GOOD BUILDING PRACTICE FOR NORTHERN FACILITIES

FOURTH EDITION - 2019

This document is a draft version and is currently in the development stage. This preliminary publication intends to gather private sector agencies initial review and feedback only.

Government of
Northwest Territories

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FOREWORD

Building in the North is indeed more demanding than building in more temperate climates. The *"Good Building Practice for Northern Facilities 2019"* guidebook serves to illustrate the technical differences encountered when building in the cold northern environment. It is aimed at providing all groups involved with buildings - building developers, building designers, building constructors, suppliers, and administrators and operators - with a comprehensive set of practical recommended technical best practice northern building guidelines.

The *"Good Building Practice for Northern Facilities 2019"* updates northern construction recommended best practice by incorporating 10 years of changed codes and standards since the previous 2009 edition, and adds new sections for Civil, Environmental, Geotechnical, and HBMA considerations, as well as updating recommendations for more sustainable development and improved energy conservation for all northern buildings.

The recommended best practices format of the *"Good Building Practice for Northern Facilities 2019"* renews the challenge to builders and designers to be innovative when applying recommended best practices. Building constructors and designers are encouraged to present alternatives to the recommended best practices found in the new edition of the guidebook, and share in the continued renewal of the guidebook by presenting new or innovative ways of resolving technical problems, reducing building life-cycle cost, and improving building energy conservation.

The *"Good Building Practice for Northern Facilities 2019"* was developed then refined by incorporating input from building designers, building contractors, suppliers, facility operators, members of the general public, research consultants, Infrastructure and other GNWT department staff, who worked together to achieve a consensus regarding northern building practices that are appropriate, economic and realistic.

The *"Good Building Practice for Northern Facilities 2019"* goes beyond the four stated objectives of safety, health, accessibility for persons with disabilities, and fire and structural protection of buildings in the *National Building Code of Canada 2015* and the *National Fire Code of Canada 2015*, both adopted in the NWT by the NWT Fire Prevention Act and Regulations.

The "Good Building Practice for Northern Facilities 2019" supplements the minimum stated objectives of the building and fire codes, specifically when experience and information gathered from members of the northern building development and management community indicate that;

- when there is a demonstrated economic value benefit to northern building durability and energy conservation, to be gained by incorporating specific products, systems or methods, those features are recommended to be incorporated;

- more technically sustainable practices are needed to be applied in northern building, relative to the minimal requirements of the *National Building Code of Canada 2015* and the *National Fire Code of Canada 2015* applied in more temperate regions;

- code requirements should be clarified to take into account differences in northern community climate factors, infrastructure and services; and

- Northern building development and operation experience has demonstrated that conditions particular to remote northern communities require an approach different from typical Canadian building industry practice.

We are confident that all northern builders will find the *"Good Building Practice for Northern Facilities 2019"* to be an indispensable guidebook, and challenge users to contribute towards its further development in the next edition.

(Sign)

ACKNOWLEDGEMENTS

GENERAL BUILDING OBJECTIVES

INTRODUCTION

The primary objective of *Good Building Practice for Northern Facilities* is to provide a technical reference handbook to help building developers produce the best value in northern buildings. Buildings designed specifically for the northern climate and physical site parameters, for minimum capital cost consistent with lowest life cycle cost, will provide ongoing economic service and good quality accommodation for program delivery. The goal of *Good Building Practice for Northern Facilities* is to incorporate proven methods and materials, while supporting improved building performance and new technology.

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A1 LOCAL RESOURCES

Construction projects provide important opportunities for communities to gain experience in building development. Input by community residents can provide valuable information on project definition and construction methodology. Local expertise can benefit building design with information on snow drifting patterns, preferred orientations, anticipated use patterns and examples of successful materials or methods. Local contractors and certified trades persons typically present the best value for initial construction and ongoing maintenance, by being both familiar with local conditions and near at hand to the building, and able to provide local labour.

1.1 EQUIPMENT SUPPLIES AND PRODUCTS

The use of locally available equipment, supplies and products benefits the community and can reduce construction costs. Bringing specialized equipment into most communities is extremely expensive. Building design and construction methods should be suitable for available equipment, and where possible locally available supplies and products.

1.2 OPERATION AND MAINTENANCE

Given the growing number of building projects and the limited numbers of experienced trades persons in the North, new building construction should be seen as an opportunity to develop building maintainers in the community.

A2 TOTAL SERVICE LIFE COST or TOTAL COST OF OWNERSHIP

Wherever alternative designs are considered, the alternative representing the lowest total service life cost is recommended to be selected. Wherever alternatives are shown to have the same total service life cost, the alternative with the lowest capital cost is recommended to be selected. The total service life costing should be based on the expected design service life of the building and its systems. For comparative purposes a 40 year design service life is recommended, corresponding to the "Medium Life" category of 29 to 49 years specified in Table 2 of "Guideline on Durability in Buildings", CSA Standard S478-95(2001). Refer to GBP G4.4, "Durability".

The goal should be to balance other project development considerations, such as, for example, where direct benefits to the community will be realized (e.g., incorporating locally available materials); or where a product preference is stated in another GBP article, with current cost and technical performance capacity to support the design service life.

A3 APPROPRIATE TECHNOLOGY

To achieve the previously described goals and produce buildings that perform well and keep occupants comfortable, several basic principles have evolved. These principles can help guide building choices, to ensure they are appropriate for northern conditions.

3.1 SIMPLICITY AND EFFICIENCY

Available funding dictates "lean" buildings. It is recommended all building design solutions strive to:

- Minimize enclosed volumes and building perimeter for the required floor areas;
- Provide efficient program delivery by careful planning of related activity areas using uncomplicated floor plan layouts;
- Provide adequate and well-planned but efficient service and circulation areas;
- Plan for future expansion as simply as possible without major disruption to building users.

In terms of detailed development, the building design solution is recommended to:

- be kept simple to improve the speed of construction in a curtailed construction season and to offer greater opportunity for employment of local trades persons and labourers;
- incorporate materials and methods that will permit quality construction under adverse environmental conditions in a curtailed construction season;
- limit the variety of materials and minimize the number of specialized trades required on the project;
- ensure procedures needed to operate and maintain the building can be put into practice using readily available labour, maintenance products and equipment.

3.2 RELIABILITY

Essential building systems like heating, ventilation and fire protection must be reliable in the harsh winter conditions of the NWT. Standby equipment and installations that facilitate quick repairs are an essential characteristic of building systems. Building components, including interior and exterior finishes, must also be rugged enough to withstand the conditions to which they are exposed without the need for frequent or specialized repairs. Any equipment or system that needs servicing by specialized trades people or parts that are difficult to obtain, is not recommended, though at times unavoidably necessary.

3.3 STANDARDIZATION

The intent of *Good Building Practice for Northern Facilities* is to standardize system elements based on proven successes, so that the final product is cost effective, energy efficient, readily operable and maintainable by local people. Given the vast size and regional variation within the NWT, buildings must respond to differences in:

- community settings
- climatic zones
- transportation systems
- site conditions

Variations to recommendations reflecting local or regional differences and preferences are noted in this document where applicable.

3.4 DURABILITY

A basic durability requirement that helps buildings achieve lowest total service life cost is cited in "Guideline on Durability in Buildings", CSA Standard S478-95(2001). Total service life cost includes necessary repairs and renovations during the design service life. The Basic Durability Requirement states, "Buildings and their components shall be conceived, designed, constructed, operated and maintained in such a way that, under foreseeable environmental conditions, they maintain their required performance during their design service life. The predicted service life of buildings and building components and assemblies should meet or exceed their design service life. In the event of renovation, the design service life of the revised structure shall be reconsidered".

Essentially a conservation requirement, basic durability requirements apply to building operation and maintenance, in addition to initial construction. In the event of repairs necessary to correct damage or premature deterioration, the repairs shall be designed, constructed, and maintained to provide the required performance over the design service life agreed upon between the Owner and the Designer.

3.5 COMMISSIONING

Durability and quality assurance can be assessed in advance of building operation commencement by commissioning. Commissioning of northern buildings is recommended for assuring the building can perform adequately in the harsh climate conditions of the northern environment. Commissioning tests and verifies the operation and performance of building systems, subsystems and components at the completion of construction, but actually commences early in the development, design and construction process.

"Commissioning GNWT Funded Buildings", an advisory document explaining commissioning, is a good example of recommended commissioning procedures developed to meet northern conditions and can be found at (http://www.pws.gov.nt.ca/pdf/publications/CommissionBldg.pdf).

A4 OTHER DESIGN CONSIDERATIONS

4.1 ARCHITECTURAL CONSIDERATIONS

It is not the intent of *Good Building Practice for Northern Facilities* to prescribe any particular form or style of northern building. Rational application of good design principles in response to programmatic, climatic and available resources will generate practical northern building style. Developing a particular architectural style appropriate for buildings in the north is a real challenge to designers.

Previous suggestions that buildings should fit into the immediate site unobtrusively, with the massing and finishes related to the context of the community still apply. Although this can be a justifiable design approach, it is nearly impossible to achieve in many small northern communities when adding large new buildings. To be successful, it is recommended a design thoroughly address the following concerns:

- the design must communicate the function of the building so its use is obvious and visually apparent to all community members;
- the design should incorporate recognizable local symbols appropriate to the design;
- colours, materials and forms are selected to support and enhance other design decisions;
- scale and bulk appearance of the building should be consistent with the building's intended use and other buildings nearby;
- whether it blends into, contrasts with or dominates a site, the relationship of the building to the site should be consistent with its function and local traditions for access under all weather conditions for all community residents for maintenance as well as general public access;
- whether it is private, public, friendly or decorous, the relationship of the building to the public access routes like streets should be consistent with the function and local traditions for access, including vehicle parking consistent with community vehicle use;
- whether they contrast with or are similar to adjacent buildings, the relationship between buildings should allow clear access for safety and maintenance consistent with the building functions.

Finally, the design of northern buildings must strike a balance between buildings that are stylistically appropriate in small communities, and the demand for buildings that are energy efficient, and simple to build and maintain. This is generally achieved by using uncomplicated shapes for doors and windows, and simple uncomplicated roof shapes that minimize snow and ice accumulation.

4.2 OTHER RELATED DOCUMENTS

Design encompasses a number of activities within architecture and engineering. During the design phase of any project several documents are produced, each with a specific objective. *Good Building Practice for Northern Facilities* provides recommended best practice performance criteria, preferred materials or methods, and logistical considerations as a technical supplement to other related documents such as functional programs, specifications and pre-design documents like space programs. The following provide examples of the distinctions that can be made between the documents:

Document	Example of Contents
Functional Program	a coffee maker and small appliances such as a toaster and microwave oven will be used
GBP (electrical)	recommends use of split receptacles wherever coffee making is anticipated
Specifications	"Flooring to be 4.5 mm thick Mondoflex by Mondo Rubber"
GBP	Recommends sports flooring may be either PVC or rubber depending on the type of use the floor will have
Submission Requirements	provide consumption estimates for heating and electricity
GBP	provides recommended energy consumption targets

The objective of *Good Building Practice for Northern Facilities 2009* is to provide a benchmark of technically effective design choices bridging from the intent of the functional program to the myriad of technical solutions available.

4.3 GEOTECHNICAL VERIFICATION OF SITE STRUCTURAL CAPACITY

A geotechnical investigation is recommended to be conducted for all northern facilities in order to determine the structural capacity, recommended foundation structural alternatives, and identify in advance of design building durability influences, like surface and ground water presence.

The great variability of site conditions in the NWT, including many of the conditions found in different kinds of permafrost types, and the potential that the permafrost may thaw, or warm sufficiently within the design service life of the structure, requires addressing larger and different number of technical issues than is required in the design of foundations in southern Canada with temperate climate. Permafrost is a temperature description of the ground being at or below zero degrees Celsius for at least two consecutive years. It does not describe the ground materials or soils, which may vary from bedrock and ice free gravels, to ice rich soils and even ice.

The geotechnical investigation is recommended to include the assessment of the current ground temperature and expected climate warming during the life span of the structure. It has to address the availability of construction materials and schedule, tolerance of the structure to differential settlement and surface drainage that may affect the thermal regime of the foundation.

For larger structures subsurface geotechnical investigation in fine grained frozen soils with ground temperature above - 6°C should be sufficiently deep enough to obtain temperature and soils typification data to allow considerations of different foundation design options. The reference publication, *Geotechnical Site Investigation Guidelines for Building Foundations in Permafrost*, developed by Dr. Igor Holubec for GNWT Public Works & Services, completed in 2009, is available at the “Publications” section of GNWT Public Works & Services Asset Management Division web page.

4.4 UNIVERSAL ACCESSABILITY – BARRIER FREE DESIGN

The policy of inclusivity for all northerners to benefit from access to northern buildings is supported by the National Building Code of Canada 2010 Div. B. Section 3.8, “Barrier-Free Design”. All northern buildings to which the general public has access are recommended to meet these requirements as a minimum.

Because of the wide variation of local weather conditions across the north, barrier-free access ramps are recommended to be installed including weather protection appropriate for the local weather conditions of the community in which the building is located. Snow and ice build-up can be reduced by canopy extensions and orientation to avoid snow-drifting. Surface materials should be selected for ease or snow and ice removal as well as meeting traction characteristics for wheel chairs, walkers, canes and crutch tips.

4.5 ASSET SECURITY

The inclusion of security considerations into the design of northern buildings is best done during the initial stages of project planning. That way security measures are incorporated into all building systems and subsystems early in the design process, assuring a high value being assigned to them.

The selection of security measures specified for a building should consider the costs of security in relation to capital and operating costs, and any potential restriction on service program delivery capacity. The combination of security measures and flexibility for increasing or decreasing levels of security in keeping with program requirements can be considered for the most cost effective protection.

A5 CODES AND REGULATIONS

5.1 NATIONAL BUILDING CODE OF CANADA and NATIONAL FIRE CODE OF CANADA

The *National Building Code of Canada 2010* and the *National Fire Code of Canada 2010* have been adopted without change in the NWT, in the *NWT Fire Prevention Regulations* enabled by the *NWT Fire Prevention Act.* The *Authority Having Jurisdiction* is the Northwest Territories Fire Marshal, operating from the Office of the Fire Marshal at the Department of Municipal and Community Affairs in Yellowknife.

The Fire Prevention Act and Regulations can be found at

http://www.justice.gov.nt.ca

Bulletins from the Office of the Fire Marshal

Bulletins from the Office of the Fire Marshal clarify NBC requirements, or give notices of exemptions acceptable to the Fire Marshal. Copies are available through the Office of the Fire Marshal in Yellowknife, and Regional offices, and at

http://www.maca.gov.nt.ca

5.2 NATIONAL ENERGY CODE of CANADA for BUILDINGS 2011

The "*Model National Energy Code of Canada for Buildings 1997*" was published in 1997, but it has not been adopted by the NWT. A new version, *"The National Energy Code of Canada for Buildings 2011"*, available in 2011, will continue to include both prescriptive and performance compliance methods for determining building energy consumption conformance to recommended performance benchmarks. For more detailed information, refer to GBP Article G-3, "Energy Management".

5.3 MUNICIPAL BYLAWS

All municipal bylaws and ordinances must be observed in the design and construction of facilities in the NWT. Construction outside of a municipality on Commissioner's Land is regulated directly through the Department of Municipal and Community Affairs (MACA).

5.4 DESIGN PROFESSIONALS

- Professional Engineers

  The practice of Engineering is regulated by the Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists. (NAPEG), under the authority of the "Engineering and Geoscience Professions Act". The act can be found at http://www.justice.gov.nt.ca and the web site of NAPEG at http://www.napeg.nt.ca/.

- Professional Architects

  In the NWT, the Practice of Architecture is regulated under the "NWT Architect's Act", and through the Northwest Territories Association of Architects (NWTAA). The act can be found at http://www.justice.gov.nt.ca and the web site of the NWTAA at www.nwtaa.ca.

- Professional Landscape Architects

  In the NWT, the Practice of Landscape Architecture is conducted by members of the NWT Association of Landscape Architects (NWTALA). The Association can be reached at NWT Association of Landscape Architects, P. O. Box 1394, Yellowknife NT, X1A 2P1.

5.5 SI METRIC REQUIREMENTS

All new construction in the NWT is recommended to be designed in SI metric units because the NBCC 2010 and NFCC 2010, as well as the standards and design data referred to in them, are designated in metric SI units. Actual materials may be designated in metric or feet and inches, and soft conversion to metric is acceptable.

Note that this requirement may be relaxed when these guidelines are applied to renovation projects and where the original documents are in feet and inches measures: either metric or feet and inches measure are recommended to be considered for use in that case.

- Soft conversion

  Physical size remains unchanged. Products are described to the nearest metric unit.

  For example, a 24 x 48 (inches) ceiling tile is 610 mm by 1220 mm (actual size).

- Hard conversion

  Physical sizes are changed and products designated in metric.

  For example, a 24 x 48 (inches) ceiling tile is changed slightly in size to become 600 mm x 1200 mm (actual size).

ENVIRONMENTAL REGULATIONS / PERMITTING

INTRODUCTION

While planning infrastructure projects in the Northwest Territories there are a number of environmental regulations that must be taken into consideration. Projects must be in conformity of the Mackenzie Valley Resource Management Act, Waters Act, the Regional Land Use Plans, and the Land Claims, both settled and unsettled. These regulations will affect the projects timing schedules; therefore they should be acknowledged and included in the planning of projects well in advance.

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B1 ENVIRONMENTAL REGULATORY CONDITIONS

Considerations related Environmental Regulatory Conditions in the NWT include:

- Canadian Standard Association for Phase 1 and 2 Environmental Site Assessment
- Mackenzie Valley Resource Management Act
- Waters Act
- Land Claims
- Land Use Plans

1.1 ENVIRONMENTAL SITE ASSESSMENT

When undergoing an Environmental Site Assessment to determine site conditions, the Canadian Standard Association guidelines must be followed. This includes the Phase 1 ESA CSA Z768-01 and Phase 2 ESA CSA Z769/00. Refer to Chapter C – Environmental Site Assessments.

1.2 LAND AND WATER USE

Land and Water use is regulated by the 4 Land and Water boards in the NWT. These consist of the Mackenzie Valley Land and Water Board, Sahtu Land and Water Board, Wekeezhii Land and Water Board, and the Gwich'in Land and Water Board. When considering building infrastructure, the development must be in compliance with the Mackenzie Valley Resource Management Act, Waters Act, Land Claims, and the Various Land Use Plans.

1.2.1 Mackenzie Valley Resource Management act

The Mackenzie Valley Resource Management Act (https://laws-lois.justice.gc.ca/PDF/M-0.2.pdf) and the Mackenzie Valley Land Use Regulations (https://laws-lois.justice.gc.ca/PDF/SOR-98-429.pdf) are the guiding documents for land use, including the development of infrastructure. The Land and Water Board websites have various documents to assist with the land use permit applications, including the Guide to land use permitting process (https://glwb.com/sites/default/files/documents/MVLWB%20Guide%20to%20the%20Land%20Use%20Permitting%20Process%20-%20Jun%201_13.pdf)

Criteria for a Land Use Permit include the use of explosives, use of vehicles or machines, storage of fuel, and machinery for moving earth or clearing land. A full description of land use permit criteria can be found within the Mackenzie Valley Land Use Regulations.

1.2.2 Waters Act

The Waters Act (https://www.justice.gov.nt.ca/en/files/legislation/waters/waters.a.pdf), the Waters Regulations (https://mvlwb.com/sites/default/files/documents/TAB%207%20-%20Waters%20Regulations%20-%202014.pdf) and the Mackenzie Valley Federal Areas Water Regulations (https://laws-lois.justice.gc.ca/PDF/SOR-93-303.pdf) are the guiding documents for water use, including the association of the development of infrastructure. The Land and Water boards have various documents to assist with the water licence application process, including the guide to completing water licence applications to the Mackenzie valley land and water board (https://glwb.com/sites/default/files/documents/Water%20License%20Apps%20Guide%20Oct%202003%20-%20Revised%20Jul29-15.pdf)

The criteria for a Type "A" Water Licence is the use of more than 300 cubic metres per day.
The criteria for a Type (B) Water Licence include:

- the use of 100 or more cubic metres per day and less than 300 cubic metres per day
- Construction of a structure across a watercourse that is 5 metres or more in width at ordinary high water mark at the point of construction
- Constriction of a permanent in-stream structure
- All water course training that isn't covered under water use and deposit of waste permitted without a Licence

A full list of licensing criteria can be found within the Waters Regulations.

1.2.3 Land Claims

The following land claim agreements are the guiding documents for land use within the land claim boundaries.

- Gwich'in Comprehensive Land Claim Agreement (https://www.eia.gov.nt.ca/sites/eia/files/gwichin_comprehensive_land_claim.pdf)

- Sahtu Dene and Metis Comprehensive Land Claim Agreement (http://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ/STAGING/texte-text/sahmet_1100100031148_eng.pdf)

- Tlicho Land Claims and Self Government Act (https://laws-lois.justice.gc.ca/PDF/T-11.3.pdf)

- Inuvialuit Final Agreement (http://www.irc.inuvialuit.com/sites/default/files/Inuvialuit%20Final%20Agreement%202005.pdf)

- Deline Self-Government Agreement (https://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ-LDC/STAGING/texte-text/deline_selfGov_report_1431537951693_eng.pdf)

1.2.4 Land Use Plans and Interim Measures Agreements

Land use planning allows to better and more effectively manage the lands and resources. It helps create certainty for if, where, when and how development can take place. Infrastructure development must be aware and in compliance with the following land use plans when being considered in the region:

- Sahtu Land Use Plan (https://sahtulanduseplan.org/plan)
- Gwich'in Land Use Plan (http://www.gwichinplanning.nt.ca/publications/lupd/final%202003/Gwichin_Plan_2003.pdf)
- Tlicho Land Use Plan (https://research.tlicho.ca/lands-protection/tlicho-land-use-plan)
- Deh Cho First Nations Interim Measures Agreement (https://www.eia.gov.nt.ca/sites/eia/files/dfn_ima.pdf)

ENVIRONMENTAL SITE ASSESSMENTS

INTRODUCTION

Prior to purchase of lands, transfer of lands, renovations, building additions, and new construction, it is necessary to understand what we are getting into regarding the potential presence of hazardous materials and/or environmental pollution either on the site.

There are two stages of Assessment available to ascertain presence and volume of potential contaminants, all of which have specific testing and remediation requirements.

The two levels of assessment utilized in the NWT are:

- Phase I Environmental Site Assessment (Phase I ESA)
- Phase II Environmental Site Assessment (Phase II ESA)

In order to understand and manage the risk, and to avoid extras and cost overruns, we need to understand these two tools; which to use, and when. In the following section these tools are explained regarding procedures, and their appropriate uses.

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C1 PHASE I ENVIRONMENTAL SITE ASSESSMENT

An Environmental Site Assessment is a report prepared for a real estate holding, and identifies potential or existing environmental liabilities. A Phase I ESA is **non-intrusive**, in that sampling of soil, air, surface water, groundwater and/or building materials is NOT conducted during a Phase I ESA. The Phase I ESA is generally considered the first step in the process of environmental due diligence. The systematic process is outlined in CSA Standard Z768.

A variety of situations can trigger the requirement for a Phase I ESA to be conducted:

- Purchase of real property by a person or entity not previously on title.
- Contemplation by a new lender to provide a loan on the subject property.
- Redistribution of ownership.
- Change in land use.
- Existing property owner's desire to understand toxic history of the property.
- A regulatory agency who suspects toxic conditions.
- Divestiture of properties.

1.1 SCOPE

A Phase I ESA is, by definition, non-intrusive, and documents potential soil contamination, groundwater quality, surface water quality and possibly issues related to hazardous substance uptake by biota through review of data only. Further, the examination of a site includes any chemical residues within the structure, inventory of hazardous substances (including petroleum) stored or used on site, assessment of mold and mildew, and evaluation of other potential indoor air quality issues.

1.2 TASKS

The tasks listed are common to all Phase I ESAs.

- Site visit to view present conditions, hazardous substance usage, petroleum product usage, and to evaluate any likely environmental hazardous site history. These include Asbestos Containing Material (ACM), Lead Based Paint (LBP), potential lead in drinking water, mold, radon, wetlands, permafrost, threatened and endangered species, polychlorinated biphenyl (PCB), mercury, landfills, abandoned oil and gas wells etc.

- Evaluate the risk from neighboring properties.
- Conduct interviews with personnel associated with the property and the area.
- Review of land title.
- Conduct record searches with public agencies; it is not recommended that this work be out sourced to information services when dealing in a Northern environment. Contacts include spill data bases, Environment and Natural Resources, Hamlet/Town/City office, SAO, facility managers and the like. Each area in the North is specialized.
- Examine historical aerial photography.
- Examine geological data, topographical mapping and the like.

1.3 PREPARERS

Often a multi-disciplinary approach is taken in compiling a Phase I ESA, since skills in chemistry, atmospheric physics, geology, geotechnical engineering, and microbiology are frequently required. Southern firms often specialize in the preparation of Phase I ESA at a cost of about $3000 to $5000 per Phase I or whatever the market will bear. Therefore, the economics require the Consulting firm to use their most junior staff and turn the job around quickly. However, this is the area of environmental science with the <u>**MOST**</u> risk. Many firms conduct Phase I ESA to break even, and will automatically recommend a Phase II ESA.

Many locations require professional registration such as a Professional Engineer, Professional Geoscientist or Professional Geologist, registered and in good standing in that jurisdiction and the firm to have a Permit to Practice in that jurisdiction. In the NWT the bar has not been set very high and unfortunately just about anybody can claim to be qualified to conduct a Phase I ESA. Remember you get what you pay for!

C2 PHASE II ENVIRONMENTAL SITE ASSESSMENT

Following the completion of a Phase I ESA, if an environmental issue has been identified, a Phase II Environmental Site Assessment may be recommended. This is an intrusive investigation, where soil and possibly groundwater/surface water conditions are sampled and compared to existing Northwest Territory and/or Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines or Criteria. Again, the systematic process is outlined in CSA Standard Z769.00 (2013).

2.1 GENERAL COMPONENTS

The principal components of a Phase II ESA are as follows;

- Review of existing Phase I ESA and other background information.
- Development of a sampling plan.
- Planning a site investigation, complete with underground utility locates.
- Conducting the site investigation.
- Interpretation and evaluation of the data gathered during the investigation.
- Reporting of the facts, complete with recommendations.

2.2 CONFIDENTIALITY AND LEGAL LIABILITY

The client has the expectation of confidentially, and **does not** expect voluntary disclosure of results and findings, or even the fact that an assessment has been carried out.

Any hazardous situation or emergency condition encountered in the course of an assessment should be reported to the client. The client is obligated to notify the user and any persons working on the site who may be affected by the conditions. Notification of relevant authorities shall originate with the client. The assessor shall be objective and free from influence throughout the ESA process. The assessor should be independent of the client. The assessor shall disclose to the client, in advance of commencing the Phase II ESA, and note in the report, any conflict of interest. The assessor shall demonstrate knowledge gained through an appropriate combination of relevant formal education, training, skills, and experience to perform a technically sound and rational Phase II ESA.

Even when a Phase II ESA has been executed with an appropriate standard of care, certain conditions, such as contaminates of concern that are under buildings or are of low mobility, can present difficult detection problems.

2.3 HEALTH AND SAFETY

The assessor shall observe all site health and safety considerations applicable to the work being undertaken. A health and safety plan shall be developed prior to the site investigation. All persons on the site shall have appropriate health and safety training, and be familiar with the health and safety plan prior to accessing the site. Tailgate safety meeting shall be conducted prior to the start of work.

2.4 SCOPE OF WORK AND FIELD WORK

The client shall summarize the purpose of and the intended use of the Phase II ESA. It is prudent in continuous permafrost conditions to conduct the intrusive investigation during maximum thaw. The client and assessor shall establish a list of potential contaminates of concern, and identify the potential source. Criteria shall be established prior to commencing the site investigation.

In the North, the methodology of the investigation is often determined by the resources at hand, which should be recognized prior to conducting the work. Is the intrusive investigation being conducted by test pitting or boreholes? If sampling of ground or melt water (in permafrost conditions) monitoring wells will be required. What, if any, underground utilities are present? Develop a sampling plan.

Often it is useful and cost effective to utilize geophysics prior to the intrusive investigation to determine potential drill or test pit targets. An electromagnetic survey such as EM-37, followed by the use of ground penetrating radar, is useful to potentially identify buried objects such as drums, barrels and/or storage tanks.

The objective of intrusive sampling is to obtain samples for comparison against criteria. As the nature of contaminates of concern may not be identified from the Phase I ESA, field screening may provide an indication of their present and worst case sample identification. The types and numbers of samples collected during an investigation are largely determined by the judgment of the assessor, in consultation with the client. A sufficient number of samples shall be collected to identify contaminates of concern and determine horizontal and vertical limits of potential contamination.

Sample collection, preservation and handling must be conducted in a manner to avoid cross contamination, and to ensure hold times meet laboratory requirements. Further, quality assurance shall identify the number and type of quality assurance/quality control (QA/QC) samples, both in the lab and the field. As part of the QA/QC, equipment cleaning must be conducted before and throughout the investigation.

Samples and stratigraphy soil description are paramount during the investigation. Geotechnical terms and descriptions must be adhered to. Data must be presented in either test pit logs or borehole logs. As well, soil criteria are dependent on sieve analysis.

2.5 INTERPRETATION

The assessor shall evaluate the information obtained during the investigation, and present it in such a manner as to help the client understand the significance of the findings. The data shall be summarized, and general trends or patterns described. Figures of the location of the site, the site borehole and test pit locations, as well as trends or patterns, are required. Data will need to be compared to appropriate criteria. Inconsistencies or anomalies need to be described. Identify uncertainty and concerns associated with the findings.

2.6 REPORTING

Many locations require the work to be conducted by, or under the supervision of, someone with a professional registration such as a Professional Engineer, Professional Geoscientist or Professional Geologist, registered and in good standing in that jurisdiction, and the firm shall have a Permit to Practice in that jurisdiction.

The report shall consist of a written report with a summary of findings and conclusions. Data shall be presented in a logical and unambiguous manner to help the client understand the significance of the findings. The report shall be complete, so that it is a stand-alone document. Any limitations encountered shall be sufficiently detailed. All findings resulting from the investigation shall be included in the report. The report shall present conclusions relating the findings to the scope of work. The report shall state whether there is no evidence of the contaminate of concern, or if the contaminate of concern exceeds criteria, complete with the horizontal and vertical limits of the contaminate. Draft reports will be given to the client for review and comment. Upon receipt of the client's comments, final reports will be submitted, and final payment initiated. If the limits of the contaminate of concern cannot be defined, a delineation investigation may be required; this is considered part of a Phase III ESA and outside the scope of work of the initial Phase II ESA.

A Phase III ESA examines the need for, and methods of, remediating the previously identified contamination on a site. If delineation has not been completed, Phase III sampling is conducted to delineate the physical extent of the previously identified contamination, both horizontally and vertically.

Phase III ESA investigations may involve intensive testing, sampling and monitoring, "fate and transport" studies, and other modeling, as well as the design of remediation and remedial action plans. A Phase III study normally involves assessment of alternative cleanup methods, risk management strategies, cost and logistics. Phase III ESA reports will also detail the steps needed to minimize risk, to preform site cleanup and conduct follow-up monitoring.

C3 UTILIZATION of PHASE I ESA and PHASE II ESA

Keeping with the needs of property facilitators, please find a suggestion when a Phase I ESA or Phase II ESA are required.

A Phase I ESA is suitable during the acquisition of new land and where the neighboring properties may be a concern.

If the property exists, is owned by the GNWT, or will be purchased by the GNWT, it is best to conduct a Phase II ESA or a combined Phase I/II ESA to determine if there are issues with the property.

Should the conclusion of the intrusive investigation conclude that the limits of the contaminate of concern have not been defined, meaning the contamination is open to depth or horizontally, a Phase III ESA may be required to establish the limits of the contamination.

ESAs are mostly concerned with soil, groundwater surface water contamination. Please note, Yellowknife has elevated Arsenic (As) guideline soil for criteria. It is not the client's responsibility to educate the assessor as to NWT guideline criteria, but is useful in evaluation of proposals. Do not refer to a Phase I or II ESA as a modified ESA.

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CLIMATE CHANGE IMPACTS

INTRODUCTION

In recent decades, a strong warming trend has emerged in the Northwest Territories that is over twice as pronounced as the worldwide increase. Cumulative changes in the NWT infrastructure-relevant environmental conditions resulting from climate change will be substantial and irreversible.

Assessments regarding the effects of climate change on northern facilities shall be supported by all entities engaged in northern building and infrastructure development.

Climate change aspects of critical importance to the design of facilities are mentioned through this section. This section is to be read in conjunction with the Geotechnical, Civil and Structural sections herein.

Table of Contents (to follow)

D1 CONSIDERATIONS

The impacts of climate change on the north are greater than the global average. The effects will likely have implications for the health and safety of residents, culture and heritage, infrastructure and the economy.

Observed impacts in the north include:

.1 An increase in the frequency of extreme weather events resulting in greater snow accumulation, winter rain, icing, and higher winds.[1]

.2 Since the capacity of the atmosphere to hold moisture (water vapour) increases with temperature, Arctic regions can expect more extreme snowfalls during months when temperatures remain below freezing.[1]

.3 Rapid spring melting.[1]

.4 More sudden, intense precipitation events. For temperatures above 10°C, the scientific studies indicate that extreme short duration rainfall events (e.g. heavy one day rainfall) also could increase significantly (by as much as 14%), highlighting significant implications for community drainage risks and permafrost thawing. [2,3]

.5 Greater weather instability in general.[1]

.6 Shifting Vegetation – forests are replacing the tundra as the treeline moves northward.[4]

.7 Increases in wildland fires occurrence and severity (due to dry conditions)[4], compromised forest productivity, and shifts or expansions in ranges of tree and plant species, diseases and pests.[2]

.8 Ice (ice build-up, ice accretion, freezing rain): Although it is expected that winters will become warmer, ice accretion (on structures) may increase due to the increases in freeze/ thaw cycles. This includes ice build-up on water bodies, bridge and road surfaces, sidewalks and other structures.[5]

.9 Surface and bottom water temperatures of lakes, reservoirs, rivers, and estuaries will increase.[6]

.10 Impacts to Permafrost:

.a Ground temperatures are warming in response to warmer air temperatures. This is leading to some thaw of permafrost.

.b Changes to groundwater systems as permafrost thaws and an increase in connections between surface water, shallow groundwater and deep groundwater systems including an increase in the mobility of groundwater near the surface.[4]

.c In regions with permafrost, the very top layer thaws and freezes every year. Observations in recent years show that the depth of this active layer is increasing.

.d Ground settlement and slope instability, as a result of permafrost degradation.

.11 Increase in air temperature:

.a Due to the air temperature increase, the rate of water evaporation is expected to be higher than the amount of water received from increased precipitation.[6]

D2 EXPECTED CLIMATE CHANGE IMPACTS

The information in the section below includes input from local geotechnical and civil engineers, architects, as well as industry specialists and information ascertained from the report[6] and literature review[7] that the PIEVC Engineering Protocol has generated for projects around Canada, including the NWT, as well as from the CSA reports referenced in this document.

2.1 INCREASE IN SNOWFALL:

- Attention must be taken in the design of roofs and canopies to anticipate future snow loading requirements. For design and maintenance requirements for existing buildings, refer to CSA S502-14;
- Use current and predictive climate data when establishing snow loading;
- Consider roof shape and layout, to limit snow drifting potential;
- Consider future increased snowfall conditions when developing site layout.

2.2 INCREASE IN RAINFALL, STORM FREQUENCY AND STORM SURGES:

Designs are to consider potential for increased drainage requirements, to avoid overloading drainage infrastructure and reduce the risk of flooding, ponding and ground erosion.

2.3 WARMER TEMPERATURES:

When planning projects, consider that changing temperatures will alter the timing and duration of northern shipping and transport opportunities. The NWT may experience shorter winter road seasons and changes in the timing and duration of seasonal weight limits in the trucking industry, leading to challenges transporting supplies and building materials to remote communities accessible by winter roads. The short construction season in these communities may be further reduced. Refer to the GNWT Infrastructure website for up-to-date information on highway conditions and barge schedules.

2.4 INCREASE IN WIND SPEED AND FREQUENCY:

Design of infrastructure is to consider future conditions for wind loading.

2.5 MELTING OF PERMAFROST:

Design of infrastructure is to consider changing ground conditions. Refer to GBP Chapter E "Geotechnical" for considerations related to building foundations. Refer to NISI CSA PLUS 4011 for the recommended approach to designing for these future conditions.

D3 MITIGATION

The GNWT is committed to climate change mitigation. Design of GNWT facilities is to incorporate actions to limit the magnitude and rate of long term climate change. Refer to the following documents for further information and strategies:

- GNWT Climate Change Strategy;
- GNWT Energy Strategy;
- GBP Chapter L – Energy Efficiency

D4 ADAPTATION

Climate change adaptation involves anticipating the adverse effects of climate change, and taking action to prevent or minimize the damage caused, or taking advantage of opportunities that may arise.

As an adaptation policy, all new GNWT construction projects shall follow the CAN/CSA standards listed, as applicable;

- CAN/CSA-S500-14: Thermosyphon Foundations for Buildings in Permafrost Regions;
- CAN/CSA-S501-14: Moderating the Effects of Permafrost Degradation on Existing Building Foundations;
- CAN/CSA-S502-14: Managing Changing Snow Load Risks for Buildings in Canada's North;
- CAN/CSA-S503-15: Community Drainage System Planning, Design, and Maintenance In Northern Communities; and
- CAN/BNQ-2501-500: Geotechnical Site Investigation for Building Foundations in Permafrost Zones.

4.1 DESCRIPTION OF STANDARDS

.1 CAN/CSA-S500-14: Thermosyphon Foundations for Buildings in Permafrost Regions

This standard helps to ensure the ongoing stability of thermosyphon-supported foundations of new buildings constructed in regions of permafrost. It supports users by: (a) describing the life cycle of thermosyphon foundations (e.g., installation, monitoring, design, maintenance), (b) providing guidance on how to maximize the life-time of these systems, (c) specifying what materials should be used in thermosyphon foundations, and (d) describing performance expectations of thermosyphon foundations alongside monitoring and maintenance requirements that should be considered.
Website Link: http://shop.csa.ca/en/canada/infrastructure-and-public-works/cancsa-s500-14/invt/27036862014

.2 CAN/CSA-S501-14: Moderating the Effects of Permafrost Degradation on Existing Building Foundations

This standard outlines procedures to maintain, assess and mitigate permafrost loss below and next to existing buildings. It supports users by: (a) outlining measures to maintain permafrost underneath or next to buildings, (b) providing structural assessment practices for areas impacted by changing permafrost, (c) describing steps to mitigate permafrost degradation, and (d) specifying long-term monitoring and maintenance practices.

Website Link: http://shop.csa.ca/en/canada/infrastructure-and-public-works/cancsa-s501-14/invt/27037462014

.3 CAN/CSA-S502-14: Managing Changing Snow Load Risks for Buildings in Canada's North

This standard describes safe snow removal methods from the rooftops of buildings in Canada's North, and aims to reduce the risk of high snow loads to buildings and occupants. It supports users by describing: (a) maintenance procedures to reduce the impact of high snow loads on buildings, (b) practices to remove snow, and (c) assessment and monitoring practices to understand snow load risks on community infrastructure.
Website Link: http://shop.csa.ca/en/canada/infrastructure-and-public-works/cancsa s502-14/invt/27037662014

.4 CAN/CSA-S503-15: Community Drainage System Planning, Design, and Maintenance in Northern Communities

This standard provides guidance on planning, design, construction, rehabilitation and maintenance of drainage systems in Canada's North. It supports users by: (a) outlining techniques to implement and plan community drainage systems that consider how the climate is changing, (b) promoting health and safety in Canada's northern communities, (c) providing solutions that reflect local capacity and financial barriers, and (d) describing practices for community planning with the goal of conserving current community infrastructure.
Website Link: http://shop.csa.ca/en/canada/infrastructure-and-public-works/cancsa-s503-15/invt/27037832015

.5 CAN/BNQ-2501-500: Geotechnical Site Investigation for Building Foundations in Permafrost Zones

This standard describes how to perform geotechnical site investigations so that the results can be used to design building foundations. It takes into consideration - in a risk management framework - the conditions at the building site including local and distinct permafrost characteristics, seasonal and inter-annual climate conditions, and projected climate conditions over what will be the service life of the building foundations.
Website Link: https://www.bnq.qc.ca/en/standardization/civil-engineering-and-urban-infrastructure/geotechnical-site-investigation-for-building-foundations-in-permafrost-zones.html

.6 Other Guidelines and Relevant Information:

.a PLUS 4011: Technical Guide: Infrastructure in Permafrost: A Guideline for Climate Change Adaptation

This guideline is for decision makers working in permafrost regions, who have a role in planning, purchasing, developing, or operating community infrastructure. It assists non-technical experts by providing guidance and information on: (a) different foundation types for community infrastructure in permafrost, (b) a process to ensure that climate change is considered when siting and designing foundations, (c) climate change trends in the north, and (d) permafrost as an environmental variable that should be considered when designing infrastructure.

An updated version of this guide is anticipated in 2019. The guide will provide resources to predict future temperature and weather impacts.

Website Link: http://shop.csa.ca/en/canada/infrastructure-and-public-works/plus-4011-1st-ed-pub-2010/invt/27030762010

4.2 ANTICIPATED STANDARDS:

The Standards Council of Canada is moving forward with NISI Phase ll (2016-2020) to develop additional standards for northern infrastructure. Areas of focus for NISI Phase II include:

Planning, design, operation and maintenance of wastewater treatment in Northern communities using lagoon and wetland systems;
Selection of foundation types for buildings in permafrost;
Fire resilient building design and materials;
Techniques for dealing with high winds as it pertains to Northern infrastructure; and
Erosion protection in permafrost.

D5 RESILIENCE

Infrastructure resiliency involves the design and operation of urban systems in a way that accommodates sudden and unexpected changes in climate. Existing and new buildings in the north need to adapt to evolving conditions, so that they can recover from environmental shocks and stresses, before they occur.

To make buildings more resilient, designers should:

- Generate design solutions that include the assessment of susceptibilities of existing buildings, infrastructure and project sites and surroundings;
- Use available data to assess future climate changes and weather events, to inform their design process;
- Consider the robustness of a system and infrastructure when subjected to stress, as well as its adaptability in response to changing conditions and objectives;
- Do a risk and criticality assessment of associated infrastructure, design standards, and O&M procedures that could be impacted by changing climate;
- Consider the effects of climate change over the full lifetime of the project at the onset, and not assume a static climate during design.

D6 RESOURCES:

.1 The 2030 NWT Climate Change Strategic Framework: The Framework outlines how the territory plans to respond to challenges and opportunities associated with a changing climate, moving towards an economy that is less dependent on fossil fuels and doing its part to contribute to national and international efforts to address climate change.

The goals of the Framework are:

.a Transition to a strong, healthy economy that uses less fossil fuel, thereby reducing greenhouse gas emissions by 30% below 2005 levels by 2030;

.b Increasing understanding of climate change impacts occurring in the NWT;

.c Building resilience and adapting to a changing climate.

The Framework was developed at the same time as the 2030 Energy Strategy.

The Framework will guide the implementation of the 2019 -2023 Action Plan, currently in draft version, which puts into motion the vision of the Framework.

.2 The 2030 Energy Strategy sets out the GNWTs long term approach to supporting secure, affordable and sustainable energy supply and use in the NWT.

The goals of the Strategy are;

.a To guide the long-term development of secure, affordable and sustainable energy for transportation, heat and electricity;

.b To support energy efficiency and conservation; and

.c To promote renewable and alternative energy solutions for the NWT.

.3 The Northwest Territories Energy Initiatives Report: The GWNT has established the Northwest Territories Energy Initiatives Report which provides an annual overview of energy development, generation and use in the NWT, as well as related GNWT projects and initiatives.

It contains information on:

.a NWT energy consumption and greenhouse gas emissions,

.b Electrical Generation in NWT communities,

.c Opportunities for hydro energy, wind speeds, geothermally favorable areas in the NWT,

.d GNWT Energy Projects and Programs

.e Information on the Arctic Energy Alliance

.f Energy Efficiency Incentive Program

.g EnerGuide for House Program

.4 Capital Asset Retrofit Fund:

The GNWT has established the Capital Asset Retrofit Fund (CARF) which is an energy conservation program for GNWT infrastructure. The CARF program supports numerous energy conservation projects in smaller communities across the NWT.

Working with existing GNWT buildings, the mandate of the program is to;

.a Reduce energy consumption and operational costs;

.b Improve overall comfort for building users;

.c Reduce greenhouse gas emissions associated with operations;

.d Increase the useable life of government assets;

.e Identify new energy technologies appropriate for the NWT.

GNWT buildings undergo energy audits, including benchmarking a facility to determine its energy usage in comparison to similar buildings.

Once the energy audits are complete, the GNWT Department of Infrastructure determines which buildings will benefit from an energy retrofit under the CARF program.

A technology that has been successfully implemented to reduce greenhouse gas emissions is the installation of biomass as a source of fuel.

For more information, contact the Department of Infrastructure, Asset Management Division.

.5 The GNWT Environment and Natural Resources (ENR) Climate Change Website: Provides relevant information, news, updates, links and fact sheets regarding climate change in the NWT.

.6 NWT Hazard Identification Risk Assessment Report (2014) is an examination of the risks that pose the greatest threats to people, property, environment and economy of the NWT. The project includes the current hazards associated with climate change. The analysis projects which hazards could occur more frequently or become more extreme in future due to climate change.

.7 The Northwest Territories Greenhouse Gas Emission Summary Report 2015: provides NWT greenhouse gas emission targets, GHG emission data specific to sectors, and describes NWT's progress on GHG emissions.

.8 Scenarios Network for Alaska + Arctic Planning: Projections of air temperature and precipitation can be obtained by using a tool developed by the University of Alaska. This tool is user-friendly and permits scenarios to be developed for specific locations in the western Arctic.

The tool references climate scenarios from the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR5). Projections are based on the Representative Concentration Pathway (RCP) scenarios. Projected monthly changes in climate are available for the RCP4.5 (moderate), RCP6.0 (moderate), and RCP8.5 (high), relative to the 1961 to 1990 baseline period.

.9 Canadian Climate Data and Scenarios: The Government of Canada source for climate change projections presents climate change scenarios from the Coupled Model Intercomparison Project Phase 5 (CMIP5)

The climate scenarios from the CMIP5 climate models, whose results were used in the IPCC AR5, are available. The website provides projected seasonal climate changes for each province and territory in Canada. A series of tables showing Canadian patterns of climate change computed from the CMIP5 climate models are provided. Seasonal averages of projected changes in climate are available for the RCP2.6, RCP4.5, and RCP8.5. The site also provides the opportunity to develop downscaled projections for specific areas, but this is not user-friendly, and intended more for experienced practitioners.

.10 Public Infrastructure Engineering Vulnerability Committee (PIEVC): The Vulnerability Committee leads an on-going national initiative to determine and mitigate the engineering vulnerability of Canadian public infrastructure to the impacts and risks of current and future climate. It facilitates the development of practices, guidelines and tools to aid Professional Engineers and Geoscientists in their day-to-day practice of designing, constructing, operating and maintaining public infrastructure. The Committee also serves as an advisory body to Engineers Canada in recommending changes, additions and amendments to government policies, processes, regulations, codes, standards and related instruments necessary to address Canada's infrastructure vulnerability to current and future climate.

.11 GNWT Highway Conditions: An interactive map showing all major highways, crossings and ice-roads across the GNWT. This map provides information on maximum truck weight allowances, recent weather conditions and whether roads are open or closed,

D7 REFERENCES

(1) CAN/CSA-S503-15. (n.d.). *Community drainage system planning, design, and maintenance in northern communities*. Northern Infrastructure Standardization Initiative Standards.

(2)CSA Group. (n.d.). *Managing Changing Snow Load Risks for Buildings in Canada's North* (CAN/CSA-S502-14). Northern Infrastructure Standardization Initiative Standards.

(3) U.S Army Corps of Engineers, 2011. U.S Army Corps of Engineers Climate Change Adaptation Plan and Report 2011. Washington, DC. Accessed from http://corpsclimate.us/docs/usaceadaptnplanreport2011v02.pdf

(4) The IPCC concluded in its *Special Report on Climate Extremes* (SREX), published in 2012, that "Integration of local knowledge with additional scientific and technical knowledge can improve disaster risk reduction and climate change adaptation (high agreement, robust evidence).

(5) GNWT. (2018). 2030 NWT Climate Change Strategic Framework. Retrieved November 8, 2018, from https://www.enr.gov.nt.ca/sites/enr/files/resources/128-climate_change_strategic_framework_web.pdf

(6) Cviip, P., C., & Canada, E. (2008, April). Adapting to Climate Change, Canada's First National Engineering Vulnerability Assessment of Public Infrastructure. Retrieved November 8, 2018, from https://pievc.ca/sites/default/files/appendix_a_case_study_summaries.pdf

(7) Simonovic, S. P. (2008, February). Engineering Literature Review: Water Resources - Infrastructure Impacts, Vulnerabilities and Design Considerations for Future Climate Change. Retrieved Fall, 2018, from https://pievc.ca/sites/default/files/appendix_c_literature_reviews.pdf

GEOTECHNICAL

INTRODUCTION

Geotechnical considerations relate to the ground on which a building is constructed and the interaction of that building with the ground. Normally collecting information on the geotechnical characteristics of a site is an initial step in planning for site development. This section provides basic guidance on the site characterization process.

Common approaches to supporting buildings on or in the ground are also described in this section. The applicability and performance characteristics of the various foundation types are described.

The geotechnical discipline interacts significantly with the civil and structural disciplines for building design and site development. Therefore, GBP F - Civil and GBP G - Structural, should be read in connection with this section.

Building design and site development must account for the projected climate over the design-life of the structure. General information on the subject is given in GBP C – Environmental Site Assessment, which should be read in to complement the information provided in this section.

The Canadian Standards Association has prepared a guideline for climate change adaptation when designing infrastructure in permafrost areas, with a focus towards foundation design (CSA 2019). The guideline describes a risk-based approach for evaluating the levels of investigation and analysis that should be undertaken during the design of the structure to account for climate change impacts.

Any aspect of design of construction that depends on soil or groundwater conditions requires the involvement of a suitably qualified Professional Geotechnical Engineer licensed to practice in the Northwest Territories and Nunavut.

Table of Contents (to follow)

E1 SITE CHARACTERIZATION

1.1 SITE SELECTION

Northern soils conditions often contain permafrost, Permafrost is defined as a region where the ground is continuously frozen for two or more years. Appendix B of CSA (2014a) provides a useful background on the distribution and characteristics of permafrost.

Continuous, discontinuous and sporadic permafrost zones, each with different performance characteristics for the structural support of buildings, are found throughout the North. It is important to properly investigate and select sites for buildings, access routes and other infrastructure in permafrost areas.

Often a site for a proposed development is selected for reasons not related to geotechnical considerations. But, if there is a choice of sites for a proposed development, it is recommended to seek geotechnical advice to inform the decision. At this stage, a desktop geotechnical evaluation, as described in the following section, is likely to be sufficient. Recommendations will be provided if further investigation work is warranted to evaluate alternative sites.

A key objective of this initial evaluation is to characterize the anticipated permafrost conditions at the site:

- Permafrost zone – continuous or discontinuous, which is also related to whether the permafrost will be “warm” or “cold”.
- Likelihood of the subject site being underlain by permafrost; and
- If present, the expected nature of the permafrost, whether ice-rich or non-ice-rich.

Other significant considerations for site selection are:

- Anticipated surface drainage characteristics;
- Anticipated groundwater regime;
- Site grading and fill requirements; and
- Potential natural hazards such as slope stability or erosion.

1.2 GEOTECHNICAL EVALUATION

A geotechnical investigation is recommended to be conducted for all northern facilities in order to determine the bearing capacity, recommended foundation alternatives, and identify in advance of design other constraints to site development, like surface and groundwater presence.

The great variability of site conditions in the Northwest Territories, including many of the conditions found in different kinds of permafrost types, and the potential that the permafrost may thaw, or warm sufficiently during the design service life of the structure, requires addressing larger and different number of technical issues than is required in the design of foundations in southern Canada with temperate climate.

The Standards Council of Canada arranged for the development of a standard providing guidance on conducting site investigations in permafrost areas (BNQ 2017), which is commonly referred to as the “BNQ Standard”. This broadly describes two levels of evaluation:

- A Preliminary Site Evaluation or Desktop Evaluation is based on a review and interpretation of available information, such as previous geotechnical reports from the same area, geological publications, air photo and satellite imagery, and Environment Canada climate data. The BNQ Standard provides a comprehensive list of the items to be addressed, but the objectives are to characterize the geotechnical, hydrological and climate conditions of the site. A site visit may be incorporated into the evaluation, but this is not normally done for remote communities. The evaluation should include an assessment of the geotechnical risk of the project, which may include a recommendation to conduct a subsequent site investigation. This level of evaluation is normally appropriate for the schematic design stage of a project.

- A Site Investigation involves some form of subsurface investigation to identify the extent, characteristics and properties of unfrozen and frozen soil and bedrock; the presence of ground ice; the presence of groundwater; and the ground thermal regime of the building site. The BNQ Standard provides a comprehensive list of items that may be addressed and describes several techniques or types of equipment that may be used to conduct the site investigation. This level of evaluation is normally appropriate for the design development stage of a project.

Both levels of evaluation will result in the preparation of a report that presents the findings from the review or investigation and provides recommendations for site development.

Two important characteristics that should be determined for foundation design are:

- Ground temperature: Ground temperature varies with depth and seasonally, however one way to characterize ground temperature is mean annual ground temperature (MAGT), which is the ground temperature below a depth of about 10 m or 12 m that exhibits little (about less than 0.1°C) seasonal fluctuation. The strength and deformation characteristics of soil are dependent on its temperature, with cold permafrost being stronger than warm permafrost, all else being equal. Permafrost that is colder than about -4°C can be considered “cold” permafrost, which has some resilience to climate induced warming. Permafrost that is warmer than about -2°C can be considered “warm” permafrost, which is vulnerable to development or climate induced warming. Permafrost with intermediate temperatures would need to be evaluated on a project-specific basis.

