of the building, the contractor must ensure that:

- Ventilation ducts and filters have been cleaned and fire stop registers have been tested;
- The sewage removal and ventilation system has been tested for airtightness and water tightness;
- The sewage holding tank has been tested outdoors before being installed in the building, and a water tightness test has been conducted once all plumbing has been installed;
- The drinking water tank and supply system have been cleaned and disinfected with a chlorine solution, which must then be disposed of; the tank and system must then be rinsed with drinking water and all screens must be cleaned;
- All indicator lamps (interior and exterior) must be tested.

Air pressure test

1. The air pressure test must be performed by closing all openings in a system or any part of a system to be tested, and filling it with air at a pressure of at least 35 kPa.
2. The test is deemed satisfactory if the pressure remains stable for 15 minutes, without having to add more air.
3. The pressure gauge must be graduated from 0 to 70 kPa.

Water pressure test

1. Water must be raised to a level at least three metres above all parts of the section tested.
2. The water test must be conducted by closing all openings in the drainage system and the section to be tested, except the top end where water is introduced until the system has been completely filled.
3. The test is deemed satisfactory if the water level remains stable for 15 minutes.

4.7.3 Access

Adequately sized access points must be provided for maintenance, replacement or operation of dampers (intake, return and exhaust), fire stop registers, filter, heat exchangers, etc. Heat exchangers, for example, must be able to be cleaned on each side to remain efficient.

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APPENDICES

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APPENDIX I: ORGANIZATIONS AND AUTHORITIES FOR ANY CONSTRUCTION PROJECT IN NUNAVIK

I.1: FEES AND SERVICES PROVIDED

For more information on leasing/rental rates, services available, equipment rental, human resources or a specific community, please contact the northern villages and landholding corporations (contact information below).

NORTHERN VILLAGE	LANDHOLDING CORPORATION
<p>AKULIVIK PO Box 50 Akulivik QC J0M 1V0 Tel: 819 496-2222 Fax: 819 496-2200</p>	<p>QEKEIRRIAQ LHC PO Box 59 Akulivik QC J0M 1V0 Tel: 819 496-2640 Fax: 819 496-2629</p>
<p>AUPALUK PO Box 6 Aupaluk QC J0M 1X0 Tel: 819 491-7070 Fax: 819 491-7035</p>	<p>NUNAVIK LHC PO Box 29 Aupaluk QC J0M 1X0 Tel: 819 491-7045 Fax: 819 491-7045</p>
<p>INUKJUAQ PO Box 234 Inukjuak QC J0M 1M0 Tel: 819 254-8845 Fax: 819 254-8779</p>	<p>PITUVIK LHC PO Box 285 Inukjuak QC J0M 1M0 Tel: 819 254-8101 Fax: 819 254-8252</p>
<p>IVUJIVIK PO Box 20 Ivujivik QC J0M 1H0 Tel: 819 922-9940 Fax: 819 922-3045</p>	<p>NUVUMMI LHC PO Box 157 Ivujivik QC J0M 1H0 Tel: 819 922-9944 Fax: 819 922-3045</p>
<p>KANGIQSUALUJJUAQ PO Box Kangiqsualujjuaq QC J0M 1N0 Tel: 819 337-5270 Fax: 819 337-5200</p>	<p>QINIQTIQ LHC PO Box 160 Kangiqsualujjuaq QC J0M 1N0 Tel: 819 337-5449 Fax: 819 337-5752</p>

NORTHERN VILLAGE	LANDHOLDING CORPORATION
<p>KANGIQSUJUAQ PO Box 60 Kangiqsujuaq QC J0M 1K0 Tel: 819 338-3342 Fax: 819 338-3237</p>	<p>NUNATURLIK LHC PO Box 39 Kangiqsujuaq QC J0M 1K0 Tel: 819 338-3368 Fax: 819 338-1071</p>
<p>KANGIRSUK PO Box 90 Kangirsuk QC J0M 1A0 Tel: 819 935-4388 Fax: 819 935-4287</p>	<p>SAPUTIK LHC PO Box 119 Kangirsuk QC J0M 1A0 Tel: 819 935-4269 Fax: 819 935-4440</p>
<p>KUJJUAQ PO Box 210 Kuujuaq QC J0M 1C0 Tel: 819 964-2943 Fax: 819 964-0734</p>	<p>NAYUMIVIK LHC PO Box 209 Kuujuaq QC J0M 1C0 Tel: 819 964-2870 Fax: 819 964-2280</p>
<p>KUJJUARAPIK PO Box 360 Kuujuaarapik QC J0M 1G0 Tel: 819 929-3360 Fax: 819 929-3453</p>	<p>SAKKUQ LHC PO Box 270 Kuujuaaraapik QC J0M 1G0 Tel: 819 929-3348 Fax: 819 929-3275</p>
<p>PUVIRNITUQ PO Box 150 Puvirnituaq QC J0M 1P0 Tel: 819 988-2825 Fax: 819 988-2751</p>	<p>DIRECTION GÉNÉRALE DU NORD-DU-QUÉBEC PO Box 151 Puvirnituaq QC J0M 1P0 Tel: 819 755-4838 Fax: 819 755-3541</p>
<p>QUAQTAQ PO Box 107 Quaqtuaq QC J0M 1J0 Tel: 819 492-9912 Fax: 819 492-9935</p>	<p>TUVAALUK LHC PO Box 102 Quaqtuaq QC J0M 1J0 Tel: 819 492-9281 Fax: 819 492-9302</p>

NORTHERN VILLAGE	LANDHOLDING CORPORATION
<p>SALLUIT PO Box 240 Salluit QC J0M 1S0 Tel: 819 255-8953 Fax: 819 255-8802</p>	<p>QAQQALIK LHC PO Box 30 Salluit QC J0M 1S0 Tel: 819 255-8908 Fax: 819 255-8864</p>
<p>TASIUJAQ PO Box 54 Tasiujaq QC J0M 1T0 Tel: 819 633-9924 Fax: 819 633-5026</p>	<p>ARQIVIK LHC PO Box 52 Tasiujaq QC J0M 1T0 Tel: 819 633-5335 Fax: 819 633-5337</p>
<p>UMIUJAQ PO Box 108 Umiujaq QC J0M 1Y0 Tel: 819 331-7000 Fax: 819 331-7057</p>	<p>ANNITURVIK LHC PO Box 148 Umiujaq QC J0M 1Y0 Tel: 819 331-7831 Fax: 819 331-7832</p>

I.2: FORMS AND CONSTRUCTION IN NUNAVIK

To obtain assistance when filling out application forms or obtain more information about construction in Nunavik, don't hesitate to contact the following people.

<p>COORDINATOR, NUNAVIK LANDHOLDING CORPORATION ASSOCIATION</p>	<p>PO Box 179 Kuujuaq QC J0M 1C0 Tel: 819 964-2925 Fax: 819 964-2613</p>
<p>URBAN PLANNER RENEWABLE RESOURCES DEPARTMENT, KATIVIK REGIONAL GOVERNMENT</p>	<p>PO Box 9 Kuujuaq QC J0M 1C0 Tel: 819 964-2961 Fax: 819 964-0694 http://www.krg.ca</p>

I.3: CLASS II AND III LAND LEASES

FOR THE REGION LOCATED EAST OF 76 DEGREES LONGITUDE

**MINISTÈRE DE L'ÉNERGIE ET
DES RESSOURCES NATURELLES
DU QUÉBEC**

**DIRECTION RÉGIONALE
DE LA GESTION DU TERRITOIRE PUBLIC**
837 Sacré-Cœur Blvd
Saint-Félicien QC G8K 1S7
Tel: 418 695-7877
Fax: 418 695-8133

FOR THE REGION LOCATED WEST OF 76 DEGREES LONGITUDE

**MINISTÈRE DES FORÊTS,
DE LA FAUNE ET DES PARCS**

**DIRECTION RÉGIONALE DE LA GESTION
DU TERRITOIRE PUBLIC**
1122 Highway 111 East
Amos QC J9T 1N1
Tel: 819 444-5641
Fax: 819 444-5837

A land lease application form can also be obtained from:

<https://mern.gouv.qc.ca/territoire/droit/formulaire-utilisation-terres-etat.html>

I.4: TO OBTAIN SPECIFIC INSTRUCTIONS FOR ALL LAND SURVEY WORK IN NUNAVIK:

**MINISTÈRE DE L'ÉNERGIE
ET DES RESSOURCES
NATURELLES (MERN)**
**BUREAU DE L'ARPENTEUR GÉNÉRAL
DU QUÉBEC**
**DIVISION DES TERRITOIRES
AUTOCHTONES ET DES FRONTIÈRES**

5700, 4th Avenue West, Suite F-310
Charlesbourg QC G1N 6R1
Tel: 418 627-6263
Fax: 418 643-6512
email: services.specialises@mern.gouv.qc.ca

For more information on the Bureau de l'arpenteur général du Québec, visit the Ministry's website:

<http://www.mern.gouv.qc.ca/information-fonciere>

I.5: TO OBTAIN CERTIFICATES OF AUTHORIZATION

**MINISTÈRE DU DÉVELOPPEMENT
DURABLE, DE L'ENVIRONNEMENT ET DE
LA LUTTE CONTRE LES CHANGEMENTS
CLIMATIQUES**

**DIRECTION RÉGIONALE DU
NORD-DU-QUÉBEC**

180 Rideau Blvd, 1st Floor
Rouyn-Noranda QC J9X 1N9
Tel: 819 763-3333
Fax: 819 763-3202

For more information on certificates of authorization from the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, visit the Ministry's website:

<https://mern.gouv.qc.ca/territoire/droit/formulaire-utilisation-terres-etat.html>

I.6: FOR CONNECTION TO THE ELECTRICAL AND TELEPHONE SYSTEM, CONTACT:

HYDRO-QUÉBEC

1 800 472-5103

BELL CANADA

819 773-5515

I.7: FOR MORE INFORMATION ON ARCHAEOLOGICAL SITES, CONTACT THE FOLLOWING ORGANIZATIONS.