- Porewater salinity: The presence of salt or other ions in the porewater of soil depresses its freezing point, such that some water remains unfrozen below 0°C. This affects the strength and deformation characteristics of a soil, thus the capacity of a foundation that relies on the soil for support. Porewater salinity less than about 5 parts-per-thousand (ppt) can be considered low. Porewater salinity greater than about 10 ppt can be considered high.

Logistical constraints, equipment availability and budget may limit the degree to which the procedures described in the BNQ standard can be adhered to. Therefore, there is a requirement for judgement to be exercised in the development of a geotechnical evaluation program and for collaboration between a geotechnical engineer and the owner’s representative to define a scope for the evaluation.

It is generally desirable to conduct site investigations in the spring, summer or fall, when the surface conditions are more readily observed, but access constraints may require that the site investigation be conducted during the winter. While desktop evaluations can be undertaken any time, and with relatively short notice, lead time of more than 6 months is desirable to plan site investigations. This will permit appropriate site access to be planned and may permit the work to be combined with other projects in the area, resulting in more economical mobilization/demobilization costs.

E2 SITE PREPARATION

This section presents comments of a specifically geotechnical nature. The reader is directed to GBP F - Civil, for a more general discussion of site preparation considerations.

2.1 SITE GRADING

Avoid cutting into existing slopes to accommodate building foundations where permafrost is present. Grade adjustment is recommended to be limited to the active layer (the upper layer of ground that freezes and thaws annually) as required for drainage.

Permafrost soils with high water content can melt and/or lose bearing capacity when the insulating top cover is removed. Very wet permafrost soils may even flow when they thaw. Any modification of the terrain must carefully address the effect it will have on the natural balance of the site.

2.2 GRANULAR PADS WATER PROTECTION

Most development within communities will occur on sites that have had fill previously placed. A geotechnical engineer should be consulted to determine if the nature and thickness of the fill is appropriate for the proposed development.

The thickness of the fill will influence the trafficability of the site, and the degree to which site grading can be achieved without disturbing natural soils. If the foundation relies on the fill for support, then the magnitude of the support is related to the thickness of the fill.

If the building is to be constructed on a previously undeveloped site, then it is normal to clear trees, brush and other vegetation from the site. But organic topsoil or peat are not normally stripped from site in permafrost areas. A geotechnical engineer should be consulted for guidance if exceptions to these general practices are contemplated and for recommendations on fill placement.

Leaving organic soil in place reduces the thermal impact on underlying permafrost. Even compressed organic soil provides a greater degree of insulation than no organic soil, because it can retain more moisture.

Where granular pads are installed as a part of a foundation system on a site that may be subjected to surface water accumulation, it is recommended an impermeable geotextile liner be installed to divert surface water away from the pads.

Surface water and freeze-thaw will consolidate and heave granular materials. The objective is to divert water around the pad, rather than allow it to seep under or through it, and potentially degrade permafrost or form ice lenses which could cause foundation heaving.

2.3 BELOW GRADE INSULATION

Where below grade insulation is used either to control season frost penetration or to protect permafrost, rigid, extruded polystyrene insulation shall be used.

Other types of insulation, such as expanded polystyrene, have higher moisture absorption properties, that results in impeded insulation efficiency and deterioration through freeze-thaw action.

E3 FOUNDATIONS

3.1 FOUNDATIONS PLANNING FOR FOUNDATION DESIGN

Unless the site is known to be underlain by sound bedrock, it is necessary to determine if the site is underlain by permafrost before foundation design can be planned. If the site is not underlain by permafrost, conventional geotechnical practices can be followed. The Canadian Foundation Engineering Manual (CGS 2006) is a useful reference for foundation design on non-permafrost sites. However, foundation design in the north warrants increased attention to controlling seasonal frost action, than may be practiced in more temperate climates.

If a site is underlain by permafrost, foundation design will require that permafrost be maintained during the service life of the structure, with rare exceptions. The National Building Code, foundation design for permafrost soils requires the services of "a person especially qualified in that field of work".

Whether a structure is to be heated or unheated influences the approach taken to preserving the permafrost. An unheated structure offers greater flexibility with foundation alternatives. Since most buildings are heated, the following discussion focuses on heated buildings on permafrost.

The desired floor type influences the selection of a foundation type. Buildings with heavy floor loads, such as garages, normally warrant an at-grade floor, which limits the means available to preserve the permafrost. If a floor can be structurally supported, then it may be practical to maintain an open air space beneath the building, to prevent heat loss from the building entering the ground.

With structurally supported floors, there may still be a desire to incorporate a mechanical crawl space beneath the floor. If so, the bottom of the crawl space should generally not extend below original ground.

Basements are generally not applicable on sites underlain by permafrost, so are not discussed in this document.

It is advised to design facilities with large roof overhangs to help reduce heating the ground around the foundation as well as shed water away from the foundations. If roof overhangs are not incorporated, then it is recommended that other methods, such as gutters, be used to divert any water well away from the foundations.

Appendix A of CSA (2014a) and Chapter 3 of CSA (2019) describe the foundation types commonly used in permafrost. Additional information is provided in the following sections.

3.2 PILES (DEEP FOUNDATIONS)

Piles, generically referred to as “deep foundations”, have become one of the most common foundation systems used in the North. Piles penetrate the ground to derive their support from the soils or rock at depth and are designed to be stable and low maintenance systems. When properly designed and constructed, they undergo little to no settlement and can resist seasonal frost action.

Scheduling of piling work has to take into consideration the availability of materials and equipment in the community, as well as seasonal soil conditions that might impede construction. It is best if piles are installed while soils are frozen and before early summer, so that the site will bear the traffic of equipment, bored holes will be less prone to sloughing, and foundations are ready for a superstructure start in the late winter or spring, particularly when materials arrive by winter road or sealift.

3.3 PILE TYPES

3.3.1 Rock Socket Steel Pipe Piles

Where bedrock is found at relatively shallow depth (typically less than about 10 m) piles can be anchored into the bedrock to provide a stable foundation. Compression loads are supported through a combination of end-bearing and grout to pile/rock bond and uplift loads are resisted entirely by grout to pile/rock bond. Because this foundation type does not require permafrost to be maintained, subject to site grading and drainage considerations, the building can be set at or near grade.

If it is possible to maintain a clean, dry rock socket, either with no casing or temporary casing, the pile can be grouted into the rock socket.

This is the most common type of rock socket pile, but grout should be placed into a clean, dry rock socket to mobilize effective bond with the steel and rock.

If ground conditions are such that it is difficult to maintain a clean, dry rock rocket, then a specialized drilling system should be used to install the pile.

A specialized drilling system permits the pile to be installed as a casing, permitting a clean, dry rock socket to be drilled beyond the end of the pipe. This variation normally has an anchor embedded in the rock socket to provide for load transfer and resistance to tension loads.

A permafrost grout should be used, capable of hydrating in ground with a temperature below 0°C.

A variety of products exist and operate either by triggering rapid and high heat of hydration, such that hydration occurs before the grout cools off, or by being formulated to hydrate at temperatures below 0 °C.

3.3.2 Adfreeze Steel Pipe Piles

Adfreeze piles are embedded and frozen into the permafrost where they transfer their load to frozen ground by developing a shear, or adfreeze, bond between the pile shaft and the surrounding ground. The design premise is that the pile will undergo settlement over time (creep). A nominal creep settlement of 1 mm per year is commonly assumed, but this criterion can be negotiated with the building designer/owner.

These piles are widely applicable in areas of cold permafrost and low soil porewater salinity.

Because of the temperature and salinity dependent characteristics of permafrost, installation in warm or warming permafrost results in increased creep rates, which impose design challenges.

While less air space may preserve permafrost, at least 1 m improves ventilation and limits the potential for snow drifting.

The use of adfreeze piles require that an air space, typically at least 1 m high, be maintained under the building.

The annulus around the pile should be of sufficient size to permit the backfill to flow readily to the bottom of the drilled hole.

The drilled pile hole should have a diameter at least of the pipe size, plus four times the largest particle size of the backfill used.

The pile backfill should be placed in a saturated condition, with the use of generous amounts of water.

The term slurry is often used for adfreeze pile backfill. Regardless of its consistency, saturated backfill consolidates more readily, reduces the potential for voids to form, and enhances the adfreeze bond between the steel and the backfill.

3.3.3 Timber Piles

Timber piles were commonly used as adfreeze piles in the past, that is, installed into pre-bored holes. Timber piles are rarely used in the Northwest Territories, having largely been replaced by steel. The use of timber piles shall not be considered without the consultation with and guidance of a geotechnical engineer.

There has been a history of existing timber piles rotting, primarily within the active layer, and compromising the integrity of building foundations. Restoration of such building foundations is project specific so general guidelines are of little value. Geotechnical and structural engineers should be consulted to develop a remediation strategy, considering the remaining service life of the building.

3.3.4 Driven Steel Piles

Driven piles are rarely used in permafrost areas but can be considered in warm permafrost with high unfrozen moisture content. They have been installed with without predrilling or by predrilling a slightly undersized hole pilot hole.

The design and installation of driven piles in permafrost should only be undertaken by experienced practitioners.

Piles driven into permafrost typically require high driving energy. Care must be taken to avoid inadequate embedment or pile damage.

3.3.5 Concrete Piles

Cast-in-place concrete piles are not recommended for any northern building use, unless the mix is specifically designed for rapid hydrations at high temperatures or for hydration at temperatures below 0°C. Neither is common practice in the north, and would require project specific design.

Cast-in-place concrete piles are seldom used because it is difficult to ensure adequate concrete quality in most northern communities, and because of the problems related to casting concrete in frozen ground.

There is no precedent for the use of precast concrete driven piles in the Northwest Territories. Potential future use should be considered only by experienced practitioners.

Precast concrete piles can be damaged in transit and handling if appropriate equipment and procedures are not used. Difficult driving conditions at sites underlain by permafrost will result in high driving stresses that must be carefully monitored.

3.3.6 Thermopiles

Thermopiles are the trade name for incorporation of thermosyphon technology (see Section 3.10) into adfreeze piles This technology is relatively common in Alaska and has now been used in Canada. An advantage is that it builds resiliency to climate change impacts into the foundation, thus making the use of the adfreeze pile concept feasible where it would not otherwise be expected to give satisfactory long-term performance.

The design of Thermopiles should only be undertaken by experienced practitioners.

This foundation type is non-routine and the design process is complex. General principles are outlined in CSA (2014c).

Attention to quality control is required while drilling pile holes to predetermined depths.

Thermopiles are prefabricated, and the tolerance for cutting off at the desired grade is less than for conventional adfreeze steel pipe piles.

3.4 GRADE BEAMS AND VOID FORMS

If used in conjunction with piles, void form is required below grade beams to allow the ground to move up without pushing the grade beam up.

Void form creates a cushion between the soil and the underside of a grade beam. When frost expands the soil, the void form is compressed, absorbing forces that could otherwise lift the structure.

Closed cell foam materials are recommended as they re-expand to maintain the void and do not readily absorb water.

Void form materials that compress readily and do not absorb water are recommended for use where groundwater levels are predictably high around building substructure.

Water-saturated void form materials freeze and transfer the force from freezing subsoils upward affecting grade beam stability and durability.

3.5 MONITORING PERFORMANCE

General guidance on performance monitoring is provided in CSA (2014a and c).

The installation of equipment to measure, record and report the performance of pile foundations and thermosyphon supported foundations of northern buildings is recommended to be provided as part of building commissioning wherever a need for verifying foundation settlement rates can be identified, and monitoring is supportable by the owner.

Monitoring projects may be instigated by the building owner, by building design specialists or researchers, educational institutions or cold-climate research agencies.

Results of foundation performance monitoring are recommended to be made available by the owner to the design community, and to the building design authority as part of past occupancy technical performance evaluation.

Measurement of building performance and sharing the information with the design community and the national agencies responsible for developing building climate design criteria helps adjust new buildings to be more resilient and risk adverse to changing climate factors.

3.6 FOOTINGS (SHALLOW FOUNDATIONS)

Footings are usually generically referred to as “shallow foundations” and are constructed either on or within a few metres of grade. Footings derive their support for compression loads from bearing pressure on the ground surface. Uplift loads are resisted by the weight of and friction with the soil in which the footing is buried.

3.7 FOOTING TYPES

3.7.1 Surface Footings

As the name implies, surface footings are set on or near the ground surface, which generally is a built up granular pad. This foundation type tends to be used for light loads, such as residential construction. Timber pads with wedges or screw jacks are common variations of this foundation type. This foundation type moves with the ground, so seasonal movement is to be anticipated. This foundation type offers little resistance to uplift or lateral loads.

3.7.2 Multipoint Foundations

A multipoint foundation is a variation of a surface footings that uses a three-dimensional framework of tubular steel or aluminum to develop a rigid truss system. The premise is that the stiff framework moves as a plane, so that if there is differential movement of the pad, this will not be directly transmitted to the structure. This inherent load transferring capability allows this system to work on relatively weak soils. This foundation type is commonly used for housing but has also been used for a power station.

A TRIODETIC® foundation (also referred to as space frame) is a specific, proprietary type of multipoint foundation that is commonly used in the north.

There are many logistical benefits associated with the use of multipoint foundations. The multipoint foundation system is made of relatively light components that are shipped to site in compact crates that can be easily handled on construction sites. There are no heavy equipment or specialty tools needed, and ease of assembly can facilitate the use of local labour, with minimal training required.

A disadvantage is that the framework typically requires more than 1 m of clearance under a building, so that access becomes more challenging.

Discrete bearing points should be supported by timber pads.

There is no manufacturer's requirement to set the galvanized steel bearing plates on footings, but it is considered to be good practice.

3.7.3 Buried Footings

Buried spread footings are installed with insulation either above or below the footing, such that it is situated near the top of permafrost (or bottom of the active layer). This foundation type still requires an air space to maintain permafrost. An objective of using this foundation type is to limit seasonal frost movements. While this foundation type can mobilize greater bearing pressure than surface footings, construction is more labour intensive and success is dependent on timing of construction, efficiency and workmanship. Because of these challenges, buried spread footings are not commonly used.

3.8 FOOTINGS AND RELATED SUBSTRUCTURE COMPONENTS

Pressure preservative treated shallow wood pads are preferred. Concrete is acceptable where quality concrete can be assured, and only recommended when it is precast. Compressible thermal insulation to place concrete on frozen ground is not recommended.

Wood can be easily shipped and assembled, and can also be easily adjusted on site to line up with column grid lines.

When pressure preservative treated wood for footings and related buried substructure components is to be used, pressure preservative materials are recommended to conform to the type of preservative and treatment appropriate for the service environment of the foundation system.

Variably wet service environments combined with extreme deep cold climate conditions can greatly affect the service life of preservative wood materials. A national certification program has been implemented by the Canadian Lumber Standards Accreditation Board (CLSAB) to deal with the treatment, inspection and application of a certification mark for pressure treated wood products to Canadian Standards (http://www.cwc.ca/). Pressure treated wood products are marked with a tag showing the preservative used, the type of use, the product group and the plant certification number. Site inspections can now look for these tags or marks to determined whether the pressure treated wood comes from certified producers and is being applied for the right use.

3.9 ADJUSTMENT FOR FOOTING MOVEMENT

Adjustable wedges or screw jacks allowing 100 to 150 mm of vertical adjustment are recommended.

Periodic or annual height adjustment should be anticipated for levelling buildings supported on shallow foundation.

A minimum clear height of 600 mm must be available for maintenance, but 1000 mm is preferable.	*Adequate clearance is essential to provide access for workers and equipment. Higher air spaces improve ventilation and reduce the degree of snow accumulation.*

3.10 THERMOSYPHONS (STRUCTURAL SLABS-ON-GRADE)

A structural slab-on-grade is a variant of a surface footing, where an at-grade floor is required. Often, the building structural support is provided by footings that are cast integral with the slab, as thickened zones within the slab. Heated buildings on-grade will conduct heat through the floor, into the subgrade. On permafrost, a means is required to protect the permafrost. This is most commonly and effectively achieved by using a combination of thermosyphons and insulation. The use of thermosyphons is a specialized area of practice, and the design, construction and operation of buildings on permafrost is governed by CSA (2014c), and the reader is directed there for a thorough discussion of the subject.

3.11 VENTILATED PADS

It has been attempted in the past to construct heated buildings with slab-on-grade floors on ventilated pads. Ventilation was achieved either by natural air flow through ducts, or mechanically supplemented with fans. The performance has generally been poor for heated buildings, and this foundation approach is not recommended. Natural ventilated slabs can easily fail if ducts are blocked by snow or fill with water, causing heat transfer from the facility into the frozen soils, which can lead to substructure settlement and superstructure movement. Mechanically ventilated slabs have similar problems to the natural ventilated alternative along with the added risk of mechanical failures, increased maintenance requirements, and higher initial cost.

Ventilated pads could be considered in areas of continuous permafrost, for unheated buildings or other unheated structures, such as fuel storage tanks.

3.12 ARENA FOUNDATIONS WATER DAMAGE PROTECTION

Ice arena foundation and similar structures which are vulnerable to deterioration through the action of groundwater need to be protected from underground flooding with a drainage liner installed beneath the ice rink area. The drainage liner is to be sloped to dedicated drain points so that meltwater from the ice can be pumped or completely drained away from the foundations and the building perimeter each spring.

E4 REFERENCES

- Bureau de Normalisation du Québec, 2017. Geotechnical Site Investigations for Building Foundations in Permafrost Zones. Standards Council of Canada Publication: CAN/BNQ 2501-500/2017.

- Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. BiTech Publishers Ltd.

- Canadian Standards Association, 2015. Community drainage system planning, design and maintenance in northern communities. Standards Council of Canada Publication: CAN/CSA-S503-15.

- Canadian Standards Association, 2014a. Moderating the effects of permafrost degradation on existing building foundations. Standards Council of Canada Publication: CAN/CSA-S501-14.

- Canadian Standards Association, 2014b. Managing changing snow load risks in Canada's North. Standards Council of Canada Publication: CAN/CSA-S502-14.

- Canadian Standards Association, 2014c. Thermosyphon foundations for buildings in permafrost regions. Standards Council of Canada Publication: CAN/CSA-S500-14.

- Canadian Standards Association, 2019. Technical Guide – Infrastructure in permafrost: A guideline for climate change adaptation. Canadian Standards Association Publication: PLUS 4011-19.

CIVIL

INTRODUCTION

This section must be read in conjunction with other relevant sections.

There are a great variety of site conditions in northern communities, including conditions found in different kinds of permafrost as well as different soil types. All of these variations can affect site development.

Table of Contents (to follow)

F1 SITE DEVELOPMENT

1.1 DEFINITION

Civil work includes all work required to:

- Prepare the site for building foundations;
- Grade the site to promote drainage away from the foundation and to direct all surface drainage and roof drainage water to a suitable drainage course;
- Provide access to the site and building for the construction phase, and for staff, visitors and services (pedestrian and vehicular traffic) of the completed building;
- Provide sufficient on-site parking for all expected types of vehicles;
- Create outdoor activity areas such as playgrounds and green spaces;
- Create suitable preparation and conditions for plant landscaping for microclimate control (such as snow drifting) and building sun-shading and appearance;
- Provide landforms for any building security provisions (such as separation space from public access to vulnerable building elements) or at building access points and entrances.

1.2 SITE DEVELOPMENT CONDITIONS

Reasonable site development conditions include a site that:

- Is well drained and not subject to periodic flooding;
- Is not too steeply sloped;
- Is not situated near unstable land forms such as the edge of a riverbank, or at the base of a potentially unstable hill;
- Does not require excessive fill or excavation to obtain adequate drainage;
- Has boundary dimensions suitable to accommodate the shape and size of the proposed building and ancillary uses, with ample perimeter space around the proposed building for vehicle access, parking and ancillary uses on the property;

- Does not disrupt practical well-established community use patterns or create the need for access through a separate property,
- Permafrost, if present or other geotechnical conditions do not lead to overly expensive construction or inordinate risk of failure.

1.3 GEOTECHNICAL

Refer to GBP E – Geotechnical for geotechnical requirements.

1.4 PERMAFROST

Permafrost is a description of the ground. It is soil in which the soil temperature as at, or below, zero degrees Celsius for at least two consecutive years. It does not describe the ground materials or soils, which may vary from bedrock and ice free gravels, to ice rich soils and even ice. Permafrost may be continuous, discontinuous, sporadic, or isolated, generally depending on the site location.

The potential that the permafrost may thaw, or warm significantly within the design service life of the structure, requires that the design address a broader and more varied set of technical issues than required for site development in southern Canada's more temperate climate. Northern communities located near lakes or rivers experience unique seasonal ground temperature fluctuations and ground and surface water movement, making thorough investigation of a site near a water body prior to development essential to construction success and future facility operation.

1.5 TOPOGRAPHICAL

Complete topographical information should be obtained for site grading and surface profiling for effective surface water management.

A topographical survey of the site is a necessity before design can proceed. The precision required is partly dependent on the nature of the topography. In general for most sites a contour interval of 0.25m is adequate. For very flat sites it may be necessary to use a contour interval of 0.1m or even 0.05m.

The topographical survey should pick up all drainage features including spot elevations and locations for high and low spots, drainage features such as culvert inlet and outlet inverts, driveways, sidewalks, water courses, ponds and any other feature that affects or is affected by drainage. It should also note the location and type of vegetation.

1.6 VEGETATION

Include identification of existing vegetation, which provides ground cooling shading from the sun, and which if removed, could cause rapid temperature changes in the buried portions of the site.

1.7 ENVIRONMENTAL

Refer to GBP C – Environmental Site Assessments for requirements for Environmental Site Assessments.

1.8 CODES AND REGULATIONS

A particular site may be subject to additional regulatory requirements, including:

Zoning and Land Use:	Local municipality or GNWT – MACA
Water and sewer:	Refer to local municipality and Good Engineering Practice for Northern Water and Sewer Systems[1]
Garbage removal:	Refer to local municipality.
Parking:	Refer to local municipality.
Fuel delivery:	Refer to local distributor.
Power:	See GBP K - Electrical.
Telephone:	See GBP K - Electrical.

Depending on the location and nature of the development it may also be subject to the requirements of the applicable land and water board. Refer to GBP B – Environmental Regulations / Permitting of this document.

F2 INSTALLATION CONSIDERATIONS

2.1 SCHEDULE

In many northern communities, there is a very limited period of time when site work can be done. Buildings are often completed in the late winter or spring, before the site work can be finished. Temporary facilities providing access, vehicle and pedestrian traffic, and surface water control are therefore required to allow the completed building to operate safely and economically.

Remote community access means that supplies and equipment may need to be mobilized to site and demobilized well in advance of construction in time to meet barge or winter road schedules. Missing a shipping schedule may mean a delay of a full year in the construction schedule.

2.2 LOCAL RESOURCES AND EQUIPMENT

Sitework should be designed to ensure work can be completed using equipment and operators which are locally available.

Local equipment and operators for hauling, spreading and compacting fill are often limited in small communities. Often there is more than one project being built at the same time and resources may have to be shared with another project, or with ongoing community maintenance requirements. Don't assume equipment and operators will be available for the exclusive use of one project.

Where it is contemplated to use local materials, make sure to determine their suitability and availability during the design process.

F3 DRAINAGE

3.1 FACTORS AFFECTING DRAINAGE

- Precipitation
- Topography
- Soil Type
- Cold Climates
- Vegetation
- Installation/Construction
- Maintenance
- New Development

3.1.1 Precipitation

Drainage issues are generally more problematic in locations with higher annual precipitation although more arid climates may have more severe runoff events. Often in arctic and subarctic climates the spring freshet, or snowmelt, is the most severe event.

3.1.2 Topography

Flat topography does not drain as well as steeper topography and is more susceptible to ponding. Steeper topography usually has better defined drainage channels. It is important that drainage issues be considered during design to overcome the problems that these conditions can cause.

3.1.3 Soil Type

Sites developed on granular material such as gravel or coarse sand generally have fewer drainage issues than those built on riverine and lacustrine deposits such as clays and silts. Granular materials are generally free-draining and do not retain water. They are less susceptible to freeze-thaw movement. Clays and silts can heave when the ground freezes, disrupting pipes, foundations and other structures built on or in the ground.

3.1.4 Cold Climates

Cold climates can have several effects on drainage:

- Where permafrost is present, underground drainage pipes may not be the best choice for drainage systems. The pipes may become frozen during the winter and not allow drainage in the spring;
- French drains may be a suitable alternative to underground pipes in some cases;
- Culverts are subject to icing in cold climates, particularly when temperatures alternate between thawing and freezing;
- Snow storage in winter can affect the drainage system, preventing orderly runoff in the spring by blocking drainage paths. This can lead to saturated areas that may cause problems;
- Frozen ground does not usually permit subsurface drainage;
- Annual freezing of saturated frost-susceptible soil can result in frost heave, and subsequent settlements as the ground thaws.

3.1.5 Vegetation

Vegetation can have several affects, both positive and negative.

a. Positive:

  - Vegetation canopy slows and softens impact of rainfall on soil, reducing erosion potential;
  - Vegetation slows flow velocities;
  - Root systems bind soil and reduce potential for erosion.

b. Negative:

  - Vegetation can clog channels if allowed to grow without maintenance;
  - Roots can clog perforated pipe;
  - Leaves can clog drains.

In general, the positive effects of vegetation outweigh the negative effects, and the negative effects can usually be lessened with a good maintenance program.

3.1.6 Installation/Construction

Sometimes mistakes are made in constructing and installing infrastructure. Common errors include:

- Culverts too high to properly drain;
- Culverts prone to icing;
- Poorly graded pipes, culverts or ditches, either too flat or too steep;
- Lack of adequate erosion protection;
- Lack of sedimentation controls.

3.1.7 Maintenance

The condition of the infrastructure can have a detrimental effect on drainage.

- Pipes can be damaged, usually by snow removal equipment;
- Sediment can build up at the ends of culverts. Over time the culvert can be completely plugged, or even buried;
- Ditches and swales can become overgrown with vegetation such as grass or shrubs.

3.1.8 New Development

The nature of any development usually affects drainage to some degree.

- Pavement, whether for streets, driveways or parking decreases the amount of rainfall that will infiltrate into the soil and increases the runoff.
- Buildings generally reduce infiltration and increase runoff.
- Consider the impact of any new development on existing drainage patterns. Also consider the impact on existing snow storage and handling methods and whether changes will be required.

Designing temporary stormwater storage into a system can reduce the size of drainage infrastructure such as storm sewers and culverts.

F4 EROSION PROTECTION

The following is a short introduction to erosion protection. For more detailed information refer to the document Erosion and Sediment Control Manual[2].

4.1 FACTORS AFFECTING EROSION

- Climate;
- Soil characteristics (particle size, structure, organic matter content);
- Vegetative cover;
- Topography.

4.1.1 Climate

Rainfall and temperature have significant effects on erosion. The wetter the climate, the more runoff, and the more potential for erosion. However, in an arid climate soil may be more susceptible to erosion when it does rain.

4.1.2 Soil Characteristics

In general finer grained soil is more prone to erosion than coarser grained soil. That is silt is more erodible than gravel. However, very fine-grained soils such as clay have properties that bind the particles together and are less erodible than silts. Silt is generally the most erodible soil type. Organic matter can provide some reinforcement to fine grained soils.

4.1.3 Vegetative Cover

Vegetation can be very valuable in reducing erosion for two reasons. First, the root systems can reinforce the soil structure. Second, a vegetation cover can slow the velocity of the runoff. Vegetative cover is often the preferred means of erosion protection.

4.1.4 Topography

Runoff from steeper slopes generally has a higher velocity than runoff from more moderate slopes. Higher velocity flow has more erosive potential than slower moving water.

4.2 EROSION PROTECTION METHODS

There are many ways of protecting against erosion. These are fully discussed in the Erosion and Sedimentation Control Manual.

F5 MAINTENANCE CONSIDERATIONS

5.1 SNOW MANAGEMENT

The long-term annual duration of a ground snow cover, and the need to clear snow from portions of a developed site, are normal conditions in all northern communities. Any aspect of a site that does not function well when covered in snow does not function well for a large portion of the year.
Consideration is recommended to be given to:

- How the snow must be removed (hand or machine);
- Where removed snow will be piled and room for snow storage. Don't forget snow removed from the roof;
- Snow drifting patterns and melt water drainage in spring that may be affected or caused by the snow pile;
- Protection of building, vegetation and fixed site improvements from accidental impact damage by snow removal equipment.

5.2 SPRING THAW

In most northern communities the spring thaw occurs suddenly. The consequences from the spring snow melt can be much more severe than those from rainfall. Grading must be designed to avoid and/or reduce those consequences. These consequences are more fully discussed in Section 7.3.

5.3 PLANTED AREAS

Planted areas and planting materials are recommended to be selected for harsh northern climate conditions and minimal maintenance attention. Effective selection of plant materials can provide good surface water management, wind and water based erosion control, shading from excessive sunlight, and protection from wind scouring and snow drifting.

Native northern plant species adapted to the local community climate environment are recommended to be selected for water stress tolerance. Plantings and plant species requiring additional regular irrigation to what is provided by the annual precipitation cycle are not recommended for use in northern site development.

Harvesting seeds and cuttings from the development site for reuse will ensure that plantings are acclimatized however care must be taken in storage to ensure survival. Failing that, harvesting seeds and cuttings nearby will help. Plant materials imported from southern nurseries are likely to have poor survival rates.

F6 ACCESS

6.1 PEDESTRIAN ACCESS

Buildings accessible to the public should be easily identifiable, with prominent, clearly visible entrances. All pathways, ramps and stairs leading to entrance ways should be easy to keep clear of snow and also be protected from vehicle traffic.

6.1.1 Walkways

Finished walkways should be provided, leading from the edge of the roadway and community walkway system and from all parking areas, to all regularly used building entrances. Surfaces should be well drained and finished with contained, finely crushed granular material, or pavement.

This minimizes mud tracked into buildings during spring and fall. This is particularly important for facilities with high rates of public access such as schools, health centres, community recreation facilities, shops, stores, hotels, restaurants, and general office buildings.

Hard surfaces or grating surfaces should be considered at entrances

Clean hard surfaces intercept dirt before it is tracked into the building.

Avoid locating walkways immediately adjacent to walls of buildings, or where falling snow and ice from roofs is a potential safety hazard.

Traffic near the building face can increase the incidence of vandalism damage to building finishes. Snow and ice packing on roofs needs to land away from pedestrian walkways.

6.1.2 Ramps and Stairs

Refer to Architectural section for design parameters for Ramps and Stairs.

Whenever possible, eliminate the need for ramps and stairs by shaping the site. Grade elevation at building entrances should be as close to finished floor elevation as possible, while still providing effective water drainage away from the building walls.

Sloped grade often permits removal of snow with small motorized equipment rather than by hand, such as is normally the case with stairs and ramps.

One ramped path of travel to a building entrance is recommended instead of providing both stairs and a ramp. Wherever possible, a ramp with a straight run is recommended to be provided. Where the height requirement dictates that a ramp must be long enough to be returned upon itself through landings, then stairs are recommended to be provided in addition to the ramp.

Stairs and ramps are often installed independently, though they lead to a common landing. This creates two paths of travel. A single access ramp that can accommodate all traffic including freight and furniture can reduce costs, reduce snow clearing requirements and satisfy barrier-free access requirements and policy.

Areas of granular fill materials leading to or from

This controls erosion from normal use, while still exits must be evenly graded for effective drainage and contained with wood, stone, concrete or metal retainer curbs.

providing effective water disposal off the walking surface.

Low maintenance open metal or fibreglass grating is the preferred surface material for exterior ramps, stairs and landings. Gratings should meet the requirements of applicable codes and the referenced standards.

This allows snow to pass through, diminishing accumulations at entrance ways.

Wood surfaces are acceptable for most pedestrian stairs and ramps.

Wood is easily damaged by snow clearing, but is easily repaired or replaced using easily available materials and carpentry skills.

Concrete stairs and ramps are acceptable.

Where available and not cost-prohibitive, concrete can provide a durable, easily cleaned surface. The cost of long ramps and high stairs may be prohibitive. In some communities lack of suitable aggregate may rule out concrete.

6.1.1 Snowdrifting

Locate building entrances where snowdrifts will not normally form. If this is not possible, find another means of reducing the snow accumulation, including canopies and wind deflectors to improve wind-scouring of snow.

Entrances are typically located so that predominant winds scour the area. Certain building configurations are also prone to snow accumulation, such as inside corners, but other building shape features can be positioned to help the wind prevent snow accumulating at entrances.

Avoid locating entrances and exits at the inside corners of buildings.

Inside corners are prone to snow accumulations.

6.2 VEHICULAR ACCESS AND CONTROL

In many northern communities there are no municipal requirements for parking or service vehicle access to buildings. In general, requirements should be determined considering the following:

- Vehicles commonly in use in the community may include cars, trucks, snowmobiles or all-terrain vehicles;
- Where parking for users of northern buildings is to be provided as a requirement, and where location of exterior electrical outlets for vehicle heaters may be required;
- Type and size of service (fire response, ambulance response, fuel, water and sewage) vehicles and personnel that must be able to approach and park their vehicles next to building entrances or connection points on the exterior of the building year-round, with a minimum of difficulty, meaning no obstruction by snow, standing water or steep slopes, and clear lines of sight to verify the access route is safely clear of pedestrians;

- Required protection of building surfaces from vehicle impacts.

6.2.1 Routes and Parking

Access routes and parking must accommodate the turning radius of local vehicles, including service vehicles and firefighting equipment.

Normal mode of transportation and type of service vehicles vary from community to community.

Vehicle routes and parking areas on site should be clearly marked, using physical barriers that remain visible in winter conditions if necessary.

This is done to identify and control vehicle traffic around buildings and to provide some protection for pedestrians, landscaping, slopes of building pads or buildings. Boulders, logs, heavy timber or fencing can all be considered.

6.2.3 Parking Stalls

Minimum dimensions for car or truck parking stall is 2.5 m x 6 m. Recommended sizes are generally larger, 3.0 m x 7.0 m for stipulated truck parking spaces.

Use standard parking stall dimensions, especially in communities where no area requirements exist. Many communities have a large number of full-sized and extended frame pickup trucks.

Minimum dimensions for an ATV or snowmobile parking stall is 2 metres x 2 meters. Drive-through parking spaces are recommended for snow machines.

ATVs and snow machines or snowmobiles are the most common vehicle in many communities - not all are able to back up.

6.2.4 Vehicle Plug-ins

Refer to GBP K – Electrical.

6.3 SERVICES AND UTILITIES ACCESS

With winter conditions lasting from six to eight months of the year in many northern communities, it is important that building service points are easily accessed by trucks and personnel, and protected from snow and ice build-up. Municipal utilities and fuel service in the majority of northern communities is by tanker truck. Fuel (primarily heating oil) is delivered exclusively by truck. Power and telephone are generally provided by overhead service distribution, but occasionally by underground installations. Some northern communities have access to piped natural gas, and others have propane distribution buried on sites.

Extra precautionary measures must be taken to identify buried utilities locations prior to digging any earthwork on a developed site. Broken underground pipes and wires take much longer to repair or replace in northern communities, where skilled trades and repair or replacement materials may be located far away from the community. Interruption of power, gas or water in winter, whether above ground or buried, can have expensive consequences and place buildings and occupants at substantial risk from extreme cold.

6.3.1 Delivery Vehicles

Provide adequate space for delivery vehicles to pull off main roadway when they are servicing a building, yet still come close to building service connections without risk of impact.

This keeps service vehicles from blocking other traffic, a municipal requirement in some communities.

6.3.2 Service Connection Access

Provide access stairs and platforms wherever people must access fill points or connect to services located more than 1.5 m above ground level.

Proper stairs allows delivery people to connect to raised building service access points easily and safely.

6.3.3 Service Connection Access

Ladders or ships ladders are not acceptable due to the winter slipping risk and injury potential.

6.4 BUILDING ORIENTATION

Snowdrifts can impede access and exits from buildings, cause excessive structural loads on roofs, block windows, and provide easy access to the building roof by unauthorized persons.

6.4.1 Snowdrifting

Snowdrifting around buildings should be managed through careful orientation on the site, and designed so that problems can be minimized or avoided. Wind control devices, such as scoops or accelerators, can be beneficial if supported by snow-drifting simulation studies.

Although such devices have proven effective, they are an expensive alternative to proper building orientation on the site to take advantage of natural wind scouring. In certain communities, wind frequently shifts directions, making it difficult to rely on scouring by predominant winds, so well-designed wind deflection devices are recommended to be included as an effective snow management tool.

F7 FILL AND GRADING

7.1 GRANULAR MATERIALS

Granular materials are in short supply in many communities. It is important to arrange for granular materials well in advance. In some communities it is necessary to haul granular material over a winter road. If the geotechnical resources available in the community are not known a granular source investigation may be required. It may be possible to include this investigation in the geotechnical site investigation. Refer to Section D5 – Geotechnical.

7.2 FILL

Granular materials can be quarried from suitable local land sites or transported from a remote source and stockpiled near the community. Where local supplies have been identified, the contractor or the subcontractor must obtain permission to quarry from the appropriate authority:

- the community government
- the Territorial Government (Lands & MACA)
- the Federal Government
- in many cases ownership may have recently been transferred through a land claim settlement to beneficial control by a local development corporation.

In general it is preferable to buy granular materials locally, rather than to develop a source.

7.2.1 Built-Up Granular Pads

Provide an impermeable liner on slopes of pads that lie in the path of runoff in permafrost areas.

This is done to divert water around the pad, rather than allowing it to seep under or through it, potentially degrading permafrost. See also GBP Subsection D5 – Geotechnical, for additional information.

7.2.2 Excavation

Avoid cutting into existing soils where permafrost is present.

This exposes frozen soil causing degradation of permafrost. See also GBP Subsection D5 – Geotechnical, for additional information.

7.3 GRADING

Although frozen for much of the year, building sites can be susceptible to significant damage during spring runoff or as a result of ponding or erosion and saturation by moving surface water:

- Flooded basements, tank rooms or crawl spaces can cause sewage holding or other tanks to float, damaging pipe connections and/or the structure;
- Structural integrity of foundations can be jeopardized by water adjacent to foundation elements;
- Ponding water can cause permafrost degradion;
- Access to building by users or services can be impeded;
- Water accumulating against foundation walls can seep into the building or saturate the foundation system with risk of water-based deterioration;
- Water ponding against embankments softens the embankment and can accelerate erosion;
- Water ponded against embankments can compromise the integrity of the embankment.
- Water-permeable granular pads supporting building foundations becoming severely eroded by water seeping under or through the granular materials, resulting in soils consolidation, settlement and damage to the substructure;

7.3.1 Finished Grades

Finished grades should have a minimum 4% slope away from the building for a minimum distance of 2 metres to obtain effective surface water drainage and disposal away from the building perimeter walls.

This provides drainage away from the foundation without promoting erosion by runoff.

7.3.2 Retaining Walls

Where grade differences cannot be accommodated by slopes of less than 1:4 (25%), because of site constraints or limited fill materials, retaining walls may be considered.

Using retaining walls can reduce the total amount of fill required; however, it is generally a more labour intensive and expensive means of stabilizing slopes. A specific geotechnical and structural design is almost always required for a retaining wall.

7.3.3 Roof Drainage

Many northern buildings do not have eaves or parapets. This results in roof drainage running down the walls an often into the foundation. Ensure roof drainage is directed well away from the building.

Downspouts with discharge leaders can direct roof drainage away from building foundations.

7.3.4 Drainage Channels

Drainage channels or shallow ditches (swales) to manage initial drainage on newly developed sites must be in place on site before spring runoff: this may require temporary installation of swales or berms.

Construction schedules dependent on barge delivery generally result in winter construction: the building is usually ready for occupancy by spring or early summer, but site work cannot be completed until mid to late summer.

F8 SITE REHABILITATION AND LANDSCAPING

A comprehensive landscaping plan is recommended to incorporate requirements noted in the sections above. Landscaping using lawns, flower beds, trees and shrubs, however, is not usually a practical consideration in most northern communities. Nonetheless, care needs to be taken in finishing sites around northern buildings for beneficial appearance, as well as for public safety and to control erosion.

8.1 EXISTING VEGETATION

Maintain as much existing vegetation on site as possible and protect from vehicular traffic.

This protects the soil from erosion, insulates permafrost and generally improves appearance of site. Below the tree line, trees and bushes can provide shelter from wind, trap drifting snow and provide shade in the summer.

8.2 EXISTING VEGETATION

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8.3 VEGETATION – NEW/ADDED

Any plant material added to the site must be hardy, suitable for the locality and require little or no maintenance - transplanting of local species is encouraged where an acceptable source can be found in the community. Harvesting of seeds and cuttings for revegetation should be considered.

Growing conditions are too harsh for most plants commonly used elsewhere in Canada. Development of landscape maintenance and gardening can provide specific technical benefits to site durability and building safety and comfort.

8.4 SOIL

If soil or topsoil is required, it must be available within the community, along with any necessary additives to achieve effective plant nutrition.

Mixed, prepared topsoil is simply not available in most communities. If required in any quantity, costs can be high.

8.5 PLAYGROUNDS

Soft, sandy surfaces should be provided wherever play structures are installed.

Sand and gravel surfaces require continuous maintenance for removing dog feces and other contaminants. Sandy surfaces are recommended for use where dogs are barred from access or the sand can be routinely replaced.

Refer to CSA Z614-14[3].

Sand is difficult or impossible to obtain in many communities. Artificial safety surfaces may be required.

Many communities are now using rubberized block surfaces around playground equipment.

F8 REFERENCES

- Government of the NWT - Municipal and Community Affairs. (2018). *Good Engineering Practices for Northern Water and Sewer Systems.*
- Government of the Northwest Territories – DOT *Erosion and Sediment Control Manual and Appendices*, 2013
- Canadian Standards Association Z614-14 - *Children's Playspaces and Equipment*.

STRUCTURAL

INTRODUCTION

Structural design of northern facilities must consider several conditions not typically found in the rest of Canada. When choosing a structural system, some of the unique considerations that must be accounted for include:

- Permafrost and related boreal hydrology
- The Arctic climate and its accelerated climate change effects
- Availability of resources such as materials, skilled labour and appropriate equipment

This guide presents a detailed discussion on the variety of issues prevalent in northern Canada building design. The guide is broken down into the following sections: notable codes and regulations; climate change design adaptation; unique logistical concerns; loading stipulations prevalent in the northern regions; an evaluation of wood, steel and concrete structures and miscellaneous structural comments. All information related to foundation design can be found in the Geotechnical section of this guide.

One significant difference from the previous guide is the detailed discussion on the effects of climate change. Chapter D describes the overarching effects from climate change, and each subsequent section presents unique ways in which climate change has altered its scope. A more detailed overview of how Climate Change has influenced other aspects of building practice in the NWT is found in Chapter D.

Table of Contents (to follow)

G1 CODES AND REGULATIONS

1.1 APPLICABLE CODES

Structural designs completed in the Northwest Territories (NWT) must follow applicable Canadian Codes, Standards and Guides. This usually includes, but is not limited to the most current versions of:

- The National Building Code of Canada, including the National Building Code structural commentaries;
- Canadian Standards Association (CSA) Design Standards, as appropriate;
- CSA Material Design Standards as appropriate, including:
  - CSA A23.3-14 – Design of concrete structures;
  - CSA O86-14 – Engineering design in wood;
  - CSA S16-14 – Design of steel structures;
  - CSA S136-16 – North American specifications for the design of cold-formed steel structural members;
  - CSA S304-14 – Design of masonry structures.
- Publications and design guides from trade associations including, but not limited to:
  - CISC -Canadian Institute of Steel Construction
  - CSSBI - Canadian Sheet Steel Building Institute
  - CPCA – Canadian Paint and Coatings Association
  - CWC – Canadian Wood Council
  - CPCI – Canadian Precast Prestressed Concrete Institute

In addition, the following are a list of codes which require particular consideration during the structural design process of Northern facilities.

- NWT Fire Prevention Act
- NWT Fire Prevention Regulations
- NWT Architects Act
- NWT Engineering and Geoscience Professions Act
- CAN/CSA-S502-14 Managing Changing Snow Load Risks for Buildings in Canada's North
- CAN/CSA-S500-14 Thermosyphon foundations for buildings in permafrost regions
- CAN/CSA-S501-14 Moderating the effects of permafrost degradation on existing building foundations
- CAN/CSA-S503-15 Community Drainage System Planning, Design, and Maintenance
- CSA S500 series have been produced under the Northern Infrastructure Standardization Initiative (NISI). Additional codes and guides are being developed by CSA and NrCan under the NISI program.

1.2 ENGINEERING REGULATIONS

As per the NWT Engineering and Geoscience Professions Act, all designs require the seal of a Professional Engineer registered with the NAPEG and licensed to practice in the NWT and NU. This includes designs of proprietary systems or products such as pre-engineered or pre-manufactured components sourced from inside or outside of the Territories.

G2 CLIMATE CHANGE DESIGN ADAPTATION

In recent decades, a strong warming trend has emerged in the Northwest Territories that is over twice as pronounced as the worldwide average increase. Many other significant changes are expected besides the temperature changes, with notable examples including the changes in sea level and changes in precipitation types and intensity.

Cumulative changes in NWT infrastructure-relevant environmental conditions resulting from climate change will be substantial and irreversible. Assessments regarding the effects of climate change on northern facilities should be supported by all entities engaged in northern building and infrastructure development. In recent years, governments around the world have began implementing climate change protocols on new infrastructure in attempt to minimize the effects that new infrastructure has on buildings.

For the development of infrastructure, it is important to be aware of any Climate Change guidelines, policies or instructions mandated by any of the agencies of departments within the Federal or Local Government.

Climate change aspects of critical importance to the structural design of facilities are mentioned throughout the entire structural section. It is imperative that any new facility design considers these effects from the design to the completion of construction and ongoing maintenance of the building.

G3 LOGISTICS

The climate in the north is cold but relatively dry. The summers are short, sunny and temperate with temperatures traditionally rarely exceeding 25 degrees Celsius. The winters are long and cold with temperatures reaching -40 degrees Celsius. The short summer construction season presents many logistical issues not commonly found in warmer, southern regions and requires structures that can be erected quickly so they can be closed in before winter. Some notable logistical issues are outlined below.

3.1 TRANSPORTATION AND HANDLING

Transportation costs can contribute a large portion of the overall project cost. Size restrictions may apply, and weight and volume should be optimised to facilitate sealift, barge or air freight. Projects encouraging the use and development of local resources and labour play a significant part in lowering northern construction costs.

Climate change is expected to greatly affect both summer and winter road transportation. Particularly, warming temperatures are shortening winter road operating periods by slowing set-up of frozen conditions in the fall and hastening melt-out (particularly of portage sections) in the spring. This will decrease the functionality of these roads, with large socioeconomic implications for road-linked communities and industries. In addition to winter road impacts, climate change will also contribute to permafrost degradation, changes to freeze-thaw cycles, and increased extreme summer rainfall events over all-season road infrastructure. These impacts may in turn cause risk of reduced spring, summer and fall season road functionality.

Construction equipment availability is often limited in northern communities. Consideration for the availability of adequate and suitable equipment to ensure successful execution of the project should be included in all project stages, including the design and construction planning stages. Equipment, components or materials transported to site should be sized and packaged to ensure safe, manageable, and efficient transportation. Transporting materials to sites in communities served only by annual sealifts, summer barges, or by winter roads must be carefully planned well in advance to ensure timely delivery to site to avoid costly construction delays.

3.2 SCHEDULE

The construction season is much shorter in the North than elsewhere in Canada. It is imperative that facilities are closed in before severe winter conditions set in. Structural work must proceed quickly and smoothly; extra care must be taken to ensure it is also completed correctly in one operation. Material delivery schedules and seasonal soil conditions generally determine optimum foundation work schedules. Variables include the transportation system to be used (barge, sealift, air, all weather road, or winter road) and the foundation system selected (piles, shallow footings, buried footings, or slabs). Site preparation may be performed a year in advance to permit consolidation of placed fill. Foundation work can be installed in advance of the superstructure to meet delivery or other scheduling constraints. This is particularly appropriate with foundation designs that are not affected by remaining in place without the superstructure load.

3.3 STANDARDIZATION

The size and type of structural elements used in a facility should be standardized. This will decrease waste, simplify construction procedures, and reduce erection time. Whenever possible, simplify detailed design and minimize the number of operations required to install components. Uncomplicated details are likely to produce a better building.

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G4 LOADING CONSIDERATIONS

Climate change is leading to new climate driven structural design factors for building support and environmental (rain, snow and wind) loads. Structural design must account for the projected climate over the design-life of the structure. However, projected climate change coupled with increased volatility of extreme climate events is introducing uncertainty into the environmental conditions that these designs must be prepared for. This creates the need for a risk-assessment approach to building engineering design that can accommodate both long term climate change and an increased variance of future weather events. To address this need, the Canadian Standards Association (CSA) prepared a guideline in 2010 for climate change adaptation when designing infrastructure in permafrost areas. Note that a more recent version is currently under development to replace the 2010 version and should be used once made available. This guideline describes a risk-based approach for evaluating the levels of investigation and analysis that should be undertaken during the structural design process to account for climate change. This risk-based approach to climate change induced snow, rain and wind loading modifications is recommended, particularly in light of more severe climate change in the Canadian Arctic relative to lower Canadian latitudes.

Part of a risk-based approach to future loading considerations is application of future climate projection information. However, at present there is no Canadian guideline that specifies site specific climate projections for load considerations. Until such a guideline is available, site-specific projections can be developed from ad hoc sources, with the assistance from suitably qualified professionals. For example, a tool referred to as Scenarios Network for Alaska + Arctic Planning (University of Alaska Fairbanks, 2018) permits scenarios to be developed for specific locations in the western Arctic. The tool is based on climate scenarios from the latest Intergovernmental Panel on Climate Change Assessment Report (IPCC, 2014). Similar data is also available from the Climate Atlas of Canada (Prairie Climate Centre, 2018)and the Pacific Climate Impacts Consortium (University of Victoria, 2013).In many cases, the interpretation and further processing of this information will be required to arrive at metrics suitable for integration into engineering designs.

4.1 SNOW AND RAIN LOADING

In the majority of North America, climate change is projected to decrease the length of the snow season and average snowpack depths. In the northernmost parts of Canada, however, it is anticipated that climate change will increase maximum snow depths, as increases in wintertime snow outweigh increases in temperature above 0°C (CSA, 2010). Increases to winter precipitation are reflective of an overall intensification of the water cycle, with higher precipitation rates and enhanced storm intensity.

Because of potentially drastic loading changes resulting from climate change, facility design and development will need to accommodate at least 1) greater amounts of denser snow and 2) increased rain loading. Additionally, designers must account for deluge rainfall and snow melt events leading to more water-related risk to facility foundations.

Structural design protocols for snow loads on roofs of facilities likely to be used as places of refuge during emergencies need to follow incorporated structural design analysis procedures in the current version of the National Building Code of Canada, applicable for use in the Northwest Territories. Increased incidences of roof collapse in various parts of Canada in the past ten years have resulted in the recognition that historically defined snow loads may be increasing, and facilities designed for a long service life are more likely to be exposed to unforeseen heavier snow loads.

Structural design must also consider the resulting non-uniform loads caused by accumulation of the increased rain loading, which if enough accumulation occurs, can create both structural and building envelope issues. The structural design must consider the 1/50 one day rain and include the effect of ponding from plugged roof drains. The removal of rain water at drains can be restricted by hail or from the formation of ice dams on the roof, which are created when too much heat escapes a portion of the roof, melting the snow and ice on the rooftop. Once the melted snow/ice follows the drainage path, it eventually re-freezes at colder areas of the roof, such as at sub-freezing eaves troughs.

4.2 WIND LOADING

Although wind pressures can be very high, especially in the central and high arctic, they are similar to those experienced in other parts of Canada. With the presence of climate change, structural design may have to account for the increased variability of wind events and gust levels which create less predictable and higher wind loading. For example, there is emerging indication that coastal winds will increase substantially, particularly in the fall and winter, because of sea ice loss. However, projections of interior wind changes are not currently robust enough to support definitive design decisions. In this case, it is recommended that increased safety factors are used to account for potentially large changes in wind loading.

4.3 SEISMIC LOADING

New facilities shall be designed and constructed in accordance with the seismic requirements of the National Building Code of Canada. For design and evaluation of non-structural building components (i.e., building contents, piping, light fixtures, etc.) refer to the CAN/CSA-S832-14 (CSA, 2014).

G5 FOUNDATIONS

Refer to GBP Chapter E – Geotechnical.

G6 WOOD STRUCTURES

Due to their versatility and general availability, conventionally framed stick-built or factory assembled wood structures are appropriate for many northern conditions. Wood materials have a high strength-to-weight ratio, are more compact, and less susceptible to damage in transit than some prefabricated assemblies. Rigid framed timber structures that are weather-enclosed with insulated non-structural panels are not commonly found in northern construction, however they have the potential to be a viable energy conserving alternative to conventional frame construction.

Wood structures generally have very fast erection times even with limited skilled labour, however one must consider the availability of wood at the project area, and there exist unique considerations in wood design which are not prevalent in steel structures, such as moisture content and the isotropic behaviour.

6.1 FLOORS

Special attention must be paid to coordination of the structure with the building envelope and mechanical systems: floor assemblies must often accommodate thick thermal insulation, plumbing runs and ventilation ducts. The special environmental separation requirements of floors elevated above grade are reviewed in detail in the architectural GBP H1.3 – Floor Assemblies.

Consider using plywood web joists, steel tube web wood joists or light wood trusses in place of dimensional lumber greater than 210 mm depth. Engineered joists provide improved strength-to-weight ratio; reducing shipping costs; and are less prone to shrinkage than dimensional lumber. Engineered joists and trusses can also accommodate increased spans and may require fewer lines of foundation bearing.

Adequate protection of floors during fire events must be considered in structural design as to negate the possibility of premature collapse, which would greatly hamper fire fighting activities.

6.2 WALLS

The structure must be coordinated with the building envelope design to ensure adequate space is provided for insulation, and that elements such as sheathing and blocking are located to benefit both structural and envelope design. Special attention must be paid to the structural support of air barriers, particularly at building corners where wind loading is greatest.

6.3 ROOFS

The roof structure must be coordinated with building envelope design to ensure ventilation, air barrier and vapour barrier functions are satisfied, particularly since high air humidity and moisture levels will cause rapid deterioration of wood structural members. When insulation systems are installed above the primary deck, fastening systems must be designed to resist the wind uplift forces acting upon the insulation and roof finish.

The use of prefabricated or site-configured roof trusses may save time and money, and reduce the required number of interior support posts. Trusses, however, may experience significant uplift forces due to cold weather. This occurs due to heavy insulated roofs, in which the top chords of the roof remain cold whereas the bottom chords stay warmer due to the insulation. This temperature difference, combined with fluctuating daily temperatures, may lead to significant moisture differences in the lower and upper parts of the truss, which can in turn create uplift of the bottom chord. This uplift can create stresses in the connections between the interior partition walls and the truss, which can lead to cracking in the drywall, or more consequently, damage in the truss. While truss uplift cannot be completely avoided, special design considerations must be used to minimize the impact.

6.4 TIMBER FRAME CONSTRUCTION

Timber frame construction for housing and small northern facilities is an acceptable construction alternative to conventional stick framed construction. Traditional timber framing is the method of building with heavy timbers jointed together. The incorporation of timber has evolved over the past years to be a more common building material due to advances in timber construction. One unique aspect of timber frame facilities is that the large structural wooden members are typically exposed at the interior and/or exterior faces to showcase the aesthetics of the structure.

To construct a smaller timber structure, the beams and columns can be assembled into a structural frame through carefully fitted interlocking wood joints, pegs and splines. The precise joints are cut prior to arriving on site which minimizes the frame assembly time on site. Another joint option is to use metal fasteners on structures supporting larger loads.

Once the frame is completed, the facility is enclosed, often with pre-fabricated structurally insulated panels to create a complete building envelope. One benefit of timber framed structures in the north is that the simpler assembly of the frame and envelope allow for a rapid framing and enclosing process.

Although the materials involved typically are more expensive than a traditional stick-frame construction, the stronger timber allows for much larger openings/spans, and the rapid construction time can help minimize the overall cost of the project. Timber framed structural systems permit simpler building envelope weather enclosures to be installed more rapidly and with improved environmental separation.

6.5 CROSS LAMINATED TIMBER PANELS

Cross laminated timber panels have gained significant traction in recent years in building design. These panels are comprised of multi-layer mass timber members where each layer is oriented alternating perpendicular directions, bonded by adhesives and pressed to form a solid straight rectangular panel. These panels are particularly useful in the design of floors of roofs. Once the pre-fabricated panels arrive on site, they are generally quick to construct, with minimal training.

6.6 PRESSURE TREATED WOOD

A national certification program has been implemented by the Canadian Lumber Standards Accreditation Board (CLSAB) to deal with the treatment, inspection and application of a certification mark for pressure treated wood products to Canadian Standards. Pressure treated wood products are marked with a tag showing the preservative used, the type of use, the product group and the plant certification number. Site inspections can now look for these tags or marks to determine whether the pressure treated wood comes from certified producers and is being applied for the correct use. http://www.cwc.ca/

6.7 STRUCTURAL INSULATED PANELS

Structural Insulated Panels (SIPs) are an acceptable construction technique for northern facilities where either conventional stick-framing or timber framing is used. Structural Insulated Panels are building panels that are built prior to arriving on site that serve as structural, insulating and sheathing purposes all at once. SIPs consist of a foam insulation core; typically made of polystyrene; sandwiched between two sheathing panels, which are most commonly industry standard oriented strand board or plywood.

As the panels are prefabricated and are specific to design of each project, the manufacturer must be included in the project from the start to ensure that the panels shipped out to site in the proper sizes and in a timely manner. Building considerations such as the location of electrical outlets and wiring must be dealt with during the design stage as they are installed into recesses and holes that are pre-cut into the panels. Contractors do not have a lot of flexibility with on-site design changes due to the prefabricated nature of the building system.

Joints between SIPS need to be well-sealed for continuity of the air and vapour barriers and to prevent moisture from entering the panel, which can lead to structural deterioration of the panels over time.

There are several benefits associated with using SIPs, with one benefit being its exceptional insulating properties compared to conventional building systems. The lack of air permeable wall cavity prevents any convective heat losses within the panels. The large panels also have less framing compared to a stick-framed wall, which reduces heat loss that occurs from thermal bridging.

Rapid enclosure of the exterior weather protecting envelope for small buildings increases construction efficiency and reduces exposure time to cold weather. Segments of walls, floors and roofs assembled in controlled factory conditions provide the potential for higher quality of framing and sheathing assembly, and lowered construction costs. With an adequately trained construction crew, SIP structures can be erected rapidly, which is particularly important in the north where construction seasons are very short.

Depending on the situation, using SIPs can be either cost-effective or cost-prohibitive. SIPs differ from typical wood building construction due to the added design services and shipping costs associated with them, however, this can pay off in reduced labor costs if a trained crew erects a building quickly, or if several facilities of the same design are being erected. With such short construction seasons, often the construction method that requires less time and a faster building envelope enclosure is the preferred method, even if it does add design costs.

G7 STEEL STRUCTURES

Before deciding to use a steel structure, the designer must be satisfied that local equipment is available to move and lift components into place, that shipping costs are reasonable in comparison to wood systems, and that local labour and businesses can provide construction resources. Bolted connections are preferable to extensive specialized field welding.

7.1 FLOORS

Structural steel floors should be designed to prevent transient footstep induced vibration from exceeding the annoyance threshold. Refer to the most recent version of applicable CSA and NBCC guidelines for more information regarding vibration control.

For all HSS members that may be subject to freezing, drain holes should be provided at the lowest point to prevent any ice from forming within the members. It is recommended that neoprene seals are utilized around all fastening penetrations exposed to water.

7.2 ROOFS

With the increased popularity of pre-fabricated structures using open web steel joists, a designer may encounter the situation in which a gerber girder intersects the joists. When designing cantilever roofs with continuous gerber girders, refer to *Roof Framing with Cantilever (Gerber) Girders and Open Web Steel Joists*(CISC, 1989).

7.3 PRE-FABRICATED BUILDINGS

Pre-engineered and prefabricated steel frame facilities are common in the North. The many different types and number of distributors have made prefabricated metal facilities competitive and an option worth considering for certain types of building. These include garages, fire halls, arenas and warehouses - all facilities with regular and uncomplicated floor plans, which are easily defined and require large open spaces. Custom steel structures may be appropriate for larger non-combustible facilities.

The main advantage with pre-fabricated buildings are the logistical benefits when compared to conventional steel construction. These structures are relatively quick to construct due to their modular nature. Pre-fabricated buildings are generally lighter than conventional steel, resulting in smaller transportation costs and easier handling procedures. Pre-fabricated members can generally be handled by relatively light weight equipment when compared to the equipment required to handle conventional steel members.

G8 CONCRETE

Structural concrete is seldom used because of difficulty with quality control, climate and the higher cost of winter hoarding, materials freight cost, variable aggregate resources and lack of batch plants in small communities. However, as trade skills, materials, batching plants and roads all become more readily available, structural concrete will become more economical.

The use of concrete is challenging in the North because granular materials, mixing equipment and construction phase testing facilities are not available in many communities. Variable soil conditions and a curtailed construction season can also make using concrete problematic as a structural material. In communities where ready-mix concrete is available, concrete is recommended for: multi-story non-combustible construction; deck infill for steel frame construction; and for some precast structural elements. Where very small quantities are required, so as to make hand batching feasible, concrete use is recommended to be limited to foundation elements, which are covered in the Geotechnical Section of the GBP. Concrete masonry units for wall construction are recommended where substructure conditions and transportation availability support competitive economics.

8.1 FLOORS

Refer to the Geotechnical section for details regarding slabs on grade. Precast concrete or hollow core slab panels may provide a viable alternative to suspended in-situ concrete slabs.

8.2 WALLS

Cast-in place concrete is not recommended for wall construction, except where no other assembly can be used to meet NBC requirements, or where it can be shown that concrete would be the most economical choice. Precast concrete facing panels, concrete tilt-up construction, and concrete masonry units for wall construction is recommended where substructure bearing conditions and transportation availability support competitive economies.

8.3 ROOFS

Cast-in-place concrete is not recommended for roof construction, except where no other assembly can be used to meet building code requirements, or where it can be shown that concrete would be the most economical choice.

G9 ADDITIONAL CONSIDERATIONS

9.1 VIBRATION REQUIREMENTS

When laying out a building, it is important to locate emergency generators at grade level whenever possible to avoid structural vibration problems. If that is not preferred and the emergency generators are located on upper floors, specify an inertia base of 1.5 times the weight of the equipment during structural design.

9.2 STRUCTURAL ALUMINUM DESIGN

If aluminum structural members are designed in a building, then it must be ensured that any aluminum members that come in to contact with concrete, masonry, wood, or metals other than steel shall be coated with an appropriate coating system, or an inter separator (e.g., neoprene) shall be provided between the aluminum and these materials. Steel members that come in to contact with aluminum shall be coated with an appropriate coating system or zinc-coated. Aluminum members shall not be placed where runoff from other metals might come in contact with them.

9.3 CORROSION PROTECTION

It is imperative that the designer specifies that all structural members that may be in contact with spill, leaks or corrosive solutions are protected against corrosion. This is especially common in mechanical rooms where the structural floors are supporting brine tanks and water softeners.

9.4 EXTERIOR WALL DESIGN

Structurally design and detail the fastening, support, and back-up systems for exterior walls, brick veneers, cladding and attachments. Specify galvanizing of steel connections outside the air barrier and shop welding of welded connections. In the design of exterior wall back-up systems, limit deflections according to the properties of the cladding or veneer being used.

9.5 RADON GAS MITIGATION

New facilities should be designed to minimize entry of Radon gas and allow for Radon removal.

G10 REFERENCES

- Canadian Standards Association, 2010. Technical Guide - Infrastructure in permafrost: A guideline for climate change adaptation. Canadian Standards Association Publication: PLUS 4011-10
- Canadian Standards Association, 2019. Technical Guide – Infrastructure in permafrost: A guideline for climate change adaptation. Canadian Standards Association Publication: PLUS 4011-19.
- Canadian Standards Association, 2014. Seismic risk reduction of operational and functional components (OFCs) of buildings. Canadian Standards Association Publication: CAN/CSA S832-14
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ARCHITECTURAL

INTRODUCTION

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H1 BUILDING ENVELOPE

Considerations related to building envelope design in the NWT shall include:

- Energy efficiency
- Durability of materials
- Low air leakage
- Water resistance
- Life cycle cost (high fuel/electricity cost)
- Long heating season with a short drying season
- Temperature ranges from -50C to +30C
- Generally dry climate with total annual precipitation mainly from snow
- Snow drifting
- Climate change

Required minimums or maximums referred to in the Good Building Practice shall be used, unless the designer can show that alternative proposed methods will provide operational efficiency savings and extended durability over the planned service life of the building. The requirements in this section are intended to supplement and clarify the requirements of NBC Part 5, and NBC 9.25 for practical and effective application meeting northern climate conditions, which often create a more demanding building envelope performance environment than found in many other parts of Canada.

1.1 AIR MOVEMENT, WATER AND VAPOUR PROTECTION

NBC Div. B Part 5, "Environmental Separation" and NBC Div. B Section 9.25, "Heat Transfer, Air Leakage and Condensation Control" contain the minimum standards required for environmental separations for buildings in Canada. Successful application of NBC Div. B Part 5, or NBC Div. B Section 9.25 requirements can be more difficult to apply in the north than in other parts of Canada because of the short construction season, extreme environmental conditions affecting material performance characteristics, and periodic shortages of experienced installers.

Performance verification of northern building envelopes may be required as part of the commissioning process, using various techniques such as thermographic surveying, pressurization tests, mock-ups, smoke testing, data loggers and/or other verification methods.

1.1.1 Control of Rain and Snow Penetration

The requirements of NBC Div. B Subsection 5.6.1, *"Protection from Precipitation"*, and NBC Div. B Subsection 5.6.2, *"Sealing, Drainage, Accumulation and Disposal"* apply.

NBC Div. B technical provisions for precipitation when used comprehensively have been found to be effective for northern buildings.

1.1.2 Control of Surface and Groundwater

The requirements of the NBC Div. B Section 5.7 *"Surface and Groundwater"* apply, to be used in combination with effective site grading best practice requirements in *GBP F7 (Fill and Grading).*

1.1.3 Control of Vapour Diffusion and Condensation

Building enclosure assemblies shall comply with NBC Div. B Section 5.5 "Vapour Diffusion".

Location of the vapour barrier in the warmest portion of the building envelope, on the interior side of the thermal insulation, is recommended best practice for Northern buildings.

For walls and suspended floors, provide only one plane of high water vapour resistance (low water vapour permeance), along with natural ventilation for drying the assembly of incidental condensate or frost, and drain the assembly to the exterior.

For northern roof systems, position the vapour barrier on the warm side of the thermal insulation, preferably in the same plane as the air barrier.

The objective of controlling vapour diffusion and condensation is to eliminate water vapour migration from the warm interior air into the building envelope, and to ensure that any water vapour that does pass through gaps in the vapour barrier is not trapped permanently in the envelope where it can cause deterioration of building materials and/or support mould and fungus growth.

Water vapour that migrates toward the cold outward portions of the building envelope can condense and accumulate in the envelope as frost over the winter months.
The moisture resulting from melted frost must be able to drain away or evaporate during the warm season before the next winter.

Snow and ice covered unventilated low-slope Northern roofs present a special case envelope assembly which is at greater risk when retaining trapped water.

Whether from frost formation, from air leakage into the assembly, or from precipitation ingress, unventilated roofs tend to decay much faster than ventilated roofs because they trap heat from solar radiation as soon as the reflective snow cover is lost, speeding up the rate of decay.

1.1.4 Control of Vapour Diffusion through Concrete Slabs

Concrete slabs on grade shall comply with NBC Div. B Section 5.5 *"Vapour Diffusion".*

Uncontrolled water vapour pressure and moisture diffusion through concrete slabs on ground can best be prevented by effective installation of suitable low permeance materials directly to the underside of concrete slabs on ground.

A continuous low permeance membrane conforming to ASTM E 1745 and having a thickness of not less than 15 mils shall be installed under concrete slabs on grade to stop the transfer of water vapour and moisture.

Failure to prevent moisture wicking up through concrete slabs results in moisture migration through concrete slabs, and can lead to microbial growths (mold and mildew) and failures of adhesives, flooring coverings, coatings and excessive humidity in occupied spaces.

All concrete slab-on-grade floors that will or may receive floor coverings or floor coatings must have a continuous vapor retarder below the slab.

Caution must be exercised if floor covering or coatings are contemplated for existing slabs on grade where it is not known if an effective vapour retarder was installed prior to the installation of the slab.

1.1.5 Air Leakage Rates

The maximum air leakage rate values for air barrier system in opaque insulated portions for Northern building envelopes are:

Although the NBC Div. B Section 5.4 and NBC Div. B Section 9.25 require all buildings to have an effective air barrier system, the maximum leakage criteria provided of 0.02 L/s/m2 in NBC Div. B Sentence 5.4.1.2.(1) applies to buildings in all parts of Canada, including the more temperate regions. The NRC-IRC has suggested these lower air leakage values in NBC Div. B. Appendix Articles A-5.4.1.2.(1) and (2) are applicable to all parts of Canada, as guidance when testing air barrier systems as opaque insulated portions of a building envelope. This amount of air leakage through the opaque insulated portions of the envelope will limit the transfer of water vapour into an envelope assembly to what can be 'managed' on an annual moisture deposition and drying cycle.

.1 0.15 litre/sec/m2 @ 75 Pa for all buildings with a low indoor air relative humidity less than 27%.

This will typically apply to buildings with low to moderate part day occupant loads and few sources of water vapour, or to buildings that have dehumidification systems, typical of warehouses, large volume *stores, low occupant load offices, vehicle storage, airplane hangars and repair facilities, and similar.*

.2 0.1 litre/sec/m2 @ 75 Pa for all buildings with a normal indoor air relative humidity between 27 and 55%.

This will typically apply to buildings with moderate to high part day occupant loads, schools, community halls, health centres, libraries or higher occupant load offices.

.3 0.05 litre/sec/m2 @ 75 Pa for all buildings with a normal indoor air relative humidity greater than 55%.

This will typically apply to multi-family residential occupancies, group homes, student residences or long term care facilities, and to humidified portions of hospitals, indoor pools and spa rooms.

1.1.6 Air & Vapour Barriers - Materials and Assembly

.1 Vapour Barriers

Materials used to form the vapour barrier must be:

.a Durable, mechanically supported, and protected from deterioration. Design to meet or exceed the service life of the building.

Differences in chemical composition, creep behaviour, elasticity, thermal expansion, shrinkage, and moisture changes could result in reduced permeability or durability of the vapour barrier.

.b Impermeable to water vapour and meeting the requirements of NBC and reference standards CAN/CGSB 51.33-M or CAN/CGSB 51.34-M.

Vapour barriers should be tested for continuity, including doors, windows and other closures. Excessive air leakage at any one location is a failure of the entire system.

.c Physically and chemically compatible with other building components.

Materials with low vapour permeance, such as plywood, foamed plastic insulation with vapour impermeable facings, will be barriers to vapour movement. Vapour that is passing through the assembly toward the exterior during the drying phase must be allowed to migrate to the exterior through open joints between sheets or perforations, or moisture will risk becoming trapped between water vapour tight layers.

.d Continuous: Verifiable sealing of joints, corners and penetrations is required for all northern building envelope vapour barrier systems.

Performance verification of Northern building envelopes is recommended to be provided using infrared thermographic surveying for final commissioning with the *building pressurized and with adequate differences between the interior and exterior air temperatures.*

.e Installed by trained personnel, in compliance with manufacturers' instructions, including approved application methods.

Install vapour barriers so as to never create moisture entrapment between layers of impermeable materials.

Any wall material with low vapour permeance that is located on the low vapour pressure (generally cooler) side of the envelope assembly, must be installed in such a way that vapour can drain or dry.

.2 Air Barriers

Materials used to form the air barrier system must be:

.a Durable, mechanically supported, and protected from deterioration. Design to meet or exceed the service life of the building.

The purpose of an air barrier system is to prevent air movement through the building envelope assembly.

.b Eliminate the movement of air through the building envelope.

Differences in chemical composition, creep behaviour, elastic movement, thermal expansion or shrinkage or expansion due to moisture changes could result in the loss of strength, continuity, impermeability or durability of the air leakage barrier.

.c Physically and chemically compatible with other building components.

Testing air barrier continuity ensures that there is an acceptably low uniform level of air leakage when doors, windows and similar closures in the entire envelope are included. Excessive air leakage at any one location is a failure of the entire system.

.d Continuous: Verifiable sealing of joints, corners and penetrations is recommended for all northern building envelope air barrier systems.

.e Installed by trained personnel, in compliance with manufacturers' instructions, including approved application methods.

Materials used to form the air barrier system are recommended to have air permeance test values less than 1/10th of the air leakage rate recommended in *Article GBP 1.1.5 (Air Leakage Rates)*, for the opaque insulated portions of a Northern building air barrier system.

.3 Air and Vapour Barrier Location

.a Provide mechanically supported (fully adhered to a stiff material) coincident air/vapour (AV) barrier membranes on the outside of structural framing or sheathing.

By locating the AV barrier (and thermal insulation) on the exterior of structural assembly, the potential for moisture damage from condensation in the wall assembly is greatly reduced. This also allows for fewer mechanical and electrical penetrations.

.b Performance verification testing of northern building envelopes may be required during the commissioning process.

.c Provide large scale details to show how air barrier continuity will be achieved and how differential movements and construction sequences will be accommodated. Drawings shall include details showing:

- Penetrations;
- Wall/roof connections;
- Changes in plane;
- Joints between dissimilar material, and;
- Building expansion and movement joint locations.

.4 Cold weather application of adhered A/V membranes:

.a Self-adhered sheet material is required to be roller-applied over an appropriate primer and installed at temperatures within the manufacturer's stated limitations

.b Heat fused A/V membranes installed over a non-combustible substrate is considered a good approach when temperatures do not permit the installation of a self-adhered membrane.

.c Pre-manufactured sheathing panels incorporating a factory bonded air vapour barrier should be considered when construction is taking place over the winter months when application of a self-adhered membrane is not possible due to low temperature limitations.

.5 Small wood frame buildings:

Polyethylene sheet and cavity fill insulation may be considered for small wood frame buildings providing measures are taken to ensure the continuity of the air and vapour barriers such as:

.a Minimizing penetrations by providing strapping on the interior of polyethylene vapour barrier.

.b Careful detailing of all air and vapour barrier penetrations.

.6 Sealants:

Sealants used as part of a building envelope assembly must be:

.a Serviceable to -50ºC in their fully cured state.

The performance of sealants is dependent on choosing the correct sealant for the substrate as well as installation of the sealant under manufacturer's recommended temperature and moisture service conditions.

.b Able to be installed under temperature and moisture conditions that may be encountered

Construction often occurs in cold temperatures in the NWT. Silicone and elastomeric sealants are available that can during their installation.

be applied at sub-zero temperatures and remain serviceable at temperatures down to -50ºC. Many other sealants cannot be properly applied at sub-zero temperatures and lose their ability to fulfill functional requirements at cold temperatures.

.c Strong enough to resist the anticipated loads without deforming or moving out of position.

See also Canadian Building Digest #155 – "Joint Movement and Sealant Selection".

.d Elastic and compressible to accommodate movement of the joint.

Silicone based or one component elastomeric sealant types that meet the performance criteria are recommended. Acrylic and solvent curing types (example Butyl caulking) have been found to perform less effectively in the Northern environment.

.e Chemically compatible with adjacent materials.

Multi-component products are recommended for specialized applications, such as curtain walls and exterior panel or pan systems.

.f Accessible for service or replacement.

.g Placed in primed joints of proper dimensions and proportions with backing rod or bond breakers to prevent unintended adhesion to adjacent surfaces.

1.1.7 Roof – Assembly and Materials

.1 Air/Vapour Barriers should be:

- Protected from mechanical damage;
- **Fully supported and adhered;**
- Located on the plane of exterior face of structural elements.

Fully adhered AV barrier membranes have proven to be the most durable and reliable in use. Condensation and moisture build-up within roofs can cause deterioration of the assembly. Locating the structural roof on the warm side of the AV barrier is a reliable means of preventing condensation within the assembly

AV barrier may be located on the interior of roof framing only on small naturally ventilated roofs, where not affected by high winds / wind-driven snow.

Cold naturally vented attics are not recommended for buildings where residential occupancies generating high interior air humidity are the primary use. Great care must be taken to ensure continuity of AV barriers, and a means of naturally ventilating the roof assembly, that will prevent snow infiltration through the vents into fibrous mineral insulation.

1.2 THERMAL RESISTANCE AND INSULATION

Design building envelopes to meet or exceed the energy performance requirements as outlined in the National Building Code and the National Energy Code for Buildings.

Performance verification of northern building envelopes is recommended to be provided using infrared thermographic surveying for final commissioning with the building pressurized and with adequate differences between the interior and exterior air temperatures.

The thermal resistance of the building envelope serves two important functions: to minimize heat loss through the envelope and thereby reduce building energy consumption, and to prevent moisture condensation on surfaces interior to the building envelope.

1.2.1 Recommended Thermal Resistance Values

For northern buildings intended for human occupancy, and designed without an energy modeling study, the minimum effective RSI value of opaque building envelope assemblies is to be:

- Suspended floors: RSI 7.0
- Floors above thermosyphon grids or thaw susceptible soils: custom design value
- Floors on grade on non-thaw susceptible soils: RSI 3.5 or custom design value
- Walls: RSI 5.6
- Roofs: RSI 8.75

An acceptable overall level of thermal resistance is to be achieved regardless of the type and placement of the insulation in the assembly. The recommended minimum overall thermal resistance values provided are benchmark values to be used in the absence of an energy modeling study.

For unheated or minimally heated buildings, such as ice arenas and parking garages, thermal resistance may not be a functional requirement of the building envelope. Seasonal use buildings may have reduced overall thermal resistance values specifically designed for the period of the year they are to be occupied.

Buildings or portions of buildings not intended to meet typical human comfort conditions may have lower envelope thermal resistance values and still meet energy consumption standards.

1.2.2 Thermal Insulation Location in the Envelope

Design the thermal insulation system to be mechanically secured on the cold side of the coincident AV barrier system.

.1 Where the coincident AV barrier system is located on the exterior side of the structural framing, rigid insulation or semi-rigid mineral fibre thermal insulation is to be used. Mineral fibre thermal insulation shall conform to CAN/ULC-S702-97.

Provide fire stopping in insulated cavities in conformance with the NBC.

Insulation applied to the exterior of the building structure provides a uniform insulating value over the entire building envelope. Compressible mineral fibre insulation can also be used, provided it is protected, drained and vented to keep it dry as required by NBC 5.3.1.3.

The overall thermal resistance of the assembly is reduced by the structural members. Heat loss by thermal bridging through structural members is recommended to be minimized by using insulating sheathing on their exterior. Thermal resistance varies at the junctions of floor and wall, and wall and roof; it is difficult to avoid thermal bridging by framing members at these locations. Insulating sheathing is a practical method for increasing thermal resistance at such locations.

.2 Where the coincident A/V barrier is permitted to be located on the interior side of structural framing, compressible fibrous thermal insulation may be used in the structural framing space, provided the requirements of NBC 5.3.1.3 are met.

1.2.3 Continuity of Thermal Insulation

Thermal bridging by structural members shall be recognized and minimized in the building envelope design.

Where insulation is installed outside the structural framing, it should be installed in two layers at right angles. The insulation may be secured with two layers of girts or strapping installed at right angles, or with one outer layer of girts screw-fastened through the lower layer of insulation into structural framing.

The intent is to reduce thermal bridging through girts or strapping.

Purpose-made fiberglass clip systems are acceptable.

Fiberglass clip systems further reduce thermal bridging, and are preferred over metal girt systems.

Where insulation is permitted to be installed within structural framing, a layer of insulating sheathing should be provided on the exterior of the framing or the exterior structural sheathing.

The intent is to reduce thermal bridging through structural members. This is already common practice in northern buildings.

1.2.4 Preventing Localized Cold Spots

Design concealed service spaces and voids in envelope assemblies are supplied with heat and to the interior warm zone of the building to avoid moisture condensation and frost formation within such spaces.

Cold spots, with surface temperatures falling below the dew point, can occur in concealed spaces, despite good thermal insulation, unless a heat source for the compartment is provided.

Design placement of interior furniture and fittings on exterior walls to allow interior air movement, preventing localized cold spots.

Ensure convection air from radiation is free to move up walls and beneath windows to avoid localized cold spots.

1.2.5 Thermal Break

Provide a thermal break between highly conductive interior and exterior structural elements such as steel piles.

Thermal breaks serve to minimize heat loss from the building.

Conducting heat from the heated portions of the floor assembly into thaw susceptible soils could potentially reduce the bearing capacity of structural members supported in thaw-susceptible warm permafrost soils and affect the long term durability and stability of the building substructure.

Reducing thermal bridging using thermal breaks prevents interior cold spots and excessive heat loss.

1.2.6 Fire Resistance

Non-combustible insulation should be used where practicable

Many communities in the NWT have limited fire fighting capabilities. Local fire departments may not have experience in controlling fires in large buildings. Reducing fire loading in structures by using non-combustible materials where practicable can aid in reducing the magnitude of a fire and the possibility of a total loss when a building fire does occurs.

1.3 FLOOR ASSEMBLIES

Often Northern buildings are elevated above the ground surface to eliminate heat flow into thaw susceptible soils. Elevated floors are subject to additional heat loss, air leakage, snow infiltration and water vapour diffusion, not normally found in floors constructed on the ground or above crawl spaces.

.1 Thermal Conductivity:

Where possible, provide thermal insulation located entirely on the underside of the floor structure. When thermal insulation is permitted to be located within the structural framing of an elevated floor, an air space on the warm side of the insulation is an effective means of reducing thermal conductivity. Where cavity fill insulation is used in a floor

An air space will reduce thermal bridging through the floor structural components. A false floor provides benefit for residential and institutional occupancies such as residential care facilities, schools and day care facilities, halls, auditoriums and gymnasiums, and similar buildings where assembly, a continuous layer of semi-rigid or rigid insulation shall be installed on the underside of the floor assembly prior to installing the floor system soffit material.

occupant comfort at floor level is a consideration.

.2 Drainage and Ventilation:

Drains and water supply pipes should not be situated within an elevated floor assembly (just as they should not be installed within the cold portion of exterior walls in Northern buildings) unless the thermal insulation and air barrier are on the cold side of the framing, or they can be installed within an accessible Suspended Utility Service Space.

.3 Finishes:

Exterior soffit materials for elevated floor assemblies shall be:

- Durable;
- Light weight;
- Easily installed;
- Easily removable and replaceable for maintenance access to contained services with locally available trade skills;

*The joints of some water vapour impermeable exterior soffit finish materials should **not** be sealed in an effort to create an external air barrier. The glue layers in a plywood soffit for instance resist water vapour migration and create a cold side vapour barrier if the joints are sealed. A second vapour barrier in the floor system will trap moisture within the assembly.*

The underside of a suspended floor is not generally in contact with water, snow or soil, nor is it generally visible. Batten strips covering soffit material joints prevent snow, dust and insect entry, but should be positioned to allow enough air movement to effectively ventilate an elevated floor.

Where plywood sheathing is permitted as a soffit material, it shall be pressure-treated against decay.

1.4 WALL ASSEMBLIES

When designing and constructing wall envelopes, care must be taken to make the air and vapour barrier systems in building envelope walls continuous at all openings and penetrations, and at joints with floors and roofs. As much as possible, insulation systems shall be continuous at all structural elements to prevent thermal bridging and excessive heat loss and cold spots.

1.4.1 Rainscreen Cladding and PERSIST Techniques

Exterior wall systems should be designed and constructed using the PERSIST system.

Cladding systems should be designed in accordance with the 'rainscreen cladding technique' (pressure equalization practice) providing natural air ventilation and air drying of the exterior cladding material. Provide a self-draining naturally ventilated air compartment between the exterior cladding and the sheathing or insulation of the wall. Divide all self-draining naturally ventilated air compartments behind the exterior cladding into pressure equalization compartmented voids no more than one storey in height, and no more than 6 m wide along building faces. At corners, compartments should be no more than 2.4 m wide, with compartments closed at corners.

The wall insulation is recommended to be protected with a water vapour permeable weather barrier (spun-bonded olefin), to help limit incidental wetting of the insulation or wall sheathing.

Continuous thermal insulation should be installed completely on the cold (exterior) side of the building structure and the mechanically supported coincident air/vapour barrier.

PERSIST stands for Pressure Equalized Rain Screen Insulated Structure. With this system, air/vapour, thermal and environmental barriers are installed on the exterior of the building structure. The advantages of this system includes; protection of building structural components, application of a continuous structural air/vapour barrier reducing air leakage, greater thermal resistance values, and installation of a Rain Screen system which allows for drying of the wall assembly.

http://www.infrastructure.alberta.ca/Content/docType486/Production/DTSeries01PERSIST2016.pdf

A vented pressure equalized rainscreen cladding system reduces the pressure differences between the exterior environment and the wall system preventing moisture from being drawn into the wall assembly and allows for drying of the assembly during the summer drying season.

1.4.2 Exterior Wall Cladding

Good Building Practice for Northern Facilities does not specify where particular materials are to be used. Materials selected by the designer are expected to conform to the best practice recommendations noted in the various articles in this document. Considerations include: aesthetics, maintenance, durability, warranty, ease of repair and availability of materials in remote Northern communities.

.1 Exterior Wall Cladding – General

Exterior wall cladding shall conform to NBC 5.6 *"Precipitation"* and relevant GBP Subsections herein.

Air pressure equalization compartments for rainscreen wall design can be created by using strapping applied to support the exterior cladding. Strapping to be designed to allow for drainage.

Exterior wall cladding systems shall:
Have patterns, fasteners and edge joints designed for ease of maintenance;
Be accessible for replacement in locations exposed to potential damage;

Recurring damage can be caused to the cladding on the lower portion of exterior walls of buildings accessible to the public, and where service vehicles or snow clearing or other mechanical equipment is used near the building wall.

Encourage rapid drainage of melt water;
Allow wind-driven rain to drain rapidly from the surface;
Have the ability to dry naturally.

Vertical installation of fluted, board or grooved materials promotes faster drying and reduces weather deterioration of materials.

.2 Metal Exterior Wall Cladding

Metal wall siding panels should be factory preformed steel sheet, minimum 0.6 mm (24 gauge) base metal thickness, zinc coated, and factory prefinished on the weathering face. Thicker gauge may be required in locations susceptible to vandalism and impact.

Metal cladding is widely used on northern buildings.

Deep rib profile siding should be installed with the flutes vertical to facilitate snow and ice drainage and minimize vandalism access to upper portions of walls.

Consider physical protection to metal cladding at areas most susceptible to damage, such as entrance ways.

Penetrations through corrugated metal cladding for mechanical and electrical equipment should be detailed with either a site fabricated or prefabricated color matching metal pan with a hemmed finish

Surface mounted finish matching or corrosion resistant mounting plates may be used for the attachment of equipment and fixtures.

edge trim designed to accept metal cladding and prevent moisture intrusion. Avoid using large amounts of sealant to detail penetrations as much as possible.

Aluminum siding is not recommended for northern buildings.

Aluminum is typically vulnerable to impact damage, and subject to large thermal expansion and contraction. Temperatures in NWT experience large fluctuations, causing rippling and "oil-canning" to occur more readily.

.3 Insulated Metal Panels

Insulated metal panels (IMPs) may be considered for pre-engineered industrial buildings. Extreme temperature differentials can cause expansion and contraction of the panels and can cause failure of the joints between panels..

It is recommended that joints between IMPs be sealed on the interior by installing a self-adhered membrane over the panel joints in order to maintain the air/vapour barrier. Self-adhered membrane should be protected from mechanical damage by the installation of a sheet metal strip over the membrane

.4 Wood Exterior Wall Cladding

Wood cladding may be acceptable where weather conditions and maintenance resources support its use. Lap joint, channel or drop joint siding is recommended. Board and batten or tongue and groove jointed siding is acceptable, but these board styles should be installed vertically to speed water drainage and promote rapid drying.

Wood is readily available, relatively inexpensive, and can be installed with basic carpentry skills and tools available in most communities, but requires periodic refinishing to offset weathering.

Horizontally installed boards retain melt water and rain, wetting the wood for longer duration. Research has found shorter service life and splitting, warping and staining results when wood cladding stays wet for long periods.

Spruce or cedar siding is acceptable, and siding may be air-dried or kiln-dried.

A semi-transparent oil-based stain finish is recommended for ease of routine maintenance, and solid colour acrylic-latex stains are acceptable, provided they are water vapour permeable. Non-vapour permeable paint finishes for exterior wood should be limited to fascia and trim, which should be back-primed to minimize vapour migration and paint blistering.

Although wood siding requires regular maintenance, semi-transparent stain is easily applied and a variety of colours and lustres can be used. Non-vapour permeable paint seals wood and does not allow moisture from the concealed side of the rainscreen to migrate freely outward. As a result, non-breathing paint can peel prematurely.

Metal and cement composite cladding

Wood siding should not be used on buildings with insufficient maintenance resources or increased vandalism or fire risk, and not on south and west elevations with intense sunlight exposure.

products are preferable for such conditions.

.5 Vinyl Exterior Wall Cladding

Vinyl exterior cladding is not recommended, based on the material's intolerance for temperature extremes and high fuel contribution to a structural fire.

Expansion and contraction in hot and cold temperatures causes warping and splitting at the fastening points. Vinyl also becomes very brittle in cold temperatures making it susceptible to impact damage easily. Vinyl is combustible and will add intensity to a building fire and will produce toxic fumes when burned.

.6 Stucco Exterior Wall Cladding

Stucco exterior cladding is not recommended for use on northern buildings, as it is not flexible enough to accommodate typical stresses on exterior walls caused by foundation system movement. Stucco use should be limited to building walls above the zone of potential impact damage (above 1.2 m elevation), and when the building foundation is very stiff and not expected to move from temperature and moisture changes in the soil conditions.

Moderate to large impacts from vehicles can damage stucco. Matching colour and texture materials are generally unavailable or difficult to obtain for simple repairs, forcing costly larger areas of required wall replacement.

.7 Cement Board Exterior Wall Cladding

Cement board exterior cladding siding or panels are acceptable for building exteriors which are susceptible to increased weather deterioration, minor abrasion and impact damage, and where non-combustibility for increased fire safety is important.

Cement based cladding resists deterioration from wetting and drying, resists minor abrasion damage, and is non-combustible (important where firefighting resources are variable or remote from the building location), and does not expand and contract very much with temperature and humidity changes.

Extreme care must be taken to follow manufacturer's installation instructions, to prevent damage and voiding warranty.

Panels are subject to cracking when not installed correctly.

Several manufacturers will not warranty their product in the NWT.

Cement board cladding on building walls subject to occasional strong impact loads (from snow clearing or vandalism) are recommended to be installed at an elevation above the impact zone, generally above the 1.2 metre elevation, or to be fully backed with 15.9 mm thick plywood or 19 mm thick oriented strand board (OSB).

Impact resistance of some types of cement based cladding is less than that of wood cladding, requiring location on the wall, use of backing boards, and attachment methods to be carefully selected.

.8 Exterior Insulation Finish Systems (EIFS) Exterior Wall Cladding

EIFS systems are not recommended in the north.

Exterior Insulation and Finish Systems (EIFS) are multilayered exterior wall cladding systems incorporating rigid foamed plastic combustible thermal insulation. They have the potential for superior energy efficiency because they reduce thermal bridging, offer much greater design flexibility than many other cladding products, but detailing mistakes have led to common moisture problems.

Because EIFS is a water-barrier system, if water does get in, it can't easily get out as there is no way for water to drain from the assembly. Water intrusion occur anywhere the siding is penetrated, windows, doors and flashings. If water gets behind the synthetic stucco, it will damage the sheathing, and in some cases the framing.

1.5 ROOF ASSEMBLIES

When designing and constructing roof systems, care must be taken to ensure adequate roof water drainage, continuity of AV barrier systems and sufficient thermal insulation for extreme temperature differentials. Refer to NBC Division B, Appendix C "*Climatic and Seismic Information for Building Design in Canada*" for climactic data affecting precipitation and snow loading data for specific locations. Refer also to CAN/CSA S502 *Managing Changing Snow Load Risk for Buildings in Canada's North.*

1.5.1 Roof – Assembly and Materials

.1 Modified Bitumen Membrane (MBM):

Two-ply fully adhered (torch applied or cold-process base sheet) MBM roof systems are recommended best practice for Northern buildings. Mechanically anchored base sheet systems are acceptable when a fully bonded air/vapour barrier is installed on the warm side of the roof insulation.

Torch applied membrane is not permitted to be directly applied to a combustible roof deck.

Two-ply, fully adhered hot-process MBM membranes can be installed with good bonding in temperatures as low as - 5 Deg. C., and have performed well to date. Repairs are relatively simple perform.

.2 Metal Roofing:

Machine sealed double folded standing seam metal roofing with expansion and contraction strain relieving anchors is recommended best practice for low slope installation. Minimum 24 gauge is required, unless otherwise specified.

Use ARCA standard Architectural Standing Seam Metal Roofing Details for roof penetrations

https://www.arcaonline.ca/manual/part-4-metal-roofing

Snow and ice retention guards are required on metal roofs, at bottom of all roof slopes.

This type of roofing has performed well on Northern building.

.3 Ventilated Attics:

Where a ventilated attic is permitted, provide adequate ventilation in conformance with the NBC .

Do not use ventilation turbines on cold ventilated attic spaces.

Ventilation turbines result in:

- *Potential for depressurization of the attic air shed;*
- *Increased heat loss out of the building.*
- *Snow infiltration into the attic space.*

.4 Shingles:

Heavy weight wind-resistant asphalt shingles are may be permitted for use in areas not subject to high winds, where the roof slope is 4 in 12 or greater, or 2.5 in 12 where low slope application shingles are used. Wood shingles are not permitted.

Shingles can be blown off steep slope roofs in areas subject to high winds. Asphalt shingles are readily available and present a lower fire hazard than wood shingles, which deteriorate in low humidity environments and with long solar exposure.

.5 EPDM or Rubber Roofing:

EPDM or other single ply loose laid membranes are not recommended for use on northern buildings.

Loose-laid membranes will allow water to migrate laterally beneath the membrane, making it difficult to trace leaks.

1.5.2 Low Slope Roofs

Design low-slope roofs with a minimum drainage slope of 4% (1:25) leading to internal drains positioned at the low points of the roof. Drain water to:
continuous high performance gutters (eaves troughs) at the eaves and drain channels, or
down pipes, or
a free-fall drip edge on buildings where the cladding is selected to resist water and dust staining.

Without a dedicated slope ensuring adequate water drainage, water retention and early water-shedding membrane deterioration occurs when ponding retains dust, and organic acids form along with moulds and occasionally moss in the more humid areas, and ice expansion and contraction causes surface deterioration of granule protected membranes.

Recommended best practice for continuous water-shedding membranes for northern low slope roofs is a bonded elastomeric membrane such as (Styrene Butadiene Styrene) SBS-Modified Bituminous Membrane or a low-slope standing seam metal roof membrane.

Low slope roofs retain accumulated snow and ice. Low slope roof membrane selection influences snow retention characteristics and total snow accumulation and structural loading over the Northern winter, and influences ice-slab formation, migration and injury risk exposure beneath roofs without installed snow and ice guard protection.

1.5.3 Stepped Roofs and Rooftop Penthouses

Avoid stepped roofs with adjacent different height levels of the water-shedding membrane. If two different roof levels are required, they should be connected by a continuous sloping transition section.

Stepped roofs accumulate extensive snow drifting causing unbalanced structural loading and potential overloading, increasing the risk of structural collapse or deformation of the roof structural components. Snow accumulated in crevices and between stepped sections of a roof traps building heat and infra-red heating from the sun, causing a wet film of melted snow to be held against joints, flashings and penetrations in the roof water-shedding membrane under the snow, and on vertical wall segments between the stepped sections of the roof. Ice-lensing and bursting of roof membranes at joints and flashings can result, causing early deterioration of the roof.

Design roof and roof mounted equipment so as to minimize the amount of snow build up on low slope roofs.

Obstructions on flat roofs such as mechanical penthouses can create areas for snow to build up, increasing the snow loading of the roof.

1.5.4 Roof Eaves and Canopies

.1 Eave Projections

Eaves and canopy projections beyond the line of the AV barrier must not weaken the air tightness of the building envelope. Where the AV barrier is located outside of the structural framing, eaves and canopies should be supported by structural members which do not pass through the AV barrier.

Eaves provide an effective way to divert rain and meltwater away from low building walls, windows, doors and the building perimeter at grade. Careful design is necessary to make sure the AV barrier is continuous from wall to roof. Continuity of the AV barrier may be compromised if the structure is extended through the building envelope to provide eaves projections, rather than attached to the exterior face of the AV barrier.

Minimal eaves projections ranging from 100 to 200 mm are preferred in colder and drier regions of the NWT. Larger eaves projecting 300 to 600 mm are necessary in wetter regions and in specific communities where the rainy season concentrates annual rainfall into a short period of the year, and wind driven rain increases the rate of periodic wetting of building walls.

Minimal eaves projections are considered adequate in colder drier regions, where structural wind loads on eaves need to be minimized, and rain and meltwater runoff is less severe than in wetter regions below the tree line. Cold eaves are a location for ice-damming when the roof snow pack melts, creating falling ice injury risk and trapped meltwater seepage into non-continuous water-shedding membranes.

.2 Eavestroughs and Downspouts

Eavestroughs shall be designed to:

- accommodate local weather conditions,
- contain roof water runoff and direct it to suitable locations away from the building walls and grade perimeter,
- prevent ice damming, and withstand ice and snow structural loading.
- 24 Gauge Eavestroughs and Downspouts

Ice build-up renders traditional light sheet metal eaves troughs positioned at the eaves top line ineffective, as well as easily damaged during spring melt. Stronger steel eaves troughs with a designed spillway rim well below the eaves line will prevent ice damming and ice buildup at the eaves edge.

.3 Fascia to be metal, 24 gauge minimum.

.4 Eaves or canopies are to be provided on all new and renovated buildings and designed to divert snow, ice and water originating on roofs away from exterior doors.

Lack of weather protection above doors creates a potentially unsafe condition from falling ice and snow.

.5 Low parapet upstands at roof edges in place of eaves are acceptable for internally drained low slope roofs. Avoid parapets on perimeter drained roofs, as well as through-parapet scuppers.

Parapet height should be limited to what is needed for preventing snow, ice and water from being blown off an internally drained roof. Parapets on perimeter drained roofs, using scuppers or through parapet leaders for draining roof water perform inadequately during thawing and re-freezing cycles due to ice damming and backup of drainage water on roof surfaces.

1.5.5 Roof Access and Fall Protection

Where roof foot traffic is anticipated, the surface material at walkways and access routes should be slip-resistant and wall marked.

Access to the roof will be required for inspection, cleaning and maintenance of roof equipment and the roof itself. Providing wear-resistant, slip-resistant and clearly identified walking routes, helps direct routine foot traffic access and egress safely on and off the roof under varying weather conditions.

All weather roof access hatches are recommended to be installed for routine access to all low slop roofs, to allow all-season safe access for maintenance personnel, equipment, tools and materials.

Fall arrest anchor points need to be available for securing fall restraint safety equipment used by personnel accessing the roof. Fall arrest anchor locations and design must be acceptable to the authority having jurisdiction.

Skylights installed in potentially snow covered roof areas should be defined by visually apparent permanent physical markers that extend above the anticipated accumulated snow depth.

Even smaller building roofs require safe and convenient access for maintenance personnel, in order to encourage regular preventive maintenance work to be carried out in timely fashion, and maintenance needs identified well in advance of deterioration of equipment and installed materials.

All Northern roofs must incorporate fall prevention systems, meeting the requirements of the Workers Safety and Compensation Commission (WSCC), The NWT Safety Act, and CSA Z259 series.

Identification of skylights that may be snow covered will reduce the risk of impact damage or someone accidentally falling through the skylight.

Install fall prevention anchors in a manner that provides for continuity of the drainage plane, and occasional repair or replacement of the water-shedding membrane.

1.5.6 Clerestory Windows

Clerestory windows are preferred alternatives to skylights. Design should:

- Prevent snow accumulation;
- Resist driven rain intrusion in the flashing and roofing details;

Weathering effects from driven rain and snow drift accumulation are magnified *around projections extending above the roof.*

- Have a minimum sill height of 200 mm;

Driven rain at clerestory window heads, and drifted snow at the sill, need to be accommodated in the flashing and roofing details to resist wind effects on enclosures above the general roof plane, where clerestory glazing is installed.

- Have eaves extensions to divert driven rain away from the window head;
- Have glazing positioned in the same plane as the A/V Barrier to minimize heat loss and condensation on the interior frame and glass surfaces;

Clerestory windows are positioned in the warmest upper portion of the building interior air shed and encounter the largest thermal stress gradient between interior and exterior environments. Placing the glazing in the same plane as the A/V barrier decreases the thermal gradient across the window, reducing expansion and contraction of the glass and frame, extending glazing seals and service life.

- Incorporate condensate capture trays in the frame or air system diffusers positioned to direct ventilation air to the glass surfaces.

Operable clerestory sash is not advised, fixed glazing is recommended. Building ventilation from clerestory vaults is better achieved using operable ventilation louvres.

Operable sash maintenance is problematic and expensive for clerestory window. Also, the air and weather seals between operable sash and frames allow more air transfer and energy loss than with fixed glazing.

1.5.7 Roof Skylights

Roof skylights and light tubes are not preferred.

Past experience with skylights in the NWT has been mixed. Skylights (including translucent structural panels) have provided a number of facilities with light in areas where windows were not possible.

If skylights are permitted, exceptional care must be taken to selecting glazing type, frame materials, condensation and heat loss control features, and positioning the skylight above the main drainage plane for positive water drainage and to avoid snow

The quality of overhead natural lighting from skylights is comparable to lighting from windows, but the northern and cold climate performance limitations experienced with skylights cannot be ignored. Condensation has caused damage and ice accumulation and related water-film deterioration of the skylight and its flashed seals.

to interior furnishings and adjacent wall and ceiling surfaces. Occupant discomfort complaints include overheating and glare. Extensive roof damage has occurred as a result of poorly sealed skylight units.

Details must be provided verifying the above considerations.

Effective skylights should incorporate:
Thermal resistance matching the windows;
A steeply glazed surface slope for drainage (i.e. 3:12 to 6:12) or a continuous framed self-draining one-piece moulded plastic unit;
Placement of the skylight units on raised upstands above the roof plane a minimum of 400mm to allow for drainage, expansion and contraction control, and flashing of joints;

A maintenance review of skylights proposed for locations where vandalism or forced entry is a known problem is recommended, in order to also provide increased building security at such locations.

Adequate air circulation across the interior of the skylight to minimized condensation, and ample interior condensation gutters must be provided;

Air circulation minimizes condensation by warming the interior glazed surfaces and gutters or trays can be positioned to accumulate condensation and allow it to re-evaporate.

Thermally broken or thermally resistive framing members that are detailed with a secondary drainage plane leading to the exterior to meet the environmental separation requirements of NBC Div B Part 5;

Accumulation of water cannot be totally eliminated on sloped surfaces intersected with framing members. Joints exposed to standing water will eventually leak. Secondary drainage allows the water that passes through the primary weather seal to drain to the exterior.

Blinds or have a tinted shading factor for reducing overly strong sunlight. The blinds must be easily operable by facility users.

Glare and overheating during long solar days can be reduced by blinds or reduced infrared spectrum light.

1.6 BASEMENTS AND CRAWLSPACES

Basements and buried strip and pad footings are possible in many locations where the foundation system can be supported deeply enough below the active layer, or where the ground is unaffected by the freeze thaw cycle. Such foundation systems require careful design to minimize heat transfer and ground vapour and water intrusion.

.1 Unheated crawlspaces:

Open crawl spaces below buildings on thaw-susceptible soils shall be securely enclosed with a material that is:

- Durable;
- Allows for air movement under the building;
- Secure;
- Accessible for maintenance.

This is typically achieved using minimum 14 gauge welded wire mesh and equipped with lockable gates to allow for access.

The objective is to prevent unauthorized and unsafe uses of the open crawl space under the building.

.2 Heated or semi-heated enclosed crawlspaces:

Provide protection from ground moisture in enclosed crawlspaces, using a ground sheet.

Protection from moisture in the ground is identified in NBC Section 5.8.

Comply with NBC 2015 Div. B Sections 5.3, 5.4 and 5.5. for separation requirements between the crawlspace and the interior conditioned space.

The different crawl space environment can result in air/vapour leakage, unwanted heat transfer, or condensation and mould infestation.

.3 Crawl space drainage:

An open crawl space is to be graded at a minimum slope of 4%, drained to sump points, or away from the building.

An enclosed crawl space is to be graded at a minimum slope of 4%, drained to a

Ensure that surface and ground water does not accumulate in crawl spaces. Standing water in crawl spaces can lead to high humidity levels in the building causing unhealthy interiors and premature deterioration of building enclosure assemblies. The objective is to dispose of any runoff away from an open crawl space, and sump pit or sewer drain which must not break the continuity of the ground moisture barrier (ground sheet).

to collect and remove and dispose of ground water that may be present in an enclosed crawl space.

Comply with NBC 2015 5.7. Surface and Ground Water.

.4 Utilidettes:

Where pipes and ducts are incorporated into a suspended floor system above an open crawl space, provide a suspended utility space (utilidette) to enclose them within the environmental separation provided by the building envelope.

Utilidettes shall be constructed to allow maintenance staff ease of access.

Using utilidettes to enclose grouped pipes and ducts in a floor system elevated above an open crawl space can eliminate the need for an expensive continuous suspended utility space.

.5 Service spaces/trenches below building:

Where maintenance staff are required to access mechanical and electrical service equipment, service spaces will be a minimum of 1.5 m tall and 1.0 m wide.

Sufficient space is required to allow maintenance personnel ease of access to conduct maintenance tasks on equipment and services installed in basements, crawl spaces and service trenches.

H2 DOORS, WINDOWS and GLAZING

Care should be taken to select doors and windows that will meet the extreme cold weather performance requirements of the north. Although door and window performance standards have improved considerably with the development of precise test standards, doors and windows are often manufactured to meet performance requirements found in less severe cold weather conditions than are found throughout the NWT.

2.1 EXTERIOR DOORS AND FRAMES

All exterior doors require weather protection at the head with extended eaves or canopies to deflect falling snow, ice and water, as recommended in article GBP A3.6.7. In buildings where vandalism and forced entry are known problems, exterior doors should not be located in exterior walls which are recessed into the building, but rather in areas of high visibility. Exterior doors are recommended to be equipped with closers.

Minimize heat loss at exterior doors due to air leakage caused by:

- weather seal failure, due to extreme cold;
- loose fitting doors;
- insufficient hardware adjustment;
- poor alignment (high volume use, structural movement);
- door panel shrinkage / warping.

2.1.1 Exterior Doors

All exterior doors are to:

- be insulated
- have thermally broken jambs/thresholds
- 18 Ga. steel construction, (16 Ga. in areas of known high traffic or forced entry),
- minimum RSI 1.3 and
- conform to North American Fenestration Standard (NAFS).

Solid core or hollow wood doors cannot achieve an adequate level of insulation, warp easily in extreme dry cold, and are less durable than suitably strong metal doors.

Vestibules are to be used at busy main building public entrances, to separate the inner and outer entrance doors, where interior humidity may otherwise result in frost buildup on doors and frames, to minimize cold drafts, and to minimize energy use. In high traffic areas, vestibule should include walk-off mats to reduce

Vestibules save costly energy and increase building comfort in winter by reducing warm air loss and stopping drafts. Vestibules between outer and inner door sets are more practical and more durable than storm doors. Storm doors are available only with a light duty rating for residential application. They wear out quickly from the pollutants and contamination of interior spaces.

heavy use encountered in public buildings, and are easily damaged.

Storm doors, common in residential buildings to reduce air leakage around doors shall not be used, unless approved.

Where physical door security is a concern:

- Minimize glazing
- No hardware on the exterior of the door, unless it is a primary entrance to the facility

Some types of buildings require stronger security provisions, which can be determined in consultation with the client.

Landings are to be 38mm lower than the threshold if an exit door is required to swing outwards, or the outward swinging door recessed from the wall plane for weather protection, with increased lighting provided for surveillance.

In areas of high snow drift potential, exterior doors should not swing outward over landings where they may be blocked by ice and snow. Local knowledge or snow drift analysis should inform orientation of entries.