AVATAQ CULTURAL INSTITUTE

Inukjuak QC J0M 1M0
avataq@avataq.qc.ca (general information)
severian@avataq.qc.ca
(Archaeology Department)

**MINISTÈRE DE LA CULTURE ET
DES COMMUNICATIONS
DIRECTION NORD-DU-QUÉBEC**

19 Perreault Street West, Suite 450
Rouyn-Noranda QC J9X 6N5
Tel: 819 763-3517
Fax: 819 763-3382
dratnq@mcc.gouv.qc.ca

APPENDIX II: ADDITIONAL LAND SURVEY INSTRUCTIONS

The following instructions are provided for information purposes, as a complement to section 1.4.

Remember that it is essential to contact the Bureau de l'arpenteur général du Québec (BAGQ) at least 30 days before performing the work in the field to obtain land survey instructions. This step is necessary to submit the survey documents to the clerk of the Arpenteur général du Québec.

- The land survey plan must indicate the site (lot) where the structure will be built and especially the lot limits, measurements, area and the adjacent lots, and must be submitted to the clerk of the Arpenteur général du Québec.
- The clerk of the Arpenteur général du Québec acts as the single service point for submission of land survey documents, as a public register accessible to all. Only the BAGQ is authorized to issue certified copies of documents submitted to the clerk of the Arpenteur général du Québec. The BAGQ charges no fee to land surveyors for requests for specific land survey instructions.
- Following submission to the clerk of the Arpenteur général du Québec, the BAGQ forwards a certified copy of the document to the Kativik Regional Government's urban planner and to the appropriate landholding corporation.
- For all other private land survey work that does not create or alter a subdivision (e.g. location certificates), there is no requirement for submission to the clerk of the Arpenteur général du Québec. However, a certified copy of the document and a digital file must be submitted to the BAGQ by the land surveyor retained, to incorporate the information gathered in the field into the land surveys compilation map produced by the BAGQ's Division des territoires autochtones et des frontières.

APPENDIX III: DESCRIPTION OF PROJECTS SUBJECT TO AND EXEMPT FROM THE ENVIRONMENTAL ASSESSMENT PROCESS (FROM CHAPTER 22 OF THE JAMES BAY AND NORTHERN QUEBEC AGREEMENT)

Projects automatically **subject to** the environmental and social impact assessment and review procedure

1. Any mining operation as well as any significant addition to or transformation or modification of existing mining operations, but air and land reconnaissance, land survey, mapping and core sampling work is allowed without requiring an impact report.
2. The placement and use of large borrow pits, sand and gravel pits, and other quarries.
3. Energy production:
 - a. Hydroelectric power plants, nuclear facilities and related works
 - b. Storage tanks and water retention ponds
 - c. Transmission lines of 75 kV or more
 - d. Extraction and processing of energy resources
 - e. Thermal power plants fired by fossil fuel, with a capacity of more than three thousand kilowatts (3000 kW)

4. Tree-farming operations:
 - a. Major access roads built for forestry operations
 - b. Sawmills, pulp and paper mills or other facilities related to forestry activities
 - c. In general, any significant change in land use with a noticeable influence on an area exceeding twenty-five square miles (25 mi²)
5. Community and municipal services:
 - a. New and large sewage and waste water capitation and removal systems
 - b. Solid waste collection and disposal, including sanitary landfill and incineration
 - c. Proposed parks, ecological reserves or other similar land uses
 - d. New outfitter operations for more than thirty (30) people, including outpost networks
 - e. New towns, communities or municipalities, or significant expansion of existing sites
6. Transportation:
 - a. Access roads to communities and adjacent roads
 - b. Port facilities
 - c. Airports
 - d. Railways
 - e. Roadway infrastructure for new subdivisions
 - f. Pipelines
 - g. Dragging work to improve shipping

Projects automatically **exempt** from the environmental and social impact assessment and review procedure:

1. Any development within community boundaries that will have no direct impact on wildlife resources outside those boundaries.
2. Small hotels, motels, service stations and other similar construction alongside provincial and secondary highways.
3. Buildings constructed for housing, wholesale or retail businesses, garages, offices or craft work, and vehicle parking.
4. Thermal power stations fired by fossil fuel, with a capacity of less than three thousand kilowatts (3000 kW).
5. The following buildings:
 - Educational institutions, banks, fire stations, property intended for administration, recreation, cultural activities, religious rites, sports and healthcare, as well as property and equipment used for telecommunications.
6. Construction, modification, renovation, relocation or conversion to other uses of switching and transformer stations with a power of seventy-five kilovolts (75 kV) or less and energy transmission lines of seventy-five kilovolts (75 kV) or less.
7. Construction and extension or trunk pipelines with a diameter of less than thirty centimetres (30 cm) with a maximum length of five miles (5 mi).