Glazed/Aluminum entry door systems may be appropriate in some applications. These doors must meet the requirements of the North American Fenestration Standard (NAFS).

2.1.2 Overhead Doors

All overhead doors should be metal with replaceable panels. Manufacturers' standard metal gauge doors are adequate, unless there is a particular danger of impact damage. Where that is the case, use minimum 16 gauge metal.

Damaged panels can be easily replaced in sections rather than having to replace the whole door. Heavier gauge metal overhead doors may be special order items needing longer order time, but the increased durability reduces life cycle cost.

Overhead doors in insulated walls shall have a thermal resistance of minimum RSI 2.8.

Insulated doors provide the best value in insulated walls. Thermal resistance ratings of RSI 1.8 are common in plastic foam, insulated metal pan overhead doors.

Large dimension, flexible, angled weather seals designed for extreme exposure are to be installed at the exterior head and jambs. Threshold seals shall be of a material that will not freeze to the floor.

Weather strip designed for extreme exposure is most effective and is more durable.

Slopes shall be provided at the exterior of thresholds to ensure water and ice does not accumulate.

2.1.3 Exterior Door Frames

All exterior doors frames are to be:

- Minimum 16 gauge steel (strengthened with added reinforcement for heavy duty or known vandalism locations),
- pressed metal thermally broken welded construction frames
- Knock-down frames are not acceptable.

Door frame failure arising from wear and tear and from forced entry has been an ongoing problem in schools and arenas. Added frame strength is provided by mitered, reinforced and welded corners. Additional structural reinforcement connecting the door frame to the wall system is recommended.

In heavy duty high traffic locations, or in facilities that are subject to forced entry or vandalism, provide structural reinforcement (such as inclusion of a 12 Ga. stiffener bar welded inside the exterior side frame stiles) by the manufacturer.

The thermal break, required for energy conservation and frost prevention weakens the frame where strength is required to support connections for hinges and latching hardware.

Wood frames may be used where security will not be compromised.

Thermally insulated wood frames are suitable for light duty locations where forced entry is not a problem.

Removable mullions shall not be used with double doors, unless three point latching is provided for each door leaf, to secure each leaf to the frame head and the threshold plate.

A removable mullion (positioned in the centre between the two leaves of the door) can be forced to one side from the exterior, and allow easy forced entry if the only latching point is on the astragal bar. This weak security point can result in exit door chaining, which is a serious safety violation. The best way to correct this security weak point is to install fixed mullion frames or use three point latching.

Seal the air barrier to the door frame for energy conservation and to minimize corrosion from moisture.

Air leakage out around door frames is a common cause of energy loss. Warm interior air can condense at loose air barrier joints, and the resulting water causes corrosion of *fastenings and rotting of wood members in the wall. See GBP Article A3.1.3.*

2.1.4 Sealants

See *GBP Article A3.1.7.4.*

2.1.5 Sidelights

Sidelight frames shall be independent of door frames.

The intent is to permit replacement of door frames without replacement of the sidelights. The smaller independent frames are also easier to transport and handle on the site.

2.1.6 Vestibules

Vestibules are to be provided at all main entrances or high traffic entrances.

Vestibules help keep warm interior air inside the building, conserving fuel energy.

Vestibules and hallways in high usage buildings such as schools are to have plywood installed behind the gypsum wallboard on the lower wall to minimize impact damage.

High traffic area such as school vestibules, halls and gym change rooms are prone to rough usage. Installing plywood behind the gypsum wallboard will provide support for the gypsum wallboard thus reducing the amount of impact damage to the wall.

Laminated glazing is preferred for the exterior pane of glazing in doors and all sidelights at building entrances.

See NBC Div B A9.6.1.3. Typically used for schools, community halls, health centres, court facilities, libraries, airport terminals, and other public access buildings. Laminated glass breaks easier than tempered glass, but stays in the opening when broken. Laminated replacement panes can be cut from stock sheet to suite the opening sizes. Tempered glass may also be considered; however, it is less secure and replacement panes must be cut at the factory, resulting in either a large stock of replacements or long delivery times.

2.2 INTERIOR DOORS AND FRAMES

Interior doors and frames are subject to extreme fluctuations of air humidity within Northern buildings from winter to summer. Doors must be manufactured for particular resistance to warping out of plane, and for veneer delimitation resistance. Recommended manufacturing industry standards are contained in the Architectural Woodwork Manufacturer's Association of Canada AWMAC *"ARCHITECTURAL WOODWORK STANDARDS* - Section 9, Wood Doors subsection.

2.2.1 Interior Doors

Solid core wood doors are to be used for all interior locations where heavy duty or rough usage is expected, or where acoustic resistance for sound privacy is needed.

Solid core doors are more expensive than hollow core interior doors. Institutional grade HC interior doors are lighter to ship and just as durable as their solid core counterparts for most buildings. Solid core doors are only needed where increased impact resistance, security or sound resistance is mandatory.

Where a mortise lock set is installed in a wooden door, these doors shall be reinforced at the dead bolt on the door.

Paint grade birch veneer plywood faces are acceptable for paint finish, 'Select White' appearance grade suggested for clear finish.

Grade of door shall be appropriate to proposed finish.

Solid core wood doors are available with Fire Protection Rating (FPR) labels, and may be appropriate for use in some areas of low traffic.

2.2.2 Interior Door Frames

Interior door frames may be wood or metal. Interior door frames requiring a Fire Protection Rating (FPR) shall be metal.

Metal frames require less attention over their service life than wood.

Where a mortise lock set is installed, provide reinforcing in the frames such that the reinforcing is secured to the underlying wall structure.

Metal frames are more durable in high use locations and therefore more dependable as part of a fire separation. Labeled wood frames should be considered only at areas of very light traffic.

Fully welded metal frames are to be provided in high use locations.

Easily damaged wood frames can compromise the effective level of fire protection needed where FPR frames and doors are required.

2.2.3 Interior Bi-fold Doors

Bi-fold doors are considered appropriate for use only in residential facilities, or at door locations with very low use rates. Storage closets in offices can use Bi-fold doors for a space saving advantage over other types of doors.

Bi-fold doors are commonly used in residential facilities and offer both utility and economy, but sliding mechanisms of Bi-fold doors are susceptible to damage from heavy use. Bi-fold doors are impractical for most locations except storage closets.

2.2.4 Interior Pocket Doors

Pocket doors are a practical technical alternative where door swing space is limited and traffic volume is low. The suspension hardware track selected must allow the door to be removed and replaced without opening up the wall finishes.

Pocket doors may be technically appropriate to use where space is limited and traffic through the doorway is less frequent- such as for low-volume use washrooms or storage closets. Pocket doors are more expensive to install than swinging doors, and may present maintenance and repair problems unless the track hardware and latching mechanisms are robust and durable.

2.2.5 Interior Door Glazing

Glass shall not be used in the lower portion of doors (closer than 600 mm to the finished floor). Where glass must be used in the lower section of doors, it must be reinforced or laminated.

Although glass can be important for visibility, the lower portion of door is vulnerable to damage.

2.3 DOOR HARDWARE

2.3.1 Locksets

Selection is to be coordinated with regional maintenance staff so that operational and maintenance preferences and standard keying systems are accommodated.

Maintainer preference for keys and manufacturer's brands should be adhered to where as master and grand master keying system applying to a group of buildings is in place. However, limiting hardware to preferred manufacturers reduces the available selection of technically suitable alternative maintenance materials.

2.3.2 Overhead Door Openers and Operation

Manual operation by chain hoist is preferred. Motor driven electric door openers may be used only where they are essential to facility operation.

Motor driven electric overhead doors require more ongoing maintenance and are more susceptible to problems than manual doors. The additional cost is not usually justifiable.

Air Curtains on overhead doors shall be installed on buildings that are heated and the doors are opened and closed frequently or need to be left open for long periods of time.

The use of an air curtain for overhead doors reduce the need to open and close frequently.

2.3.3 Power Door Operators

Refer to NBC *Div. B 3.8.2.7 and 3.8.3.6.(6)* for requirements. Also refer to GBP ___.

2.3.4 Exterior Door Latching and Door Security

Building security relies on secure exterior door latching. At least two point, and preferably three point latching, shall be considered for all exterior doors where forced entry is a concern. Retracting latching auto bolts at the head frame and sill frame, internal or surface mounted, are to be used in addition to the rim or mortise latch device on the jamb.

Although more expensive initially than single point latching, three point latching provides higher security. Forced entries are a recurring problem in buildings where single point rim device latching is used. This is also useful in the high Arctic where interior building air pressure causes flexing of the door on the latch side.

A threshold plate, sloped to the exterior for drainage and cleaning of debris, is required where bolt latch cups are used in the sill assembly.

Bolt latch cups tend to become blocked by ice and debris and need to be easy to clean.

Push bar rim exit devices should be considered in place of crossbar exit devices for all exterior doors.

Crossbar rim exit devices can be chained closed by building users to prevent forced entry. Push bar rim exit devices do not lend themselves to be chained closed thus reducing the risk of building users being trapped if the building has to be evacuated.

Electromagnetic door locks set up to release with a fire alarm are a viable alternative to three-point latching for exterior exit doors. Magnetic door locks can be used in conjunction with crossbar

Electromagnetic locks increase the security of exit doors without bypassing or disabling the emergency release hardware.

and push bar rim exit devices for areas that are prone to forced entry.

2.3.5 Keying and Access Control

Building owner and maintainer preference for keys and manufacturer's brands shall be adhered to where a master and grand master keying system applying to a group of buildings is in place. However, limiting hardware to preferred manufacturers reduces the available selection of technically suitable alternative maintenance materials.

This allows buildings to be keyed separately for security reasons, master keyed or grand master keyed, and allows for cutting keys and providing submaster keys where required.

Electronic access control offers programmable access, with use of a fob or card. This is a rapidly changing technology, and requires the careful coordination of the designer, client, door hardware supplier, the electrical contractor, and the AHJ. Systems should be administered locally, with the ability for someone on site to reprogram access cards as necessary, offering flexible control of building access. Ensure access control is coordinated with door hardware for emergency exiting, and for barrier-free accessible pushbuttons.

2.3.6 Hinges

Pivot-hinges with door and frame reinforcing are shall be used for doors with high usage rates, overhead frame and door mounted closers and severe impact-abuse conditions. Four hinges per leaf are required for doors exceeding 25 Kg mass, and ball-bearing hinges required for all high traffic volume doors and any door equipped with a closer. Continuous hinges may be used where there is little risk of structural movement and heavy use is not expected.

Continuous hinges and pivot-reinforced hinges require less-frequent servicing and last longer than conventional hinges. Continuous hinges stiffen the door and the frame connection to resist racking and twisting better than conventional hinges.

Interior doors are to be equipped with ball bearing butt hinges for high traffic volume locations in institutional and commercial buildings.

Northern buildings are often more vulnerable to doors jamming, caused by racking of the frames in walls influenced by foundation movement, rather than buildings in more stable foundation environments.

2.4 WINDOWS

Window design considerations include:

- Energy conservation;
- Orientation
- Vandalism protection
- Natural light character (glare, sun angles)
- Building type / materiality, as it relates to durability
- Function
- Location
- Size – for shipping and replacement

Window glazing is recommended to be of a consistent size and of a dimension to be easily shipped by small plane for access to many northern communities. See *GBP Article A4.4.5, "Glazing*".

2.4.1 Exterior Window Frames

Frame materials are to be selected for:

- durability and reduced long term maintenance.
- High thermal resistance;

Acceptable frames, which are robust enough to accommodate effective air and vapour connection to the building envelope:

- Commercial or institutional grade fiberglass;
- Commercial or institutional grade thermally broken metal;
- Vinyl clad w ood framed windows;
- prefinished metal

Fiberglass framed windows with stiff deep frame cross-sections and a minimum 35-65 resin to glass ratio are acceptable, provided the cold-process connection of the wall air-vapour barrier to the frame has adequate

Fiberglass frames are inherently more flexible than metal or reinforced PVC frames for equivalent material thickness. Torch-applied air-vapour barrier materials cannot be used on fiberglass frames as the bonding mechanical support and durability. Acceptable fibreglass frames with metal flanges allow a torch applied vapour barrier assuring continuity of the envelope.

resins in them are combustible, requiring a cold-process air-vapour barrier connection, more problematic in cold northern construction conditions.

Frame stiffness for all types of frame materials, at latch locations for sash lock mounting must be stiff enough to compress operable air seals for tight sealing.

Poor air seal compression is the main cause of air seal failure and excessive air leakage between the operating sash and frames of northern windows.

Large windows require special consideration to ensure that the frames are adequately reinforced, that the hardware mounting is strong enough, and that the frame will remain straight and provide an effective seal. (*See GBP Article A4.4.5 "Glazing"* for additional recommendations.)

Large pane sizes are not recommended because large sealed glazing units are expensive and difficult to transport into most northern communities, and more difficult to maintain tight perimeter air seals caused by thermal expansion and contraction cycles of the frames.

2.4.2 Sealants

Sealants and methods recommended for connecting the window frame to the air/vapour barrier system of the wall are found in GBP *A3.1.7.4*. Designers are required to provide durable, strong easily constructed and well detailed connections satisfying rain-screen and air/vapour barrier continuity, and weather protection from extreme local climate conditions.
Sealants used to bond glazing into frames and operable sash are required to conform to applicable national standards for compatibility with air/vapour barrier membranes and all envelope penetrations. Refer to *NBC Div B Section 5.9 Standards*.

Extra attention needs to be provided for sealing windows into the air/vapour system of northern walls because of the extreme environmental demands on performance brought by prolonged deep cold, wall deformation caused by foundation system movement, excessive wetting of wind and rain exposed walls at certain seasons of the year, and variable and high air pressures caused by vigorous northern winds.

2.4.3 Location in Wall Assembly

Windows should be located in the wall assembly such that the interior of the frame is located on the warm side of the insulation. The glazing plane should straddle the centre plane of the exterior wall insulation.

Setting of windows at exterior wall should not create a wide interior ledge because this reduces airflow over the glass, which can allow condensation or frost to build up on the inside of the window. The intent of such placement is to provide AV barrier continuity through the window frame

Refer to the North American Fenestration Standard (NAFS).

without offset. Windows designed with nailer flanges for installation over the exterior wall sheathing are usually poorly connected to the air vapour system and become positioned in the outside portion of the wall. As such they are prone to frost and condensate formation problems.

Window locations are driven by program requirements but some window locations are at a natural higher risk of forced entry and should be technically upgraded.

2.4.4 Operable Sash

All operable sash is recommended to be casement or awning type with rugged hinges, simple rugged push bar handles and rugged cam locks, with metal rather than plastic components.

Camlocks have been found to provide the best way to compress the air seal for awning and casement operable sash. Sliding or by-passing operable sash tends to jam in frost or ice in the northern climate.

Vertical sliding or by-passing operable sash is not permitted.

Awning ventilator sash in the lower portion of a window is more likely to allow wind, dust and snow to blow in, and can be easily reached for break-ins or intrusion when the window is left open to provide natural ventilation.

Windows must be designed and installed so that operable sash, or ventilator units (vents) will not be blocked by accumulations of snow or ice on sill plates. Outward opening awning vents located in the top one third or the central one third of the window are preferred, and operable sash in the lower portion of the window not permitted, unless the lower muntin bar height is at least 1.8 metres above exterior ground level where site security is not a concern, and at least 2.6 metres above exterior ground level, or the operable sash be small enough to discourage forced entry, where site security is a concern.

Twin air seals are required for ventilating sash, as a means of reducing air leakage and for minimizing frost-sealing in winter. This allows ventilation during transition

Durable effective and easily replaceable air seals are required in the harsh northern environment. Twin air seals stop interior humid air near the interior warm portion of seasons when outside air is not too cold to introduce into the building.

the window frame and cold dry exterior air at the exterior (cold) portion of the frame, providing a transition air lock that resists condensate freezing between the operable sash and the frame.

2.4.5 Glazing

All windows are to have as a minimum double-glazed sealed glazing units with low "E" coating, or triple-glazed sealed units.

Specify low emissivity coatings for the insulating glass units, selecting surfaces to be coated that provides optimum benefit in the climate zone and orientation.

Double-glazed low-emissivity sealed glazing units or triple-glazed sealed glazing units provide the lowest life-cycle cost of any commonly available glazing system. Tinted glazing for northern latitudes is only cost effective when the window configuration and orientation will cause excessive heat gain in the long solar day of the short summer season.

Use of tinted glass with shading coefficients greater than 10% is not permitted for most windows, due to the relatively short cooling season that prevails at most locations in the North.

Glazing system selection must take into consideration functional requirements for effective energy utilization and day lighting as well as maintenance and technical needs. Standardizing window glazing will reduce the amount of different sizes of window glass to be stored in the community for replacement due to breakage.

Glazing unit size and weight should be limited to what can be transported by the commercial carrier (air or truck) that serves the community and transported within the community by local trucks without specialized handling equipment.

For communities not on the highway system the only way to transport glass is by air. The dimension of the glass should be no greater than what will fit in the aircraft regularly servicing the community.

Where fire rated glazing is required, wire mesh glass will not be accepted.

2.4.6 Window protection

A single-glazed removable sulsash of polycarbonate plastic (except in exits), laminated glass or tempered glass, or an impact resistant security film on the exterior of the glass sheet, integral with the frame, on the exterior of the window, is to be installed to protect windows where program requires. Shutters or removable panels are effective additional window protection methods, and are recommended for seasonal-use or isolated facilities where window vandalism is a potential problem.

Wherever recurring vandalism is identified as a potential problem, protection of glazing is recommended. (See notes in NBC Div B A9.6.1.3 for glazing near doors). Some additional protection is strongly recommended for buildings where windows are subject to vandalism. Schools are periodically high-risk window vandalism targets and must be included in this class of facility.

H3 INTERIOR CONSTRUCTION and FINISHES

Materials selected for interior finishes should be selected for:

- Durability, consider lifecycle cost;
- Ease of maintenance;
- Sustainability;
- Aesthetics;
- Commonly available;
- Low VOC at occupancy.

3.1 FLOORS

Flooring materials must be selected based upon the manufacturer's recommended duty environment, and the operating temperature of the floor as well as for durability to meet program requirements. Where a suitable local flooring material is available and work will contribute to the local economy, that material should be given preference if practical.

3.1.1 Resilient Flooring

Resilient flooring includes a range of synthetic flexible roll and sheet goods and small format tiles. Commonly available resilient flooring includes linoleum, sheet vinyl, polymer modified linoleum, resilient foam backed vinyl, rubber, cork and similar vapour impermeable and air impermeable products. Installation of resilient flooring onto substrates with radiant heating (hydronic or electric), and installation onto concrete slabs on grade must be done with added care, and with consideration of the limitations of both the resilient flooring material and adhesives used, as well as the potential for water vapour or moisture to be trapped under the resilient flooring and affect the glue bond.

All resilient flooring requires installation on a stiff and durable substrate material with limited flexibility to limit the strain on joints in the resilient flooring. Where resilient flooring is installed in unheated buildings, additional care must be taken to specify flooring and adhesives designed to perform in extreme temperatures. Where it is necessary to reduce possible electrostatic discharge (ESD), in facilities where static can cause interference or damage to equipment, anti-static flooring is to be specified.

.1 Resilient Flooring Linoleum
This is the preferred flooring for many northern buildings, but glue-loosening and drying deterioration has been found in some installations of linoleum on floors with radiant in-floor heating. When installed over heated floors, floor operating temperatures need to be

Linoleum has proven durability, a good range of colours, and is easy to maintain. Compared to vinyl composite tiles, linoleum is only slightly more expensive to install, requires much less maintenance, and is far more durable. It should be noted that linoleum surface texture is too slippery for wet areas such as shower rooms.

verified and kept within the floor materials manufacturer's recommendations to ensure durability and long service life.

Linoleum contains natural oils which can dry over time causing shrinkage, brittleness and edge cracking at seams if installed over heated floors, or exposed to concentrated heat from a commercial stove or similar appliance.

Linoleum is not recommended for floor areas expected to withstand repeated stress loads (such as rolling wheeled carts or vibratory impact loads).

The linseed oil based bonding materials in the linoleum are typically not strong enough to withstand repetitive heavy strain loads.

Linoleum flooring is not recommended for warehouses or display showrooms or similar locations where petroleum based liquids are present.

Recommended minimum thickness of linoleum are:

Heavy use high traffic areas: Minimum 2.5 mm thickness with welded seams.

Typical heavy use high traffic areas would include all public lobbies and corridors, private health care facilities and mercantile uses, educational facilities, passenger terminals, and major public buildings like court houses, correctional facilities and health centres.

Medium and light traffic areas: Minimum 1.8 mm thickness with welded seams.

Typical medium duty moderate to light traffic areas would include seasonal use facilities, private offices, residential accommodation and storage rooms.

.2 Slip Resistant Sheet Vinyl
Minimum 2 mm thick, homogeneous colour and pattern detail throughout thickness of product. Marbleized or granite patterns and welded seams are recommended.

Typically used in vestibules, washrooms and change rooms where floors may remain wet for some time or for residential uses where only small areas are required. Welded seams are required to provide a durable, watertight joint. Products with print-applied surface colours and patterns should not be selected because they show wear too readily on floors with medium or heavier traffic.

Surface patterned materials or cushioned backing are not recommended for areas containing tables and chairs, unless sled base

Patterns can serve to hide dirt more easily than plain colours. Cushioned flooring is not practical because it can be easily damaged by furniture.

furniture supports are used.

When installed over heated floors, floor operating temperatures need to be verified and kept within the floor materials manufacturer's recommendations to ensure durability and long service life.

Some types of adhesives used for bonding sheet vinyl flooring to subfloors will deteriorate over time with concentrated heat from an in-floor radiant heating system, leading to blistering or early delamination of the flooring material from the subfloor.

.3 Vinyl Composite Tiles (VCT)

Because VCT is easily installed using local labour it is especially appropriate where small quantities do not warrant the expense of bringing in specialized trades for installing sheet goods.

Recommended use of variegated marbleized or granite patterns and 2.5 mm minimum thickness, colour and pattern detail throughout the thickness of the tile.

Do not use vinyl composite tiles in cold porches or unheated rooms. Typically appropriate only in light traffic areas in smaller buildings.

Typical uses would include smaller buildings such as offices in maintenance garages or fire halls, field offices or summer use staff quarters. Shrinkage in cold temperatures makes VCT an unsatisfactory choice for most unheated areas.

Vinyl composite tiles are not recommended for use in wet areas or areas subject to spills.

Water and spilled fluids can enter the joints and deteriorate the adhesive. Spilled fuel oil and antifreeze are particularly bad as they also infuse the subfloor and prevent adhesion of new floor coverings.

.4 Rubber Flooring

Rubber flooring is generally recommended for special purpose use in northern buildings, where superior resiliency, durability and ease of maintenance are sought.

Rubber flooring is a better total service life cost choice than linoleum or vinyl.

Vulcanized rubber skate flooring is preferable for use in community arenas and sports rooms where impact and abrasion resistance is important.

Rubber flooring is suitable for sports activities, and is resistant to damage from sand or mud tracked in by footwear. Rubber flooring to buy can be 10 to 13 percent more expensive than vinyl, but the rubber lasts longer (typical 30 year service life with normal maintenance) and provides better performance over its service life. Installation over a deck with in-floor radiant heating is no different than *installation of vinyl over the same type of deck. Attention to heat tolerant glues and limiting the floor contact temperature to about 32 Deg. Celsius is recommended.*

Typically installed only between ice surface and areas where skates are put on or removed.

.5 Cork Flooring
Generally not recommended for general use in northern buildings other than for residential and light traffic small office occupancies.

Cork can be difficult to maintain in moist and abrasive use environments, and is relatively expensive to install. There is no inherent advantage that makes cork flooring an exceptional choice for use in northern buildings.

.6 Sports Flooring
Heavy duty vinyl sports flooring with slip resistant surface and resilient backing, suitable for surface-painted lines, is recommended over other types of materials only for activity rooms and low impact use areas, but must be protected from scuffing and puncturing unless compatible footwear usage is enforced. High impact use areas such as sports courts are best covered with the more durable cushion backed resilient rubber flooring.

For impact court sports over a flexible wood deck, a triple layer 8 mm thick covering would likely be the best combination of performance in place, durability, and cost. 6 mm thick two layer material is not recommended for impact sports floors, but is suited for areas like floor gymnastics (tumbling) and weights room floor covering where skid resistance is needed but impact rebound resiliency is not as important. Thicker triple layer materials are recommended for installation over concrete slabs and suspended infill concrete slabs where there is less flexibility in the substrate.

Resilient backed rubber sports flooring suitable for surface painted lines is recommended for use in athletic sports facilities such as community or school gymnasiums as being the most durable, most cleanable, and suitable for both community event uses as well as impact sports (court games and similar).

Depending on the substrate, rubber is better for very hard substrates like cast in place slabs, and more able to accommodate the flexing of lighter decks such as double 15.9 mm T&G plywood. It is the most resilient choice, giving back more kinetic energy than vinyl based resilient sports flooring, and has better long-term traction control for fewer slips, falls and injuries, and has better sound absorption characteristics.

3.1.2 Wood Flooring

Hardwood flooring is generally not recommended for use in northern buildings, including gymnasiums, because of the typical dry cold season service environment and risk of deterioration by occasional water damage.

Capital, installation and maintenance costs are high, and wood is easily damaged by water exposure or immersion. Wood floors in public use facilities require protective coverings when used for community events, which is inconvenient for users: where protective coverings are not used, floors are easily damaged.

Laminated wood veneer ("click-lock") flooring, more dimensionally stable with humidity changes than wood, is recommended only for areas where the building occupancy consists of light duty use with non-abrasive furniture, and with no exposure to water deterioration.

Laminated wood or synthetic plastic laminated plank flooring is difficult to maintain and repair once damaged by abrasion or water spills or floods. Surface damage cannot be easily repaired or touched up, and immersion in water for even a short period of time causes swelling and bursting of the joints between planks, which are difficult to replace individually.

Plywood flooring for storage rooms is acceptable, but not recommended for mechanical service spaces where fluid spills might occur (furnace rooms and similar).

Dry service areas with low traffic rates generally can use slip-resistant paint finished plywood as a durable low-cost floor material. Occasionally wet service areas where fluid spills periodically occur are recommended to have floors with less porous coverings than plywood.

3.1.3 Floor Tiles

Ceramic tiles are recommended for use in northern buildings where the advantages of durability and toughness outweigh the disadvantages of high initial cost. Extremely stiff substrates of concrete or concrete board underlayment are required because wood subfloors are too flexible to accommodate the tile bedding, adhesive and grout brittleness.

Although it is recognized that ceramic tile can be low maintenance, easy to clean, and very durable, initial costs are generally high in the North (especially due to transportation costs). There is also a high risk of breakage in transit, and flexible wood structures typical of most facilities do not provide a suitably stiff substrate for ceramic tiles. Susceptibility to cracking, de-bonding and grout repairs can lead to expensive maintenance. Installation requires skilled tradespersons, and repairs require special attention by maintainers.

When tile is appropriate, neutral colours should be selected and accent colours avoided.

Examples of where ceramic tile may be appropriate would include specialized facilities such as laboratories or hospital operating rooms, where the tile is applied *over stiff substrates.*

The tile finishes will outlast adjacent finishes so the colours must be able to work with changes of decor and changing colour trends.

3.1.4 Modular Carpet Tile

Modular carpet flooring consists of dense vinyl-based composite sheet backing material integrally bonded with a dense low-profile covering of carpet fibre, and is suitable for most moderate or low traffic occupancies, such as offices.

Improved product manufacturing and performance for cleaning ability, bacteriological contamination resistance, wear resistance and installation maintenance have made this material quite suitable.

Care must be taken to ensure substrates are smooth, contaminant free and not subject to excessive local heating (maximum 34 Deg. Celsius) for a durable installation.

When selecting carpet tile, consider the soil and stain hiding capabilities, colour, tone value and pattern.

Sustainable operation of modular carpet flooring in high traffic areas requires periodic reinvestment to cycle high wear area units to lower wear rate areas.

Installation of modular carpet flooring in heavy duty high traffic areas is not recommended.

3.1.5 Roll Carpeting

Roll carpeting is acceptable for use where cushioned floor and noise reduction is required, and where moisture and infection control are not concerns.

.1 Properties:

Yarn: nylon preferred;

Durability, appearance and cost of nylon loop has been found to be most suited to northern buildings.

Pile: loop only – do not use cut pile;

Hard wearing and easier to maintain than cut pile.

Density: minimum 12.0 kilotex;

Density is the standard measure of carpet "wear ability", not carpet weight (i.e., 28 oz. or 32 oz.).

Static control: carpets should be rated at less than 3.0 kV;

The dry cold climate of the North promotes static build-up, which can be uncomfortable to users and damage electronic equipment.

Colors: prefer patterned carpets only in medium color ranges. Avoid using solid colors with the exception of accent borders.

Patterns do not show wear or dirt as easily as solid colours.

.2 Installation:
Direct glue-down installation of carpet is preferred. Avoid using underlay except for limited residential lounge areas. Only loop pile carpeting that is warranted against zippering is recommended to be installed.

Gives a tight, low surface carpet that does not shift or stretch under heavy traffic. Although underlay can be more comfortable for residential lounge areas, it is not recommended for use in most northern buildings. Zippering occurs when tufts are pulled from the backing resulting in long lengthwise threads pulling out of the carpet. It occurs in loop pile carpet when the backing compound does not securely encapsulate the tuft base.

3.1.6 Epoxy Floor Finishes

A broad range of epoxy flooring materials are available for installation over cured and dry concrete substrates at lower cost and installation complexity than integral coloured concrete hardening compounds. Some epoxy flooring compounds can be specified with high chemical, abrasion resistance and moderate moisture tolerance. Epoxy flooring is not recommended for use where continuously wet conditions will be encountered, but is recommended for installation in fairly large floor areas where the edge finishing details and joints between dissimilar materials are not critical.

Careful application is required, and it is difficult to keep maintenance materials in stock because of reasonably limited shelf life of epoxy based chemicals. Warehouses, repair and storage garages and similar large floor areas are examples of where epoxy flooring may be installed with reasonable service life expectations. Epoxy coatings are less durable than integrally coloured concrete hardeners.

Epoxy flooring must be installed by a qualified installer, and installation must be covered by a manufacturer's warranty.

3.1.7 Integral Concrete Hardener

Integrally coloured or uncoloured concrete hardener is recommended where abrasion resistance, colour and surface durability and high moisture resistance are required at lower cost than resilient sheet goods installation. The concrete substrate requires carefully controlled moisture and surface characteristics to accept the hardener, which is either added to the concrete when mixed, or steel trowelled into the green concrete surface and bonds chemically with the concrete as it completes the curing process.

Consider the flooring requirements when choosing the method of hardener being applied. Refer to the Cement Association of Canada (CAC) Concrete Design Handbook.

Integral hardeners form a simple protective coating to concrete that still allows water vapour to pass through the concrete, avoiding blistering and delimitation problems created when a vapour impermeable seal is used.

3.1.8 Floor Paint

Floor paint is recommended to be slip-resistant safety paint containing suitably sized abrasive to ensure good traction of shoe soles under both wet and dry conditions. Recommended uses for non-skid concrete floor paint are dry service areas where oil liquid spills are prevented. Application of paint on concrete floors requires minimal controlled moisture in the concrete. Using only vapour permeable paint is recommended. Refer to Master Painters Institute, Architectural Painting Specification Manual.

Industrial quality slip-resistant floor paint is typically suitable for low traffic, non-public areas where protection from water, dirt or spilled oil is required, such as mechanical or fan rooms, and equipment storage rooms.

3.1.9 Base Trim and Accessories

Wood baseboards are recommended where the additional cost of installation and dedication of suitable maintenance facilities, available for repair and abrasion damage touch up, are considered worth the appearance benefit.

Wood baseboards require ongoing maintenance to repair abrasion damage from impacts and scuffing from floor cleaning equipment.

Integral coved base is recommended for wet areas and where infection control is a concern, and where the additional cost is warranted.

Floor materials used for typical wet service areas require the least problematic base trim materials, where the joint between the floor and the wall can be periodically resealed to compensate for water deterioration.

Resilient rubber base trim is recommended for light and medium duty general service areas in northern buildings. Vinyl base trim is less durable and more problematic to maintain, and is recommended to be used only in passive service areas such as storage rooms. Resilient base to be installed in one continuous piece lengths.

Care must be taken to ensure durable yet strippable adhesive and that controlled installation conditions are provided, including suitable use of moulded corners.

3.1.10 Entrance Mats and Grilles

Avoid building in recesses for foot-cleaning mats or grilles at building entrances. Use seasonably removable foot cleaning mats instead.

Ice and snow are tracked into buildings for up to half the year, making recessed grilles not only difficult to keep operational, but a slipping hazard. The recessed detail is difficult to build and cannot function with season melt water unless adequately connected to a floor drain, which typically will plug with residual tracked soil and ice.

3.2 INTERIOR WALLS AND PARTITIONS

3.2.1 Framing of Walls

Wood or steel stud framing is acceptable for interior non-load bearing walls.

The use of steel studs simplifies work of electrical and mechanical trades, is relatively simple to install, and may be reusable when renovations are undertaken. For non-load bearing partitions, steel stud framing is generally less expensive to ship into a community.

Interior load bearing (structural) walls are recommended to be framed with wood studs.

Load bearing steel studs typically required specialized design and installation standards, including increased gauge specification, specialized blocking and *engineered treatment of beams, while wood framing can follow building code-based design criteria.*

Provide Fire Separations as required by NBC.

3.2.2 Demountable Wall Systems

Demountable wall systems are recommended primarily for use in large floor areas where reconfiguration of rooms to meet changed program requirements is frequently required.

Demountable systems can allow flexibility for room layouts, provided detailed construction at joints provides for effective acoustic separation and matching prefinished panels are available to replace damaged and discarded panels.

Provide adequate support for wall hung equipment and displays.

3.2.3 Moveable Wall Systems

Wherever appropriate based on the program requirements, movable wall systems can be used to allow for maximum flexibility, adaptability and ability to reconfigure the space.

3.2.4 Mechanical Equipment Service Room Walls

.1 Heat Transfer:

The preferred means of reducing heat transfer from mechanical rooms to other occupied rooms is to avoid locating them adjacent to (or above/below) one another. Where this cannot be avoided, the interior walls separating the rooms should be thermally insulated. Coordinate with acoustic separation requirements below.

Overheating of rooms adjacent to mechanical rooms is a common problem in larger buildings such as schools, apartment buildings and similar residential accommodation such as group homes and health centres.

.2 Sound Transfer Reduction:

The preferred means of acoustically separating mechanical rooms from occupied spaces is to avoid locating

Refer to NBC 2015 Div. B Section 5.8, "Sound Transmission" and NBC 2015 Div. B, Section 9.11, "Sound Transmission".

them adjacent to (or above/below) one another. Where this cannot be avoided, walls, floors and ceilings of mechanical rooms should be rated to STC 50. Whenever possible, the acoustic isolation should continue through the floor to minimize sound transmission by the structure.

See also GBP J8 (Mechanical- Air Distribution) 8.5.10 (Acoustic Control).

3.3 CEILINGS

When selecting ceiling finishes, consider:

- Durability;
- Maintenance;
- Ability to withstand occasional accidental impact damage;
- Periodic wet cleaning, where necessary (eg. health care facility, kitchens, bathrooms);
- Acoustics;
- Fire resistance rating;
- Light reflecting properties.

3.3.1 Gypsum Wall Board

Gypsum board is common in our northern buildings, and is generally a preferred ceiling finish.

Gypsum board is an industry standard with skilled trades persons available at most northern locations.

Provide access hatches as required for building systems maintenance.

Gypsum board ceiling finish is an effective method for achieving a fire resistance rating where required, and is easily repaired.

3.3.2 Exposed Roof Decks

Exposed wood or metal roof deck material is an acceptable ceiling finish where it meets program requirements.

Typically used in gymnasiums, community assembly buildings, warehouses and schools, but may be considered wherever roof assembly allows decking to be exposed and such a finish provides sound control and light reflectance appropriate to the use of the space.

Perforated metal deck should be used where acoustic reverberation must be controlled.

Tight-knot appearance grade is the recommended minimum grade of material for wood roof deck material.

3.3.3 T-Bar Suspension Grid

A suspended ceiling system is recommended typically where large ceiling areas need to be covered, where frequent access is required, and where spatial layouts are prone to change.

Acoustic units (lay-in tiles) can provide a practical finish concealing ducts and wiring, and providing some sound absorption. They are mainly intended for ceilings where access to the plenum space above is routinely needed.

Avoid using suspended ceilings with lay-in acoustic units in:
public use areas where the ceiling height is lower than 2.5m above the floor;
above stairs;
above areas in dusty locations that require frequent cleaning;
in areas prone to moisture (eg. Washrooms, janitor rooms, etc.).

Susceptible to impact damage and very difficult to clean. Adequate clearance above the ceiling grid needs to be provided for easy removal and replacement of lay-in acoustic units without damaging them.

Use of the plenum space above suspended ceiling systems for un-ducted ventilation purposes such as relief or return air distribution is not recommended.

Accumulated dust and debris deposited by the ventilation system or re-distributed from debris left in the plenum space encourages development of moulds and bacteria colonization of the fissures in lay-in acoustic units, and adhesion of the same in dust-laden surfaces which are impossible to clean. The cumulative bad effect on indoor air quality is difficult to correct without tearing out the complete ceiling assembly and replacing it.

Where possible, acoustic tile and ceiling grid is to be reused in renovations.

3.3.4 Textured Ceiling Finishes

Porous or soft textured ceiling finishes are not acceptable for use in northern buildings. Dust and smoke from wood burning appliances (where present) cause discolouration and increase the retained dust load on of interior surfaces.

Easily damaged, and difficult to refinish because of particle release when re-wetted with water-soluble paints.

Low-relief rolled plaster skim coat finishes

Hard reasonably impervious surfaces are

(California stucco) are acceptable alternatives to soft spray-textured stipple coat finishes.

easily vacuum-cleaned of dust and readily repainted without particle release.

3.3.5 Metal Ceiling Liner Panels

Where sheet metal panels are used as an interior ceiling finish, panels are required to be factory preformed steel sheet, zinc or Galvalume finish coated, and prefinished on the exposed face with factory applied corrosion resistant paint.

Typically used with pre-engineered metal buildings as an interior finish for garages, vehicle service storage buildings, fire halls, and similar industrial occupancy buildings. Lighter gauge material is easily dented and should only be used where there is no exposure to damage. Pre-coated steel with a durable protective coating is recommended to resist the rusting caused by moisture condensation on the metal surfaces caused by typical northern humidity and temperature seasonal fluctuations.

Thickness should be minimum 0.475 mm (26 gauge) base metal thickness, where not exposed to impact damage, and 0.635 mm (24 gauge) if within a potential impact damage zone.

3.4 PAINTING AND WALL FINISHES

Regular maintenance by cleaning, patching and refinishing should rely on local skills. Walls subject to intentional or unintentional damaging impacts need to be reinforced where they are likely to be kicked, hit with projectiles, or bumped. Surfaces should be washable, and easily repairable and able to be refinished by local tradespersons with materials that can be easily obtained and stored in the community.

Wall finishes must be selected based on:

- Ease of installation;
- Availability of materials;
- Availability of local labour;
- Ease of maintenance;
- Aesthetics.

3.4.1 Gypsum Board

Gypsum board is the preferred wall finish in most northern buildings.

An industry standard providing good fire resistance and a smooth, easily repaired surface.

3.4.2 Plywood Backing

Gypsum board finishes shall be backed by or surfaced with plywood where there is a potential for vandalism activity, mechanical damage, and in sports facilities where projectile impacts can damage surfaces. Plywood backing shall be used as required for mounting panels, millwork and equipment.

High traffic volume areas are subject to damage (i.e., from doors or impact damage from users) that will damage un-strengthened gypsum board.

3.4.3 Hardwood Veneer Plywood

An acceptable wall finish where appearance and durability are important.

High traffic volume areas are subject to damage (i.e., from doors or impact damage from users) that will damage un-strengthened gypsum board.

Use select grade for clear finish, or paint grade for a painted finish.

Use recessed screw fasteners in heavy use areas like gymnasium walls.

3.4.4 Wood Panelling

Tongue and groove board finish is acceptable. Wood veneer panelling is recommended to be limited to communities where skilled trades people are available for maintenance.

Provides a reasonably durable wall finish. Suitable for use in gymnasiums, change rooms, lobbies and foyers to enhance wall appearance and be easily refinished by sanding and varnishing.

Nails not to be used due to tendency to "back out".
Hardwood veneer panelling requires skilled finish carpenters to install and maintain it. Prefinished vinyl veneer panelling should be avoided because it is difficult to repair if damaged, and difficult to match in replacement.

3.4.5 Metal Wall Liner Panels

Where metal panels are used as an interior wall finish, such panels should be factory preformed steel sheet, zinc coated, refinished on the exposed face. Thickness should be minimum 0.5 mm (26 gauge) base metal thickness, where not exposed to traffic and 0.6 mm (24 gauge) if within reach of occupants.

Typically used with pre-engineered metal buildings for the interior finish of garages and fire halls. Lighter gauge material is easily dented and should only be used where there is no exposure to impact damage.

3.4.6 Acrylic / Latex Paints

Water-based acrylic latex paints are recommended for use in Northern buildings. Recommended products are listed with the (MPI) Master Painting Institute (APL) Approved Products List, found in the MPI Manual, available from:

http://www.paintinfo.com/mpi/store/archman.htm

Environmental and health concerns have encouraged manufacturers to develop water-based paints that are now comparable with oil-based alkyd paints for durability. Painting trades preferences are also beginning to stipulate the use of water-based products because of health concerns. Minimizing the availability of harmful products (including solvents) and off-gassing of solvents and paint dryers is also an important consideration. Recommended best practice is found in the MPI Manual.

3.4.7 Alkyd Paints

Oil-based alkyd paints may be acceptable for use where the risk of cold weather damage to stored, shipped or newly installed paint is a consideration. Recommended products are listed with the (MPI) Master Painting Institute (APL) Approved Products List, found in the MPI Manual, available from:

http://www.paintinfo.com/mpi/store/archman.url

Although able to withstand freezing during shipping and storage, VOC (volatile organic compounds) emissions, and the need to use and store solvents for cleaning, make alkyd-based paints more demanding in application than water-based paints. Painting trades preferences are also beginning to stipulate the use of low VOC paint products because of health concerns. Minimizing the availability of harmful products (including solvents) and off-gassing of solvents and paint dryers is also an important concern in many northern communities. Recommended best practice is found in the MPI Manual.

3.4.8 Vinyl Wall Coverings

Vinyl wallpaper over gypsum board is not accepted.

Although this was once the standard for demountable office partitions, this product is no longer used in GNWT facilities.

3.4.9 Special Coatings

Special high-build acrylic or epoxy coatings may be acceptable for use only where they will be applied to a reinforced drywall, plywood or concrete substrate requiring specialized corrosion resistant protection. Water-soluble or low VOC products are recommended.

The purpose of special coatings is generally to provide a very damage or corrosion resistant finish, and so the substrate should be equally resistant.

3.4.10 Wall Tiles

Ceramic wall tiles are recommended for use for wall coverings in northern buildings, where it can be shown that the advantages of durability and ability to withstand routine sanitation cleaning, as is required in commercial food preparation facilities and similar buildings, overcome the disadvantages of high initial cost, cracking and de-bonding susceptibility, and problematic grout maintenance.

Although it is recognized that ceramic tiles can be low maintenance, easy to clean, and very durable, capital costs are generally high in the north due to a combination of transportation and trades cost considerations.

Very stiff substrates are recommended to increase the durability and initial installation quality of ceramic wall tiles. Cement board securely screwed and adhesive fastened to wall structural framing is a minimum substrate requirement for ceramic wall tile installation.

Examples of where ceramic tiles may be appropriate would include specialized facilities such as laboratories or hospital operating rooms.

Ceramic tiles must be applied over stable substrates. Stable substrates include concrete masonry units (CMU's), cast concrete, and Portland cement bearing wall panel materials.

3.4.11 Acoustic Treatment

Where acoustic reverberation time must be reduced, acoustic treatment can be installed on interior walls and ceilings.

Acoustic panels are to be selected for ease of cleaning, installation, and aesthetics.

Where acoustic separation between adjacent spaces is required, bring dividing wall to underside of deck or provide a vertical acoustic baffle above the finished ceiling. Laying acoustic batt above ceiling tile is not acceptable.

Obtain advice from a qualified acoustic engineer to determine the location and extent of acoustic treatment required.

3.4.12 Wall Protection

Provide wall protection where damage from impact is anticipated.

Available solutions include, but are not limited to:

- Vinyl wall panels;
- Plywood;
- Sheet metal;
- Corner guards;
- Bumper rails;
- Crash rails.

Wall protection should be selected for:

- Function;
- Aesthetics;
- Texture;
- Cleanability;
- Durability;
- Life cycle cost;
- Sustainability.

Porous surfaced materials may trap dust particles and mould spores, over time contributing to a potential reduction in indoor air quality. Smooth surfaced fabric covered attenuation panels are recommended where airborne dust and fibres are a common occurrence.

H4 FINISH CARPENTRY

NAAWS "North American Architectural Woodwork Standard" is to be used as a quality benchmark for finish woodwork.

4.1 CABINETS AND SHELVING

Refer to the relevant sections of NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS" – most current edition, published by the Architectural Woodwork Manufacturer's Association of Canada.

4.1.1 Casework

Custom grade casework, including drawers, shelving, doors and edge banding as described in NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS" is the recommended quality reference for casework in northern buildings.

NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS" establishes three quality grades: economy, custom and premium. Custom grade detailing is recommended for most northern buildings as being the best combination of economy and durability to accommodate the seasonal fluctuations in northern air humidity.

.1 Cabinet Doors:
Edge banded hardwood plywood doors are acceptable on a project by project basis, and as long as they do not exceed 450 mm(w) x 1200 mm(h) in size.

Large plywood doors are prone to warping due to seasonal humidity fluctuations (mainly excessive dryness in winter) in northern regions.

In areas of high use or prone to impact, solid wood edge-banding is required.

4.1.2 Clear Finish

.1 Materials:
Where a clear finish is to be used, birch veneer hardwood plywood should be used. To be Select White or Red, as described in NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS".

Reasonable appearance and cost.

.2 Matching:
Book matching is preferred. Slip matching is acceptable. Random matching is not acceptable.

4.1.3 Paint Finish

Where a paint finish is to be used, paint grade plywood, as described in NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS", is acceptable.

Where a smooth surface is important, but wood grain appearance is not.

4.1.4 Hardware

.1 Finish:
  .a brushed metal should be used.

Good quality, durable and simple hardware is best suited to all northern buildings, where durability and long service life is sought.

.2 Cabinet hinges:
  .a concealed hinges preferred
  .b soft-close preferred
.3 Drawer glides:
  .a ball bearing type preferred
  .b soft-close preferred

.4 Cabinet door and drawer pulls:
  .a simple design preferred.

4.1.5 Shelving

Supports:
Generally to be supported on metal standards for adjustable shelf brackets. Lateral support to prevent overturning is required on free-standing shelf units.

To allow shelf reconfiguration.

Materials and Finishes
Clear finish birch plywood or plastic laminate finish complete with hardwood edge banding should be provided for all public or visible locations.

Visually apparent shelving is typically recommended for libraries, schools, community offices, health care facilities and similar areas accessed by the general public.

Plastic, plexiglas or glass shelving should be limited to display cabinets.

Display shelving has limited application in schools or community centres, but would more often be found in visitor centres, cultural centres or museums. Because glass or clear plastics need to be kept very clean, and are subject to scratching or breakage, their use is recommended to be limited.

Melamine surfaced or painted shelves are acceptable for storage rooms or low visibility locations. Plywood substrate only.

A less expensive alternative to clear finishes where appearances are not as important. Typically acceptable for storage rooms, garages, fire halls, or seasonal use buildings.

Ensure wood is acclimatized prior to installation, because of the extremely dry climate in the north.

4.2 COUNTERTOPS

Refer to NAAWS “NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS”.

4.2.1 Countertops

Solid surface countertops are to be used in public areas, and where heavy use is anticipated. They are also to be used where infection control is a priority.

Plastic laminate countertops may be used in lighter duty areas, where approved.

Experience has shown that post-formed counter tops are often damaged in transit, and exposed edges at nosings/overhangs are easily chipped.

4.2.2 Solid Surface

Solid surface countertops are to be acrylic-based, thermoformable, with a Flame Spread Index <25, and a Smoke Developed Index <25 (Class 1/A – ANSI/UL 723).

4.2.3 Plastic Laminate

When used, it should be general purpose grade, complete with backing sheets, velour or suede finish. Texture patterns preferred in all high rate of use areas. Solid colours acceptable only in low-use areas.

Low-use areas, where solid colours are acceptable, would typically include office reception counters, seasonal-use buildings and staff washrooms.

4.2.4 Chemical Resistance

Where chemical resistance is required, use laboratory grade plastic laminate, laboratory grade solid surface, or stainless steel.

Typically required in school science labs, health centres, labs and film development rooms, and biological analysis labs.

4.3 MISCELLANEOUS FINISH CARPENTRY

Refer to NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS", various applicable sections.

4.3.1 Grade

Custom grade as described in NAAWS "NORTH AMERICAN ARCHITECTURAL WOODWORK STANDARDS" – 1st Edition.

Recommend clear fir, birch or maple throughout. Avoid pine.

Fir, birch and maple are hard enough to withstand scratching or denting, whereas pine is soft and susceptible to damage from everyday activities.

4.3.2 Coat Racks

Ensure spacing and sizing of coat pegs are adequate for heavy winter parkas, coveralls and similar garments.

Typically provided in schools, community offices and group homes.

Parka hooks in school corridors should be installed with a protective over shelf to help prevent head height injuries.

Wood dowel coat hooks mounted at child access heights can present an eye injury hazard.

4.3.3 Radiation Covers

Premanufactured metal radiation cabinets are preferred. Custom wood radiation cabinets or covers are acceptable only for special use buildings if a simple means of removing sections to allow cleaning of fins and access to valves is provided. Covers that require dismantling of millwork to access valves are not acceptable. Wood radiation cabinets or custom covers are not recommended for use in intensively used buildings such as arenas and schools and similar buildings used by the general public.

The design of custom wood radiation cabinets in past installations has made it impossible to clean the fins without dismantling woodwork. They also have a higher initial cost than standard metal cabinets, and increased repair and maintenance cost.

Experience shows that garbage and debris accumulates in radiation cabinets making ready access for cleaning essential.

H5 SPECIALTIES

Specialties include fixtures, furnishings, fittings and installed equipment not addressed in other GBP sections or articles. Specialties need to be selected for:

- Availability;
- Installation simplicity;
- Ease of repair;
- Function;
- Durability;
- Ability to resist damage;
- Can be repaired or replaced with materials and skills available in the local community.

5.1 WASHROOM ACCESSORIES

Durability and damage resistance are important because washroom accessories are often subject to abuse, including scratched or applied graffiti. Coordinate washroom accessories with the local/regional janitorial supplier to ensure accessories work with available cleaning and paper products.

5.1.1 Shower Surrounds

Glass fibre, reinforced acrylic moulded units, or PVC pre-formed units are recommended. Integral grab-bar systems or the ability to attach standard grab bars are recommended.

Pre-moulded units are easily cleaned, easy to install, and provide a durable surface.

Ceramic tiles or prefinished panel materials requiring jointing on site are less preferable for small installations, but are acceptable in institutional settings where routine maintenance is provided to maintain grouted joints and fixtures.

Routine sanitation using antibacterial and anti-fungal chemical cleaners causes early deterioration of plastic surfaces, but work well with impervious ceramic faced wall tiles. Periodic re-grouting as an ongoing operational cost needs to be considered.

Health centres and Long Term Care facilities are subject to special requirements, to be prescribed on an individual basis.

5.1.2 Toilet Partitions

Solid plastic partitions are preferred.

Typically required in all public washrooms, where durability and ease of cleaning are important.

Standard manufacture plastic laminate or baked enamel finish metal partitions are less durable but may be acceptable upon approval.

Site-built partitions generally cannot withstand heavy use and become a maintenance problem for cleaning and repairs.

Site-built partitions are not acceptable.

Floor mounting is recommended. Suspended units should be considered when frequent sanitation cleaning of the floor is required, such as in a health care facility or similar washroom used by the general public.

Suspended partitions generally require additional bracing to achieve the same robustness and impact resistance as floor mounted systems. Suspended systems are more expensive because of the extra structural support required at the ceiling, and the additional fittings needed to attach the system to the building overhead structure.

5.1.3 Washroom Accessories

Work in consultation with building staff and maintainers to provide washroom accessories that meet their needs. Washroom accessories shall be stainless steel.

Standard of acceptance are products manufactured by:

- Bobrick
- Bradley
- Frost Metal
- ASI Watrous

5.1.4 Backing

Solid wood blocking or backing must be installed for all fixtures, fittings, furnishings, equipment and hardware to be mounted on wood framed or steel stud framed walls.

Secure, safe and vandal-resistant installation is aided by solid anchor points for installed accessories, including toilet compartment partitions where they are attached to walls and ceilings.

5.2 SIGNS

The following recommendations describe sign types and styles currently recommended for the environmental conditions affecting GNWT buildings. Signage to comply with requirements of CSA B651-12.

5.2.1 Language

On all signs, Official Indigenous Languages of the Designated Area shall be placed before all other Official Languages. The order of English or French is not outlined and is at the discretion of the Department. International graphic symbols are to be used as appropriate.

In practice, when all languages are being used, it is recommended that the translations be listed in alphabetical order of the languages. (ex: Chipewyan, Cree, English, French, etc.)

Buildings accessible to the public are recommended to follow the current official languages policies in effect in the jurisdiction in which the building is located.

Official government language policies have broad practical application for all sign requirements in NWT communities. Buildings typically affected include public facilities like air terminals, schools and health care facilities, in addition to commercial and mercantile occupancies.

Official language policies are available from the Office of the Languages Commissioner: https://olc-nt.ca/

5.2.2 Exterior Signs

Cast bronze letters or painted cast aluminum letters, individually mounted, 12.7 mm thick, 200 mm high are recommended for durability. Syllabics should be in modules of 50 mm to a maximum of 200 mm. Roman Orthography (English) lettering is recommended to be upper case Helvetica for facilities designated for general public access.

These have proven to be acceptable and practical in use for the past several years.