8. Investigation, preliminary study, research, technical studies and surveys prior to any development, work or construction.
9. Tree farming operations where these form part of management plans approved by government, subject to the provisions of paragraph 23.5.34 of the James Bay and Northern Quebec Agreement.
10. Municipal streets and sidewalks built in compliance with municipal bylaws, as well as the operation and maintenance of roadways and roadway fittings.
11. Repair and maintenance of municipal works.
12. Temporary facilities used for hunting, trapping, harvesting of wildlife resources, as well as outfitting services and camps for fewer than thirty (30) people.
13. Extraction and handling of steatite, sand, gravel, copper and timber, for personal and community use.
14. Limited woodcutting for personal or community use.
15. Borrow pits for road maintenance.

The preceding provisions are not interpreted as restricting the requirements related to environmental impact assessment under the federal impact assessment and review process applicable to federal projects.

APPENDIX IV: RECAPITULATIVE TABLE OF REQUIRED AUTHORIZATIONS

The following table summarizes the authorizations issued by each organization.

ORGANIZATION	AUTHORIZATION	APPLICABLE FEES
VN	Development permit for projects on Class I lands	Administration fees
	Authorization to excavate natural materials from Class I lands	N/A
CF	Memorandum of understanding signed with the contractor on occupancy and use of Class I lands during construction	Rental costs during the construction period, which may differ from those outside the construction season
	Land leases for occupancy of Class I lands	Administrative and leasing fees
	Right to obtain gravel or other mineral materials from Class I lands	Compensation fees for extraction of minerals (price per tonne)
KATIVIK REGIONAL GOVERNMENT	Certificate of authorization for projects on Class II and III lands	N/A
MINISTÈRE DU DÉVELOPPEMENT DURABLE, DE L'ENVIRONNEMENT ET DE LA LUTTE CONTRE LES CHANGEMENTS CLIMATIQUES	Certificate of authorization for drinking water and sewage treatment and for waste disposal; Certificate of authorization to operate a new quarry or borrow pit	N/A
MINISTÈRE DE L'ÉNERGIE ET DES RESSOURCES NATURELLES	Land leases for projects on Class II and III lands and in NVs of Puvirnitug and Ivujivik	Administrative and leasing fees
BUREAU DE L'ARPENTEUR GÉNÉRAL DU QUÉBEC	Specific instructions for all land survey work on Class I lands and for all land survey work in Puvirnitug, Ivujivik and on Class II and III lands	N/A

APPENDIX V: NOVOCLIMAT PROGRAM

The Novoclimat Program was introduced in 1999, to improve the energy performance of new residential buildings and to influence the residential construction industry to upgrade its construction techniques. It also contributes to attainment of the energy savings objectives of the Québec Energy Strategy 2006-2015, To Build the Québec of Tomorrow. Novoclimat is modelled on similar voluntary programs in the United States and Canada, especially the federal ENERGY STAR and R-2000 programs for new housing, which evolve as technology advances.

Version 2.0 of the Novoclimat Program is the result of a full review that took effect in 2013. Compliance with the prescriptive requirements in this second generation of the program helps reduce energy use of new residential buildings by about 20 percent compared with similar buildings designed under the requirements of part 11, Energy Efficiency, of chapter 1 of the Quebec Construction Code (QCC).

The Novoclimat technical requirements constitute guidelines that apply during building design and construction to ensure attainment of the objectives set by the program. These have been developed to facilitate the design of housing that meets certain criteria for energy efficiency, comfort, air quality and durability. They specifically target the following goals.

- Reduce thermal loss from buildings through better insulation, better airtightness of the envelope and use of high-performance window systems.
- Reduce energy use of installed appliances by setting performance criteria for heating, ventilation and air conditioning (HVAC) systems and for water heating systems.
- Maintain good indoor air quality, improve occupant comfort and promote building durability through the establishment of demanding installation criteria and the use of healthy, durable materials, efficient products and water-saving equipment.

APPENDIX VI: AIR LEAKS THROUGH THE ENVELOPE

Leaks generally occur through cracks and small openings in insulated windows, doors, walls, floors or roofs. Their extent depends on how the building is designed, the quality of materials, how they have been assembled and the difference in air pressure on both sides of the envelope.

Leaks through the envelope often cause the following problems: high heating costs, rotting or corrosion of materials due to water infiltration and the appearance of hidden mould due to condensation of humidity in internal components of the envelope.

The three primary mechanisms that allow the passage of air through a building's envelope are: the chimney effect, wind action and mechanical ventilation.

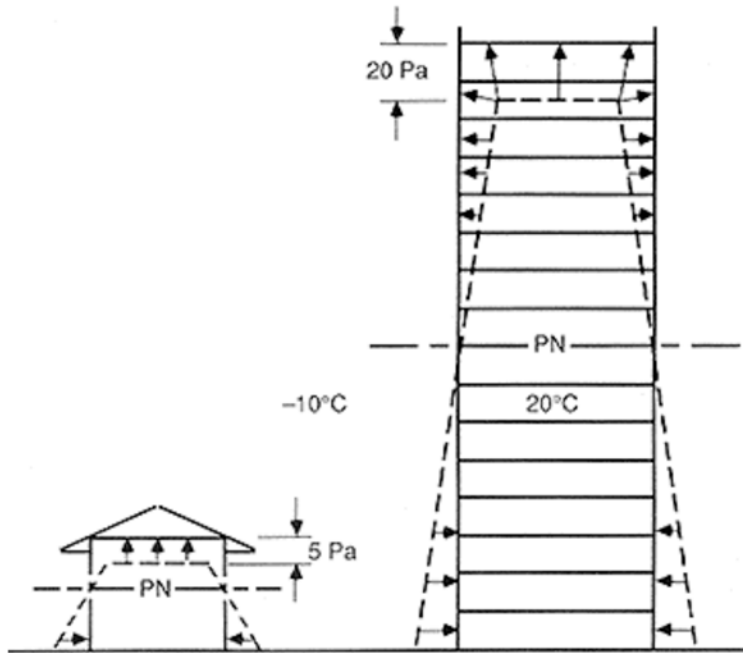


FIGURE VI.1: PRESSURE DIFFERENCES IN A BUILDING
SOURCE: NRC ARTICLE: "UNE DÉFINITION DE PARE-AIR," PRODUCED AS PART OF BUILDING SCIENCE INSIGHT 86

VI.1: CHIMNEY EFFECT

Figure VI.1 shows the positive pressure that warm air exerts outward on the upper portion of the building and the negative pressure on the lower part of the building.

In multi-storey buildings, the chimney effect tends to cause ex-filtration in the upper portions and infiltration in the lower portions. The higher the temperature, the less dense the air becomes, which explains why warm air is lighter than cold air. So warm air rises and this floatability exerts outward pressure on ceilings and the upper part of walls. Openings in the vapour barrier let hot, humid air escape under the roof and into the wall structure, where it cools and deposits humidity on cold interior surfaces of the roof or wall sheathing.

VI.2: Wind action

Uncontrolled air currents through the envelope reduce the well-being of occupants and cause many disorders. Wind blowing against a house produces positive pressure, pressing in the exterior face of the wall exposed to the wind and causing infiltration. The wind also produces negative pressure or depression on the other walls, causing ex-filtration. This negative pressure draws indoor air to the outside through small openings and the humidity in this warm air condenses inside the wall structure, on cold components.



FIGURE VI.2: PRESSURE GENERATED ON A HOUSE BY WIND
SOURCE: NRC ARTICLE: "UNE DÉFINITION DE PARE-AIR," PRODUCED AS PART OF BUILDING SCIENCE INSIGHT 86

VI.3: MECHANICAL VENTILATION

Figure VI.3 shows the air flows entering and exiting a house that are necessary to use equipment such as the boiler, dryer and range hood.

While extraction ventilators reduce pressure inside a house by extracting air, poorly balanced mechanical ventilation systems, including fresh air ventilators, can generate positive pressure. Air and humidity then move outward and into the attic, where condensation can occur.

Careful design and construction are necessary to minimize air leaks and ensure water tightness as well as energy efficiency appropriate for buildings in Nunavik. To do this, managers, designers and builders must have a very thorough knowledge of air, water and vapour barrier systems.



FIGURE VI.3: AIR ENTERING AND EXITING A HOUSE / SOURCE: NRC ARTICLE: « LE MÉCANISME DE VOTRE MAISON : VENTILATION ET CONTRÔLE DU FLUX D'AIR »

APPENDIX VII: MINIMUM PROPERTIES OF AN EFFECTIVE AIR BARRIER SYSTEM

VII.1: CONTINUITY

A continuous air barrier requires more than the lack of holes or flaws. A system that must act as an air barrier has to include suitable joint materials and sealing details to prevent any flows in the following meeting points: around doors and windows; at wall-roof, wall-foundation and wall-insulated floor junctions; around any architectural projections such as a porch, balcony or sun baffle; around electromechanical components such as wires, pipes and ducts crossing through the building envelope, etc. in brief, the winning solution is to ensure total continuity between all system materials to obtain an airtight “shell.”

VII.2: STRUCTURAL STRENGTH

The component designed to serve as an air barrier must be able to withstand the excess pressure applied or must be protected with another suitable material. It must be resistant to the pressure or suction of the strongest excess wind loads without breaking or tearing away from its support. The air barrier must not rip off its support or fail due to creep under sustained pressure through draft, pressurization or extraction created by ventilators. The air break and its support must be rigid enough to resist movements. Thus, unless sandwiched between two rigid plates, an air barrier sheet must be strong enough to resist air pressure or depressurization, which is hard to achieve with thin membranes.

VII.3: LOW AIR PERMEABILITY

One essential characteristic of an air barrier is strong resistance to air flows. Since absolute air impermeability is rarely possible, or even necessary, air barrier materials will be required to provide low air permeability. For classification purposes, materials are rated with an index called the “air permeability rate” in private or government laboratory tests. In this regard, the Canadian Construction Materials Centre standard sets a maximum allowable rate of 0.02 L/s.m² at a pressure differential of 75 Pa. Note that this threshold is not very demanding since commonly used air barrier membranes sold in hardware stores achieve rates between 0.005 and 0.0017 L/s.m². In the air barrier/vapour barrier membranes category, extremely low air permeability rates can be attained, on the order of 0.0003 L/s.