5.2.3 Interior Signs

.1 Room Names

Laminated plastic, 3 mm thick plates, engraved or subsurface printed lettering and symbols are durable and practical.

These have been proven to be acceptable where used for the past several years.

Colours should be coordinated with building interiors.

.2 Directory Boards

Removable inserts are preferred. Avoid using individually mounted letters.

These are simple to install and provide a neater appearance than individually mounted letter systems.

.3 Interior Doors

All doors are recommended to be identified with names and space designation numbers to match the names and room numbers on the building record drawings and updated as changes are made to the floor plan.

Maintenance co-ordination and way-finding for persons unfamiliar with a particular building are improved with clear and up to date room and space identification.

5.3 WINDOW COVERINGS

Daylight control is particularly important during the summer months when most NWT communities experience eighteen to twenty-four hours of daylight for as many as four months of the year. Bedrooms in residential facilities need to be able to be darkened effectively with curtains or blinds provided, as well as any rooms where screens and projected images may be used.

5.3.1 Blinds

Roller blinds are recommended for most applications. Anti-ligature devices are recommended, and the blinds should have an easily cleanable surface.

Horizontal blinds are acceptable

- where windows are located to minimize incidental damage from rough use or impacts,
- Where excessive raising and lowering is not a requirement.

Perforated plastic (accordion style folding) or small slatted metal blinds are acceptable.

Plastic or metal are simple to clean, compared to fabric blinds.

Fabric blinds should be selected for durability, ease of vacuum cleaning, and light transmission properties to meet the

Some fabric blinds have tightly woven smooth textured surfaces allowing vacuum cleaning.

need of the program, including appropriate fire-resistance.

Caution: Some flame resistant finishes can be washed out by cleaning. Selection of fabrics must take this into account.

5.4 MAJOR APPLIANCES

Nationally recognized major appliance brands, supported by strong North American distributor and repair agencies, are recommended to be selected for installation where repair services for less commonly available appliance brands are not always available.

5.4.1 Kitchen Appliances

Preferred manufacturer brands of stoves, fridges, freezers and other major kitchen appliances are recommended to be confirmed with local building asset management agencies. Standard sizes and energy efficient models meeting current Energy Star ratings should be selected.

The objective is to simplify the number of parts stocked, and simplify repair trade's maintenance routines and time requirements.

5.4.2 Laundry Equipment

Preferred manufacturer brands of washing machines, dryers or other laundry equipment are recommended to be confirmed with local building/asset management agencies. Standard sizes and energy efficient models are recommended to be selected.

The objective is to simplify the number of parts stocked, and simplify repair trade's maintenance routines and time requirements.

H6 COORDINATION

This section identifies some structural, mechanical, electrical or site considerations that typically require design integration with architectural building components and systems.

6.1 MECHANICAL EQUIPMENT

Mechanical equipment major installations such as boiler rooms and ventilation fan rooms should be positioned in the building for easy and convenient access. Situating ventilation rooms in upper stories of buildings and on roofs, whether exposed to the weather or enclosed in mechanical penthouses, creates access problems for servicing, routine inspection and major component replacement, requiring space for access stairs. Wherever possible, it is recommended to locate mechanical equipment service spaces at or near convenient ground floor access, and near a building perimeter location near service vehicle parking spaces.

6.1.1 Space Requirements

Adequate space should be provided in mechanical rooms for plumbing, heating and ventilation equipment, including required clearances and access for maintenance. See notes in *GBP J (Mechanical)*

Cramped mechanical rooms with minimal clearances and inadequate access for maintenance, limits efficient maintenance and operation, reducing the service life and economic benefit of efficient operation of mechanical systems and components.

Space in wall and floor assemblies is often required to accommodate plumbing and ducts. Great care must be taken that these spaces do not deteriorate the continuity and effectiveness of the environmental separation functions (air, vapour and thermal separation) of the building envelope.

Providing adequate space can be problematic where long plumbing runs are required and structural floor space is limited.

6.1.2 Access to Service Spaces

Control and maintenance of heating and ventilation system equipment requires access to controls and equipment. Access panels are typically required to be provided in ceilings and walls.

Fairly frequent access is typically required, especially when building is newly occupied and operator is becoming familiar with system, or during seasonal weather changes or renovation to building subsystems.

6.1.3 Windows and Skylights

Heat gain and heat loss through windows, clerestory glazing and skylights must be taken into consideration by heating and ventilation system designers. Long solar days in the more northerly latitudes, combined with a generally warming mean annual air temperature (MAAT) trend in northern communities requires thorough analysis for the energy modelling of northern buildings. Refer to *GBP L (Energy Efficiency).*

Changes to architectural design are recommended to be systematically passed on to mechanical design consultants as standard operating procedure for the integrated design process. When ventilation systems cannot manage unexpected summer heat gains, the facility can become uncomfortable and exceed workplace environmental standards required by the Workers' Safety and Compensation Commission.

6.1.4 Stair Access to Mechanical Service Space

The use of vertical ladders to access elevated mechanical rooms or service spaces is not recommended. Stairs, including alternate tread stairs, should be the means of accessing these spaces.

Vertical ladders make access to mechanical spaces very difficult and unsafe because both hands and feet are required to use a vertical ladder safely, making equipment, replacement parts and tool carrying difficult.

A ships ladder is only acceptable if it is the only possible means of access. Ships ladders must be accompanied by a hoisting mechanism to allow equipment and tools to be hoisted to and from these areas.

Ships ladders are acceptable if it is not possible to install stairs, and there are no other means to access the mechanical areas. Recommended use of alternate tread stairs which are more compact than standard stairs and comparable in footprint to a ship's ladder is encouraged. A hoisting mechanism is also required to enable tools and equipment to be raised and lowered.

6.2 ELECTRICAL EQUIPMENT

Electrical equipment major installations such as standby generators, main entrance switch gear, primary control centres and building communication and control service equipment rooms should be situated in the building for easy and convenient access. Wherever possible, it is recommended to locate standby generator service rooms near to, or combined with, mechanical equipment service spaces at or near convenient ground floor access, and by a building perimeter location that is near service vehicle parking spaces. Refer to *GBP K (Electrical)* for detailed requirements.

6.2.1 Space Requirements

Adequate space is required for electrical equipment, including required clearances and access for maintenance. This may require coordination with mechanical design as well as electrical design. See *GBP K (Electrical)*.

Cramped electrical and mechanical rooms with minimal clearances and inadequate access for maintenance limits efficient maintenance and operation, reducing the service life and economic benefit of efficient operation of mechanical and electrical systems and components.

6.2.2 Access

Pull and junction boxes need to be accessible in the event electrical changes are required.

Although access is not frequently required, lack of access means that ceilings and walls will have to be patched any time they must be accessed. See GBP K (Electrical) and the Canadian Electrical Code requirements are recommended to be fully complied with.

6.2.3 Electrical Outlets

Electrical service equipment and distribution components are recommended to not be installed in the building exterior envelope unless they are positioned fully on the interior (warm) side of the air-vapour barrier system. Outlets located on exterior walls, roofs and floors, and conductors that run through the building envelope must be positioned so that they do not interrupt the continuity of the building air and vapour barriers, or create thermal bridges across the thermal insulation components of floors, walls or roofs.

Electrical components poorly sealed into the building envelope are a primary cause of excessive heat and air leakage and uncontrollable energy losses. Positioning wires and conduits and the service points they feed fully within the insulated and interior air shed portion of walls, roofs and floors provides the most sustainable and economical operation of the building.

6.3 LIGHTING DESIGN

Fixture locations shall be coordinated with structural and mechanical components to provide effective maintenance access. Lighting fixtures need to be positioned to allow access to the lighting fixture to change bulbs and ballasts.

The objective is to avoid the need for on-site changes and to prevent lighting obstructions. Electrical and mechanical rooms with high ceilings and minimal clearances around piping etc., make it extremely difficult to access lighting fixtures when changing ballasts, bulbs and fluorescent tubes.

Exterior lighting fixtures situated higher than three meters above the ground shall be equipped with fall arresting wall hooks for worker safety harness attachment.

Wall hooks are required for personnel to attach to whilst accessing the lighting fixtures for maintenance.

Fixture styles should be coordinated with decorative or architectural themes.

Fixtures in prominent or well populated areas of the building are to be selected collaboratively by the electrical designer and the architectural designer.

Day lighting zones and electrical lighting zones are recommended to be coordinated.

Adequate daylight can make electric lighting redundant at times; however, energy savings can only be realized if electric lighting can be selectively turned off when not required.

6.4 RECESSING OF FITTINGS

Avoid mounting electrical service equipment where risk of injury to persons exists because of individually projecting fittings, hardware, or similar items. If these items are within two metres of the floor level, provide protective enclosure guards or recess the equipment.

The intent is to minimize the risk of people running into installed equipment or hitting it with carried tools or equipment.

H7 ACCESSIBILITY

Barrier-Free (BF) accessibility in our existing and new buildings is important to the GNWT and the Territory.

This section identifies items to be followed when addressing the issue of barrier-free accessibility for existing buildings for persons with physical, sensory, developmental and mobility challenges. The aim is to provide inclusive spaces, designed for equitable use among people with diverse abilities. The information in this section has been adapted from the Technical Design Requirements for Alberta Infrastructure Facilities.[1]

7.1 NEW CONSTRUCTION

The following list indicates the accessibility requirements for all new GNWT construction projects;

.1 Meet CSA B651-12 requirements in the following areas of the facility:
- all spaces accessible by the public
- all resident areas and spaces accessible by residents
- all administrative office spaces

.2 Where requirements cannot be met, a written explanation shall be provided for approval.
.3 Where disparity or conflicts exist in the documents provided, the more stringent requirement shall apply.
.4 No mirrors to be used in circulation areas.
.5 Kitchens design to deviate from B651 standards. Kitchens will include one counter that is height adjustable, size to be 1000 wide x 600mm deep. Counter shall match surrounds. This counter will be completely open underneath. This requirement does not need to be followed for kitchenettes (small kitchen with no cooking area).
.6 Tactile indicators are not required at curb ramps.
.7 Tactile direction indicator surfaces are not required.
.8 In washrooms that have more than five stalls, one stall shall be designed as a toilet stall for users with limited mobility, following CSA B651, clause 6.2.7.3

7.2 BARRIER FREE ACCESSIBILITY IN EXISTING BUILDINGS

Requirements are described in conformance with the “critical path method” which provides the order in which requirements should follow in sequence. If the sequence is not followed, portions of the building may be upgraded to barrier-free status but may not be accessible. For example, a washroom may have been upgraded, including all washroom items including door opening size, but if there is not the required space adjacent to the door to accommodate operation of the door by persons with disabilities the washroom is not barrier-free accessible.

7.2.1 References

- *CAN/CSA-B651-95, Barrier-Free Design*, Canadian Standards Association.
- National Building Code (NBC), latest edition, Section 3.8.

7.2.2 Level of Barrier-Free Accessibility

The first step in developing a barrier-free accessibility upgrading project is to set the level of accessibility based on general objectives and funding available. The level selected will be determined from each of the three variables below.

.1 Number of Floors
  .a Main Floor only
  .b Main Floor plus other floor(s)
  .c All Floors

.2 Extent of Upgrade
  .a Public Areas Only
  .b Throughout Standard of Upgrade

.3 Standard of Upgrade
  .a To meet the National Building Code (NBC)
  .b To meet the NBC plus CSA Standard B651

Thus the minimum level of accessibility upgrade, based on this classification system, is Main Floor/Public Areas Only, as indicated in the National Building Code and the maximum level of upgrade is All Floors/Throughout/NBC plus CSA-B651.

Notwithstanding the foregoing, the level of barrier-free accessibility or portions thereof, shall be determined by the GNWT in consultation with the project stakeholders, on an individual project basis.

7.2.3 Design Requirements

Refer to Section 3.8 of the National Building Code (NBC), which provides the minimum requirements for Barrier-Free Design. As all projects are unique, some may require minimal renovations to achieve the projects and the NBC barrier free requirements, while in other cases, extensive renovations may be necessary. These circumstances should be identified early in the pre-design/programming phase, so as to be appropriately defined in the scope of work.

Refer to the CSA Standard B-651 for design assistance. Wherever possible, incorporate the requirements of this standard into the design, within the scope of work of the individual project.

Where the NBC and CSA Standard B-651 address the same issues, when practical, the more stringent recommendations should govern. For items listed in NBC 3.8.3.1, CSA B651 shall be applied, where possible.

7.2.4 Code Analysis

Perform a comprehensive building code analysis of the particular building including building occupancy, occupant load, fire resistance rating requirements, corridor and stair widths, exit requirements, and required number of water closets and lavatories based on occupant load. With this analysis, provide the particulars of the code pertaining to Barrier Free design and section 3.8 of the current NBC, as these relate to the building to be renovated.

Note: the occupant load is based upon area available for people, not number of persons using the building. Optimally all concerns should be addressed.

7.2.5 Design Development

Ensure all the following issues are addressed in order, unless directed otherwise by the GNWT or as dictated by the project circumstances.

.1 Site Accessibility
- .a Consider barrier-free parking, complete with curb cuts/ramps, exterior lighting, and signage.

.2 Building Access
- .a Building Entrance Accessibility: consider method of accessing the building entrance from the street, parking areas and walkways.
- .b Building Entrance: consider thresholds, powered door operators, location of controls, guard rails and required number of barrier-free entrances.
- .c Consider appropriateness of location, dignity and prominence of barrier-free devices.

.3 Accessibility of Path of Travel within Main Level
- .a Access to Facilities: consider width of corridors and exits, differing elevations of floor levels, flooring requirements, door width and door location requirements, door hardware requirements.

.4 Personal Facilities
- .a Hygienic Facilities: determine if existing washrooms can be modified or if it is more feasible to introduce new separate washrooms to meet barrier-free requirements. Then, consider required sizes of facilities, building plumbing fixture requirements, washroom accessories and mounting heights.
- .b Personal Use Facilities: consider requirements for drinking fountains and service counters.

.c Consider the value added function of a universal barrier free washroom that can serve as baby change room, and a trans-gender washroom.

.5 Accessibility to Other Levels

.a Stairwells: consider stair width, landing sizes, stair surfaces and nosings, handrails and guardrails, and lighting.

.b Areas of refuge: consider where and to what extent the areas of refuge are required. Often these are provided within stairwells, but not always. Coordinate the Barrier Free fire escape planning with the local fire chief or authority having jurisdiction.

.c Chair Lifts: determine if chair lifts can be used to provide access to other levels while ensuring the required exit width is not minimized when chair lift is in operation.

.d Platform Lifts: consider the travel distance limits and location. Generally, platform lifts are only acceptable for use within one floor level.

.e Enclosed Platform Lifts: consider use restrictions, travel distance limits, requirements for shaft and machine room, and location.

.f Elevators: consider size, travel distances and speed, suitability of various types, location, accessibility and design of controls.

.6 Accessibility of Path of Travel Within Other Levels

.a Consider the requirements for each accessible floor to provide at least the same level of barrier- free accessibility provided on the first barrier-free level.

.7 Emergency Services: Emergency Lighting, Exit Signs, Fire Alarm, Area of Refuge.

.8 Signage within the Barrier-Free Path of Travel:

.a Minimum NBC Requirements: provide signage for barrier-free services and facilities provided.

.9 Building Security

.a User Actuated Systems: consider mounting heights of actuation devices and requirements for audible and visual signals to indicate when door lock is released.

.b Remote Actuated Systems: consider mounting heights of call devices and requirements for audible and visual signals to indicate when door lock is released.

7.2.6 References

- Technical Services Branch, A. (2018). Barrier-Free Accessibility in Existing Buildings. *Technical Design Requirements for Alberta Infrastructure Facilities*. Retrieved November 30, 2018.

MECHANICAL

INTRODUCTION

People have come to expect a closely controlled, comfortable indoor environment with ample supplies of hot and cold running water in the buildings where they live and work. Making buildings comfortable in a Northern climate requires more energy than in a temperate zone, and ever rising energy costs have a great impact on operational costs of Northern facilities. The efficient and economical use of energy is an important consideration in building mechanical design. Developments in controls and mechanical systems have increased building energy efficiency. However these sophisticated systems may be more difficult and costly to maintain, especially in remote locations where qualified workers are not always available.

For this reason, 'simple and reliable' mechanical systems are desirable in all buildings. Of course, the demands made of a system limit just how simple it can be. There are no trouble-free systems. The guidelines and recommendations in this section are based upon installations that have been found to function well and require the least maintenance. A balance must be struck between the sometimes conflicting demands for occupant comfort, energy conservation, and building system simplicity and reliability, not only in the field of mechanical system design but in all aspects of facility design. Whenever possible, a team or "integrated design" approach should be considered, in which all design disciplines and building stakeholders work together throughout the design process. This process tends to result in more sustainable, comfortable and efficient buildings than the traditional building design procedure in which mechanical and electrical services are fitted in to a completed architectural plan.

Table of Contents (to follow)

J1 CODES AND REGULATIONS

Note: The latest edition of a code, regulation, standard, or other referenced document is to be used. "Latest Edition" is herein deemed to mean the latest edition of a code or standard adopted by the local "Authority Having Jurisdiction" or referenced in the relevant codes. It is the responsibility of the designer to ascertain which version is the "Latest Edition" of any relevant Code or Standard.

- National Building Code of Canada
- National Fire Code of Canada
- Fire Prevention Act of the Northwest Territories (and enabled regulations) (See G6 "Codes and Regulations")

Other documents referenced by the NBC, the NFC, or this document include, as applicable:

- National Fire Protection Association (NFPA) Codes
- National Plumbing Code of Canada
- ASHRAE Handbooks, Standards and Guidelines (or sections thereof)
- SMACNA (Sheet Metal and Air Conditioning National Association) Publications and Guidelines
- American Society of Plumbing Engineers Data Book
- GNWT "Good Engineering Practice for Northern Water and Sewer Systems"
- GNWT Department of Health and Social Services Building Standards for Potable Water and Sewage Holding Tanks
- NWT Safety Act
- NWT Boiler and Pressure Vessel Act
- NWT Gas Protection act
- CSA Z317.1 Special Requirements for Plumbing Installations in Health Care Facilities
- CSA Z317.2 Special Requirements for Heating, Ventilation, and Air Conditioning Systems in Health Care Facilities

- CSA Z317.13 Infection Control during Construction, Renovation, and Maintenance of Health Care Facilities
- CCME Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum Products and Allied Petroleum Products
- Canadian Construction Association Mould Guidelines for the Canadian Construction Industry CCA 82
- CSA B214 Installation Code for Hydronic Heating Systems
- CSA B139 Installation Code for Oil-burning Equipment
- CSA B149.1 Natural Gas and Propane Installation Code
- CSA B149.2 Natural Gas and Propane Tank and Cylinder Installation
- CSA B365-01 Installation Code for Solid-Fuel-Burning Appliances and Equipment
- CSA B366.1-M91 Solid Fuel-Fired Central Heating Appliances
- National Energy Code of Canada for Buildings*
- GNWT Petroleum Products Division Standard Specifications, Detail Drawings, and Design Rationale for Northern Fuel Storage Facilities
- Other documents as applicable

*The design process for facilities shall include an Energy Modeling analysis referenced against the NECB and may (at INF's request) include an Energy Modeling Workshop, to maximize the energy savings potential of the facility while maintaining the cost effectiveness of the relevant payback period.

J2 OPERATION AND MAINTENANCE

2.1 GENERAL

See G1 "Local Resources" and G4 "Appropriate Technology".

2.2 MAINTAINABILITY AND OPERABILITY

Facilities should be designed and equipment selected so that maintenance is minimized and servicing is made easy, and operation is convenient. During the planning and design review processes, input from facility maintainers should be sought, addressed, and incorporated into the building design, in order to address the future maintenance requirements of the facility as proactively as possible. Operators can contribute a unique perspective on how the facility will actually be operated, information which is commonly not available from facility design guidelines or the equipment manufacturers. Retrofitting the needed maintenance provisions into a completed facility is usually less cost-effective, and can pose a threat to personnel safety and quality of workmanship until resolved.

2.3 ACCESS

The design of mechanical systems must take into account the location and ease of maintenance access of the building's systems and equipment. For example, the quality and frequency of servicing can be adversely affected if maintenance must be carried out in cramped, uncomfortable and inaccessible spaces by a maintainer wearing heavy winter clothing. Concealed ducts or equipment are to be located and provided with access so that servicing is made easy. Mechanical rooms and crawl spaces should be designed to provide adequate space for servicing or replacement of all equipment.

In mechanical equipment spaces, adequate service access is required for the transport of equipment, material and tools in or out of the space. Additionally, where anticipated maintenance activities will require handling of heavy components or hard-to-reach spaces, appropriate lifting provisions should be included in the design of the space, such as maintenance monorails, jib cranes, or aisle-ways for portable lifting devices. Provision is to be made for the hoisting of heavy replacement parts where equipment is installed above the floor level or on mezzanine levels.

Vertical or ship's ladders are not an acceptable means of access to any equipment room above the main floor. It is dangerous to climb a ladder while carrying tools or materials. A full stair is to be provided, preferably one accessed from the outside of the building, so as to avoid the need to transport equipment through the building.

For equipment suspended from the ceiling (for example, fans), adequate servicing access is to be provided for maintenance and repairs. This may require installation of a platform or portable lift (and the allowance for adequate storage space for this unit). Fall restraint equipment may also be required.

Oil-fired heaters are not to be suspended from the ceiling.

Where equipment will be subject to predictive maintenance techniques (e.g. oil sampling, vibration monitoring, thermal imaging), safe access should be provided to the relevant sampling points (e.g. drain plugs, bearings).

2.4 LIFE CYCLE MANAGEMENT

It is desirable to determine the life expectancy of a facility, its major equipment, and critical components. This provides transparency for all stakeholders of the relative lifespans and enables early consideration of equipment overhaul and replacement schedules and costs. When specifying and selecting equipment, the life cycle cost over the life of the facility should be considered – including the anticipated costs of equipment and component replacement – and not merely the initial purchase price.

2.5 SPARES

Spare parts are required for certain elements and equipment in a building. Replacement equipment and parts are often difficult to transport to small remote communities, with correspondingly long lead times.

A Critical Spare Parts List must be developed during the project, in conjunction with the equipment manufacturers, and the initial set of spare parts shall be provided by the project at turnover. The spare parts list will be developed on a project-by-project basis, and based on a spare parts criticality analysis which considers:

- Recommendations from the equipment manufacturers
- The requirements of the local regional facility manager
- The criticality of the spare part (i.e. “What happens if we don’t have it?”)
- The availability of the spare part (including delivery to the community)

Separate from the Critical Spare Parts List for operations, a Commissioning Spares List should be developed to ensure that project commissioning is not delayed due to lack of a spare part. The Commissioning Spares List should be developed soon after equipment orders are placed, and include parts which can rapidly fail during equipment startup, for example: drive belts, fuses, filters, gaskets, and seals. Upon completion of commissioning, any leftover commissioning spares should be checked into the spare parts inventory along with the critical spares.

Spare parts which are consumed during construction and commissioning are to be replenished at the end of commissioning. Some codes (i.e., NFPA 13) mandate numbers of spare parts to be provided.

The supplying of spare parts in "kits" or "lots" by equipment vendors should be discouraged, as this results in a future barrier to precise warehousing and inventory management of individual parts as they are consumed. Rather, vendors should recommend, supply, and label spare parts in an itemized fashion.

2.6 STANDARDIZATION

In the interest of maintenance, the equipment for any particular function should be compatible with the existing O&M parts inventory currently used in the area, region or community. Standardization of equipment also minimizes training requirements for maintainers, and accordingly can improve reliability.

2.7 OPERATION AND MAINTENANCE MANUALS

O&M manuals are to be provided for every project unless specified otherwise. Their contents are to be as per the requirements of ASHRAE Guideline 4 and be organized in a similar fashion.

Draft O&M manuals must be provided two (2) weeks before Substantial Completion. Final completed O&M manuals are required before the project is deemed complete. Record drawings**

J3 IDENTIFICATION

The operation and maintenance of mechanical systems requires maintainers to have a good understanding of the building systems and their components. The use of a standard system for piping and equipment identification is an important aid in maintenance and troubleshooting. Such a system should include pipe colour-coding and direction-of-flow arrows, valve and controller tags indicating valve name, location, and setting and equipment identification tags or labels. An associated identification list shall be posted for reference in a visible location in the relevant mechanical spaces.

Piping systems shall be identified according to the ASME A13.1 Standard “Scheme for the Identification of Piping Systems”.

Ductwork shall be identified with painted labels showing the type of airflow (supply, return, exhaust, etc.,) and arrows showing direction of flow.

All piping, ducting and other identification shall be installed with a view to easy reading from a position standing on the ground.

Equipment nameplates should be easily read. If other installation requirements make it impossible to read the nameplate from a normal observer’s position, then a copy of the nameplate should be made, laminated, and installed in a visible location nearby.

J4 PLUMBING AND DRAINAGE

The selection of the type of plumbing system has a significant impact on mechanical construction costs and building operational costs.

Some questions to consider are:

- Does the community have a municipal system?
- If it has a municipal system, whether to connect to it or not.
- If a tanked system is selected, what is the size of the water tank and where in the building will it be located?
- If the building has a fire sprinkler system, what size of the tank is needed for fire water?
- If a tanked sewage system is selected, what is the size of the sewage tank and where will it be located?

These requirements generally apply to systems contained within the building. Refer to the document "Good Engineering Practice for Northern Water and Sewer Systems" for a more complete discussion of municipal servicing requirements which affect building construction.

4.1 DOMESTIC WATER - PIPED SERVICE

Less than 25% of all NWT communities have piped service. In some of these locations water lines are buried; where lines are not buried, they are run in above-ground utilidors.

Water treatment in all communities consists of the addition of chlorine and/or filtration, and is the responsibility of the municipality. Even though the NWT has abundant fresh water, capital and operating costs of delivered water are high, making water conservation very important.

4.1.1 Municipal Connection

Connection to a municipal system is preferred, when available.

While this is usually more costly, especially when installation of a manhole is required, connection to the municipal system has the following advantages:

lower cost than water truck delivery
the building will not run out of water

Where municipal water supply pressure exceeds 551 kPa (80 psi), the National Plumbing Code of Canada requires provision of a pressure-reducing valve (PRV). In some areas of Yellowknife, municipal water supply pressures may exceed this level.

Municipal water pressures must be checked to determine if a pressure-reducing valve will be required on the incoming main.

Some areas of Yellowknife can experience large pressure surges.

4.1.2 Water Meters

Water meters are to be installed only in buildings that are connected to a municipal water system.

Metering of water is required for buildings connected to a municipal water supply in order to monitor water consumption. Buildings supplied by a truck delivery system do not require water meters, as the truck meter measures the quantity of water delivered.

4.2 DOMESTIC WATER SUPPLY - TANKS

Water delivery by truck for storage in holding tanks located within buildings is common in smaller NWT communities. Deliveries are generally made once or twice a week on a regular schedule. Water conservation is especially important where tanked water is used. The space required to store adequate water for a building can be considerable. A structural designer should be consulted regarding proper tank support.

4.2.1 Potable Water Supplies

.1 Consumption Estimates

In the case of additions to existing buildings, it must be determined whether the existing tank is large enough; if it is not, more water storage must be provided. The actual water consumption records from the past three years can be reviewed to determine the actual water use. This figure can be used (in conjunction with the recommended

Actual building water consumption may deviate significantly from the estimated consumption used to size the original water tank. Actual consumption is often much lower than anticipated. The lower consumption may be due to changes in usage (for example, little use of showers in school change rooms) or the installation of low-water-use fixtures during renovations.

minimum storage quantities below), to determine whether the existing tank has sufficient capacity.

The following are the recommended minimum acceptable amounts to be used in calculating the estimated total daily consumption of potable water for new buildings:

Consumption estimates for new buildings are normally based on program information or engineering standards; however, such information is not always available or appropriate for NWT conditions.

.a Residential Occupancies:
90 litres/resident/day; 25 litres/staff/day is sufficient for non-resident staff.

This is the GNWT MACA standard for residential occupancies.

.b Non-residential Occupancies:
25 litres/person/day.

This figure is based on a review of actual consumption figures for NWT buildings.

.2 Supply
Water storage capacity for any given building is established by calculating daily usage rates based on the usage figures noted above, multiplied by the usual number of days between deliveries in the community.

It is important to consider the correct number of days between water deliveries in the community when sizing the water tank. If an arbitrary and too-large delivery frequency is used, the tank will be oversized and more costly. But more importantly, the tank water will not be refreshed as frequently and will tend to stagnate.

4.2.2 Emergency Water Supplies

Potable water storage capacity may be increased up to a maximum of 10 day supply if:

.1 a building is designated as a community reception or evacuation centre under the "Civil Emergency Measures Act", or

There are currently no regulations which govern water supplies for community reception or evacuation centres. A 10-day supply is suggested since water delivery service could be interrupted or delayed during emergencies.

Typically schools are often designated as community evacuation or reception centres, but this emergency water guideline could apply to other community buildings as well. It *is important (for this and other design considerations) to determine early on the design process whether a building is to be a community evacuation point.*

.2 a prolonged shortage of water would require the relocation of residents.

This would apply to any long-term care or detention facilities and student or staff residences.

4.2.3 Fire Protection Sprinkler System Reserve

See Section M5.2.

.1 Separate Tanks for Fire and Potable Water

Potable water supplies must be stored in dedicated tanks, separate from any water supplies reserved for fire protection.

In the past, potable water and fire water were often stored in the same tank, to the detriment of drinking water quality.

A connection between the potable water storage tanks and fire protection system should be provided so that potable water is added to total capacity of water available to fight a fire.

The provision of separate tanks ensures that drinking water is constantly replenished and kept fresh. The use of separate tanks also facilitates tank cleaning. Potable water storage tanks require frequent cleaning, while fire water supply tanks do not.

4.2.4 Tank Construction

All water storage tanks should be fibreglass or polyethylene and constructed to CAN/CGSB 41.22-93 Fibreglass Reinforced Plastic Corrosion Resistant Equipment.

The CGSB standard is a more suitable standard for water storage tanks than the AWWA C95 standard. The rated test pressures of the AWWA standard far exceed those required for an atmospheric tank. Construction to CGSB ensures better longitudinal strength of pipe *tanks.*

Water tanks must be provided with:

- a drain or tap, situated so the entire tank may be drained by gravity to exterior.
- easily-accessible access holes of minimum inside diameter 600 mm, with water-tight child-proof covers that can lock in the open position. For large tanks, the number of access holes is specified in the NWT Safety Act and regulations.

To prevent over-pressurization of the water tank when overfill pipes freeze, an interior vent line is required.

The CGSB standard does not state a working tank pressure. Tank manufacturers have stated they cannot build straight-walled tanks to meet high pressure requirements. Pressure requirements for tanks should be limited to the head in the tank, plus a slight margin of safety. Low-profile tanks must meet CGSB standards.

4.2.5 Location of Domestic Water Tanks

Potable water tanks must be located in a heated area where the temperature is kept between 5 and 15°C.

This temperature range prevents tank contents from freezing or from becoming tepid.

Avoid locating tanks in areas heated by wild loops.

This can lead to unwanted overheating of the water.

On no account are tanks to be installed below grade level.

Tanks installed below grade will over-pressurize and fail due to overfilling.

Do not locate tanks in the same room as boilers or furnaces.

Warm potable water can support bacteria and algae growth, and is unpleasant for users.

.1 Small Tanks (up to 4 200 litre capacity)

.a It is preferable to locate small tanks

This is possible when a tank is small enough to inside occupied building areas.

be located in an occupied building area, where it would be easily accessible.

.2 Large Tanks (over 4 200 litre capacity)

.a It is preferable to locate large tanks in a heated crawl space or basement. However, tanks should not be located below grade.

Tanks of this size take up considerable space, and locating them beneath the main floor does not increase the building footprint. Although the main floor level may have to be raised to accommodate tanks and their access clearance, this is generally preferable to increasing the main floor area, building envelope size and structural capacity.

.b It is acceptable to locate large tanks in a suspended tank room.

Where a heated crawl space or basement cannot be provided because of soil or site conditions, a suspended tank room is acceptable. This may require the main floor to be raised. Where possible, suspended tank rooms should be located to take advantage of any natural slopes of the building site.

.c The location of large tanks in the occupied building area may be considered.

The cost of providing the main floor area with adequate structural support and site limitations may make this alternative undesirable.

.d Bulkhead fittings not to be used with fiberglass tanks.

The coating of the tank can be compromised during installation of the fittings.

4.2.6 Fill and Vent Piping

Fill and vent piping is to be Schedule 80 PVC within the building. PVC is not to be used outside the building.

Plastic pipe gets very brittle in cold outdoor temperatures and can easily crack or break.

Where fill and vent pipe penetrates exterior walls or fire separation penetrations, the piping shall be changed to copper prior to exit.

See NBCC Section 3.1.9 regarding penetrations in fire separations

Water fill pipe connections must match the connection of the local water delivery vehicle.

The fill pipe is to be located so water delivery personnel do not have to pass a sewage pump-out connection when connecting the water truck hose to the building fill pipe. The water fill point must also be located at least 1 500 mm from the sewage pump-out connection, and at least 1 000 mm above it.

This reduces the risk of the water hose being dragged through spilled sewage at pump-out location. The water fill and sewage pump-out service points are to be determined based on the access route, with the water fill point bei ng the first point accessible to arriving vehicles.

A lamacoid identification label is to be provided at the fill point. If the fill pipe location is too high for easy access from the ground, permanent steps (and platform, if required) are to be constructed.

Fill and vent piping is to be graded back to tanks.

This is done so that water drains back to the tank, rather than spilling on the ground, where it freezes and creates a hazard for water delivery personnel.

Vent outlets are to be located on the side of water tanks or extended 100 mm into the top of the tank.

Vent outlets are necessary to vent the tank and protect it from damage, even though they may reduce the effective capacity of the tank.

Provide dual venting for all water tanks: a 75 mm primary vent to the exterior of the building and a 75 mm secondary vent terminating at an interior drain (i.e., over a janitor sink), or piped to a main building vent.

Frozen condensation from the tank can block the exterior vent in winter months, and this could cause the tank to rupture during filling.

Vents terminating outside the building may be screened, where dual venting is provided.

Environmental Health Standards allow either vent termination method. However it should be noted that a screen fine enough to exclude insects during summer will freeze over in the winter. The second vent (in duel venting systems) is required for relief.

4.2.7 Access to Water Tanks

Water tanks must be accessible to maintainers for cleaning and repairs when necessary, and must be drainable without use of an auxiliary pump. The drain must be piped to either the waste tank or to a drain point outside the building foundation. This piping can be permanent or temporary. The following access locations are preferred:

.1 Top access with a minimum of one meter clear space above the top of at least one manhole(s). Built-in steps or ladders are to be provided where the access is located more than 1 200 mm from adjacent ground level. The diameter of the tank should be sufficient to allow a person access for cleaning and maintenance.

Access to the interior of tanks should be as easy as possible to facilitate frequent cleaning. Maintainers must work in enclosed tanks in uncomfortable conditions, so the tanks themselves should be constructed to make the chore as easy as possible. Providing easy access should result in fewer complaints about contaminated water supplies.

Drain valves are to be installed at the low point of the tanks to allow draining of the tank for cleaning.

Access to these tanks may be seen by WSCC (Worker's Safety and Compensation Commission) to be confined space entry, and may require an air pack and line. The manhole should be sized to accommodate this. The designer should consult WCSS, to determine what rules apply and design accordingly.

.3 End or side access to tank is acceptable where service space height is restricted, if the tank has removable ends. Drain valves are to be installed at the low point of the tanks to allow draining of the tank for cleaning.

End or side access may provide easier access for maintainers than top access; however, tank construction is complicated by the need to provide a sealed closure at the tank ends.

4.2.8 Level Alarms

The domestic water tank must be provided with:

- Fill piping to include slow-closing solenoid valve controlled by a high-level switch

This is to prevent overfilling and using the overflow as an indicator of tank level. Post-valve closing drainage to be provided.

- a high level float-type switch, wired to an exterior “Tank Full” light (located adjacent to the water fill point);
- a low level float-type switch which turns off the domestic water pressure system when the water tank level is low. This also protects the pump from burning out.

4.3 DOMESTIC HOT WATER (HW) SUPPLY

Heating of domestic hot water can account for a significant portion of a building's energy costs. Systems must be selected based on initial capital costs as well as operating costs of the equipment.

4.3.1 Indirect-Fired Domestic Hot Water Heaters

Dedicated indirect-fired HW heaters can be used in larger buildings with hydronic heating.

This type of heater is the most energy-efficient and has a low operating cost. These heaters are normally provided for larger buildings with high hot-water usage.

See “M7 Heating” for equipment and configuration requirements of a heating plant for provision of indirect hot water heating.

Consideration should be given to provide a back-up electric hot water heater in facilities where major occupancy is seasonal. This water heater could be used by cleaning staff during times when a building is not generally occupied; for example, in schools during summer.

Schools fall into this category. They may be used for recreational purposes or other reasons in the summer months. The provision of a back-up water heater allows the boiler plant to be shut down in summer.

(If electrical costs are high, a small fuel-fired water heater may be considered.)

Combination indirect electric tanks available, electric tank with heat exchanger not needed

4.3.2 Oil-Fired Domestic Hot Water Heaters

Dedicated, oil-fired HW heaters are preferred for smaller buildings where fuel oil is used for the building heating system.

This type of heater has the second lowest operating cost (after the indirect-fired water heater). These heaters are typically installed in small to medium-size buildings, and in residential facilities.

Fuel oil usually costs substantially less than electricity.

In the town of Fort Smith and surrounding area, electrical costs are lower than in other areas of the NWT. For a project in Fort Smith, unless very large quantities of domestic hot water are required, it is probably more economical to use an electric hot-water heater than an oil-fired one.

Most of Inuvik and Norman Wells had piped natural gas systems. However, natural gas may no longer be available through town systems in these communities. Designers should determine the proper fuel to use in these communities.

Propane is available in certain NWT communities. Oil is universally available.

Both propane and oil-fired heaters are acceptable in large load buildings, with preference given to the one which uses the least- expensive fuel. The designer should specify a unit which can be easily converted between oil and propane. The unit must be rated for dual fuel by the manufacturer.

High efficiency burners only (80% or better) are to be used.

This minimizes fuel consumption.

Non-combustible block bases with 6 mm steel plates are to be used under all oil and gas-fired HW heating equipment installed on combustible floors. See CSA B139. Section 4.15.2

Past experience has shown that even equipment approved for use on a combustible base can burn into the floor.

The high limit control on fuel oil or gas-fired domestic water heaters is to be the auto reset type.

Refer to Section M7.2.2 for chimney and vent requirements.

4.3.3 Electric HW Heaters

Electric HW heaters as the sole source of hot water should be used only where few fixtures are served and estimated daily hot water use is less than 100 litres per day in all other Regions.

These heaters are typically used in smaller buildings with low HW use, in conjunction with forced air heating systems. The life cycle cost will generally be lower than that of oil-fired heaters for this type of application.

Small under-the-counter, electric, domestic hot water heaters may be used alone or in addition to an oil-fired HW heater. Electric HW heaters should also be considered where a few fixtures must be located some distance from a central domestic HW source, and a recirculating system would otherwise be needed to maintain HW.

The high cost of a recirculating system is not justifiable where the fixture use is not high. Local heaters should be considered for complex or multi-purpose buildings where hot water is required at remote areas of the buildings. Typically this would include public washrooms where HW is only required for hand washing.

4.3.4 Propane/Natural Gas-Fired HW Heaters

Propane/natural gas-fired heaters should be used where propane or natural gas is used as the fuel for the building heating system.

Their use should be restricted to communities where propane/natural gas is available: Hay River, Enterprise, Yellowknife, Norman Wells, Inuvik, etc.

4.3.5 Heater Installation

Regardless of type of heater used, all heaters are to be installed within a metal drip pan. Heaters should be piped to a drain or equipped with a moisture controlled automatic shut-off device.

A drip pan provides protection from minor leaks.

4.3.6 Temperature

Refer to the National Energy Code of Canada for Buildings.

.1 When less than 50 percent of the total design flow of a service water heating system has a design discharge temperature higher than 60°C, separate remote heaters or booster heaters shall be installed for those portions of the system with a design temperature higher than 60°C.

This system allows primary domestic HW heaters to be set at lower temperatures to save energy. This is typical for where large volumes of hot water are not required.

.4 Tempered water is required for showers, lavatories and classroom sinks in elementary schools and similar applications. The tempered water is to be provided by using a pressure- balanced mixing valve located at the fixture and set at 42°C.

This is a more cost-effective method of providing tempered water than having two separate domestic storage and distribution systems.

4.3.7 Provision for Monitoring Performance

.1 Provide thermometers in domestic water heaters.

Thermostats and gauges provide information for the building maintainers about the system's performance.

.5 Provide pressure gauge(s) at domestic hot water recirculation pumps.

.6 Provide a cushion tank on all hot water systems for expansion protection of the system.

4.4 DOMESTIC WATER SYSTEM

Domestic water pressure is provided either by a municipal system, or by individual pressure pumps in buildings with holding tanks. In older buildings, freezing of water circulation lines was a common problem, but changes to standard design principles have decreased this risk. The use of higher insulation levels, more tightly-constructed envelopes, grouping of plumbing fixtures and the locating of fixtures away from outside walls and floor assemblies are now common practices in cold climate building design.

4.4.1 Insulation

Refer to the National Energy Code of Canada for domestic water piping insulation requirements.

Insulation is not required because water supplied from ambient temperature domestic water tanks will not be cold.

Insulation is not required on domestic cold water piping systems where the domestic water is supplied from a storage tank in the building.

4.4.2 Domestic HW Circulation

Domestic hot water re-circulating lines should be provided only where heat loss due to the distance of fixture from HW tank would cause users to waste more water than they need while waiting for hot water, and where HW requirement at the fixture is estimated at more than 30 litres per day.

Re-circ lines are typically required wherever showers, baths or laundry facilities are provided and hot water use is high. The cost and complexity of re-circulating systems is generally not warranted in the case of small buildings where only a small amount of hot water is used.

When required, re-circulating lines are to be controlled by a time clock and kept off during unoccupied hours. The pump is to be of smallest motor size (kW) possible.

This reduces energy requirements.

Extend the circulating line directly to the fixture or group of fixtures to ensure hot water is readily available.

Use of the most the direct route (as opposed to running lines down corridors) means less pipe used and less water wasted.

4.4.3 Drain Valves

All water pipes must be sloped and drain valves must be provided at all low points.

To drain water lines, it is simple to use drain valves. However the National Plumbing Code also allows pipes to be blown out with air if drain valves have not been provided.

4.4.4 Location

Avoid locating water piping in the exterior wall and floor assemblies.

This reduces the possibility of pipe freezing.

Domestic water piping is to be installed only in the heated portion of the building.

Domestic hot and cold water lines installed in utilidettes are difficult to heat trace and may freeze.

4.4.5 Tees

Use factory tees only. Do not use T-drill.

Factory tees can be repaired without replacing the tee. Repairs to T-drills require special equipment that may not be readily available.

4.4.6 Access

Easy access must be provided to all valves and faucets. All fixture supplies must be provided with shut off valves for maintenance purposes.

This allows easy maintenance and repair.

4.4.7 Domestic Water Pressure Pump

Pump to be typically selected to operate at 140-280 kPa.

Higher pressure (210-350 kPa) pumps are not needed in most small buildings.

Shallow-well jet pumps are recommended.

These jet pumps are readily available. Select a brand preferred by local maintenance staff.

A sufficient number of valves are to be installed so pumps can be changed without draining the system.

Where viable, it is recommended to use ECM type pumps.

Energy savings and constant pressure control.

4.4.8 Domestic Water Pressure Tank

Bladder-type pressure tanks are preferred.

Non-bladder type tanks tend to become water-logged, making the system ineffective. Select a brand preferred by local maintenance staff.

A sufficient number of valves are to be installed so pressure tanks can be changed without draining the system.

4.4.9 Provision for Monitoring Performance

A standard pump-mounted pressure gauge on the discharge is usually acceptable.

This gauge indicates the pump outlet pressure.

4.5 SANITARY WASTE AND VENTING

The combination of the extremely cold climate and the use of low-flow fixtures in a Northern building can cause drainage problems. A good design provides a drainage system which requires minimal use of supplementary heating (such as heat trace), and allows easy access to drain lines and clean-outs for maintenance.

4.5.1 Grade

All waste lines 75 mm and smaller must be graded a minimum of 2%.

This is the minimum allowed by the NPC for plumbing lines within a building.

4.5.2 Material

The use of ABS piping for drainage lines shall not be accepted.

ABS piping tends to break down in contact with urine.

4.5.3 Location of Drain Lines

Do not locate drainage lines in exterior wall or floor assemblies.

This reduces the possibility of pipe freezing.

4.5.4 Location of Floor Drains

Floor drains should be provided in boiler rooms and fan rooms (where there are water or glycol coils). Provide floor drains in washrooms in public buildings and institutional buildings. Floor drains may be required in other locations depending upon the project.

4.5.5 Trap Seal Primers

Trap seal primers shall be used in service spaces and mechanical rooms. “Trapguard” drain inserts shall be used in all other locations.

Floor drain traps may dry out (especially in mechanical rooms) and sewer gas odours will be noticed in the building.

4.5.6 Clean-outs

Clean-outs are to be installed at all changes in direction greater than 45º on sanitary waste lines.

This is above the requirement of the National Plumbing Code. However it is strongly recommended to use this more stringent design guideline to reduce the incidence of blocked drain lines which require costly maintenance work.

4.5.7 Roof Vents and Roof Drains

.1 Uninsulated copper vent piping is to be used for the last three metres of piping before the vent exits the roof (inside the building). Uninsulated copper drainage piping is to be used for the last three metres of drain line below the roof.

Uninsulated vent jacks can freeze over. Rising vapour condenses and freezes where the vent leaves the heated building. Frost build-up can eventually close the vent entirely.

.2 Hydronic and electric heat trace. *
~~Refer to Electrical Section~~ (formerly 11.2) ~~once complete~~.

.3 Pre-insulated sloped copper plumbing vent jacks are required.

Insulation installed on the copper vent pipe within the building will prevent heat from being conducted up the roof vent and melting ice which may form in the vent pipe. Hence vent pipes should be uninsulated below the roof.

.4 All roof drains connected to building internal drain lines shall be connected by mechanical means only. Only roof drains or drain connector seals that provide a compression seal by mechanical means are acceptable for use to install drains to internal lines. O-rings, mastics, caulking and friction fit seals are not acceptable methods to connect internal roof drains.

Most roofing problems involve water leaks. Ensure that roof drains are installed at roof low points.

4.5.8 Special Traps and Piping

.1 Plaster Traps
Plaster traps should be installed on sinks used for any biology, horticulture, dental

These traps are required to prevent drain blockage caused by materials draining into the sink. The traps must be located so they are or art activities.

easily accessible for maintenance.

.2 Grease Interceptors
Interceptors must be installed wherever deep-fat frying equipment may be used.

Grease interceptors are required wherever commercial kitchen equipment is installed. They must be installed to be easily accessed or removed for cleaning. Larger interceptors may require a separate waste pump-out line.

.3 Acid Dilution Traps and Piping
Acid dilution traps and tanks must be installed wherever acids are used. They must be independently vented.

Acid dilution tanks are required in photo developing facilities, science or laboratory rooms, and elsewhere as required.

All piping and fittings used in these applications must be resistant rated for the application. (For example, acid resistant and fuse-sealed pipe may be required.)

The use of proper piping and fittings will extend the service life of the system.

.4 X-Ray developing fluids
These require suitable traps and piping.

4.5.9 Lift Stations and Sumps

If possible the use of sewage lift stations and sumps is to be avoided.

Lift stations and sumps are maintenance-intensive. If the lift station or pump fails, there will be flooding.

However, where provision of such is unavoidable, lift stations and sumps should be designed as follows.

.1 Lift Stations

Lift stations are to be provided with duplex pumps, a full-access manhole with lift-out rail assembly, and four float switches for the following alarms:

- pump 1 off
- pump 1 on
- pump 2 on

- high-level alarm

The high-level alarm is to be to an audible and visual alarm.

The lift station is to be vented as required by code.

Provide an emergency pump-out line from the lift station to a convenient exterior location. A valve is required on this line with a tag indicating “Normally Closed” and “Open for Pump-out Only”.

.2 Sumps

Sumps are to be provided with:

- a sump pump piped to drain the sump, with a check valve on the riser to prevent backflow into sump,
- a full-access manhole, and
- a float switch wired to provide an audible and visual alarm in the event of pump failure.
- The sump is to be vented to code requirements.
- Provide an emergency pump-out line from the sump to a convenient exterior location.

4.6 SEWAGE DISPOSAL - PIPED SERVICES

Less than 25% of all NWT communities have piped sewer systems (with buried or above-ground piping). When a new building is connected to existing sewer mains, the building owner is responsible for all costs associated with the connection. The work required generally extends beyond the property line and is completed as part of the general construction contract.

In every community with piped services, there may be areas still served by truck. Consultation with the municipality is essential to determine the capability and capacity of existing services, and to become aware of any planned changes or improvements to the system that may affect the project.

These requirements generally apply to systems contained within the building. The document “Good Engineering Practice for Northern Water and Sewer Systems” issued by GNWT Municipal and Community Affairs should be referred to for a more complete discussion of municipal servicing requirements affecting building construction.

Complete descriptions and standard details are included in these manuals.

4.7 SEWAGE DISPOSAL - HOLDING TANKS

Where piped services are not available, septic fields or holding tanks must be used for sewage.

There are very few areas of the NWT with soil conditions suitable for septic fields. The majority of buildings rely on holding tanks serviced by pump-out trucks operated by the municipality. The frequency of pump-out is different in each community. Sewage tanks can be located either in an enclosed crawl space within the building, or buried outside the building. In order for the sewage system to work well, regular servicing is necessary, and sewage must be emptied as often as water is delivered.

Building structural design must allow for adequate tank support.

4.7.1 Health Standard

Refer to GNWT Department of Health, Environmental Health "Building Standards - Sewage Holding Tanks"

Note: This document was developed in consultation with INF and the NWT Housing Corporation. It is currently issued as a guideline for Environmental Health Officers.

4.7.2 Capacity

Sewage holding tanks are to be sized relative to the capacity of the domestic potable water supply only (i.e., excluding reserve for fire protection), as follows:

- large or interconnected buildings: equal
- small/simple buildings: 1.5 times

This clarifies and modifies the previous interpretation of the 1.5 times capacity requirement, which was intended to apply to small buildings only and not to buildings with large tanks, such as those with interconnected occupancies.

4.7.3 Full Indicator

The sewage tank must be provided with a high-level float type switch to turn off the domestic water pressure system when the sewage tank is filled to capacity (but can still accommodate a volume of waste water equal to that of all the fixtures in the building).

This specifies the type of device referred to in Environmental Health Standards.

4.7.4 Construction

Sewage holding tanks shall be designed and constructed in accordance with CSA standards.

Sewage tanks must have a means of access for inspection and repair, with access holes of minimum inside diameter of 600 mm with water-tight child-proof covers that can lock in the open position.

Fibreglass, polyethylene or CPVC are recommended tank materials.

Metal tanks are unacceptable because of their tendency to corrode. Concrete tanks should not be used north of Great Slave Lake as weather and ground conditions may cause the tanks to crack.

If these tanks are to be buried they should be double-walled, insulated, and heat traced (with hydronic lines).

Buried concrete tanks can be used south of Great Slave Lake.

Buried concrete tanks have performed well in these areas. Due to their weight they do not require anti-flotation systems.

Buried tanks must have ballasts such as a concrete pad to which the tank is strapped.

This prevents the tank from floating or lifting when sewage level is low.

**Coordination with arch group for cross-referencing of structural reqs for tanks inside building

4.7.5 Anti-syphon Valve

Sewage holding tanks shall be provided with an anti-syphon valve.

To equalize pressure in sewage tank in the event of the plumbing vent frost closure.

4.7.6 Removal of Solid Matter

Environmental Health Standards state that, "Sewage holding tanks shall be designed and constructed to allow the complete removal of solid matter that can be expected to settle in any part of the holding tank".

A clarification provided by Environmental Health notes that this was intended to mean removal of solids by sewage pump-out vehicles. There was concern over reports that sewage tanks have, on occasion, been cleaned out manually. Tanks should be designed to allow sludge to be effectively removed by the vacuum truck - whether by sloping the tanks or by providing extra access points.

4.7.7 Location of Sewage Holding Tanks

To prevent tank contents from freezing, tanks must be located in a heated area, or must be double-walled, insulated and heat traced. The following preferences should serve as a guide:

See Figures 4-4 and 4-5 on pages 28 and 29.

.1 Tanks buried outside the building are acceptable wherever the soil conditions and water table permit. Buried tanks must be located not less than 15 m from any subsurface portion of the potable water system. The tank must be ballasted and strapped to prevent floating in standing water.

Buried tank installation allows tanks to be located close to roads for servicing and does not require additional building space.

.2 Tanks enclosed within the building (including enclosed crawl spaces) are acceptable where gravity flow is provided. The use of lift stations and/or grinder pumps is not generally acceptable.

This is typical of many buildings in areas with permafrost. Lift stations and grinder pumps increase maintenance problems and costs.

.3 Tanks located in unheated crawl spaces are not acceptable.

Heat trace would be required to prevent contents from freezing, and would be costly.

.4 Tanks located on grade or partially buried are acceptable. These tanks must be double walled, insulated and heat traced. The tank must be ballasted and strapped to prevent floating in standing water.

The placing of a tank on grade is usually less costly than locating the tank in a tank space.

Where a boiler exists, the tank should be heat traced with the heating glycol system.

Heating provided by the boiler is less costly than electricity, despite the higher construction cost.

Provide flexible piping to the tank to allow for differential movement between the tank and the building.

Movements of over 100 mm due to frost heaving are not uncommon.

The tank shall not be located under the building.

Repair of a tank under a building is very expensive.

4.7.8 Pump-out and Vent Piping

The sewage tank pump-out suction line is to be complete with a fitting termination to match the community sewage truck connection. The pump-out connection shall be securely anchored to the building and the sewage line graded back to the sewage holding tank.

This prevents sewage spills on the ground around the pump-out.

The building drainage system must be adequately vented to prevent siphoning of building traps during pump-out.

Pump-out piping is to be:

- black iron piping outside the building and extending 2 metres into the building
- Schedule 80 PVC within the building (with the exception of the first 2 metres)
- insulated within 2 metres of the building penetration
- securely anchored to the building

Plastic pipe is not to be used outside, as it may crack or break in very cold temperatures.

4.7.9 Utilidette Piping

All utilidette piping should be copper.

Heat tracing of non-copper piping is not effective.

4.8 FIXTURES AND BRASS

Fixtures are required to be low-flow to conserve water and reduce waste water. This requirement is most important for buildings on trucked water and sewage. Specific requirements can be referenced in the National Energy Code and National Plumbing Code.

4.8.1 Colour

All vitreous china or fibreglass plumbing fixtures are to be white. Coloured fixtures should only be considered under special circumstances.

This is to unify appearance and to make matching of fixtures simple if replacement is necessary.

4.8.2 Fittings and Trim

Exposed fitting and trim are to be triple chromium-plated.

The quality and durability of this finish is good.

.1 Infrared-Sensing plumbing trim is acceptable where the higher cost can be justified provided the trim is hard-wired to a power source.

Infrared sensing trim has been tried in several installations and works satisfactorily. The benefits are a cleaner public washroom, fewer odours and lower water usage.

.2 Battery-powered infrared sensors shall not be used.

The batteries run out and require replacement.

.3 Spring-loaded faucets are acceptable.

Spring-loaded faucets prevent water wastage.

.4 Wing-handle faucets are not acceptable in facilities to be used by children.

Children can break the faucet by pushing the handle back beyond its travel point.

4.8.3 Sinks

Stainless steel sinks are preferred.

Stainless steel sinks are good for durability.

P-traps for copper piping are to be cast brass. PVC traps are to match the installed drainage piping.

Lighter gauge traps require frequent replacement.

Traps on wheelchair-accessible sinks must have insulation installed on water piping and P-traps to prevent scalding.

All faucets shall have flow restrictors to ensure low water use.

This reduces water consumption and waste.

4.8.4 Hand Basins

Stainless steel basins are preferred for all high use facilities.

Fixtures in high-use buildings must be durable enough to withstand the level of abuse to which they are often subjected.

Vitreous china or stainless steel basins are acceptable in all non-public use facilities.

Non-public-use facilities are less prone to vandalism than are public buildings.

Enamel on steel and plastic or fibreglass basins are not acceptable.

Traps on wheelchair-accessible hand-basins must have insulation installed on water piping and P-traps to prevent scalding.

4.8.5 Toilets and Urinals

All toilet fixtures should be low water use type with a maximum flush volume of 4.8 litres per flush. All urinals are to be low water use type. The exception to this is to provide full flush water closets at the end of long drainage runs with minimal grade to assist in scouring the drain line of debris.

The objective is to reduce water use.

Water closets in areas susceptible to vandalism are to be complete with flush valves, not tanks.

Flush valve toilets are less susceptible to vandalism.

Vitreous china toilet fixtures are preferred. Fibreglass or plastic models are acceptable only in very low-use facilities.

Fibreglass and plastic models are not durable enough for most buildings, although they may be acceptable for installation in facilities normally occupied by fewer than 6 people.

Use of propane-fired incinerating toilets is not acceptable.

The installation of a propane supply may be difficult and installation and maintenance costs are high.

Waterless urinals are not acceptable in any buildings.

Toilet seats in public washrooms shall be extra heavy open front, elongated bowl seat ring type only.

This is a requirement of the National Plumbing Code.

Toilet seats in public facilities are vandalism targets.

4.8.6 Drinking Fountains And Water Bottle Fill Stations

Drinking fountains and water bottle fill stations must be self-contained refrigerated type. Remote refrigeration units are not acceptable.

Water is wasted when people run the water to empty warmed water from lines. Self-contained units are easier to access for maintenance and repairs.

4.8.7 Eyewash Stations

See requirements outlined in ANSI Z358.1-2014 Standard for eyewash installation guidelines.

4.8.8 Hose Bibs

Hose bibs must be keyed, non-freeze, self-draining type, 18 mm complete with stop and drain valves inside building.

They are simple to drain in preparation for winter.

4.8.9 Shock Absorbers

Manufactured water hammer arresters, c/w isolating valves, are required at all groups of fixtures as referenced in Section A-2.6.1.9(1) of the National Plumbing Code- Water Hammer Prevention.

Shock absorbers reduce water hammer and damage to fixtures and piping.

4.9 WATER AND SEWAGE TANK CONFIGURATIONS

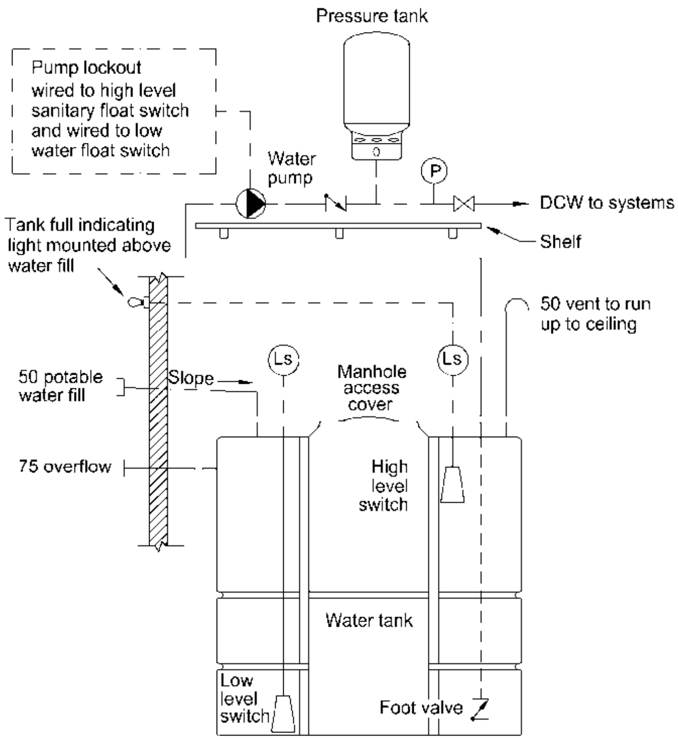


Figure 4-1: Typical Water Tank

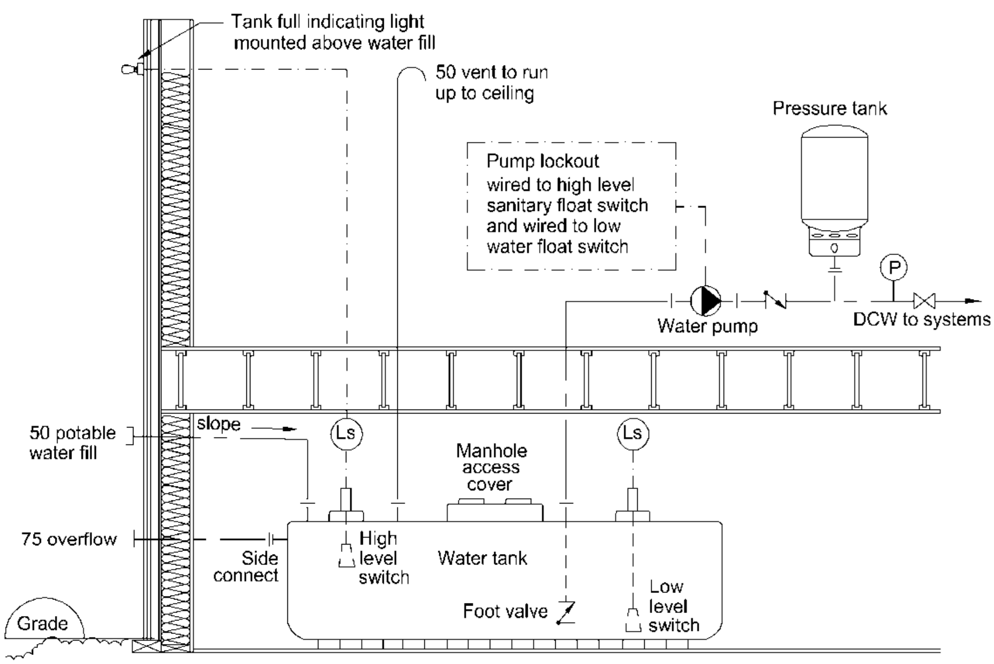


Figure 4-2: Water Tank in Crawl Space

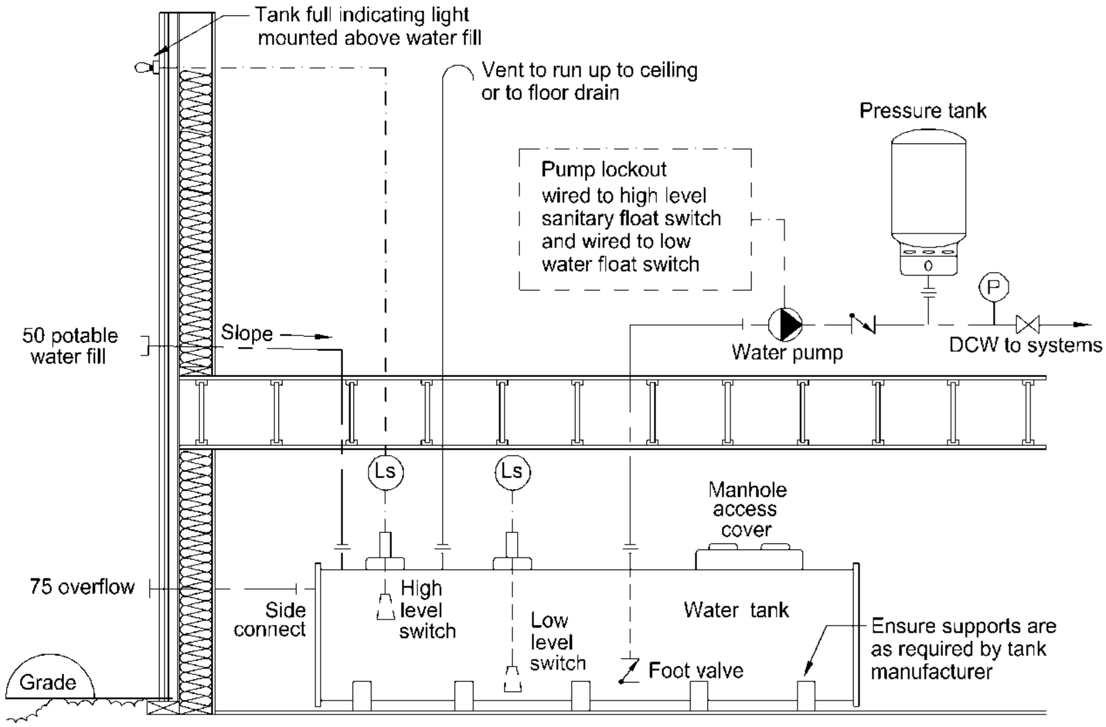


Figure 4-3: Tube Tank in Crawl Space

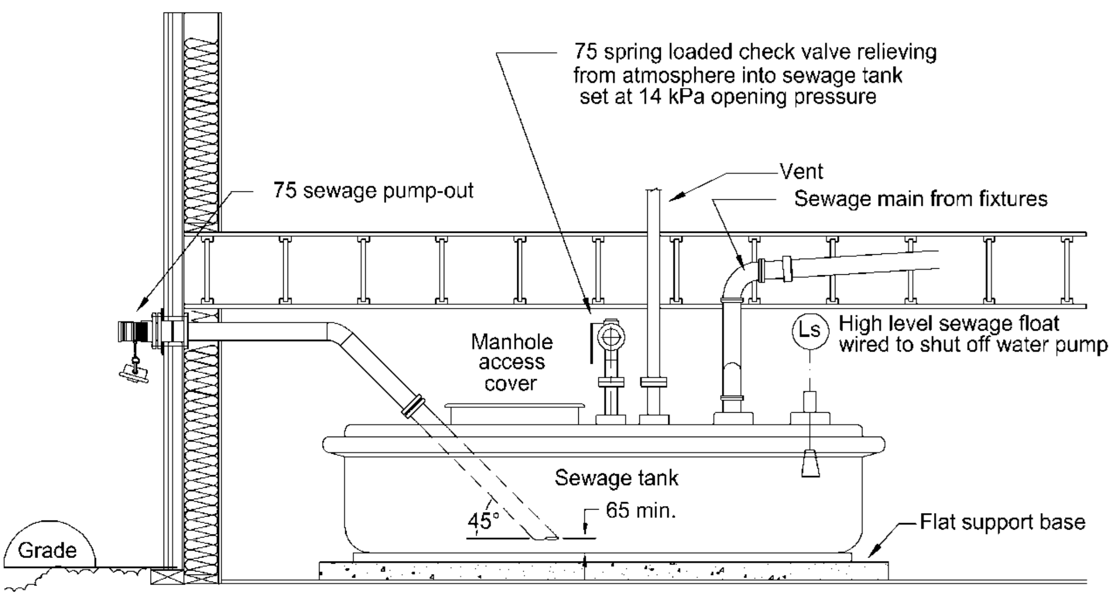


Figure 4-4: Sewage Tank in Heated Space

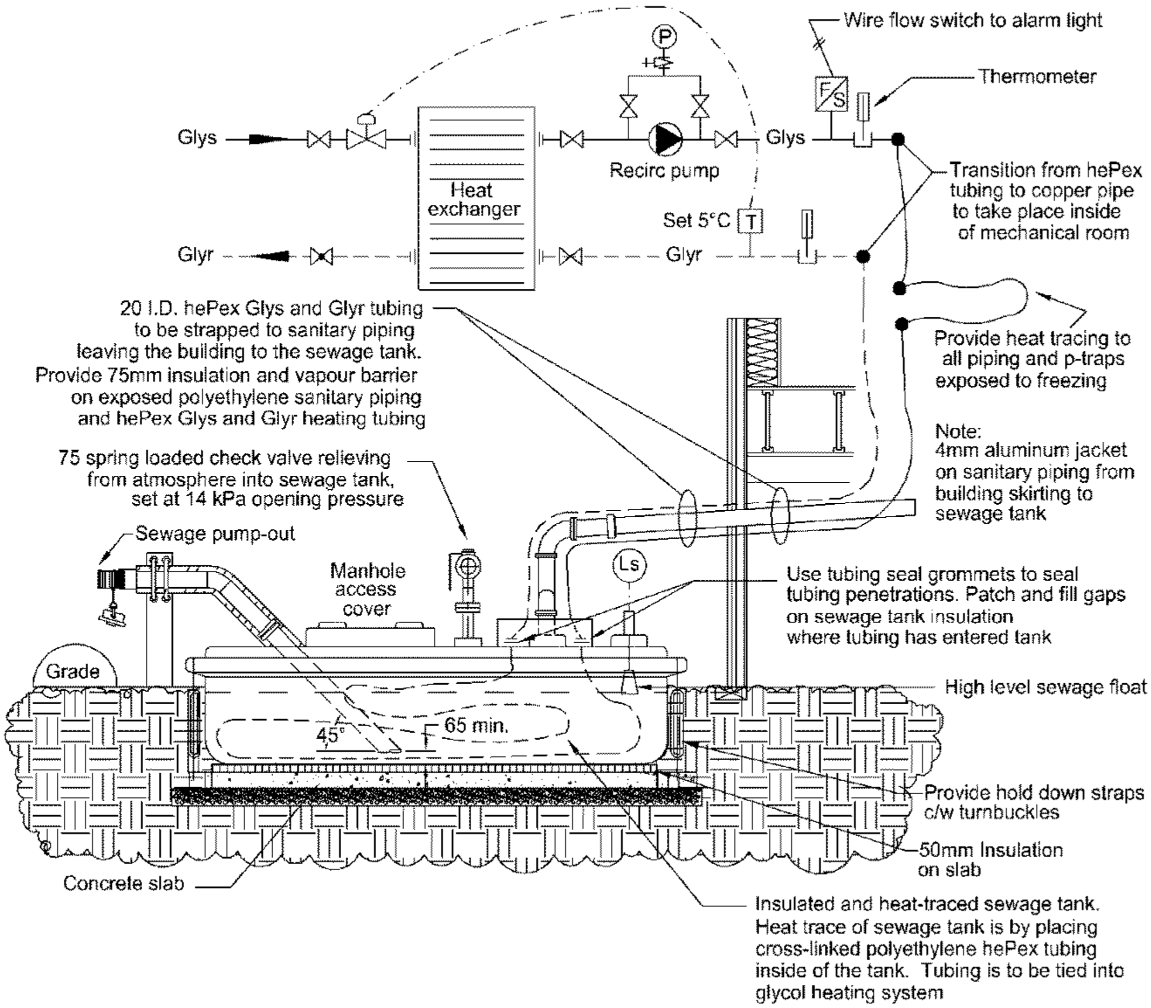


Figure 4-5: Sewage Tank Outside

*spring loaded check valve and tank vent piped inside building. Add expansion tanks, fernco couplings

Schematics to be updated

4.10 SPECIALITIES

4.10.1 Breathing Air Compressor for Fire halls

The design of a breathing air system should comply with CSA Standard Z180.1-13. Air intake to have fine mesh screen to keep insects out.

Any insect-barring material will freeze over in winter conditions.

4.11 OPERATION AND MAINTENANCE

4.11.1 Spare Parts

The following spare parts are to be provided:

- One domestic water pressure pump or recirculating pump.
- One domestic hot water recirculating pump.
- Spare faucets and/or cartridges for specialized fixtures.

4.11.2 Regional Equipment Preferences

Select equipment based upon local preference.

Maintainers should be able to provide their recommendations for equipment.

4.11.3 Code Requirements

The following code-required items shall be called for in specifications:

- Hydrostatic test of entire systems for 4 hours at a pressure of 860 kPa without measurable leaks.
- Fill, flush and fill of system. Copy of test results to be signed by owner's representative.
- Chemicals and disinfection as required by Northern Health Services.

J5 FIRE PROTECTION

Fire fighters and fire-fighting equipment available in most NWT communities is limited, and the consequences of a fire in a small remote community can be severe. The basic principles here are to ensure occupants are alerted and can get quickly and safely out of the building and to suppress localized fires quickly.

5.1 PORTABLE EXTINGUISHERS

Portable extinguishers are to be provided in all buildings. It is intended that occupants use them to extinguish small fires immediately.

5.1.1 Room Temperature Operation

ULC approved stored-pressure ABC rechargeable fire extinguishers are acceptable for use in all facilities that are occupied on a daily basis, are not subject to sudden temperature drops, are always maintainable at ambient temperature above freezing, and are equipped with low temperature alarms. Extinguishers are to be ABC rated.

ABC-rated stored-pressure extinguishers require less maintenance than other types allowed by code, such as pressure water types.

Additional Type K Kitchen fire extinguishers required where deep fat fryers are present.

Required by code.

5.1.2 Low Temperature Operation

If a fire extinguisher is located where temperatures may fall below freezing, the extinguisher must be multiple purpose dry chemical type rated for -40ºC.

Typical applications are maintenance garages, firehalls, warehouses or any other facility that may not be occupied daily; where opening of large garage doors can cause temperatures to drop quickly; or anywhere extinguishers are intended for outdoor use.

5.1.3 Location

Extinguisher positions are to be identified by permanent labeling such as lamacoid giving the location number and NFPA 10 rating of extinguisher required.

NFPA 10 requires records be kept which indicate all fire extinguisher locations in the building. After extinguishers are used or discharged there is a tendency to install larger units if the proper size replacements are not available. Subsequent installations tend to be larger than required by code.

5.2 SPRINKLER SYSTEMS

Sprinkler systems have been installed in many new buildings since the 1980s, as required by code or regulation, at the request of the Fire Marshal, or at the request of the owner.

In remote communities the cost to perform code-required testing of fire equipment can exceed the value of the system. Sprinklers should only be installed if required by code in GNWT Facilities. Stamped as-built drawings and hydraulic calculations must be provided and the installed sprinkler information must be documented: brand, type, K-factor, head count by temperature rating, length of dry pendant heads and identification by location.

Where applicable, it is the responsibility of the designer to confirm there is sufficient flow available in the municipal water mains for a sprinkler system. Specific flow tests of hydrants are recommended where municipal hydrant testing may not be available. In some instances, tests have proven the municipal services pressures not adequate.

5.2.1 General Requirements

Pipe sizes, type of piping, and fire protection system layout must be reviewed and approved by the Fire Marshal of the GNWT. Systems are to be hydraulically designed, with as-built drawings and calculations signed by a professional engineer.

The NWT Fire Marshal is the Authority Having Jurisdiction (AHJ).

Dry systems are only acceptable for use in places which are subject to freezing temperatures, such as maintenance garages, warehouses etc., and, even then, only if the size of the building makes the provision of glycol loop(s) excessively expensive.

Dry systems in areas subject to freezing are required, by code, to be tested or have all heads replaced every 10 years. This large operational cost can be avoided by the use of glycol loops. However, this expense should be assessed against the additional maintenance costs to service glycol loop backflow preventers.

In general, all crawl spaces are to be sprinklered, regardless of code requirement or the crawl space compartmentalization.

Unless the sprinkler coverage is designed for storage of combustible material, the installation of sprinklers in a crawlspace does not make it an approved storage area.

All concealed spaces shall be sprinklered.

5.2.2 Sprinkler Heads

Quick response heads rated to 74ºC are required except as noted below.

If heads respond fast, the hazard can be quickly extinguished and the quantity of water reserved for fire protection can be reduced.

High temperature heads rated at no less than 100ºC are required in mechanical equipment rooms, such as generator and boiler rooms.

High space temperatures can be found in these areas, which could cause non-high temperature heads to activate prematurely.

Dry pendant heads are required in entrance foyers.

There is a greater potential for freezing in entrance ways where doors are opening to the outside. Dry heads must be tested or replaced every 10 years.

Whereas dry heads are preferred, glycol loops can be used in spaces prone to freezing, where reviewed and approved.

Pipes in these locations are subject to freezing.

A Fire Department connection is to be provided as required by code.

Thread size, count and pitch must be confirmed to be compatible with local fire-fighting apparatus.

5.2.3 Piped Water Service Systems

Systems supplied from piped water service systems shall have incoming water main sized to provide flow rate required for occupancy of building calculated as required by relevant NFPA document. The incoming main shall be common for sprinkler water and domestic water, but will be sized to provide the greater flow requirement for either system.

A ULC-approved backflow prevention assembly shall be provided on the sprinkler side of the system to prevent backflow into domestic water system. This is required by the National Plumbing Code.

An excess pressure pump and flow switches with a built in activation delay timing are to be provided as methods of preventing false alarms during water surges etc.

Water pressure in municipal and pumped mains systems in the NWT are known to fluctuate considerably.

5.2.4 Pumps and Controllers

Fire pumps and controllers must be ULC listed and conform to the requirements of NFPA 20.

All fire pump systems shall be designed and installed such that access to and usage of regularly required testing features shall be easy and not require any provision of additional equipment.

As required by code, a Fire Pump system must be provided with a circulation relief system. A simple pressure relief system will not be acceptable.

Code-required system testing should be performed so there is minimal extra work for the maintainer. As an example, drain tests should be able to be run without a need to run a hose connection to the exterior of the building. Testing of systems is a code requirement, and systems should be designed to meet these code requirements in all aspects.

5.2.5 Water Reserve - Tanked Water Supply

Coordinate with the structural designer for proper tank support.

Wherever an automatic sprinkler system is installed, water supply calculations must be approved by the Fire Marshal, but can generally be based on the following:

.1 Buildings where NFPA 13D applies will require a capacity calculated by multiplying the required flow rate by the required duration of flow as laid out in NFPA 13D.

This will apply to single and two family dwellings only.

.2 Buildings where NFPA 13R applies will

Typically this will apply to student hostels and require a capacity calculated by multiplying the required flow rate by the required duration of flow as laid out in NFPA 13R.

group homes.

.3 Buildings where NFPA 13 applies will require a capacity calculated by multiplying the required flow rate by the required duration of flow as laid out in NFPA 13 dependant on the occupancy classification of the building. (Except schools, wherein certain areas are to be designed to ordinary hazard occupancy group 1, where duration shall be 30 minutes).

This will typically apply to all public sector buildings which require sprinkler protection as laid out in NBC Part 3 latest edition, excluding those noted previously.

The GNWT Fire Marshal has the authority to require a building to be sprinklered.

Designers are advised to confirm sprinkler requirements with the Office of the Fire Marshal for ALL building designs.
This is a code requirement.

Tankage to be provided with means of draining of the tank and access to the tank for periodic cleaning.

Firewater storage tanks are to be provided with a "Fire Water Low Level Alarm" float switch wired to a trouble signal at the Fire Alarm Panel to indicate water level in the firewater tank has lowered to less than required. This may be due to evaporation.

Water evaporation reduces the water volume available to fight a fire.

5.2.6 Carbon Dioxide (CO_2)

Use is limited as to where it is required for commercial range hoods, unless approval is given for use where special electronic equipment is installed.

It is difficult to clean up.

Wet chemical systems are now preferred for commercial range hoods.

Easier to clean up.

5.2.7 Halon

Not permitted**.**

Halon use is restricted because of environmental damage (ozone destruction) and transportation hazards.

Where previously Halon was used, use a clean agent, two stage system.

5.2.8 Tees

Use factory tees only. T-drill fittings are not acceptable.

Factory tees can be repaired without replacing the tee. Repairs to T-drill require special equipment that may not be available to maintainers.

5.3 STANDPIPE SYSTEMS

Standpipe systems shall be installed where required by NBC.

The means to perform code- required regular flow tests must be incorporated into the building overall design.

5.4 OPERATION AND MAINTENANCE

5.4.1 Spare Parts

Spare parts are to be provided as per requirements of NFPA 13 for sprinkler systems.

5.4.2 Equipment Preferences

Equipment preferences are to be obtained from the maintenance staff at each project location.

5.4.3 Code Requirements

The following code-required items shall be called for in specifications:

- a hydraulic design information plate to be mounted at the location from which the hydraulically calculated system is fed.
- a hydrostatic test of entire system for 2 hours at a pressure of 1,400 kPa without measurable leaks.
- performance of operational tests and final operating test to the requirements of NFPA 13 (or 13R, as applicable).

J6 FUEL SUPPLY

6.1 GENERAL

Electricity and fuel are required in most buildings. In the NWT most electrical power is generated by diesel power plants, and is quite expensive. Electricity costs are lower than diesel (thermal) generated electricity where hydro-generated electricity is available.

In the past, natural gas was available in Norman Wells and Inuvik. In certain communities (e.g., Hay River, Fort Simpson and Yellowknife, etc.) propane is available. However, propane is susceptible to low vaporization pressure in cold temperatures and a vaporizer is required at temperatures below -30ºC. Propane must be transported in accordance with dangerous goods regulations.

Diesel fuel is the most common heating fuel in the Territories. It has been designed to flow at temperatures as low as -50ºC. Most northern communities receive an annual supply by barge or winter road. It is stored in large tanks (a grouping of which is called a fuel storage facility or tank farm) for distribution (via truck) to required facilities and buildings for the community's use. The GNWT's Fuel Services Division (FSD) provides sales, storage, distribution and delivery services for fuels, and publishes standard specifications, design rationale and drawing details for the design of northern fuel storage facilities.

However, where possible and practical, it is desirable to use less, or no, fossil fuels and reduce greenhouse gas emissions. As mentioned in the Energy Chapter, alternative forms of heating (including the use of recovered heat from NWT Power Corporation power plants) should be considered for use in buildings where possible. Note that heat recovery from power plants may require more expensive initial construction.

Biomass is a viable fuel to use as a primary heating fuel but a backup heating plant using conventional fuels must also be provided.

The following information is intended to introduce readers to some of the unique characteristics and challenges of storing and safely distributing fuel in northern Canada:

6.2 TYPICAL ARRANGEMENTS

All oil installations must be in compliance with the CSA B139 Installation Code for Oil-Burning Equipment and other applicable regulations. The 2008 Environment Canada "Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations" must be followed.

It will be the designer's responsibility to ascertain and comply with the most stringent requirements of all relevant codes.

The "Environment Canada "Federal Petroleum Product and Allied Petroleum Products Storage Tank Systems Regulations" require the following for all storage tank systems (except those tanks less than 230 litres in volume used for home heating, and above ground storage tanks less than 2,500 litres in volume that are connected to a heating appliance or emergency generator):

- Design drawings stamped by a Professional Engineer.
- Registration with Environment Canada (this includes existing systems).
- The provision of spill protection at storage tanks, either by dike or double wall construction, regardless of tank volume, and at product transfer areas.
- The provision of corrosion protection, leak detection, and overfill protection.
- Keeping of as-built drawings on site.

Due to the stringent requirements these regulations will require, the capital and operating costs of underground storage tanks will be prohibitive. Underground storage tanks will, therefore, not be acceptable under any circumstances.

The storage and handling of fuel oil for building heating systems generally falls into four (4) categories of installations described below.

6.2.1 Fuel Storage Tanks Less Than 2,500 Litres (550 I. gal) Located Outside Building

Fuel oil tanks located outside the building are usually mounted adjacent to the building on a tank stand 1500mm minimum from any means of egress from the building and from any property line. This is in accordance with B139-15 6.3.5 and 8.3.1.

The height of the external tank is set to minimize the need of the burner pumps to lift the fuel oil to the burner. Thus, the tank stand is specified to sit the tank at or above the mechanical room floor height.

A safe ladder or stair should be provided to allow the fuel truck driver access to fill the tank. Fuel fill lines and vent lines are normally located on top of the fuel tank. The vent line is fitted with a vent whistle and must be terminated a minimum of 2,000 mm above finished grade (B139-15 9.6.6). The tank stand should be field measured by the Contractor for actual required height and must be supported on a non-combustible support.

Double wall vertical fuel vault tanks may also be used.

Oil should be heated to an appropriate temperature ready for use in oil-burning appliances. Typically, fuel flows by gravity from the outside storage tank to the appliance. If the length of oil pipe inside the heated building is short, and there is no day tank, a large diameter pipe or warming pipe should be provided to allow the fuel oil time to warm up.

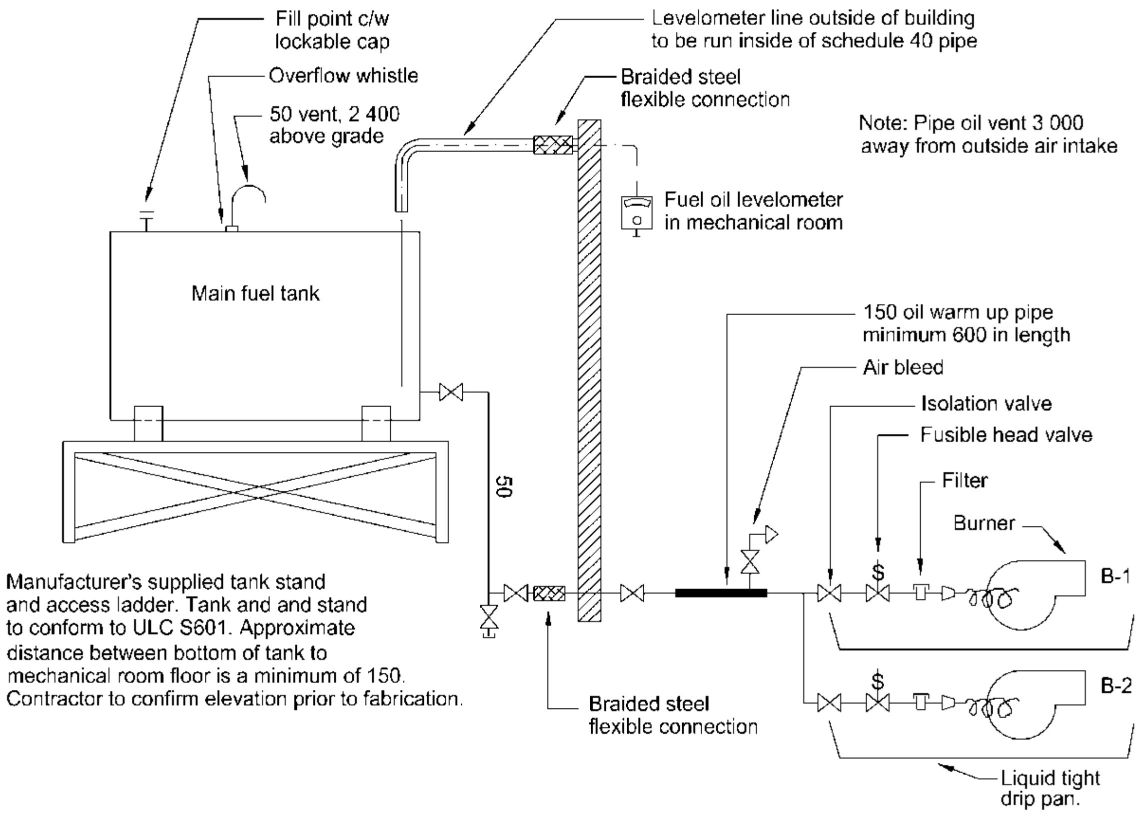


Figure 6-1: Fuel Tank Located Outside of Building

6.2.2 Fuel Storage Tanks Less Than 2,500 Litres (550 I gal) Located Inside Building

When the total fuel storage is less than 2,500 litres (550 I.gal.), the fuel may be stored either inside or outside the building (B139-15 7.2.1. figure 1(a)). Storing the fuel inside the building is not the best option. It is generally more expensive as the tank takes up building floor area, requires clearance between tank and burners, and must be set in a catchbasin sized to hold 110% of the total tank volume. Double wall tanks are also acceptable with adequate containment (B139-15 7.3.1).

Fuel oil stored inside the building must be located on the lower floor. (It is prohibited to locate a fuel tank in a crawl space.) Fuel fill lines and vent lines are run out through the building wall. The vent line is fitted with a vent whistle and should be at least 2,400 mm above ground, within hearing distance of the fuel truck operator and a minimum of 600 mm from windows and fresh air intakes (B139-15 10.5.1.8).

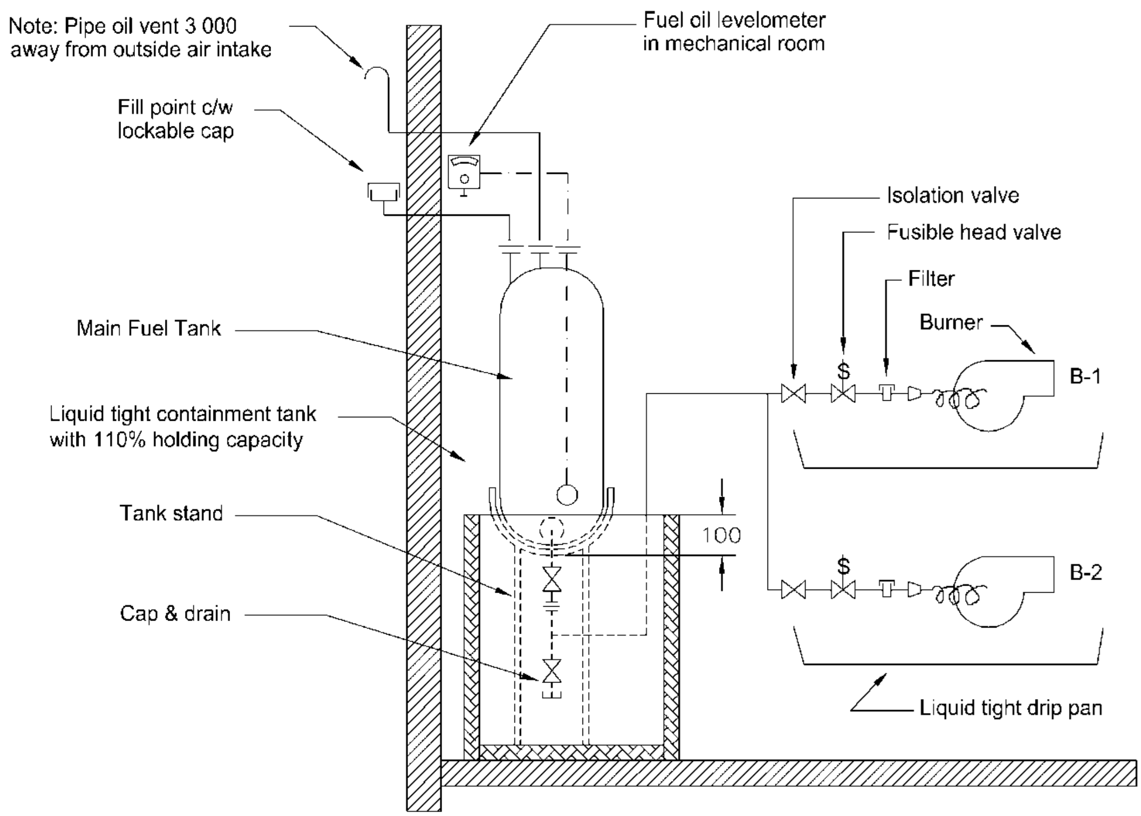


Figure 6-2: Fuel Tank Located Inside Building

6.2.3 Fuel Storage Tanks Over 2,500 litres (550 I. gal) Located Outside Building

Fuel tanks over 2,500 litres (550 I.gal) located outside the building must be a double-walled environmental tank, located a minimum of 1,500 mm from the building or from any means of egress from the building, and 1,500 mm from any property lines (B139-15 8.3.1).

Usually these storage tanks are located above ground, as soil conditions in the majority of the arctic communities are not suitable for underground (buried) tanks, and environmental protection requirements are cost-prohibitive.

The larger fuel tanks are usually mounted at grade as they are too large to mount readily on stands.

These fuel tanks must comply with CSA-B139, be ULC approved, and come complete with stairs, fill fittings, vents, etc. There are several types of fuel tanks available.

The site will dictate the tank arrangement. If the outside fuel storage tank (located at grade) is significantly below the mechanical room, then a transfer pump system shall be used (Figure 6.3). If the fuel storage tank is located significantly above the mechanical room, then again transfer pumps shall be used. If the tank is approximately level with the mechanical room, then transfer pumps are not required (Figure 6.4).

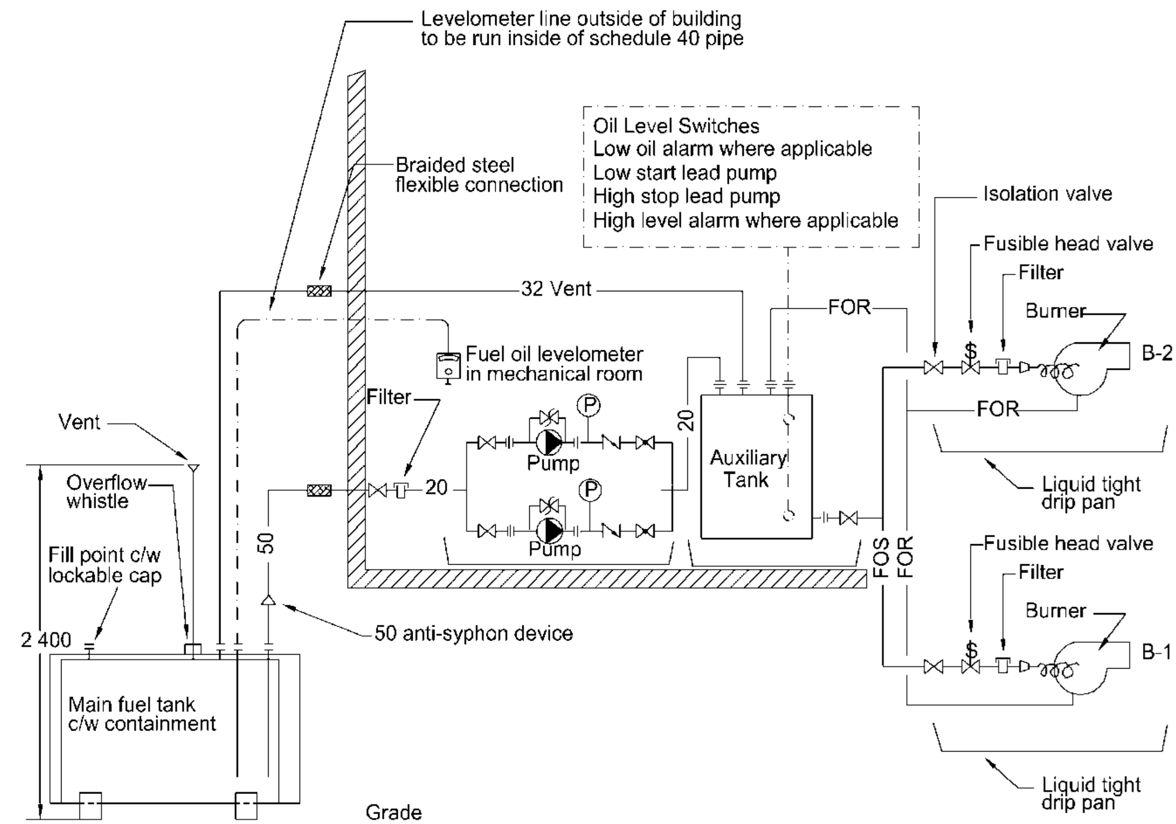


Figure 6-3: Outside Tank with Transfer Pump

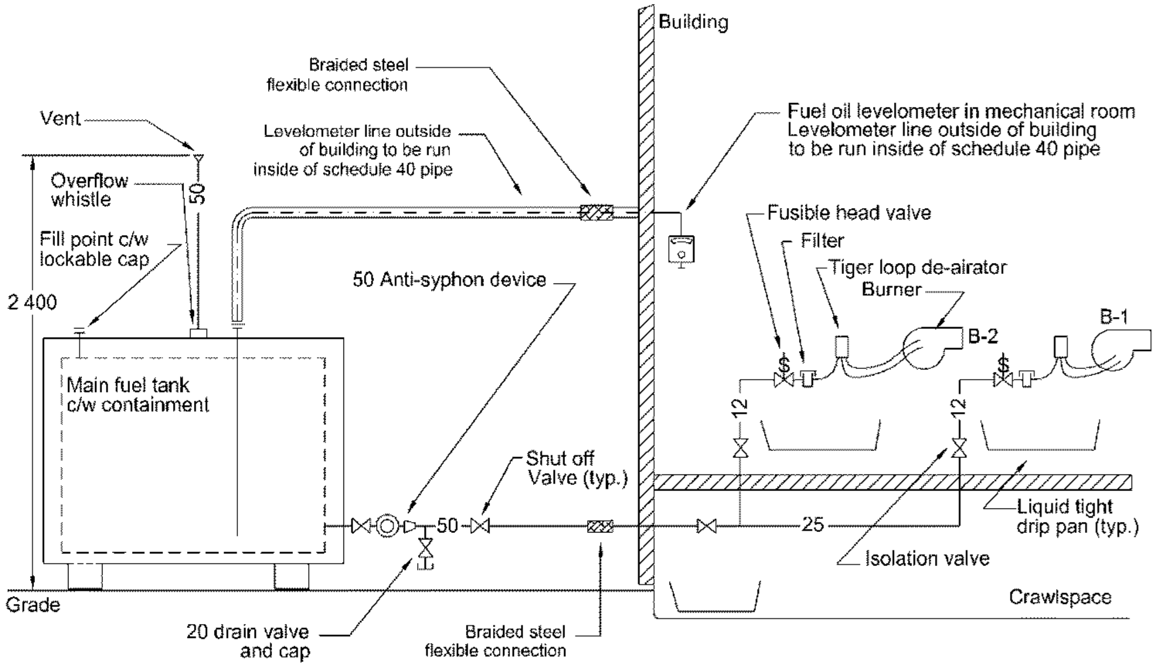


Figure 6-4: Outside Tank Over 2 500 Litres

6.2.4 Fuel Storage Tanks Over 2,500 Litres (550 I. gal) Located Inside Building

If large quantities of fuel need to be stored inside buildings (due to property line restrictions or other considerations), a fuel vault must be used. This situation is rare and is not discussed here.

6.2.5 Underground Fuel Storage Tanks

Underground fuel storage tanks are not acceptable, as explained above.

6.2.6 Value Engineering

The most important consideration in fuel system design is the selection of the fuel storage volume. If too much fuel is stored, tank and system costs will be higher than necessary. If too little fuel is stored, then more frequent delivery is required, which may overload the local delivery service and result in increased fuel costs.

6.3 FUEL OIL DELIVERY AND STORAGE

Fuel delivery is either by contract with the Fuel Services Division of the Department of Infrastructure, or through private distributors.

6.3.1 Fuel Meters and Gauges

Totalizing fuel oil meters are not required unless one tank is serving more than one unit in the same building and meters are required to monitor consumption for each unit.

Meters allow maintainers to monitor fuel consumption; however, fuel is metered by the delivery truck meter and billings reflect consumption.

All tanks should be equipped with a remote reading level gauge.

B139-15 6.5.1 requires some means of measuring the fuel in the tank, and the remote gauge can be located in the mechanical room where it is easy for the maintainers to monitor.

6.3.2 Tanks

.1 Primary Tanks

If under 2,500 litres, either a circular horizontal tank or up to two 1,135 litre oval tanks may be used. If over 2,500 litres, double-walled, self-contained, self-bermed fuel storage tanks are required.

A dike is required by B139-15 8.7.3 for tanks over 2,500 litres, whereas a self-contained tank is usually less costly and provides the best flexibility in its location and relocation in the future.

.2 Auxiliary Tanks

Auxiliary tanks may be up to 1,135 litres (250 I. gal) in size, and must be installed in a catchbasin sized to hold 110% of tank volume.

An auxiliary tank is required if a transfer pump system is used, and may be required if an emergency generator is in the building. An auxiliary tank provides storage for the purpose of warming fuel oil for use by oil-burning appliances and for an emergency generator. It provides the minimum 2 hour fuel requirement for operating the generator (when nothing else works).

.3 Stands

Fuel storage tank stands should be fabricated from steel. Combustible stands are not acceptable.

Although required by code B139-15 6.3.3, the provision of non-combustible stands is sometimes overlooked.

Coordinate with the structural designer for proper tank support.

.4 Oil-Warming Pipe

An oil-warming pipe is to be used in all applications where gravity feed from an exterior storage tank is possible. The pipe is to be constructed of standard schedule 40 pipe and is not to exceed 45 litres capacity.

When an oil pipe enters a building, the first one or two metres of the pipe will build up frost on the outside of the pipe as the fuel warms up. To facilitate this process, usually an oil-warming pipe is installed. However if there is an auxiliary tank, the auxiliary tank will act as the warm-up pipe. In the case of where there is a crawl space, the pipe looping through the crawl space will act as a warm-up pipe.

6.3.3 Fuel Tank Capacity

.1 Primary Tanks

.a In remote communities, a two- week supply, calculated at continuous maximum operating load (including heat and standby power), is the minimum required wherever a standby generator is to be installed, or when a long disruption in heating would require relocation of residents, or could potentially damage essential equipment.

Blizzards or storms can delay or prevent fuel delivery for up to two weeks.

In main centres, such as Yellowknife, Hay River, Fort Smith, Fort Simpson, Inuvik and Norman Wells, a one-week supply is the minimum required.

.2 A one-week supply, calculated on continuous maximum operating load, is the minimum required for all buildings that are not essential in the event of power failures and which can be prepared for freezing conditions (i.e., water lines drained).

Current codes and regulations will dictate the requirements for auxiliary tanks.

.3 For additions to existing buildings, use the actual fuel consumption over the preceding three years to determine whether the building fuel storage capacity needs to be increased.

Actual fuel consumption may be higher or lower than anticipated during design.

6.3.4 Location and Access

.1 Primary Tanks

Suitable platforms with steps and handrails are to be provided at the fill line on exterior tanks.

This provides a safe condition for the fuel deliverer.

Buried fuel tanks are unacceptable.

Most areas of the Arctic and sub-Arctic have ground conditions which are unsuitable for burying fuel tanks. In any case, environmental protection requirements make buried tanks costly. Current environmental regulations discourage the use of underground tanks. Do not use buried oil tanks or piping.

No fuel tanks are to be located in crawl spaces.

This is because spills might go undetected in crawl spaces.

Wherever possible, elevate the primary storage tank to allow the tank to gravity feed to the fuel burning appliances. Ensure the tank and piping is installed at an appropriate elevation and grade to allow the contents of the tank to be fully utilized.

A gravity feed fuel oil system is the most cost-effective means of providing fuel oil to a building.

.2 Warming Pipe

Where the locations and elevations of primary storage tanks and warming pipes allow fuel oil to flow by gravity, the oil-warming pipe is to be located in the mechanical or boiler room near the oil burning equipment.

Gravity feed from an auxiliary tank or oil-warming pipe to all oil-burning equipment, including a standby generator, is cost-effective and still provides warmed oil for improved combustion.

Where an auxiliary tank is used, a warming pipe is not required.

6.3.5 Spill Protection

.1 Exterior Tanks

If a fuel tank is required to have spill protection because of its size, the tank is to be of the horizontal type for above-ground installation. Double-wall tanks are preferred. However, a single wall tank installed inside a dike will be accepted as an alternate in certain circumstances. In this alternate, the containment dike is to be closed off and secured with a removable cover, and the tank is to be enclosed on all sides by a fence, leaving adequate access on all sides of the tank for maintainer access and fuel delivery. A product Transfer Area (PTA) must be incorporated into the design of all fuel tank systems of 2,500 liters and larger.

The Environmental Protection Act specifies when spill protection must be provided; unprotected dikes are a safety hazard, as they can fill with water.

Fencing discourages vandalism and tampering.

A fence is not required if the containment access covers cannot be removed.

.2 Interior Tanks

Containment with 110% capacity is required beneath all interior tanks.
A secondary catch basin must be installed to contain the interior tank and associated fuel transfer pumps. The catch basin must have a hard wired float to shut off the fuel transfer pumps and alarm.

Interior tanks are usually located in mechanical rooms. Such rooms may have painted plywood floors that would permit seepage of fuel into the floor assembly if the fuel were not contained.

.3 Auxiliary Tanks

Auxiliary tanks must be vented to the exterior tank. Vents must not be trapped.

Proper venting eliminates the possibility of tank overflowing through the vent pipe onto grade, if the transfer pump controls were to fail and interior tank overfilled. If this venting *arrangement cannot be provided, additional safety controls should be incorporated into the transfer pump controls.*

6.4 OIL SUPPLY (DISTRIBUTION)

6.4.1 Fuel Temperature

Fuel stored in exterior tanks should be warmed before reaching the burners. This can be done by providing an auxiliary tank, an oil warming pipe or an extended run of supply pipe in the mechanical room long enough to allow oil to warm to room temperature.

Oil burners operate at higher efficiency when fuel oil is at room temperature.

6.4.2 Transfer Pumps

Two bulk fuel oil transfer pumps are required wherever an auxiliary fuel day tank is installed that will be controlled by electric liquid level controllers for on-off automatic pump operation. Pressure gauges and a pressure relief valve (integral or external) are to be installed on all fuel transfer pumps.

These pumps transfer fuel from exterior primary tank to interior auxiliary tanks.
One pump is operational and the second is a standby pump that can be put into operation quickly and easily. Pressure gauges indicate pump performance.

6.4.3 Piping

.1 Materials

All exterior fuel oil piping is to be schedule 40 steel screwed pipe, minimum 50 mm in dia., valved at the tank and immediately inside the building, and properly supported.

Any buried pipe must be ULC-approved, double-walled, environmental type.

.2 Weather Protection

All exterior oil piping (buried or exposed) shall be painted and protected with weather-resistant tape.

This is intended to protect the pipe from rusting.

.3 Two-Pipe Systems

Where an auxiliary tank is installed, a two-pipe system (supply and return) is required for all oil-burning equipment.

This eliminates problems with air lock. The return of fuel to the interior tank maintains the fuel oil at room temperature.

.4 Gravity Feed

If fuel is gravity-fed to the burners directly from an exterior tank, do not use a two-pipe system.

This would cause preheated fuel to be returned to the exterior tank and condensation would occur in the tank.

6.4.4 Flex Connectors

Exterior fuel piping (supply and return) should have ULC approved braided steel flex connectors installed just before the pipe enters or leaves the building.

The flex prevents piping stress caused by differential settlement of the tank and building.

Flexible connectors should be long enough to allow for the expected differential movement. A length of at least 600 mm is preferred.

Pipe movements of up to 100 mm are not uncommon.

The burner is to be connected to the fuel piping with flexible connectors, using either Type K copper or braided steel flexible connectors.

The burner is disconnected and reconnected during routine maintenance. The flexible connector allows this to be done more easily. Braided steel connectors are preferred as the copper connectors will kink over time.

UL Listed, braided steel flexible connectors are required on the supply and return lines to the emergency generator.

6.4.5 Isolating Valves

Isolation valves must be provided on the supply line immediately adjacent to tank connection at exterior and immediately upon supply line entry into the building.

These valves allow equipment to be disconnected for maintenance or replacement.

Each piece of fuel-burning equipment must have isolating valves.

On a two-pipe system, the return line must not have an isolation valve.

An isolation valve on return line is not allowed by code.

Fusible valves are to be used for all supply lines to all oil-burning equipment, including generating plants.

The CSA B139-15 5.1.2 code specifies that heating equipment requires fusible valves. However generating plants also require fusible valves to stop flow of fuel in case of fire.

The location of the fusible link valve shall be:

- On the supply side of fuel filter, where the fuel oil filter is located 1 m or less from the burner.
- Within 1 m of the burner on the appliance side of the burner, where the fuel oil filter is located more than 1 m from the burner.

6.4.6 Pressure Gauges

Provide dial-type pressure gauges with a 90 mm dia. dial (scaled to the application) located at the discharge of each pump.

Pressure gauges installed at appropriate locations assist the building operators to monitor system performance.

Provide an isolation valve for each gauge, a snubber for pulsating operation, and a diaphragm for corrosive service applications.

The small additional cost for gauges is offset by increased operational efficiency.

6.4.7 Filters

An adequate oil filter is to be provided at each oil burner.

Filters ensure clean fuel to all burners.

6.5 PROPANE DELIVERY & STORAGE

All propane installations are to be installed in accordance with the requirements of the authority having jurisdiction and the Propane Installation Code CAN/CSA - B149.

6.6 OPERATION AND MAINTENANCE

6.6.1 Spare Parts

The following spare parts are to be provided:

One oil filter cartridge for each installed appliance.

6.6.2 Regional Equipment Preferences

Provide equipment brands preferred by and familiar to local maintainers.

Local maintainers should be consulted for their preferences.

J7 HEATING

Where fuels costs are high and the heating season is long and severe, it is important to minimize energy consumption of buildings. Within the Northwest Territories itself the climate varies; heating degree days vary from 7,300 in Ft. Smith to 10,700 in Holman, as compared to an average of 2,825 in Vancouver or 5,120 in Edmonton.