VII.4: HIGH WATER VAPOUR PERMEABILITY (WHEN PLACED ON THE COLD SIDE OF INSULATION)

Permeability is the property by which a material allows water vapour to pass through it fairly easily: under a given humidity pressure, the higher a material's permeability, the more easily this occurs. This property can be illustrated as follows: greater permeability allows the material to “breathe” easily under humidity pressure. For classification purposes, materials are rated by an index called “water vapour permeability” in private or government laboratory tests. In this regard, the Canadian CCMC standard sets a minimum allowable rate of 170 ng/Pa.s.m² for an exterior sheathing membrane, equivalent to 3 US perm (1 US perm = 57.21 ng/Pa.s.m²). This threshold is not stringent at all since the commonly used membranes sold in hardware stores achieve test results between 7 and 30 US perm.

An air barrier system in which the primary barrier is on the cold side of the insulated component should have high water vapour permeability so any humidity that has crossed the interior vapour barrier can escape quickly through the envelope and thus minimize the risk of condensation on components inside the insulated wall.

VII.5: DURABILITY

Since the air barrier system materials are never visible and never exposed directly to foul weather, they are assured of extended durability if covered within the required time during construction. Durability of the barrier system as a whole thus is linked primarily to the sturdiness of the connecting or sealing components between the various air barrier membranes that make up the system: connection between two strips of the same membrane, connection between two different types of membrane (wall-ceiling, wall-floor, wall-opening, wall-projection and other junctions). Since most of these connections are made by adhesion or sealing, and since any assembly involving adhesion or sealing on the site requires great attention to detail to be reliable, a carefully made joint between the various components of the air barrier assembly will achieve the desired reliability for this building element. The following precautions therefore must be observed: clean surfaces, totally dry materials, controlled application temperature, compatibility between materials and products, sufficient overlapping of assembled, use of primer before adhesion, minimum application pressure, etc.

The environment to which the air barrier is exposed only briefly during construction may still adversely affect the durability of certain component materials. These must be adequately protected from foul weather, UV radiation and mechanical damage during construction.

APPENDIX VIII: WATER VAPOUR PERMEABILITY

The measurement of water vapour diffusion through a construction material is called “water vapour permeability.” The lower this permeability, the better the product resists the passage of vapour and the more effective it is rated as a vapour barrier. The common unit of measurement for permeability is the perm (US perm in North America): 1 US perm equals 57.2 ng/Pa.s.m².

Vapour barrier materials on the market are classified as type I, II or III based on their permeability as determined by the standard tests, with type I providing the best performance for containing water vapour:

- type I: less than 15 ng/Pa.s.m² (0.26 US perm),
- type II: between 15 and 60 ng/Pa.s.m² (0.26 – 1.05 US perm),
- type III: greater than 60 ng/Pa.s.m² and no more than 572 ng/Pa.s.m² (1.05 – 10 US perm).

The Construction Code requirements for vapour barrier materials differ depending on the climate zone, but in all cases, their permeability must be no more than 1.05 US perm (60 ng/Pa.s.m²), which requires at least a type II product. This value is not very restrictive since simple interior alkyd paint finishes on a gypsum panel can provide such protection. For example, the commonly used 0.15 mm thick polyethylene film provides a permeability of 0.03 US perm (1.6 ng/Pa.s.m²), which far exceeds the minimum standard and gives it a type I rating. In Appendix A, the Code's Building chapter provides a table with the water vapour permeability of common construction materials.

The Canadian General Standards Board has certified various vapour barrier products sold in the market, under the CGSB-51.33-M and CGSB-51.34-M standards, allowing them to display a certificate number as proof of compliance with the Code.

APPENDIX IX: INFILTRATION IN A CONSTRUCTION ASSEMBLY

Construction assemblies are naturally designed to prevent water and snow from penetrating into components of the envelope. However, precipitation driven by strong winds manages in some cases to penetrate the exterior cladding. The Code's Building chapter states that it is not necessary to totally eliminate all accumulations or prevent humidity at all costs from penetrating a construction assembly: wind-driven rain that penetrates the exterior cladding may not affect the long-term performance of the construction assembly, provided the dampness dries out or is released before it starts to degrade building materials. A design that allows fast drying of humid or damp materials therefore must form part of the design.

APPENDIX: RAIN SCREEN WALL

The "hidden protection" type of design is primitive and little used today, contrary to the much more popular "rain-screen" design type. The distinction between these two types of walls is explained in section A-9.27.2 of the Code's Building chapter. It states (section A-9.27.20) that the rain-screen wall type has three variants.