All buildings, except seasonal use buildings or cold-storage facilities require some type of heating. Buildings can have their own heating system or be heated by a central plant located in or near the facilities. In some locations it may be possible and practical to use recovered heat from local power plants to heat individual or groups of buildings.

Fuel sources other than fossil fuel shall be used if it is practical to do so. The reduction of greenhouse gas emissions shall be a design priority.

Biomass (wood-pellet) boilers are successfully used in the NWT. These systems may be owned and operated by the building owner, or provided and maintained by an Energy Service Provider who sells energy back to the client at a certain cost.

The design temperature for indoor occupied spaces during winter is 21ºC; during summer, 24ºC.

Heating and cooling systems should be properly-sized for the actual requirements of the building.

For buildings with radiant heating these space design temperatures may be reduced by several degrees.

This reduces energy consumption.
Radiant heating heats up objects and people. The apparent temperature in a radiantly-heated space is higher than the actual measured air temperature.

Whenever possible and economical, use temperature setback within buildings during unoccupied periods.

Design temperatures shall be:
- Winter: 1% January temp.
- Summer: 2.5% July temp.

As referenced in the NBC.

These are acceptable building design criteria in the NWT.

Source weather data is available from Environment Canada for specific communities not listed in Appendix A of the NBC.

7.1 FORCED HOT AIR SYSTEMS

Forced hot air heating systems are as common in the NWT as elsewhere in the country. However, as few buildings in the NWT have basements, counter-flow furnaces are generally required, with ducts running in a raised floor. Forced hot air systems are not suitable for all types and sizes of facilities, but their relatively simple servicing requirements make them a preferred choice in small facilities or remote locations. Suspended furnaces, which are higher than 3 m off the floor surface, are not to be used unless a permanent service platform is provided.

7.1.1 Furnace Type

Two-speed fans are required where ventilation is provided by the furnace.

At either high or low fan speed, good air circulation is provided, preventing air stratification.

Refer to National Building Code Section 6.3.1.1.2 and ANSI/ ASHRAE 62 "Ventilation for Acceptable Indoor Air Quality" for ventilation rates for design.

Refer to Mechanical M7.2.2 for chimney and vent requirements.

Non-combustible block bases with 6 mm steel plates are to be used under all oil-fired heating equipment installed on combustible floors.

Even equipment which is approved for use on a combustible base can burn into the floor.

Oil-fired furnaces suspended at high level are NOT acceptable for any facility.

Maintenance access is difficult, and oil dripping from overhead fuel lines is unsafe.

7.1.2 Combustion Air

All fuel-burning appliances require a properly-sized combustion air supply.

This is a code requirement.

Combustion air ducts shall be configured so that cold air does not pool at the floor, where it may freeze equipment or pipes.

7.1.3 Heating Capacity

Forced air heating is suitable only for buildings where multiple heating zones are not required.

Forced air heating is typically used for small buildings such as small offices, sewage lift stations, water intake pump-houses, residences, or the office portion ONLY of fire-halls, garages, and small air terminal buildings.

7.1.4 Distribution

Ducts located in a raised floor are preferred over those located in ceiling spaces.

All ducts in raised floors shall be insulated.

This gives better heat distribution and avoids the need to penetrate the building envelope with ductwork.

Where exposed ducts are acceptable, they may be located overhead.

Overhead ducts do not provide as good air distribution as underfloor, but may be acceptable in some situations where comfort levels are not critical.

7.2 HYDRONIC HEATING SYSTEMS

Hydronic heating is the most commonly-used heating system in larger buildings because of its ability to heat large areas with multiple heating zones. It provides better control and comfort than forced air systems. See Figures 7.1, 7.2 and 7.3.

The total boiler plant size is one factor in determining what operators are needed. In small communities, there may be few, or no, sufficiently-qualified operating engineers, depending upon the plant size.

When selecting the type of hydronic heating system for a building, consider the building size, complexity and special requirements. For example, perimeter hot water radiators are the most commonly-used form of heating in many buildings, as they are easy to maintain and allow individual controls. For large open spaces where quick temperature swings are not required, radiant floor heating systems may be the best solution. High-traffic entrance vestibules require quick-response intense heating and so cabinet unit heaters are often used in those areas.

When using biomass boilers as a primary heating source in GNWT Facilities, the best method is to use the biomass boilers to cover the load most of the time. The biomass boilers shall be sized at 100% of the maximum building load where practical. On a case by case basis, the biomass boilers capacities should be sized to handle an optimal percentage of the peak load. Where applicable, the back-up boilers (on conventional fuel) will cut in and act as peaking boilers.

If heat recovery from power plants is used refer to Figure 7.4. (Pg. 68 to be updated)

7.2.1 Boilers

Boilers, suitable for use with propylene glycol heating solution, are preferred. Each boiler is to be sized to handle a percentage of the design load.

Sizing the multi-boiler heating plant to no more than 100% of the building design heating load ensures that the heating plant capacity will not exceed the actual building heating load. The heating plant will operate more efficiently when it is not oversized.

When fuel oil boilers are applicable, cast iron, wet base boilers shall be used

Exception is in Parking Garages or Storage Facilities which are not temperature-critical, where a single boiler may be use to simplify operation and minimize capital costs.

For boiler plant sizing and redundancy requirements for Class A and B health care facilities, Refer to CSA Z317.02

Multiple pass, forced draft, fire-tube boilers are preferred in larger buildings where the boiler required exceeds 250 kW.

With multiple boiler capacity, should one boiler fail, the other(s) can provide freeze protection and can heat the building with the air system(s) shut down to reduce heating load.

Exceptions are in Hay River, where all boilers should be provided with oil/propane dual fuel burners.

This is typically only required in large schools or colleges.

Consider current and future fuel supplies in communities when designing the heating plant. Provisions for future tie-in of biomass/ residual heating shall be included.

Hay River has both oil and propane supplies.

Plants exceeding 750 kW input should be avoided whenever possible.

Plants over 750 kW input require qualified operators, who may not be available outside larger centres. Refer to the Boiler and Pressure Vessel Regulations of the Northwest Territories regarding plant classifications and the required plant engineers.

Condensing boilers are more efficient than high-efficiency boilers but the designer must ensure that the condensing boilers will operate in the condensing mode given the local climate.

They are the most efficient burners available.

Multiple-stage firing or a modulating firing arrangement is required on boilers.

Supplier must provide documentation from the boiler manufacturer that the burner provided is compatible with the boiler.

During extreme cold conditions, single-stage firing reduces the danger of damaging boiler venting where products of combustion condense.

Energy meters (kWh or BTU) must be installed on each boiler when multiple fuel sources are provided for the building.

Energy meters allow for the accurate monitoring of energy output and tracking of utilities.

A boiler installation permit is required by the Boiler & Pressure Vessels Act & Regulations for any boilers greater than 30 kW or 102,390 Btuh).

Burner retrofits up to and including 400 MBh shall be done by a certified oil or gas burner mechanic. Retrofits exceeding 400 MBh shall be approved by either the burner manufacturer or the boiler manufacturer.

7.2.2 Chimneys and Vent Connectors

A separate chimney for each appliance is required.

Although this may increase the number of penetrations through the building envelope, shared chimneys are always oversized, which can lead to condensation and inadequate draft.

Chimneys shall be installed with a minimum of 50mm of insulation. For GNWT Facilities, design of chimneys on the outside of buildings must be approved prior to installation.

Forced draft appliances require pressure-rated chimneys.

Provide a base-tee for cleaning access for all chimneys.

Provide a permanently installed stack thermometer.

All connections and bends are to be "swept" type.

Chimney lengths should be minimized and kept within the heated building envelope as much as possible, with the exposed exterior length also kept to a minimum.

Cold chimneys cause condensation of moisture in combustion gases. The condensate freezes and builds up over the winter. It can eventually block the chimney. This condensate is also very corrosive and will lead to the premature failure of the chimney. Back pressure due to blockage or leakage through perforations can result in dangerously toxic conditions.

Where vent connectors are necessary, they are to be installed to permit easy removal for cleaning.

This encourages regular cleaning and inspection of vent connectors and chimneys.

Vent connectors must be insulated.

Insulation is required to prevent accidental burns to maintenance staff. The insulation must be easily replaceable, or there is a risk that it will be improperly replaced.

Each oil-burning appliance is to be provided with its own barometric draft regulator.

The pressure in the chimney varies considerably because of wind conditions, stack *effect from temperature difference, and, in the case of multiple fuel-burning appliances, according to the number of appliances operating at one time. Barometric dampers eliminate one major variable, and stabilize draft conditions for each fuel-burning appliance.*

Cleanouts are required on all changes of direction of the vent connectors for fuel-burning appliances.

All portions of venting are to be easily accessible for cleaning.

7.2.3 Combustion Air

Where possible, bring the air in at a low point in the mechanical room and duct to an outlet at a high level close to the ceiling. Alternatively, provide an air trap near the boiler.

This installation controls the amount of cold air drawn in for oil-burning equipment, and avoids cold air from flooding in at floor level, which can freeze water lines.

If combustion air cannot be ducted within the mechanical room to a high level outlet, then the air must be preheated using a unit heater. Quantities of preheated air are required (i.e., after expansion) to be calculated as per CSA B139, considering that special engineering practice is necessary in the extremely cold climate of the NWT. Calculations are to be based on maximum heating loads, not including standby generators.

Combustion air intakes are commonly oversized, causing more cold air than is necessary to enter mechanical rooms. This can result in the freezing of water lines and pumps located in the mechanical room. It is important to recognize the extremely cold temperature of outdoor air and problems associated with bringing it directly into a building. A 33% reduction in air quantity should be allowed to allow for the expansion of cold air to room temperature.

7.2.4 Heating Fluids

.1 Glycol

A factory pre-mixed glycol and water mix is the preferred fluid for use in hydronic heating systems.

Systems using 100% water are liable to freeze, resulting in high maintenance costs and disruption to users. Glycol can be tested regularly and inhibitors (di-potassium phosphate) added as required. Glycol does have corrosive effects, but so far these effects have been considered less dangerous than the possibility of building freeze-up.

The heating fluid used in all hydronic heating systems is to be Dowfrost HD propylene glycol factory premixed 60/40 water and propylene glycol.

Dowfrost HD is currently the only product acceptable to the GNWT unless otherwise specified by the equipment manufacturer. Use of premixed Dowfrost HD makes operator training and product storage easier, and requires the use of fewer types of test kits. A premixed glycol solution eliminates problems caused by the on-site mixing of glycol and local water. Water in a community that has more than 50 ppm of hardness ions, Ca++ or Mg++, or more than 25 ppm of chloride and sulphate is considered unsuitable for use in heating fluid. Water quality varies unpredictably between seasons and communities. A premixed glycol solution has good thermal and corrosion-inhibiting characteristics.

.2 Glycol Fill

Glycol can be charged to the system using either a motor-driven pump or an automatic pressure-controlled makeup system. The building maintainers may have a preference for automatic or manual fill.

Since most hydronic heating systems do not have continuous supervision, it is preferable to have system pressure maintained for as long as possible in cases of leaks.

The pressure relief valve on the boilers is to be piped back to an open container, not to a drain. A manual diaphragm-type pump is acceptable on hydronic heating systems under 117 kW in size. Manual vane pumps should not be used.

Manual diaphragm pumps work well. Manual vane-type pumps have not been satisfactory.

Packaged glycol fill systems do not provide high capacity to fill a large system due to the low flow rate from the pump.

7.2.5 Circulation

.1 Piping

Primary/secondary piping loops for boiler

The continuous flow of heating fluid through systems, which allow decoupled flow on both loops under varying load demands, are required.

the boiler and the controlled flow of heating fluid through the heating loops prevents boilers being subjected to temperature shocks.

Secondary heating looped shall be configured in a reverse/return arrangement. Direct return in smaller boiler installations will be considered.

The use of variable flow pumps for the secondary pumping system reduces energy consumption in buildings.

Unions, isolating valves and drains are to be provided at all heating equipment connections.

They facilitate the isolation of heating coils, heat exchangers, pumps, and heating zones for periodic maintenance and/or repair.

Isolation and by-pass valves are to be installed so that the flow through each heating coil in an air handling system can be adjusted, even if the secondary coil circulating pump and/or the three way control valve is out of service.

It must be possible to operate the system manually when the three-way control valve is removed for maintenance or repair. The forced shutdown of systems could result in loss of ventilation and heating in certain applications.

Hydronic system piping arrangements are to be designed to maintain full and balanced flow through each boiler when it is operating. Provide balancing valves in each boiler circuit to facilitate balancing of the system.

This prevents damage to boilers by overheating of boiler sections or tubes.

The T-drill pipe fitting system is not acceptable.

There has been a history of failures of T-drill joints.

The use of Victaulic fittings on glycol heating piping is acceptable in accessible locations such as mechanical spaces.

All systems, once completed, are to be flushed and degreased as follows:

On completion of hydrostatic testing, drain the entire system, fill with a 3% solution of non-foaming phosphate-free detergent and circulate for 8 hours. Drain and flush system with clean water for 4 hours, drain, check all strainers, refill and circulate for an additional 2 hours. Check strainers and repeat flushing until heating media is clear and there is no debris. Then fill the entire system with new, pre-mixed, inhibited propylene glycol. Record the total volume of glycol.

.2 Equipment

Pumps and other heating equipment must be selected allowing for the different properties of glycol and water. For example, expansion tanks must have an EDPM bladder compatible with propylene glycol, and the tank must be sized to accommodate the increased expansion of glycol over water.

Use of the 60/40 glycol/water heating fluid is not common in other parts of the country; designers may not be used to designing glycol systems.

Glycol expands more than water does.

Redundancy of pumps is required in secondary heating loops

In the event of a lead pump failure, the standby pump is automatically engaged.

Circulating pumps are to have mechanical seals. Do not use packings.

Mechanical seals are more reliable.

One set of strainers is required for each building heating system.

Strainers catch suspended particles in the system as they circulate. Strainers are not required at every pumped loop.

Side stream filters with sight glass are required on hydronic heating systems over 117 kW in size (400,000 Btu). However, side stream filters are beneficial for all heating systems. Each side stream filter is to be provided with one case of replacement 10-micron filters.

Side stream filters provide an economical, effective means of keeping the heating fluid clean. Sight glasses provide a means of determining cleanliness of the heating fluid.

Smaller heating systems are less likely to require continual cleaning, and it is not cost effective to provide side stream filters.

.3 Insulation

Insulation is required on all circulation piping. Refer to the National Energy Code for Buildings for minimum thermal insulation for heating and cooling piping. Insulation may be

Heat from uninsulated piping can cause overheating of the mechanical room, wasting energy and creating uncomfortable working conditions for maintenance personnel.

omitted from valves, unions and strainers where piping is 63 mm and smaller. Removable prefabricated insulation is to be used at all valves and unions on all piping over 63 mm.

Pipe Jacketing is required on all exposed piping. Jacketing to be PVC or approved equivalent.

Periodic access to valves and unions requires the removal and replacement of insulation at these locations, in such a way that it does not damage adjacent pipe insulation. Service life of the piping insulation is extended and ease of cleaning/maintenance.

7.2.6 Distribution

On multi-storey buildings, provide shut-off valves at each floor to enable that floor's heating loop to be shut off for maintenance, while the heating system can continue to operate in the rest of the building.

.1 Wall Fin Radiation

Wall fin radiation is preferred for most applications.

It is simplest, most commonly-used, and most familiar to system maintainers. See certain exceptions in CSA Z-317.2 for health care facilities which does not allow fin radiation in certain areas.

Wall fin covers or enclosures are to be sloping top model, minimum 14 gauge steel. Where installation location may be prone to vandalism, heavier gauge steel to be used.

Sloped tops prevent people from placing things on them and obstructing heat flow. The heavier gauge steel will be less easily damaged than standard gauge covers.

When permanent cabinets or built-in furniture must be located against the same wall as radiation units, appropriate inlet and riser vents or appropriate alternative terminal units are to be installed.

Cabinets obstruct air flow, and vents will alleviate this problem.

A shut-off valve is required for each zoned section of radiation.

This allows the zones to be isolated for repairs.

Isolation valves and unions are to be provided on both sides of zone valves, and a drain valve is to be provided on the discharge side of the zone valve. A piggy-back drain valve will not work in this situation unless there is adequate clearance to install it in its intended configuration for ease of access and drainage.

This allows the zone valves to be isolated for repairs

Continuous wall coverage of fin radiation shall be considered.

This optimizes occupant comfort and limits cold spots.

A balancing valve or globe valve must be provided on the return line for each zone of radiation.

This permits proper balancing of the heating system.

In low traffic vestibules and entrances/exits, wall fin radiation is preferred over a force flow unit. The wall fin radiation should be controlled by a zone valve and a wall thermostat c/w tamper proof metal guard.

This reduces installation costs and overheating.

.2 Force Flow Units

Force flow units are required for typical high traffic vestibules and entrances. Floor and wall mounted models should be recessed where structural conditions allow, but ensure that insulation values are not reduced where the recessed heaters are located.

Force flow heating units provide quick heat recovery in high traffic areas such as entrances.

Force flow heaters should not be installed higher than 3 metres above the floor, unless a work platform and man lift are provided.

Heating is controlled by cycling the fan and zone valve control.

Zone valves are advantageous in a variable flow system.

.3 Radiant Floor System

Where it is important that a warm floor be provided and in-floor heating is approved, a radiant floor system may be used.

The functional program should clearly outline this requirement, which will generally be considered where people will be sitting on the floor (e.g., kindergartens or play rooms).

The radiant floor piping must have an oxygen barrier.

The oxygen barrier prevents oxygen from entering the heating system and causing premature system failure due to corrosion.

Provide closer-spaced loops where heat losses are greater (at outside walls and windows).

Consider using a radiant floor heating system as a "base" system to cover a portion of the building load, and using another, quicker-acting system to supplement the heat and make the combined system more responsive to changing requirements. For example a radiant floor may provide comfortable conditions in a garage for work on or under vehicles, but the floor alone cannot heat up the space fast enough to make up for losses caused by opening of overhead doors.

Manifold panels should be located at work height and be easily accessible. Panel doors shall be lockable and have two latching points.

.4 Radiant Ceiling Panels

Radiant ceiling panel heating systems may be used in specific building locations and building types such as health care facilities. Ensure these panels are recessed and not able to collect dust.

Radiant ceiling panel systems allow the walls to be free of radiation cabinets and/or convectors, thus increasing the viable floor area and improving floor cleaning and maintenance.

.5 Radiant Wall Panels

These may be used in particular instances but it is important to ensure that furniture or other objects will not block the path of the radiant heat.

.6 Fuel-fired Radiant Heating

This type of heating may be used in buildings such as arenas or garages. However it is not particularly efficient so it is not recommended if there is a better alternative.

.7 Air Curtains

In facilities which include large overhead door openings, such as Firehalls and Garages, it is recommended to provide air curtains across the openings.

Air curtains block outdoor air from entering into the facility and cooling down the work area. Reheating the space takes a considerable time and is uncomfortable for occupants.

7.2.7 Provisions for Monitoring Performance

.1 Low Heating Fluid Cut-offs

Devices installed to allow testing of low water fuel cut-offs must allow testing without draining the boiler.

This minimizes the loss of the heating medium. See also the March 25, 1992 Technical Bulletin issued by Electrical / Mechanical Safety Section, "Installation of Low Water Fuel Cut-Offs".

.2 Boiler High Limit Controls

The high limit controls on boilers are to be the automatic reset type.

In cases where there is not a daily inspection carried out on the boilers, it is undesirable to have the boilers remain down until the high limit is reset manually. If the resets are not reset promptly, considerable damage could result to the building from frozen piping and fixtures.

Each automatically fired boiler is to be provided with a high limit control to prevent overheating, with maximum setting of 121ºC.

The sensing element shall be installed either directly in the boiler or in a part adjacent to the boiler where there are no valves or obstructions between the medium in the part and the medium in the boiler.

The limit control shall be connected so as not to permit start-up unless all conditions are safe or, if disconnected, start-up cannot occur.

Each boiler shall be provided with an operating control to operate temperature control, which shall have an independent sensing element also.

.3 Thermometers

Provide liquid-filled or dial type thermometers scaled to the intended application in the following locations:

Thermometers installed in appropriate locations assist the building operators in system operation and performance evaluation.

- heating fluid supply and return to each heat generating device.
- on both primary and secondary heating circuits, supply and return lines, chilled water supply and return to each cooling coil
- return piping from each heating zone
- supply and return piping to each main heating coil (not required on reheat coils)
- converging side of three-way control valves

In piping systems, brass or stainless steel bulb wells complete with thermal grease are required. Thermometers to be located in a visible and readable location.

.4 Gauges

Provide dial-type pressure gauges (complete with snubbers) located to measure pump suction and discharge pressure at each pump.

7.2.8 Alarms

See Electrical E9.3 "Mechanical System Alarms" and Section M9.5 "Mechanical Alarms". *Update section with new section

7.2.9 Maintenance

.1 Air Vents

Manual tee handle type air vents shall be installed at all high points of hydronic heat piping throughout the building and provided with clearly identified access covers.

This facilitates release of air locks and ease of maintenance.

Automatic air vents are to be used in mechanical rooms. Automatic air vents should not be used in occupied areas of the building.

Propylene glycol quickly deteriorates the seats of auto vents. Auto vents should be used only in the mechanical room where leaks will not damage carpeting.

All air vents must have isolation valves.

.2 Air/Dirt Separator.
All hydronic heating systems are to be provided with an air and dirt separator.

.3 Hose Bibbs Near Boilers
A 19mm combination cold and hot water hose connection is required close to boilers. Hose bibbs must be equipped with hose vacuum breakers.

This is needed for flushing of boilers. Vacuum breakers are required to prevent backflow and to eliminate the potential of contamination of the potable water supply.

.4 Access to Valves
Access doors to all control valves and

isolation valves are required.

For ease of maintenance.

.5 Radiation Fins
Radiation cabinets should be secure, but easily removable by maintainers, and should be slope-topped to prevent item storage on top of cabinetry.

For ease of maintenance.

7.3 UNIT HEATERS

Hydronic unit heaters are to be used only for spaces that are normally unoccupied, such as mechanical rooms, large storage areas, etc., and in Garages and Firehalls, where noise levels are not a consideration. Unit heaters are to be hung with appropriate vibration isolation. Balancing, isolation, drain valves, air vents and unions are required on unit heaters. Unit heaters are to be equipped with fan guards.

Unit heaters are an inexpensive yet effective means of providing a controlled heat source in unoccupied spaces. They are generally considered too noisy for other applications.

Heating is to be controlled both by cycling the fan and closing of a control valve.

The control valve is necessary to prevent overheating.

In Garages and Firehalls, unit heaters are, where possible, to be wall-mounted at an elevation which allows for easy maintenance access.

In the past, unit heaters in these types of facilities were ceiling mounted at extra high level to provide clearance for vehicles housed below. This high-level mounting resulted in access and safety problems. Legislation now calls for scaffolding, man lifts and other safety features to be used if equipment is mounted above a specific height.

Unit heaters are not to be mounted higher than 3 metres off the floor unless a work platform or man lift is provided.

7.4 HEAT RECOVERY FROM POWER PLANTS

7.4.1 Heat Recovery Recommendations

Heating systems utilizing heat from any power generating system must be designed and built as “Primary/Secondary” systems. The boiler shall provide heat to the building through a heat exchanger and not directly through the piping. The power generating system shall provide heat through a heat exchanger on the return side of the building system. A thermostatically-controlled bypass valve must be installed so if the temperature from power generation is lower than the return temperature, the system bypasses the heat exchanger. See Figure 7-4*update #, Residual Heating System.

This arrangement prevents heat from flowing back from the building to the power plant.

7.5 SCHEMATICS

The following schematics provide various typical and preferred boiler and heating loop configurations used in the North.

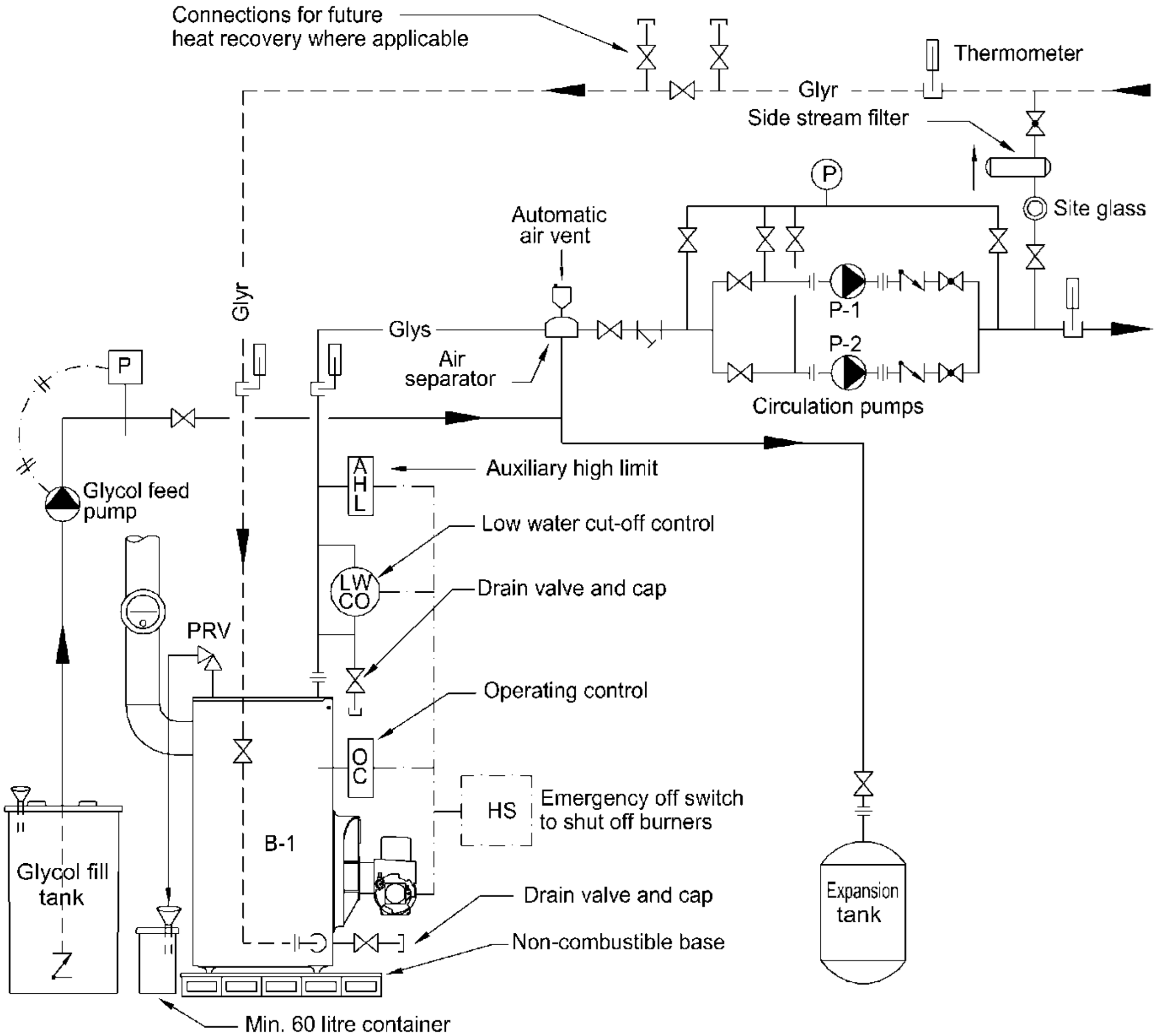


Figure 7-31: Single Boiler Double Pump

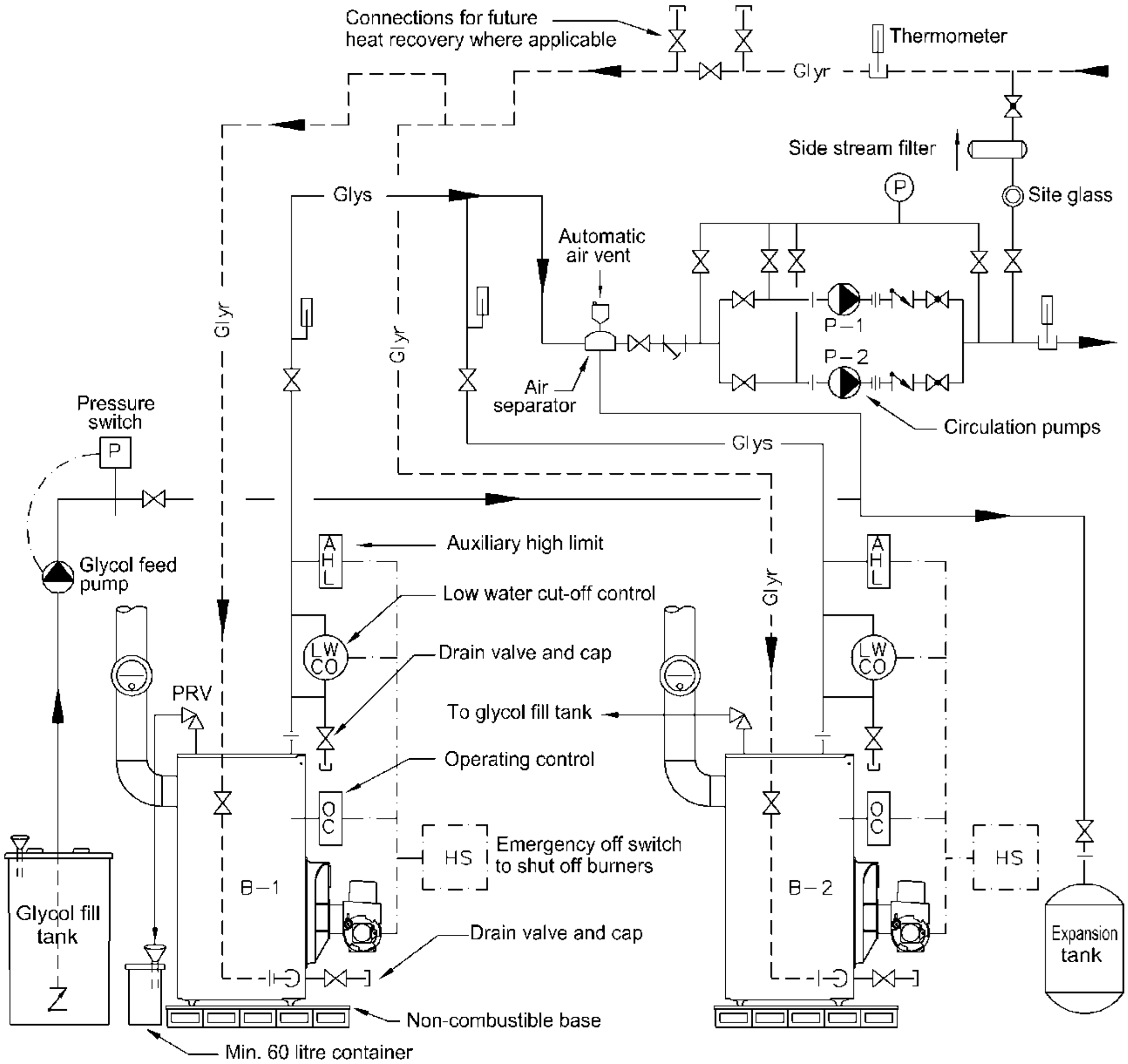


Figure 7-2: Double Boiler Double Pump

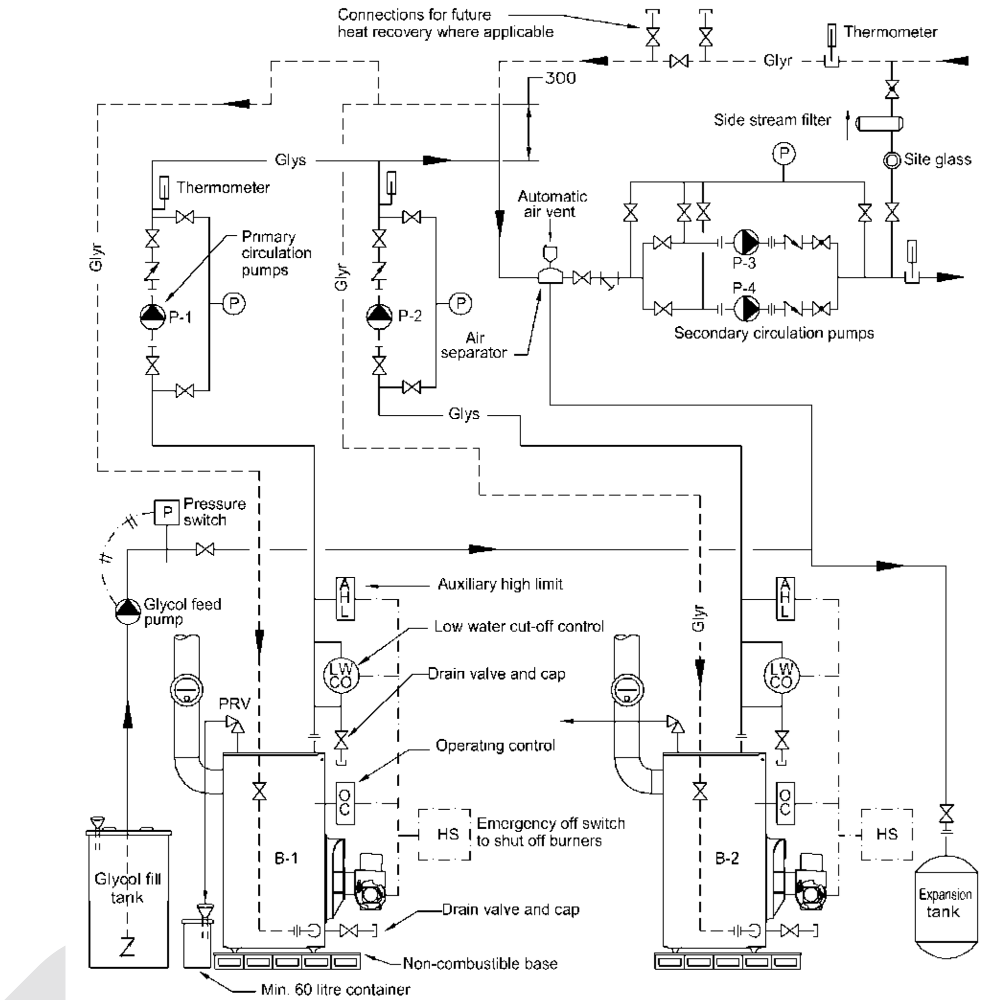


Figure 7-3: Primary-Secondary Boiler System

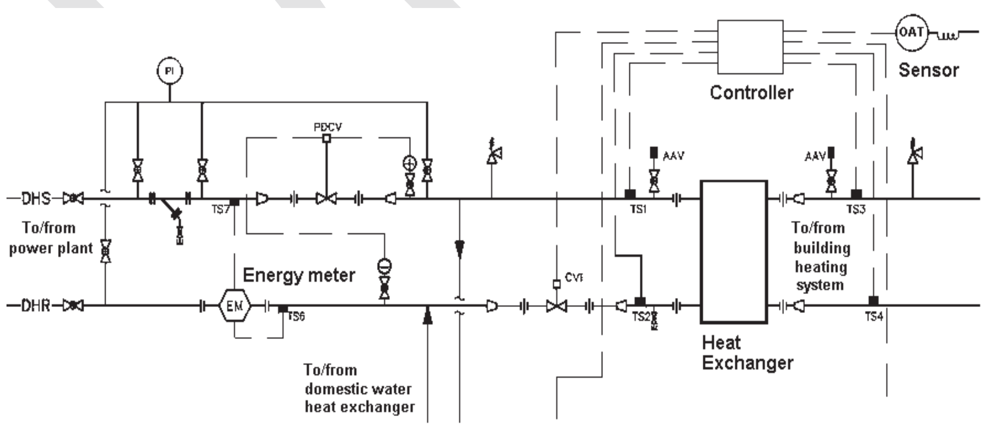


Figure 7- 4: Residual Heating System

7.6 OPERATION AND MAINTENANCE

7.6.1 Spare Parts

The following spare parts shall be provided:

- One new set of belts for each piece of machinery.
- One unused spare pump for each and every type and size of pump in the system where pumps are not supplied in tandem where there is no redundancy.
- One additional sealed drum of Dowfrost HD.
- 12 new 10 micron sidestream cartridge filters (if applicable).
- One new motor and fuel pump for each type of oil burner installed.
- A six month supply of chemicals for steam boilers.
- Thermometers/ gauges
- 5 new control valves

7.6.2 Regional Equipment Preferences

Regional preferences should be considered when selecting equipment.

7.6.3 Code Requirements

Hydrostatically test entire system at 150% normal operating pressure for 12 hours with no measurable leaks.

Drain system, fill with non-foaming phosphate free detergent and circulate for 8 hours, drain and flush for 4 hours, drain and clean all strainers, refill and circulate for a further 2 hours, and repeat until strainers have no debris, then fill entire system with Dowfrost HD.

Perform hydronic balancing on entire system where required.

Perform combustion analysis tests on heating appliance(s).

J8 AIR DISTRIBUTION

Air quality of a reasonable standard is a basic human need, not a luxury. As buildings have become increasingly air-tight in the interest of reducing energy consumption, the supply and control of ventilation has grown to be increasingly important. When ventilation is inadequate, users are not only uncomfortable, but may experience health problems. The extreme cold experienced during much of the year in the NWT can make it more difficult and costly to achieve adequate ventilation than in other areas of North America. Toxic and noxious chemicals released by building materials and finishes, dust, moulds and microbiological organisms, as well as air used by occupants, must be removed by the ventilation system.

The pressure regime in a building must be considered during design and construction. A slight positive pressure inside the building during winter is important to prevent infiltration. However the various occupancies inside a building may each require particular relative pressures compared to other areas, as in health facilities or laboratories. Building air systems shall be designed so that the building pressure regime can be adequately controlled on a day to day basis, and can respond to outside effects (e.g. strong winds) or inside conditions (the use of laboratory fume hoods, etc).

8.1 NATURAL VENTILATION

Natural ventilation uses non-mechanical means of supplying and removing air through the building. Airflow through the building is caused by pressure differences between the building and its surroundings to provide ventilation and space cooling.

The use of operable windows or outside air openings is not really a very effective way of introducing adequate fresh air or ensuring even distribution during winter months. Cold air, often accompanied by snow particles, coming in through a window or opening has a detrimental effect on occupant comfort. Natural Ventilation shall not be utilized as the sole method to provide ventilation to a building or space.

Natural Ventilation can be utilized to supplement the buildings Mechanical Ventilation system in a form of Mixed Mode Ventilation to provide additional cooling during the shoulder season or reduce energy consumption by delaying the use of mechanical cooling. The use of cross ventilation or stack effect can be used to provide a pressure difference in the building to drive the Natural Ventilation. The system should be automated and connected to the buildings DDC system. High level exhaust openings should have motorized actuators on the dampers and close during unoccupied times or close after a specified time interval. A properly-designed and controlled system relying on natural air flows can often provide adequate supplementary ventilation without adding to the mechanical and electrical complexity of a building.

The harsh climate of the Arctic makes mechanical ventilation the only practical alternative during the heating season. Systems that require the opening of windows or portholes as an integral part of the mechanical ventilation system design have proven to be unsatisfactory in winter conditions.

This does not preclude use of natural ventilation as an overall part of the ventilation strategy for a building, during shoulder or summer seasons. Natural ventilation aids in reducing the cost of electrical power and fuel.

8.1.1 Supply

Whatever the means of supply air, it must prevent entry of snow and dust.

Ventilation hoods are often used in place of operable window sections. They are typically used for residential occupancies, or small offices and schools where users are capable and willing to control ventilation. Operable windows are preferred for summer use buildings only.

Any filters or screens provided at the supply air openings must be easily accessible and easy to clean.

Supply air openings should have positive closure devices such as motorized dampers. Manual operated devices are not recommended. If manual operation is desirable, it should be tied to timers, either spring wound timers or push buttons and timed through the DDC system.

Having openings operated by timers or through the DDC ensures that the openings are not left open during the night or unoccupied times and can prevent a freezing condition.

8.1.2 Exhaust

Exhaust must be located to create an even flow of fresh air through rooms, without creating uncomfortable or disruptive drafts.

A common shortcoming of natural ventilation is that air is not mixed, or air currents are so great that paper flies off tables and desks! As a minimum the BAS should control the exhaust air opening. The BAS shall disable and close natural ventilation opens when the space or building is not occupied

Exhaust openings should have positive closure devices such as motorized dampers to enable the throttling of the natural ventilation flow.

8.2 MECHANICAL VENTILATION

As natural ventilation systems are not applicable for all season use in the north, unless allowed by code, all buildings are to have some form of mechanical ventilation. Mechanical ventilation systems are needed to ensure that adequate ventilation is provided in buildings to attain a minimum indoor air quality and comfort level. The quantity and temperature of outdoor air brought into a building must be adjusted frequently to suit changing outdoor conditions and indoor requirements. The BAS can perform this function for the building users, while maintaining simplicity in operation and maintenance.

In the interest of economy, designers are encouraged to consider more energy-efficient ventilation strategies while continuing to meet the requirements of ASHRAE 62 (Current Edition) and maintaining optimum occupant comfort levels of indoor air quality.

The heat required for ventilation air is often the largest contributor to a building heating load. Heat recovery between exhaust and ventilation air is viable in most systems and should always be considered.

As ventilation systems are also large users of the buildings electrical energy it is also important to reduce energy consumption through the use of VFD's, ECM motors, scheduling and reducing internal and external static pressures of ventilation systems through optimal design and demand ventilation strategies.

Mechanical ventilations systems are to be located inside the building, in adequately sized fan or mechanical rooms. If rooftop units must be used, there must be inside access to the roof (via stairs or ship's ladder. Vertical ladders are not acceptable). Consideration should be given to providing enclosed service access to rooftop units to allow maintenance to be performed in a protected environment.

Mechanical ventilation systems are also not to be located in rooms containing fossil fuel fired appliances such as boilers and DHWH.

Although outdoor air temperatures can rise above comfortable indoor levels during the summer months, the additional cost of providing cooling is often not justifiable in many buildings given the short period of time it will be required and the occupancy of the building during the summer months, such as schools. There are instances, however, where mechanical cooling is required and shall be assessed and recommendations made during the design process.

8.2.1 Choice of Systems

.1 Natural air supply and mechanical exhaust:

This system relies on the users. Users must open windows for supply air. Kitchen or bathroom fans are used for exhaust, and are usually on manual switches.

Limited to use in seasonal use buildings.

This system is considered unsuitable for buildings used by the public, or by groups of people who will not likely take on the responsibility of controlling ventilation.

.2 Mechanical air supply and natural exhaust:

Limited to use in small group homes or seasonal use buildings, where a forced air furnace is provided for heating.

This system relies on the users to control the exhaust. Hence it is not considered suitable for public use buildings.

The use of natural or barometric relief does not allow for effective balancing the outside air amount into the system and due to this it also does not lend itself to the use of free cooling.

.3 Mechanical air supply and mechanical exhaust:

To be used in all buildings other than those mentioned above.

A two-fan system is required.

Both supply and exhaust can be automatically controlled using temperature sensors and timers. Control does not rely on users. Improper maintenance or operational difficulties (which may be design-related) can lead to user complaints, but that is true for any building system.

.4 Mechanical air supply and mechanical exhaust in combination with natural ventilation (mixed-mode ventilation):

This system should be considered when there is a requirement for supplementary ventilation.

Both supply and exhaust can be automatically controlled using temperature sensors and timer. Control does not completely rely on *users. System optimal in shoulder seasons and for use in schools.*

8.2.2 System Configuration

.1 Constant Air Volume (CAV):

Air through the ventilation system is supplied to the distribution system from the air handling unit in a constant flow rate at a set temperature.

CAV systems are most suitable for small buildings with single thermal zones or single occupancies. Interior spaces may require terminal re-heat for occupancy comfort. Due to the constant nature of the supply there is little energy savings potential is system configuration.

.2 Variable Air Volume (VAV):

VAV systems vary the airflow delivered to the distribution system at a constant temperature. VAV system can be single or multiple zones.

VAV system can provide lower energy consumption by system fans, less fan noise and reduced wear.

Even a single zone VAV system has advantages over a CAV system for energy savings. As a minimum, air handle units should be equipped with variable speed drives on all fan motors.

Multi-zone systems to be equipped with VAV terminal units in the form of VAV Boxes. VAV boxes for internal spaces to be equipped with re-heat coils. All VAV boxes to be equipped with sound attenuators.

The use of VAV terminal units lends itself to the use of demand control ventilation measures to reduce energy consumption.

As a minimum, ductwork upstream of VAV terminal units to be medium velocity ducts, SMACNA seal class “A”, 750 Pa.

The use of medium velocity ducts allow smaller duct size to be utilized.

.3 Dedicated Outside Air System (DOAS):

A DOAS consists of two (or more) parallel systems where there is one system that is dedicated to delivering the outdoor air ventilation. The outdoor air system handles both the latent and sensible loads of

Though not frequently used in the north it has application in systems such as variable refrigerant flow (VRF) which can utilize a distributed fan coil system, Outside air is delivered directly to individual zone fan coil conditioning the ventilation air and the parallel systems handle the mostly sensible heat loads.

units (FCU) which then mix it with return air from a plenum condition it further if required (heat or cool) and deliver it to the space.

.4 100% Outside Air System :

System delivers only O/A to satisfy the requirements of ASHRAE 62. It needs to be coupled with a distribution system that has a high ventilation effectiveness such as Displacement Ventilation. A 100% O/A system is limited in its ability to provide adequate cooling and is often coupled with natural ventilation of some form of supplementary cooling systems.

100% O/A systems have been successfully utilized in schools where there are limited cooling requirements due to summer closures.

8.2.3 Outdoor Air Supply

.1 Supply

A minimum outdoor air flow rate per person is required, based upon the "normal" occupancy of the building as quoted in ASHRAE 62 (current edition).

Ventilation systems are to be sized to provide ventilation to the area served based upon the normal occupancy of that area. The use of ventilation systems sized for occasional peak occupancy within gymnasiums or halls results in oversized heating plants and ventilation equipment. These have higher capital, operating and maintenance costs, and are not as efficient as smaller systems.

For facilities which have a high "Occasional Occupancy" level, consideration should be taken in variable occupancy spaces such as Gymnasiums or Community/Assembly Halls, outdoor air volumes should be calculated and strategies utilized to vary the outside air volumes based on expected occupancies.

When sizing the heating coil and control valves for occasional peak occupancy spaces it may be necessary to provide parallel control valves or two heating coils to account for the differing amounts of heat at the maximum and minimum occupancy levels.

These could include but not limited to:

- Demand control ventilation based on CO2 concentration.
- Demand controlled ventilation based on occupancy sensors

- Two minimum outside air damper positions switched manually or through the BAS.

.2 Free Cooling

All mechanical ventilation systems shall have the ability to provide free cooling.

Most new buildings are very energy efficient. Even at quite low temperatures (i.e., -10ºC to -15ºC), there may be a need to cool the core of the building during occupied hours in order to dissipate internal heat gains from lights, equipment and people. This can be accomplished with free cooling.

8.2.4 Cooling

For most of the year, the supply air temperature can be controlled by varying the amount of outdoor air introduced into the system, and adjusting the heat supplied to heating coils. Free cooling is generally adequate for the shoulder seasons with mechanical cooling only required during the hotter days of the year.

The additional expense of cooling equipment must be weighed against the benefit of cooling. Where cooling may be needed only for a few days of the year, the use of cooling equipment is discouraged because of the added capital and O&M costs.

When even the maximum amount of outdoor air (see M8.3.1 "Outdoor Air Supply" - reference to free cooling) will produce supply air above 18ºC for an extended period of time, the need for cooling equipment should be reviewed.

Due to climate change and the changing weather patterns in the north, allowing for future cooling equipment should be considered. Allowances/space for future cooling coils in air handling units, electrical allowances for condensers, chillers or split units.

Where mechanical cooling is installed, equipment must be designed in conformance with the National Building Code.

Provision must be made for proper system shutdown in fall and startup in the spring.

8.2.5 Installation

All mechanical cooling and refrigeration systems shall only be installed and commissioned by a qualified refrigeration mechanic. The engineer is to ensure that this requirement is included in the specifications

In the past some systems were installed by non-qualified persons, and problems resulted.

8.2.6 Choice of Systems

For most buildings with minimal air handling units and minimal zones, Direct Expansion Refrigeration (Dx) systems are the most cost effect approach.

The use of energy modeling may be beneficial in determine the most cost effective approach to mechanical cooling.

Buildings with varying cooling loads, multiple air handling units and zones, the use of Chilled Water Systems (CW) provide the best control.

In rare cases where it is appropriate to couple the heating and ventilation systems it may be possible to utilize Variable Flow Refrigeration systems (VFR).

8.3 SYSTEM COMPONENTS AND CONFIGURATIONS

8.3.1 Humidification

Humidification is not typically required or recommended in most Northern buildings.

In the past, humidification systems in the North have proven to be very difficult to operate and maintain because of poor water quality in many communities and lack of maintenance attention. During extremely cold outdoor temperatures, humidification levels in a building must be kept low to prevent excessive condensation on windows and deterioration of the building envelope. This constraint reduces the benefit of humidifying the building and contradicts the rationale for providing a humidification system in the first place.

Where humidification is deemed necessary and specifically stipulated as a functional program requirement, it should be steam-generated, and the system equipped with controls that automatically reset the humidity level to the outside air temperature. Supply water to the system must be properly treated.

Steam-generated humidification is more reliable than atomization systems, which malfunction due to calcium build-up. A proper treated water supply to the humidification system is required to ensure long-term system operation.

8.3.2 Outdoor Air Intakes

To ensure acceptable indoor air quality is maintained within buildings at all times, it is critical that outdoor air intakes are located far from possible contamination sources. The location of roadways, parking and service points and prevailing winds must be considered during building site selection and design.

Properly designed hoods prevent the air intake from filling up with snow (a frequent occurrence where precautions have not been taken).

Many problems (even closure of buildings) have occurred when vehicle exhaust, diesel fumes, sewage gases and products of combustion were drawn into the building through the outdoor air intakes.

Outdoor air intakes must be positioned and designed with care to prevent snow from being drawn into the system. *See Figure 8.1.* The following design guidelines apply:

.1 Outdoor air intakes should be located on the opposite side of the building from the

This reduces the chance of bringing in objectionable odours, vehicle exhaust or flue sewage tank pump-out connection. Where that is not possible, the intake should be at least 10 metres (horizontal distance) from all trucked service points, including sewage pump-out, water fill, fuel delivery and from chimneys and exhaust outlets.

gases from chimneys with the outdoor air.

Refer to ASHRAE 62.1-2016, Table 5.5.1 "Air Intake Minimum Separation Distance" (or latest edition) for required separation from other contaminant sources, including plumbing vents, vehicular traffic, and garbage storage.

.2 Outdoor air intakes should be located on the sides of buildings scoured by the wind. Consideration should be given to the possibility of entrained snow.

A review of snowdrifting patterns is required before locating the air intake, as drifts may impede system operation for many months of the year.

.3 Intakes must be provided with downturn hoods of a sufficient vertical length (minimum 600 mm). Intake air velocity must be less than 1.5 m/s.

This design prevents contaminants (snow, wind and insects) from entering the air system.

.4 Hoods are to be elevated above the expected snow depth, not merely above ground elevation. Locate bottom of hood at minimum 300 mm above local snowfall accumulation depth.

Hoods should be mounted high enough to avoid becoming blocked by snow accumulations expected in the project location. Height and ground cover is also a consideration in respected to entrained dust.

.5 Hoods are to be set out approximately 200 mm from the wall surface, not tight up against it.

Winds hitting the face of the building can force snow up into the hood. Setting the hood out from the wall reduces snow entry during windy conditions.

.6 Hood finish is to be either natural galvanized steel or a factory coating (baked-on or powder-coated).

Normal on-site painting is not good enough, as it does not produce a tough and durable finish.

.7 Do not install insect screen on outdoor air intakes.

Insect screens can become blocked by snow and insects can be trapped in filters. If the building location (i.e., South Slave Region) absolutely requires screens, provide removable type so screens can be removed in winter.

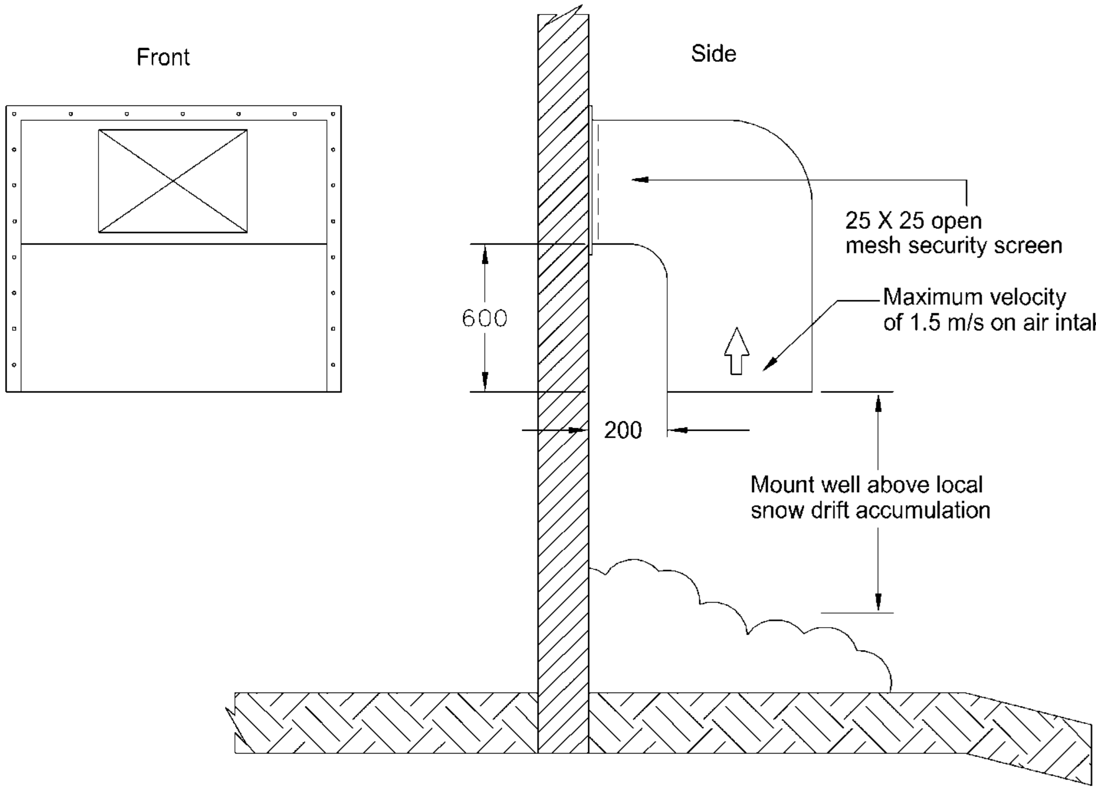


Figure 8-1: Outdoor Air Intake

.8 Dampers

Outside air dampers are to be low leakage, insulated and thermally broken type.