1. The "basic" rain screen wall, which requires no cavity behind the siding
2. The "draining" rain screen wall, in which the cavity behind the siding is open and ventilated using a support materials designed for this purpose
3. The "open" rain screen wall, the most common type, which includes a cavity 10 to 19 mm deep behind the siding, open and vented to the open air

APPENDIX XI: DEGREE DAYS

Assessment of heating in "degree days" below 18°C in a given region or city measures annual energy expenditure calculated as follows: for each day requiring heating, the annual sum of the difference between the average daily temperature and the 18°C reference temperature. Schedule C of the Code's Building chapter presents a full table of these data for the primary locations in Quebec, including four villages in Nunavik: Inukjuak, with 9,050 dd, Kuujuaq with 8,650 dd, Kuujuarapik with 8,250 dd, and Puvirnituq with 9,200 dd.

APPENDIX XII: OTHER STANDARDS

Other energy efficiency standards that specifically govern building insulation may prove just as relevant for a northern climate, such as the MERN Novoclimat 2 Program du MERN for the "house and small multi-unit building" component or Natural Resources Canada's (NRCan) ENERGY STAR home certification program or the R-2000 certification program, also from NRCan. Since their application optional, these standards are not shown in this guide. The MERN and NRCan documentation still remains a valuable source of information, especially the Novoclimat publication that contains many practical tips and is extensively illustrated.

APPENDIX XIII: ENERGY STAR CERTIFIED DOORS AND WINDOWS

ENERGY STAR certified doors and windows are tested and certified by an independent accredited organization. Product are ENERGY STAR certified based on their U value (overall heat transfer coefficient) or their ER, which exceed the Construction Code requirements.

Map XIII.I shows the distribution of climate zones in Canada by colour code. Nunavik falls within zone D, which is 8,000 degree days and more.

The two following tables show the performance ratings for ENERGY STAR certified doors for each of the four climate zones determined for Canada. The U factor shown represents the measurement of the thermal transfer rate through the component. A low U value is desirable because it indicates low thermal loss in winter and low thermal gain in summer. The U is the mathematical opposite of the RSI thermal resistance value normally assigned to insulated walls. The energy performance rating (ER), represents the measurement of general energy performance for windows, incorporating heat loss through heat transfer, solar gain and heat loss through air leakage. The higher the energy rating, the better the window's energy performance in heating season.

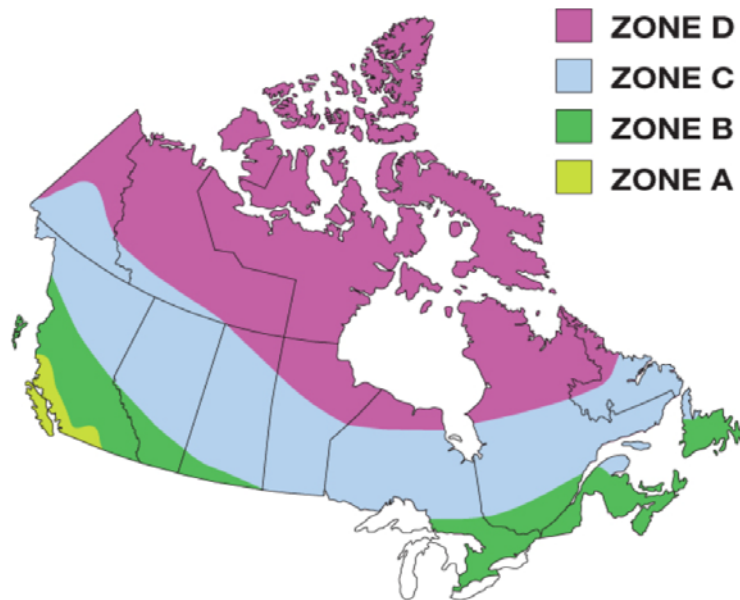


FIGURE XIII.I: CLIMATE ZONES IN CANADA / SOURCE: NATURAL RESOURCES CANADA

WINDOWS					
ZONE	Heating degree day scale	Compliance path			
		Energy efficiency rating (EER)	or	U factor	
		Minimum EER (no units) Maximum U factor 2,00 W/m ² •K (0,35 Btu/h•pi ² •°F)		Maximum U factor W/m ² •K (Btu/h•pi ² •°F)	Minimum EER (no units)
A	< = 3500	21	or	1,80 (0,32)	13
B	> 3500 to < = 5500	25	or	1,60 (0,28)	17
C	> 5500 to < = 8000	29	or	1,40 (0,25)	21
D	> 8000	34	or	1,20 (0,21)	25

TABLE XIII.1: ENERGY STAR WINDOW COMPLIANCE PATH

DOORS					
ZONE	Heating degree day scale	Compliance path			
		Energy efficiency rating (EER)	or	U factor	
		Minimum EER (no units) Maximum U factor 2,00 W/m ² •K (0,35 Btu/h•pi ² •°F)		Maximum U factor W/m ² •K (Btu/h•pi ² •°F)	Minimum EER (no units)
A	< = 3500	21	or	1,80 (0,32)	N/A
B	> 3500 to < = 5500	25	or	1,60 (0,28)	N/A
C	> 5500 to < = 8000	29	or	1,40 (0,25)	N/A
D	> 8000	34	or	1,20 (0,21)	N/A

TABLE XIII.2: ENERGY STAR DOOR COMPLIANCE PATH

APPENDIX XIV: INFILTROMETRY

XIV.1: INFILTRATION TEST

The infiltrometry test must be conducted by a specialist in this field, independent of any contractual link with the principals in the contract. This specialist must first close all exterior openings (windows, doors, ventilation dampers, plumbing drains, etc.) and check that interior doors are open, to all the free movement of air. An infiltrometer is then installed in the entry door. This device is equipped with an airtight nylon fabric that seals the door opening with a frame that adjusts to the dimensions of the door and a fan. The device measures the pressure difference between the interior and exterior to determine how much air is entering the building.

The operator that searches for leaks to find the places where changes must be made to improve the building's airtightness. These changes can be made at little cost because the envelope is still accessible from the interior. Artificial smoke is used to detect the path of infiltration, an anemometer detects air movement in places where the air is filtering in, or infrared thermography makes the places cooled by infiltration visible.

A second infiltrometry test is conducted after the remedial work to determine the building's infiltration rate upon delivery. In new construction, the results should approach the values recommended by the Novoclimat 2 energy efficiency program, shown in the attached Table XIV.1.

MAXIMUM ACCEPTABLE LEAKS ⁶					
Building type	CAH at 50 Pa	SFN at 10 Pa		TFN at 50 Pa	
Detached	1,5	0,75	1,08	0,57	0,11
Attached⁷ (e.g. semi-detached, row)	2,0	1,18	1,70	0,78	0,15

TABLE XIV.1: MAXIMUM ALLOWABLE AIR LEAKAGE, TABLE 2.2.2.1, FROM PAGE 19 OF THE NOVOCLIMAT 2 PROTOCOL

A report of the results obtained on airtightness of the building must then be submitted to the owner's representative, and must cover at least the following points:

- General building and test conditions;
- Exterior walls;
- Attic;
- Doors;
- Windows;
- Airtightness;
- Recommendations.

6. Building airtightness is measured by an infiltrometry test performed under the CAN/CGSB2-149-10-M86 standard, Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method..

7. Applies only to buildings separated in more than one area by one common walls and subject to separate infiltrometry tests of these areas.

XIV.2: THERMOGRAPHIC ANALYSIS

The building envelope—the floor (exposed to the outdoor air as in raised buildings on pilings or adjustable jacks generally built in northern communities), walls and roof—must undergo thermographic analysis to observe variances that occur in thermal behaviour and detect any anomaly. This analysis should be conducted simultaneously on the exterior and interior surfaces of the building envelope.

Ideally, the thermographic analysis should cover both the qualitative and quantitative aspects, the first gathering information on the envelope components with unexpected or abnormal thermal behaviour, and the second examining the infrared radiation measurements to assess deficient thermal behaviour caused by defective profiles.



FIGURE XIV.1: INFRARED PHOTOGRAPH OF A HOME TAKEN IN WINTER. RED REPRESENTS WARM COMPONENTS, BLUE THE COLD COMPONENTS. / SOURCE: GOOGLE IMAGES

For prefabricated buildings fully assembled in a factory, the recommendation is to conduct as many tests as possible on site to measure insulation and airtightness. The builder can then make the necessary changes without delay and without incurring additional costs (shipping materials and travel and accommodation for specialized labour) to perform the work on site. Since the temporary preparation measures are not representative of actual conditions in Nunavik and the actual occupancy or usage of the building, the analysis should cover only the qualitative aspect. Another possibility for prefabricated buildings is to install the interior finish after thermographic analysis is performed on site, so the builder can make required changes before closing in the interior walls.

For buildings constructed directly in Nunavik and for those prefabricated in panels but assembled in Nunavik, thermographic analysis will be performed on site as soon as the suitable conditions are obtained. The minimum quantities of replacement materials initially specified in the construction contract (see section 3.2.4, Replacement of materials and products) can be used for immediate execution of the required remedial work, and subsequently replaced through annual procurement.

The contracts manager will simply have to deduct the cost of using these replacement materials from the payments due to the contractor performing the work. Here again, the analysis should focus on the qualitative aspect, although the quantitative aspect can provide valuable information on the actual performance of the facility and support the compilation of statistics for future follow-up, which provides crucial data in the event of a claim against the contractor performing the work.

In addition to constituting a valuable decision-making aid for construction contract managers when paying for work, production of a thermographic or infiltrometry analysis report guarantees the quality of work and the expected performance for all components of the envelope. If the quality of work or the performance falls short of expectations, the contractor will then have no alternative but to make the necessary corrections.

APPENDIX XV: REVIEW PROPOSAL

We invite persons interested and wishing to participate in review of the *Guide to Good Practices* to submit proposed changes using this form.

Please indicate the section number in question and the pagenumber: _____

Briefly describe the amendment, addition or deletion proposed: _____

State your reason for submitting this proposal (experience in the field, appearance of a new technology, other): _____

Name and occupation: _____

Organization or company: _____

Telephone number and email address: _____

Date: _____

Mailing address: _____

Please send your proposal to the following address:

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et de l'expertise technique
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