This limits the infiltration of outdoor air.

.9 Insulation

Insulate the full length of all outdoor air ducts using external duct insulation. O/A duct insulation should be in conformance with the NECB. Placement of outside air dampers has an effect on determining the thickness of the insulation.

The use of a duct liner in an outside air intake duct is not recommended by ASHRAE.

8.3.3 Air Mixing

Packaged mixing boxes are not recommended.

Conventional equipment is designed for conditions in southern Canada or central U.S.A. In the NWT, where outdoor air temperatures may be as low as -50ºC, mixing of cold outdoor air with room temperature air is more difficult, and standard mixing boxes cannot mix the air properly.

There must be adequate provision for outdoor and return air to mix to a uniform temperature before reaching the filter and heating coil in the air handling unit. A variance of no more than about 2 Celsius degrees from one point to another should be achievable.

Supply air is a mix of fresh outdoor air and return air from the building. A temperature sensor is provided to read the mixed supply air temperature. The amount of outdoor air admitted is controlled by this sensor. If return and outdoor air are not thoroughly mixed when they arrive at this sensor, it will read the temperature of either a warm or cold stream of air and will let in either more or less than optimum amounts of outdoor air.

The following guidelines are suggested in order to ensure thorough mixing in most severe conditions:

- Arrange mixing dampers so the coldest air stream (outdoor air) is located at a higher level than the point of return of the warmer (return) air.

This promotes the mixing of warm and cold air by taking advantage of convection.

- Use opposed-blade dampers.

These dampers mix air thoroughly by directing streams of air towards each other.

- Locate the incoming air ducts at least 3 meters upstream of the heating coil, with at least one duct elbow in the mixed air before it connects to the air handling apparatus.

This gives the air more distance in which to mix well before it reaches the heating coil.

Air blenders or stratification eliminators are recommended to ensure mixing of (cold) outdoor air and return air.

Packaged air handling units with integral mixing boxes are not designed for arctic winter conditions. Their use should be avoided where possible. During extreme cold conditions, good *air mixing is important to allow air handling systems to operate normally, without nuisance tripping from low temperature controls. Effective temperature control is difficult to achieve without good air mixing.*

Exhaust and relief air ducts are to be insulated for a minimum length of 3 meters back from the damper position.

Insulation prevents the formation of condensation on ductwork exposed to cold air when the system is operating or shut down.

If the damper position is not located at the exterior wall, it is required to provide insulation on the portion of duct between the damper and the exterior opening equal to the insulation value in the exterior wall.

Outside air, exhaust air and relief air duct insulation R-values are to be as per NECB (Current Edition)

All moving equipment is to have permanent directional indicators.

To show that it is moving in the proper direction.

8.3.4 Air Distribution

When designing a building, the interior air pressure regime inside must be considered. It is desirable to have a slight positive pressure inside the building, particularly in winter, so infiltration through the envelope is not encouraged.

The stack effect will affect all buildings to some extent, as will the prevailing wind intensity and direction. The stack effect can be intentionally used in the design to encourage airflow through a building, as in the case of natural ventilation

.1 Diffusers

For conventional mixed-air systems, ceiling diffusers, adjustable for horizontal

Other systems, such as fixed horizontal diffusers or floor registers, do not promote proper air flow under all conditions and may and downward flow, located at the midpoints of approximately equal divisions of room area, are preferred. The use of several sidewall supply registers located along the longest interior wall (facing the perimeter wall) is also acceptable.

result in stratification in the winter, which is to be avoided.

Floor diffusers (for return or forced hot air heating systems only) are to be heavy gauge, not the domestic type (unless it is for a residence).

Residential grilles and registers are unsuitable for buildings such as schools, where they may be easily damaged or manipulated. Registers designed for residential use are of a light gauge metal and have built-in balancing dampers, which, if wrongly adjusted, can cause air balancing problems.

Air diffusers in the floor and supplying through the baseboard radiation are not acceptable.

Air supply through the baseboard radiation does not permit proper air diffusion and temperature control.

Displacement ventilation systems, used with radiant-floor heating, require a different design approach. Air is supplied at low velocity from displacement supply diffusers located at floor level and extracted above the occupied zone at ceiling height. The air is introduced at low velocities and at a temperature only slightly less than that of the room. For example, air at 18 degrees C is supplied to a room temperature of 21 degrees C. The air flows along the floor until it encounters a heat source (occupants, computers, lights) where it becomes warmer and more buoyant creating upward flows known as thermal plumes.

Displacement ventilation uses less total air than similar-size mixed-air systems. Less fresh air is needed because of better air mixing in the space.

.2 Variable Air Volume (VAV)

VAV systems can be utilized as an energy savings measure where there may be a large requirement for cooling. As the cooling load in the space increases the

Air flows for ventilation systems during heating and cooling modes may be different. A higher air flow rate may be required to meet the demand of the cooling load. Being able to system increases the airflow into the space. This is often done through the use of a VAV box.

decrease the flow when not required can provide savings in the energy consumed by fans.

VAV boxes can also be utilized for demand ventilation control to reduce air flow in areas of low occupancy (gyms) or when the space is not occupied.

.3 Dampers

Balancing dampers are required on all main branches at each branch duct take-off. Dampers should be in-line mounted locking-quadrant type. Duct splitter dampers are not acceptable for use for balancing. Volume control dampers (at diffusers) are not an acceptable means of controlling air volume.

Line-mounted dampers are a reliable means of balancing. The results of adjustments made with splitter dampers are unpredictable, as the air flow in the main ducts as well as in the branch duct is changed. Dampers located near to supply outlets may be noisy, due to the high duct air velocity.

Where it is not feasible to balance the diffuser utilizing standard balancing hoods, in the case of some displacement type diffusers, the use of Air Flow Valves are required.

If the use of air flow valves is required, it is important to provide minimum straight duct runs before and after the air flow valve to achieve proper readings. Refer to the manufacturer's documentation.

.4 Fire Dampers

Fire dampers are to be installed as per ANSI/NFPA 90A (complete with sleeve, fire stopping, and breakaway connections on ductwork on each side of the fire separation). Access doors are required on both sides of the fire separation, and these doors must be easily accessible for maintenance and resetting.

Use Type B fire dampers (out of stream, in which the airflow area is not reduced by protruding damper blades) rather than Type A (instream dampers) wherever possible. If Type A must be used, ensure that the system static pressure is not compromised by the penetration into the airstream (by increasing duct size at that location).

.5 Flexible Ductwork

Flexible ductwork shall be limited to short lengths (within one meter) of equipment to be connected. Flexible duct is to be fastened to the sheet metal ductwork and diffuser with an approved tie wrap or metal clamp (not with duct tape).

Improperly-fastened and/or exceedingly long flexible ducts increase the duct pressure loss, and can cause airflow problems.
Duct tape does not provide a secure seal; it tends to fall off after some time in use.

.6 Flexible Connections

Flexible connections of approved, fire resistant design are required at the suction and discharge connections of fans and air handling units. Fan equipment is to be installed so that the connecting ductwork is aligned with the fan inlet or outlet and the flexible connection does not obstruct the air flow.

The use of flexible duct connections reduces noise and vibration transmission from fan equipment through the building structure to the occupied spaces. Fan performance is adversely affected and energy use increases if the ductwork connection is off-set, or if the flexible connection projects into the air stream.

.7 Branch Take-off Ducts

Branch take-off ducts to each air supply or exhaust outlet are to be a minimum of 0.5 m in length, located in an accessible location with a duct-mounted balancing damper positioned near the take-off fitting.

Supply or exhaust (return) air outlets mounted directly on the main branch ductwork tend to cause uneven air velocities and are noisy and uncontrollable. Balancing dampers located too close to the actual air outlets cause noise.

.8 Duct Sealant

An approved duct sealant is to be used for sealing ductwork. Duct tape is **not** acceptable.

Duct tape is not satisfactory for sealing ducts. It loses adhesive properties, particularly on cold ducts.

.9 Protection

Ducts located under other mechanical equipment shall be protected by a removable catwalk to allow service of equipment without damage to the duct.

If ducting is handy for access to equipment, it will get used and subsequently damaged.

.10 Thermal Insulation

Thermal insulation is to be provided on all outdoor air intakes up to the handling unit, and on exhaust/ relief ducts leading outside.

Insulation of supply and return ducting is only required where mechanical cooling is provided.

Distribution ducts are to be insulated to the requirements of the NECB.

.11 Acoustic Insulation

Acoustic insulation is to be provided on all ducting in a fan room, on minimum first 10 m of any duct run to or from a fan.

Acoustic insulation is to be provided on all transfer ductwork and wherever fan and duct noise may be a problem.

.12 Silencers

Where the designer deems these are needed to satisfy space noise level requirement, silencers are to be provided.

.13 De-stratification Fans

Consider use of de-stratification ceiling fans in high ceiling areas (i.e., in garages, theatres, etc.) Size the fans for total area coverage. Provide protective guards over fans where they may be subject to damage.

Ceiling fans improve tempered air distribution during heating and cooling seasons, and reduce energy cost. Provide timers to prevent fans running when they are not needed.

8.3.5 Air Exhaust

.1 Location

Outdoor exhaust vents are to be located where they will not be susceptible to snow accumulation, or discharge directly into the prevailing wind. Avoid locating in the vicinity of the outdoor air intake (i.e., within 10 m).

Snow accumulation can hamper or eliminate exhaust capability. A review of snow-drifting patterns must be done before locating exhaust vents, as drifts can impede system operation for many months of the year.

Exhaust openings to be equipped with wall hoods, as per figure 8.1, to protect the opening from entrained snow/frost when not in operation.
Also avoid location whereby exhaust air discharges onto building Thermosyphon radiators.

.2 Insulation

The exhaust air ductwork must be insulated where contact is made with outside air.

This reduces the amount of condensation that may freeze and build up, reducing the size or closing off of the exhaust opening.

.3 Local Exhausts

Local exhausts should be provided in all rooms and spaces where high levels of contaminants or odours are generated.

They are typically provided in industrial arts rooms, change rooms, washrooms and kitchens.

Exhaust is to be provided adjacent/above printers and plotters to reduce volatile organic compounds (VOC) produced by printers being recirculated within the ventilation system.

Recirculating exhaust systems, such as range hoods, are not acceptable.

If the recirculation air filters are not maintained, the system is less effective.

Individual major exhaust fans are to be interlocked with the air handling system.

Unless air is being brought in to replace exhaust air, a strong negative pressure can be *created in the building which can cause infiltration.*

Local exhaust fans must not discharge into boiler rooms.

Unstable draft conditions will affect burner combustion efficiency.

Manually-controlled exhaust fans are to be provided with timed switches.

This avoids the possibility of exhaust fans being left operating for long periods of time.

8.3.6 Maintenance

600 mm x 600 mm access doors are required for fresh air dampers.

This allows operators and maintainers access for adjustments and repairs.

300 mm x 300 mm access doors are required for fire dampers.

Ensure that doors to fire dampers are easily accessible and will allow the fire damper to be drop tested and reset.

500 mm x 500 mm access doors are required for:

- exhaust air dampers
- return air dampers
- filters and coils
- balancing dampers
- mixing boxes
- reheat boxes
- turning vanes
- heat wheels
- heat pipes

Isolating and balancing valves must be installed so that the flow through each heating coil in the air handling system can be adjusted with the coil circulating pump on or off.

It must be possible to operate the system manually if the three-way valve is removed for maintenance or repairs.

Adequate access should be provided to allow complete removal of heating coils.

Basic maintenance requirements.

Provide enough unions and valves to allow equipment removal with minimal system impact.

Provide access panels upstream and downstream of heating coils, adequately sized to allow steam or compressed air cleaning of coils *in situ.*

8.3.7 Provisions for Monitoring Performance

.1 Balancing

For ventilation system balancing, instrument test holes, drilled on site and sealed with duct plugs, are preferred to permanent test ports.

Test ports are costly and not required often enough to warrant the extra expense of installing them. Test holes can be drilled on site by the balancing contractor where and as required.

.2 Adjusting Outdoor Air

Instrumentation must be installed to allow operators to monitor the temperatures of outdoor air, mixed air and supply air. Dial-type thermometers are preferred.

By monitoring temperatures, the operator can set correct proportions of outdoor air and mixed air to give desired supply air temperature. When supply air is not at the correct temperature, users are uncomfortable.

Dial-type thermometers should be used rather than other types, as they are easier to read.

Each air handling unit is to have supply air, mixed air, return air and outdoor air thermometers.

Thermometers give an indication to building operators of system performance. Thermometers and other gauges or indicators must be easily visible to a person standing in an accessible location in the room.

8.3.8 Heat/Energy Recovery Systems

Due to the need for energy efficiency in buildings, heat and energy recovery systems are to be used wherever savings from their use can be demonstrated to provide acceptable payback against the added capital costs of provision of the system.

Packaged heat and energy recovery ventilators (HRV/ERV) are acceptable for small facilities such as community air terminal buildings, small offices etc., but they must be provided with a pre-heat coil on the outdoor air intake to counter defrost cycles.

Pre-heat is the only acceptable de-frost method acceptable for HRVs and ERVs. Re-circ and exhaust only de-frost approaches limit the effective ventilation provided to the building and if not properly balanced lead to frozen heat recovery cores or overly negatively pressurized buildings.

Heat wheels, heat pipes and glycol heat recovery runaround loops may be acceptable for larger facilities.

Small HRVs/ERVs can be utilized in parallel heat recovery configurations where the use of heat/energy recovery devices within the main AHU's is prohibited through cost and or space limitations.

8.3.9 Filters

All air shall be filtered before entering coils, equipment or occupied spaces. Filters should be throw-away type, standard size.

Filters prevent dust and debris buildup. The use of standard size throw-away filters makes replacement easy and quick.

Filtering shall be achieved by two sets of filter banks, pre and final filters not by a summer-winter filter arrangement.

A summer-winter filter bank arrangement is unsatisfactory because if it is maintained properly, snow can get into the air handling system. In locations where this system was used, maintainers were not always aware that they had to remove one filter set in each season.

Pre filters are to be located prior to all coils and energy recovery devices and be a minimum MERV 6.

Filters are to be located in the return air stream prior to any energy recovery device and be a minimum MERV 6.

Size, number and designed type of filter are to be permanently labeled (lamacoid) on the unit near the filter access door.

Final filters are to be located prior to the air leaving the air handling unit are to be a minimum MERV 11.

Size, number and designed type of filter are to be permanently labeled (lamacoid) on the unit near the filter access door.

This makes it easier for maintainers.

For ease of maintenance, the design should use as few types and sizes of filters as possible.

This makes it easier and simpler to order, store, and install filters.

The pressure drop across all filter banks is to be displayed and monitored by the building automation system and a gauge at the unit.

Providing an alarm when the pressure drop exceeds a set value is an indication that the filters should be changed.

8.3.10 Acoustic Control

.1 Duct Lining

Acoustic lining should be provided in the supply air, return air and exhaust air ducts 5 m downstream and 2 m upstream of fans. Pin spot fasteners, not self-adhesive clips, are to be used.

This is required to minimize noise transferred from fans to the occupied space.

Past experience has shown that self-adhesive clips may detach and duct liner can loosen and block ducts. For this reason, a more secure fastening method is required.

Adhesive must be applied to the **entire** adhering surface area of acoustic duct lining.

There have been cases where the duct liner has come loose because of inadequate adhesion. Loose duct insulation can totally block ductwork and may not be noticeable to a maintainer.

Continuous and perforated metal liner may be required in some installations,

.2 Acoustic Separations

All components of the mechanical ventilation system must be designed so that the sound level will be within noise limits recommended by ASHRAE or by particular client or space requirements.

Mechanical noise and vibration of fans and pumps can be objectionable to building occupants. The national Building Code requires HVAC systems to be designed, constructed, and installed in conformance with good engineering practice, as outlined in the ASHRAE Handbooks and Standards, and others.

8.3.11 Mechanical Room Cooling

In mechanical rooms and boiler rooms, provide mechanical make up and/or exhaust systems to maintain the rooms at acceptable operating temperatures. Care should be taken when venting boiler rooms to ensure that the increased or decreased air pressure in the room does not affect the operation of the oil burners.

Continuous high temperatures in mechanical and boiler rooms shorten the service life of mechanical and electrical equipment and create uncomfortable working conditions for maintenance personnel.

8.4 ENERGY RECOVERY AND DEMAND CONTROL SYSTEMS

Higher energy costs and indoor air quality requirements place increasing demands on energy recovery and control system technologies.

To maintain good indoor air quality and conserve energy, consider controlling the ventilation rate so it varies according to the needs of building occupants.

Technologies such as Demand Control Ventilation (DCV), Direct Digital Control (DDC), new energy recovery equipment and associated controls provide opportunities to reduce energy consumption.

8.4.1 General

When designing new building systems, whether heating, ventilation, and/or services, every effort should be made to incorporate energy recovery and/or control systems.

These systems reduce the size of primary load equipment (i.e., boilers, chillers, burners, pumps, etc.), and so reduce overall building energy consumption. In new buildings, the cost savings resulting from the smaller size of cooling and/or heating equipment offset any initial added cost for heat recovery units.

The higher installation costs versus overall operational cost reductions should be weighed, especially on smaller systems. The client may wish to see a capital cost recovery summary as part of the system design and analysis.

Energy modelling the proposed and alternate systems can provide valuable information on energy consumption and be utilized to life cycle cost various energy efficiency measures to determine the most cost effective system arrangements.

8.4.2 Energy Recovery

Devices - General

When selecting heat recovery equipment, select devices that recover sensible heat.

Sensible heat is the most readily-recoverable energy, especially considering the low humidity levels encountered in the North.

Heat wheels can recover latent as well as sensible heat (heat pipes, heat exchangers and glycol loops cannot). Note that heat wheels cannot be used where there is danger of cross-contamination between airflows. The efficiency of heat wheels is higher than that of heat pipes or glycol loops. However, the use of heat wheels should be evaluated for use in remote communities against the level of maintenance capacity available in each community.

Use counter-flow energy recovery equipment only.

Generally, counter-flow provides the greatest temperature difference and heat transfer rate across the recovery exchanger.

The designer must bear in mind the project location and maintenance preferences when selecting types of heat recovery systems.

When selecting equipment, consider such factors as installation and operational costs, ease of operation, simplicity and maintenance, etc.

8.4.3 Demand Control Systems

On large volume systems (i.e., greater than 8 500 l/s), consider using demand control ventilation (DCV) systems with sensory controls (i.e., CO_2 sensors, time control and/or occupancy sensors). CO_2 control is best utilized in rooms where occupancy variation is high and/or unpredictable. Timed control is best used in situations where the occupancy load and load variations of a building are known over time, while occupancy sensors are best utilized in low occupancy, intermittent use areas.

When properly located and installed, DCV systems may offer greater payback than energy recovery systems due to the disparity in electrical costs and fuel costs. Reducing fan energy may have a greater impact than saving fuel oil through heat recovery.

8.4.4 Variable Frequency Drives (VFDs)

VFDs can be used to control mechanical equipment such as pumps and fans. Installation of VFDs is to be coordinated with the Electrical Designer.

VFDs can save building operating energy when used on mechanical equipment which has varying use patterns. The mechanical designer determines the need for a VFD; the electrical designer ensures that its installation is in accordance with electrical codes and standards.

Some equipment (i.e., circulating pumps) can be ordered with a built-in VFD.

A VFD should be rated to match the electrical characteristics of the motor, the starter and the circuit protection.

8.5 SERVICE FACILITIES

8.5.1 Air Curtains

Overhead garage or service doors which are often used should be provided with air curtains. Air curtains supply a flow of air down over the door openings when doors are

Where air curtains are installed on overhead doors, significant heating energy savings can result.

open. This reduces infiltration and saves energy. Enershield Energy Savings Barriers are a recommended type.

Control for air curtains can be either automatic (by activation of a door opener) or manual (switch).

8.6 OPERATION AND MAINTENANCE

8.6.1 Spare Parts

The following spare parts are to be provided:

- One set of belts for each piece of machinery.
- A one year supply of filters of each type used in the system(s)
- 12 fusible links for use in fire dampers.
- A six-month supply of chemicals for cold water type humidifiers.

8.6.2 Regional Equipment Preferences

Use equipment preferred by regional maintainers.

8.6.3 Code Requirements

Thoroughly clean all ductwork and equipment internals and externals, and final filters installed.

Perform drop test on all fire dampers installed.

Provide air balancing to NEBB/AABC Standards.

J9 BUILDING AUTOMATION SYSTEMS (BMS)

A properly-designed, installed, maintained and operated BMS provides the best possible occupant comfort and the most efficient mechanical system operation.

9.1 GENERAL

Direct digital control systems with electronically operated control devices should be used where appropriate, provided they are equipped with full UPS protection.

In remote communities, it can be very useful to have a DDC system with remote monitoring capabilities, so problems can be diagnosed and fixed without a costly site visit.

Conventional, low voltage (24volt) electric control systems are acceptable for most small buildings.

Compared to pneumatic controls, electric controls are simpler to operate and to service. The use of conventional, low voltage control systems will be evaluated on a case by case basis.

Pneumatic control systems may be used where they are specifically approved for use. They can be used in combination with electronic or direct digital control (DDC) systems. The sensing and logic is to be electronic, and controlled devices are to be operated by pneumatic operators.

Although pneumatic control systems are more complicated and require proper servicing, they are cheaper in large installations and they can provide full modulation.

Vendor supplied equipment with onboard controls shall be open protocol and able to communicate and functionally interface with BMS system.

The units will be better controlled and will not conflict with other building systems if they are also controlled from the main building BMS.

9.2 CONTROL COMPONENTS

9.2.1 Components – General

All controls, regardless of type, are to be calibrated using the metric system.

The metric system is standard.

CSA approval is required for all control equipment, including alarm panels.

Stand-offs are required for all duct-mounted controls and accessories which are mounted on externally-insulated ducts.

Stand-offs keep these items fully accessible for operation and servicing.

9.2.2 Thermostats and Sensors

Thermostats and/or sensors located in gymnasiums are to be located at a suitable height above the floor. They should be protected with a heavy duty metal guard or other means.

Gym thermostats and sensors must be protected from damage, and the students need to be protected from sharp corners.

Gyms and halls may be for public function, so thermostats require tamper-proof covers.

In cases where a space thermostat controls both a heating control valve and a variable-air volume (VAV) or cooling control in sequence, a dead-band of 2 degrees Celsius is required between the heating and cooling ranges.

This will prevent energy waste by avoiding simultaneous heating and mechanical cooling, or heating and free cooling.

Thermostats located in public areas must have vandal-proof guards.

The guards prevent intentional or unintentional tampering.

Locking-type thermostats are to be used in public facilities where only the maintainers should be able to adjust temperatures.

Where there are many building users, it is often best to allow only maintenance staff to control temperatures in public areas of facilities.

Locking type thermostats are not to be used where it is desirable to allow users to adjust room temperatures (refer to functional program for direction). Where users should be able to adjust room temperatures, range limits are to be used to restrict the amount of adjustment above or below predetermined values.

In some cases it is more appropriate to allow users to adjust room temperatures themselves, rather than having to rely on maintainers. Range limits should be provided so users cannot set temperature too high or too low.

Low voltage electric heating thermostats are to be SPST (single pole, single throw).

In cases where SPDT (single pole, double throw) thermostats have been used, the wiring has sometimes been installed incorrectly. The SPST thermostats are simpler, and less likely to be installed incorrectly.

9.2.3 Control Valves

Control valves (i.e., two and three- way control valves at heating or cooling coils) are to be sized based on a CV rating.

Incorrectly-sized control valves do not provide accurate control.

Normally-open (NO), electrically-operated heating zone valves are to be used.

There is some indication that NO valves cause more maintenance problems than NC type. However the NO type should be used, so that space heating is still possible if actuator fails.

The use of thermostatic valves is only permissible in certain applications when approved in advance.

Do not use copper-to-copper zone valve. Use flare type.

Copper-to-copper valves have caused maintenance problems.

9.2.4 Flow Switches

Flow switches are to be vane or ultrasonic type on piping 50 mm in diameter and smaller.

On smaller piping sizes, paddle-type flow switches are difficult to install properly and do not function well. The sensitivity cannot be adjusted, which can result in nuisance alarms.

Paddle-type flow switches are acceptable on piping 75mm and larger.

9.2.5 Control Transformers

The number of control devices per transformer is to be limited to 3 devices for each 40 VA transformer.

Limiting the number of control devices on a circuit prevents excessive voltage drop for each controlled device, which could cause the device to fail.

9.2.6 Damper Actuators

Independent damper actuators are to be appropriately sized and installed on each outdoor air, return air, mixing and relief air control damper.

Common damper actuators have a long connecting rod which is nearly impossible to set up, and the quality of control is reduced.

9.2.7 Energy Meters

BTU/kWh meters are required on all boiler heating systems unless otherwise specified. Meters shall be open protocol and able to communicate and functionally interface with BMS system. Metering to include temperature sensors on supply/return lines and a flow meter.

Energy meters enable the tracking and monitoring of building performance and optimization of heating systems.

9.3 VENTILATION UNIT CONTROL

9.3.1 Outdoor Air

The amount of outdoor air brought in to the system is to be controlled by a mixed-air temperature sensor with minimum outdoor air settings to recommended ASHRAE standards.

Outdoor air (normally cold) is mixed with room temperature return air to produce supply air (mixed air). The amount of outdoor air is varied to provide more or less cooling as needed.

In a variable air volume system, outside air measurement is required to ensure OA requirements are met at the lowest VAV box flow. This is achieved by using an OA measuring station.

A minimum supply rate of outdoor air must be provided by code. Note that in VAV systems, the lowest VAV box airflow must have sufficient fresh air to meet code requirement.

9.3.2 Return Air

In no case should the heating coil in the air handling system be controlled by the thermostat in the return air duct.

Normally air returns to the mixing chamber from the space at or above 20ºC. If for any reason the return air temperature falls below this, the heating coil activates and the ventilation system ends up acting as a heating system (like a forced air system), rendering the hydronic heating system thermostat controls ineffective.

9.3.3 Supply Air (Mixed Air)

Supply Air is required to be controlled at a temperature between 13-18ºC. For most of the year, the supply air temperature can be controlled by varying the amount of outdoor air introduced into the system. When the maximum amount of outdoor air will produce supply air above 18ºC for extended periods of time, the need for cooling equipment should be reviewed. See Mechanical M8.4 "Air Conditioning".

Air is normally supplied at a high level in a room or space. If it is supplied at a temperature equal to or warmer than the room, it tends to remain at a high level in the room and not come down into the occupied space where it is needed.

The mixed air temperature sensor in the air handling system (controlling outside and return air dampers) must be the averaging type.

The averaging type sensor provides accurate temperature measurement by averaging colder or warmer air streams.

In smaller electric type systems, an automatic reset type freezestat must be provided downstream of the heating coil, and must be set at 5ºC. In DDC systems, this freezestat function is integrated.

The automatic reset type freezestat is used to reduce the likelihood of the air handling systems shutting down and remaining off during cold weather extremes.

9.3.4 Heating Coils

The sensor controlling the heating coil in each AHU (air handling unit) should be located a minimum of 3 m downstream of the coil in the supply air duct, preferably downstream of the supply fan.

This distance from the coil ensures the sensor reads the actual supply air temperature (not the temperature immediately next to the heating coil).

Heating coil control valves should be controlled by fast response type controllers.

Without fast response controllers, the control valve hunts from full open to full closed position, never reaching a position of equilibrium, and occupied spaces can overheat.

Electric modulating controls are preferred for heating coils. They must remain energized even when the AHU fan is shut down.

If the controls are de-energized when the air handling system is shut down, the heating medium circulates freely to the heating coil (given that normally open valves are used) when not required, and overheating can occur.

9.3.5 Scheduling

The operation of mechanical equipment such as ventilation units is to be controlled by operator/user-activated schedules through the BMS.

Operator/user-activated scheduled mechanical equipment will operate only as required, thus reducing energy consumption and reducing operating and maintenance costs.

Where it is not possible or appropriate to provide the above mentioned schedule control, provide a 7-day programmable time clock c/w quartz control clock and battery back-up.

This will ensure that mechanical equipment is programmed to operate only during occupied periods and shut down during unoccupied periods. It also reduces operating and maintenance costs.

9.3.6 Typical Ventilation Unit Control

A typical direct digital control system has been developed for ventilation unit control. The control strategy can be applied to many ventilation units, both small and large. Refer to Figure 9.1.

A typical ventilation control strategy provides some consistency in operation and maintenance.

Any DDC system approved must have a full graphical front end as part of the package.

Coding system changes are time consuming and require a high level of skill and experience.

Software package must be the most current version available from vendor at time of contract award.

Suppliers may offer upgrades after the design stage and after the contract award. Any upgrades which are available, or are potentially available, should be offered at the bidding stage as an alternate, complete with the price impact.

9.3.7 Typical Direct Digital Control (DDC) Sequence of Operation

The ventilation system will start by pressing the system start push button PB-1, located in the general office, gymnasium, or area served. The ventilation unit will start and operate for the predetermined number of hours as preprogrammed in the DDC and will then shut down. (A gym ventilation unit would typically be set to operate for 4 hours). If additional time is required, the unit can be restarted by pushing the start button PB-1 again.

The DDC controller will start the supply fan with the HAND-OFF-AUTO switch in the AUTO position via digital output DO-1. The return fan, associated exhaust fans and heating coil circulating pumps will be hard wired to operate with the supply fan. Supply fan start-up will notify the DDC by digital input DI-2, wired to the auxiliary contact of the supply fan starter.

Upon confirmation of start up from DI-2, the ventilation unit will operate on 100% return air for a pre-set purge time to stabilize temperatures (this time might be 5 minutes). At the end of the pre-programmed purge time, the supply air control loop will assume control of the mixed air dampers, DA-1 2, and 3. The mixed air dampers will be ramped to the minimum or control position over a preset time (i.e., 10 minutes).

The supply air control loop, with inputs from supply air temperature sensor TS-1 and return air temperature sensor TS-2, will modulate the heating coil valve V-1 in sequence with the mixed air dampers DA-1, 2 and 3 to maintain the supply air temperature at the proper set point as determined by the return air reset loop. A supply air temperature reset potentiometer ADJ-1, located beside the DDC panel, will allow the operator to INCREASE or DECREASE the supply air temperature, within set limits, to suit specific building requirements.

A CO_2 sensor, CO_2 -1, located in the return air duct and sensing return air CO_2 levels from the building, will reset the minimum outdoor air position to increase the percentage of outdoor air to the building and maintain the maximum CO_2 at the desired level (i.e., 800 ppm). The minimum outdoor setpoint will be set in the DDC controller, based on the minimum building ventilation requirements outlined in the ASHRAE Standard 62 (latest edition).

Direct mount and readout analog thermometers TI-1, 2, 3 and 4 will show the operator outdoor, mixed, supply and return air temperatures. A magnehelic type of differential pressure gauge, FI-1, mounted on the unit, will provide indication of the differential pressure or loading of the vent unit filters. A differential pressure switch, DP-1, sensing filter loading, will input to the DDC controller a dirty filter condition.

A low-limit control loop with inputs from the supply air temperature sensor TS-1, located downstream of the supply fan, will shut down the ventilation unit upon sensing a low supply air temperature, after a 5 minute time delay.

The following user adjustable setpoint and control parameters will require password access:

- ventilation unit run time (2, 4, 10 hours, etc.)
- purge time at system start (10 minutes)
- mixed air dampers ramp time (10 minutes)
- minimum outdoor air position (15, 20, 30%, etc.)
- supply/return air temp reset schedule
- remote supply air temperature reset adjustment span (i.e., 31ºC)
- low limit supply air temperature setpoint adjustment (21ºC)

Provide continuous trending at 30 minute intervals for the following points:

- supply air temperature
- outdoor air temperature (one sensor per project)
- return air temperature
- CO_2 reading
- filter status (CLEAN/DIRTY)
- supply fan status (ON/OFF)

9.3.8 Typical DDC Sequence of Operation Diagram

Provide a modem module connection with remote dial-in capability on buildings where this is desired, to allow off-site monitoring of the system performance.

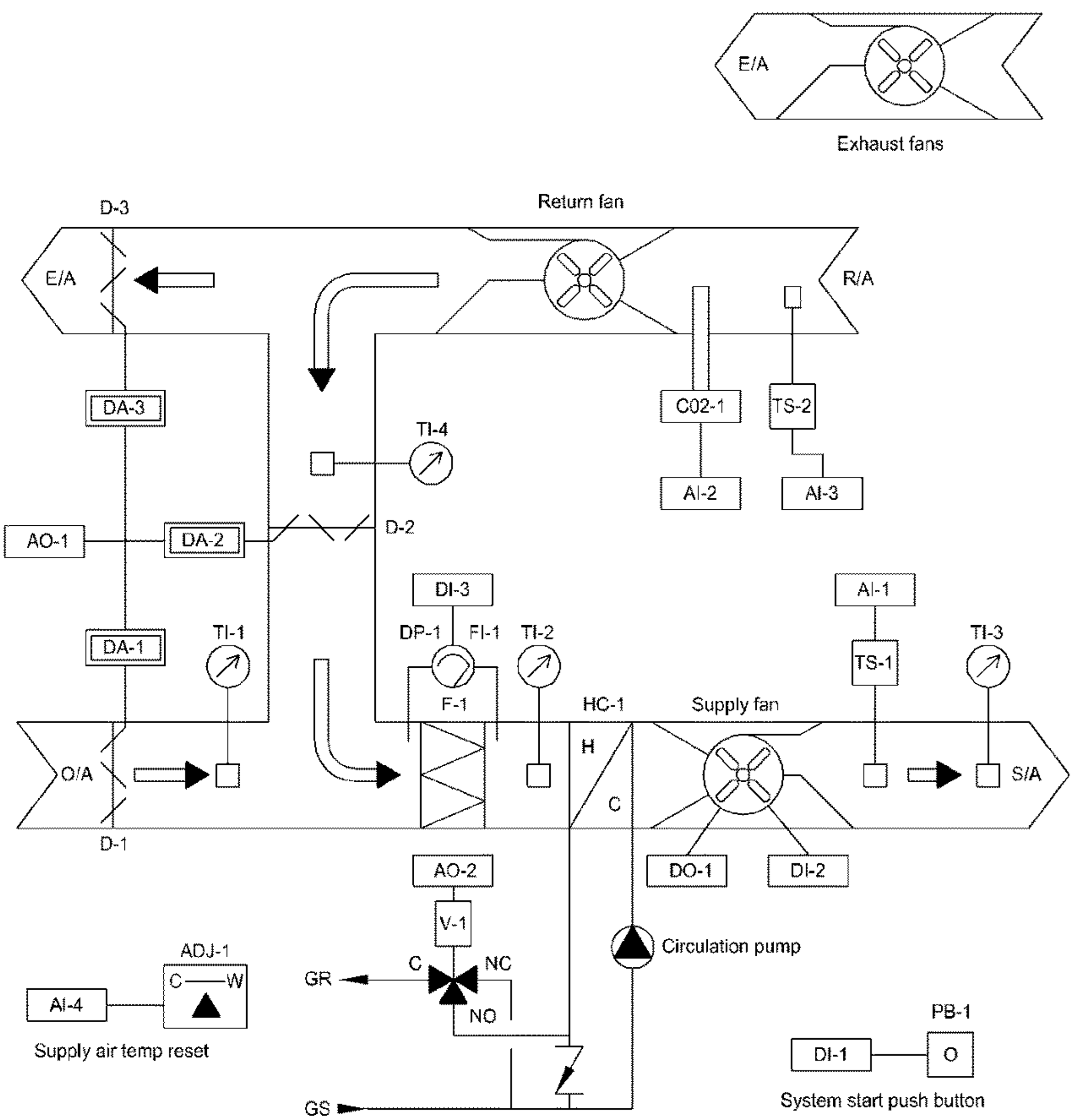
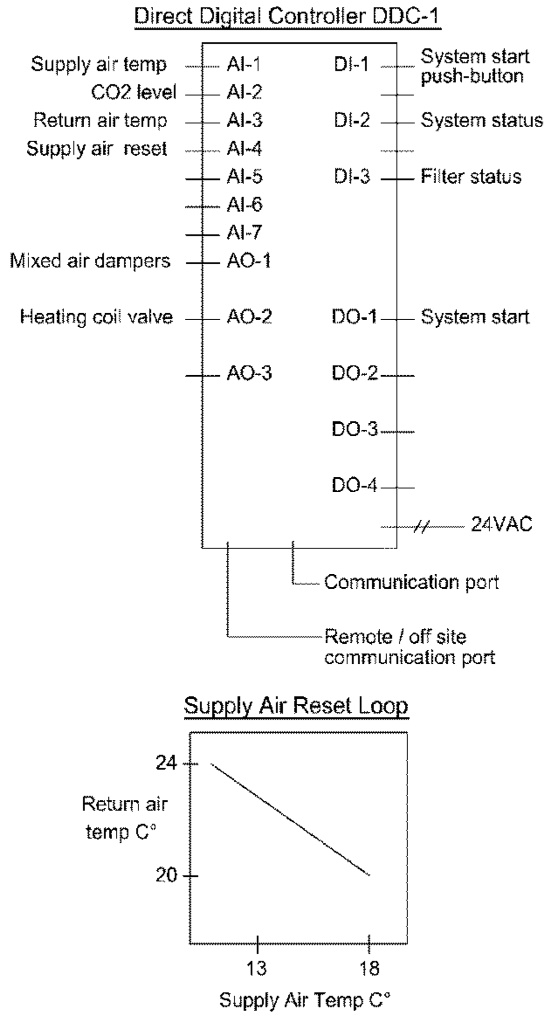


Figure 9-1: Ventilation System Control



Tag	Material Identification
ADJ-1	Manual pot with scale "Cooler - Warmer"
CO2-1	CO2 sensor and transmitter
DDC-1	Direct digital controller
DA-1,2,3	Damper actuators
DP-1	Differential pressure switch
FI-1	Filter gauge (magnehelic) and DP switch
PB-1	System start push-button - momentary contact
TI-1,2,3,4	Duct mounted thermometers (75 mm)
TS-1,2	Duct mounted bulb temperature sensor
V-1	3 way control valve and actuator
AI	Analog input to DDC controller
AO	Analog output from DDC controller
D1	Digital input to DDC controller
DO	Digital output from DDC controller
D-1,2,3	Control dampers
F-1	Filter section
HC-1	Heating coil

Figure 9-2: Direct Digital Controller Identification

9.4 HYDRONIC HEATING CONTROL

9.4.1 Radiation Control

In buildings without BMS, Radiation zones are to be controlled by a low-voltage room thermostat controlling the normally open (NO) two-position control valve. In buildings with BMS, normally closed (NC) control valves are acceptable.

This gives a cost effective radiation zone control.

All heating loops, including those installed in washrooms and storage rooms, are to be provided with individual or zone control, and not allowed to 'run wild.'

The small additional initial cost of providing control is much less than the long term energy saving.

9.4.2 Force Flow and Unit Heaters Control

Force flow units and Unit Heaters are to be equipped with control valves. On a case by case basis, it is acceptable to provide a terminal unit with only motor control.

This provides a cost effective control of force flow units and unit heaters.

The room thermostat is to be located on the wall, but not directly in the air stream from the unit, and shall be provided with a locking guard.

9.4.3 Boiler Temperature Control

Provide indoor/outdoor controls for boilers with 2 or 3 step settings.

Seasonal adjustments to boiler temperatures are made automatically (increased in cold weather, decreased in warmer weather), thereby increasing energy efficiency.

If existing domestic HW tanks are dependent on boilers do not use this method of control. However, dedicated HW tanks are to be used in new buildings.

9.5 MECHANICAL ALARMS

9.5.1 Mechanical Alarms

In buildings with BMS, mechanical alarm points can be configured on an as-required basis through the building operator's station.

In the absence of BMS, Mechanical alarms should be minimized and restricted to essential building conditions. Low building temperature is the only condition that is considered critical. A low building temperature alarm must activate the automatic dialer and the outdoor alarm light.

Elaborate alarm systems, which are costly to install and maintain, have caused many nuisance call-outs and may become ignored. The probability of false alarms is reduced with only one (i.e., low building temperature) alarm designated as critical.

9.6 OPERATION AND MAINTENANCE

9.6.1 Spare Parts

The following spare parts are to be provided:

Specialized wrenches, screwdrivers etc., required to access and adjust control equipment.

9.6.2 Regional Equipment Preferences

Use equipment preferred by local maintainers.

9.6.3 Code Requirements

Provide as-built shop drawings and schematics for all systems to be mounted on wall visible to O&M staff.

9.6.4 Identification

When a DDC system is installed, all addressable components must be provided with a permanent lamacoid identification label and points list in control panel.

ELECTRICAL

INTRODUCTION

Electrical energy in most of the isolated northern communities is provided mainly by isolated (non grid connected) diesel driven generators, with only a few communities being supplied by hydroelectric plants. This has resulted in relatively high electrical energy costs in the North. At the same time, technology over the years has been providing many new and innovative energy saving electrical systems that in the South appear cost effective. However, the lack of reliable and clean electrical energy, the lack of qualified or experienced trades people, and the isolated nature of the North can quickly affect the life cycle costs of any installed system. Careful planning and design is needed to install electrical systems that are simple, reliable and robust enough for the northern operating environment. Seasonal changes in the north include harsh winter conditions, and a large variation in natural daylight, which require special design considerations. Guidelines and recommendations covered in this section include installations that have been found acceptable by the Department of Infrastructure to date, balancing the sometimes conflicting demands for occupant satisfaction, energy conservation, simplicity and reliability.

Table of Contents (to follow)

K1 CODES AND REGULATIONS

Environmental separation requirements are stated in NBC Div. B Part 5, "Environmental Separation" and NBC Div. B Section 9.25, "Heat Transfer, Air Leakage and Condensation Control". Successful application of NBC Div. B Part 5, or NBC Div. B Section 9.25 requirements can be more difficult in the North than in other parts of Canada because of a short construction season, very cold temperatures affecting the performance characteristics of materials, and periodic shortages of experienced installers.

Documents referenced in this section include:

- National Building Code of Canada (NBC)
- National Energy Code of Canada (NECB) [2]
- Canadian Electrical Code (CEC)
- Underwriters Laboratories Canada (ULC), various
- Underwriters Laboratories Incorporated (ULI Canada), various
- Canadian Standards Association (CSA), various
- Illuminating Engineering Society (IES) Lighting Handbook and various Recommended Practices
- Institute of Electrical and Electronics Engineers (IEEE) Color Book Series
- GNWT Electrical / Mechanical Safety Section – Electrical Bulletins
- Electrical Certifications Accepted in the NWT: http://www.pws.gov.nt.ca/en/services/electrical-and-elevators/information-certified-products
- American Society of Heating, Refrigeration and Air – Conditioning Engineers (ASHRAE) 90.1 "Energy Standard for Buildings Except Low Rise Residential"
- ASHRAE Guideline 4 "Preparation of Operating and Maintenance Documentation for Building Systems." – Latest Edition
- GNWT Office Accommodation Fit-up Technical Standards and Criteria: https://www.pws.gov.nt.ca/sites/pws/files/office_space_technical_standards.pdf

[2] This Design Protocol sets out requirements for building design for energy efficiency; the building must comply with all the mandatory provisions in the National Energy Code for Buildings (NECB), and must be at least 10% more efficient than the NECB reference, as shown by use of the EE4 software (or the EE Wizard, which is applicable to some types of building analysis). The design process for certain types of facilities shall include an Energy Modeling analysis utilizing the EE4 program and, where called for by the Client, an Energy Modeling Workshop, to maximize the energy savings potential of the facility while maintaining the cost effectiveness of the relevant payback period. Funding applications to NRCan shall be made naming the Client Department as the "Owner" of the facility.

Related offices include:

- Electrical / Mechanical Safety Section Offices – Yellowknife, Hay River, and Inuvik
- NWT Power Corporation – Hay River (head office) Northland Utilities – Yellowknife and Hay River

K2 OPERATION AND MAINTENANCE

2.1 GENERAL

See General A1 “Local Resources” and A3 “Appropriate Technology”.

2.2 ACCESS

Electrical systems generally require relatively little maintenance. However, easy access to equipment that must be serviced is important. Adequate access hatches and working space needs to be provided for all electrical equipment as required by the Canadian Electrical Code to ensure a safe working area for servicing or replacement of electrical equipment.

For example, access to lighting control systems is best provided at floor levels where a qualified maintainer can stand and work in front of, rather than from a ladder in difficult to approach or cramp ceiling spaces.

Locating of control systems and components for security, digital control system components, telephone terminations, data terminations, sound reinforcement systems should also be designed for ease of access for maintenance purposes.

2.3 SPARES

The building owner in consultation with the design team should determine what spare parts should be provided. The following is a list of required regular and emergency spare parts that should be stored in each facility for communities that are not on the road system:

- 1 set of each type of manual starter heater
- 5 spare fuses of each type used (i.e., control fuses)
- 1 spare coil of each starter size
- 1 spare control transformer of each type used
- 5 spare pilot lights of each type used (i.e., fire alarm panels, MCCs, transfer switch),
- 2 of each type of LED light fixture used.
- 5% spare 1P-15 Amp breakers within each panel board, minimum of 2.

- 5% breaker spaces within each panel or distribution board, minimum of 2.

If a generator is required, provide:

- 5 spare oil filters
- 5 spare fuel filters
- 5 spare air filters
- 2 spare fan belts of each type used

Rationale
Spare parts are often difficult, if not impossible, to get within many communities, and there is often a long time lapse required to send in spare parts. As a minimum, an inventory of spare parts as listed, if maintained, should cover most of the regular and emergency maintenance required on electrical systems during a facility's life time. Spare parts used for repair during warranty period are to be replaced at the end of the warranty period.

2.4 STANDARDIZATION

In the interest of maintenance and economy, it would be prudent to ensure that all distribution panels, starters and switches be of the same manufacturer throughout a specific facility.

2.5 CODE REQUIREMENTS

Some codes, such as CSA-282 or CSA-Z32 have specific requirements with regards to spare parts, special tools, log books for testing and maintaining of systems. These requirements shall be included in the project specifications for the Contractors information. Refer to subsequent sections for these requirements.

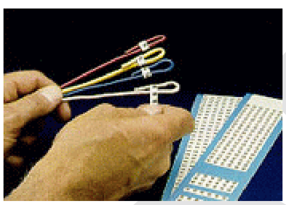
K3 IDENTIFICATION

Clear identification of electrical equipment is particularly important for the electrical system. Local maintainers and trades people should be able to quickly understand and locate related system equipment. Consistent identification in all public sector buildings is required to ensure that maintainers and operators can easily become familiar with any public sector building in any community.

At a minimum the language should be English for identification of components and systems. Abbreviations and acronyms should be used in a consistent and clear manner.

Various levels of identification can be incorporated within a specific building. According to the Canadian Electrical Code, identification of main distribution panels, sub-panels, motor control centres, and motor starters is required. Additional steps in identification are listed below for possible implementation.

3.1 CONDUCTOR IDENTIFICATION


Tape style identification

Heat shrink identification

Printable sleeves

Self-laminating conductor markers shall be used to identify conductors at all panel boards, motor control centres, junction boxes, terminal cabinets and outlet boxes, device locations, and patch panels. The numbering system can include circuit numbers on power circuits located on the switch or receptacle conductors. In low voltage and control system wiring, the numbering shall match the control diagrams. The numbering for communication systems (Telephone, Data, Public Address, Intercom), fire alarm system, security system (CCTV Camera, Access Control, Inrusion Alarm), health electrical systems (Nurse Call, Patient Wandering, Infant Abduction), and other all electrical

Circuit numbers are useful to identify wiring for trouble-shooting and to avoid accidents by preventing contact with energized conductors. Due to the increasing complexity of electrical systems, it has become important to identify wiring with control diagrams of the system, to be able to trace wiring when correcting operation and maintenance problems. The minimal cost of identifying the conductors is paid back during trouble-shooting, and during training of maintainers or when modifying the system.

systems (Panic Alarm, etc.) will match between device locations or outlets and controllers or patch panels. Labels to be provided at both ends of cable with clear, descriptive correlation to device fed.

3.1.1 Power Distribution Identification

A copy of a single line diagram of the normal and emergency power distribution is required to install beside the main electrical distribution system of a building where there is emergency power, or where there are greater than 2 branch circuit panels, or where the service is greater than 200 amps.

This provision ensures the safety of maintenance and emergency response personnel (e.g., firefighters) to provide a clear understanding of the installed system and where to de-energize equipment when servicing.

Single line diagram shall include:

.1 Configuration, type, voltage current rating of all switchgear, transformers panel boards & motor control centres.

.2 Type, frame size, trip size, interrupting rating of all overcurrent protective devices.

.3 Available fault current at all switchgear, switchboards, panel boards and MCC's.

.4 Type Size and current ratings of services & feeders.

.5 Connected load and anticipated demand load at all switchgear, switchboards, panel boards and MCC's.

.6 Provide copies of "as-built" single line diagrams as part of the Operating and Maintenance Manuals.

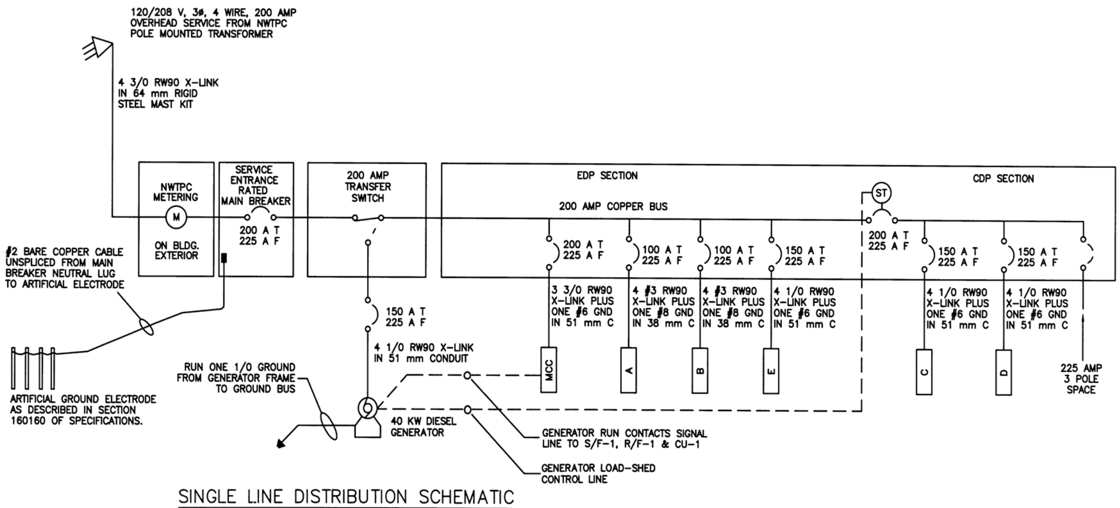


Figure 3-1: Sample Single Line Diagram

3.2 RACEWAYS / JUNCTION BOX IDENTIFICATION

3.2.1 Junction Boxes

Provide identification of the enclosed systems by painting the junction box cover plates. See Electrical System Identification Tables E-1 and E-2.

This is useful when tracing system conduits, for locating devices and system components when troubleshooting or when making additions or deletions to the system.

3.3 EQUIPMENT IDENTIFICATION

See Electrical System Identification Tables E-1 and E-2.

3.3.1 Panel Directory

Computer generated or typewritten panel directories are required.

Handwritten directories vary in legibility and durability.

Room numbers used for circuit identification shall be those that are identified on the contract documents.

Maintainers should have access to the original and subsequent drawings for reference. The room numbers are required by other sections of the GBP.

At times both a room name and number may be used.

Common names of rooms that are unlikely to change may also be used for quick identification. Eg: Mechanical Room, Electrical Room, Janitorial etc.

The directory shall allow for the identification of any future loads added to the panel. A copy of the file shall be included in the O&M manual.

This provision would provide ease of future updating the directory when changes are made.

3.3.2 Terminal Cabinets

In terminal cabinets for control wiring and low voltage wiring, identify terminal strips and wiring with appropriate labeling. Provide a computer generated or typewritten directory.

This is done for operations and maintenance staff (maintainers or factory representatives) to be able to quickly understand the enclosed system, trouble shoot problems or to add and delete parts of the system.

3.3.3 Control Diagrams

Copies of the control diagrams of the enclosed system shall be located within enclosures designed for such and an additional copy provided within the appropriate section of the O&M manual.

Many simple or complex control systems are located in public sector buildings. No matter the complexity, control diagrams provide the electrical or maintenance staff with the information they need to understand the proper operation of the system. The minimal cost of providing control diagrams is paid back during future trouble-shooting, and during training of maintainers or when modifying/repairing the system.

3.3.4 Labels and Lamacoids in Service Rooms

Fasten all lamacoids on equipment either by mechanical means or adhesive backed. Ensure lamacoid is applied on clean level surface.

Mounting labels on controllers ensures identification is not painted over during maintenance activities.

Type D labels shall be provided for relays in control cabinets.

Relays in control cabinets must be identified for maintenance and trouble-shooting.

3.4 RECEPTACLE AND COMMUNICATION OUTLET IDENTIFICATION

Receptacles are required to identify the corresponding circuit and panel as it is important that a building user, unfamiliar with the electrical system, be able to quickly re-set breakers or troubleshoot communication devices.

3.4.1 See Electrical System Identification

See Electrical System Identification Tables E-1 and E-2.

This is typically required in health care facilities, schools, and offices. It is required in all GNWT facilities unless otherwise indicated.

3.4.2 Receptacle Labels

Mount labels on the cover plate of the receptacles.

This practice ensures identification for all the cover plates in a room for ease of maintenance.

Use adhesive labels.

Adhesive labels are cost effective and simple to use.

3.4.3 Communication Outlet labels

Mount labels on the cover plate of the outlets.

This practice ensures identification for all cover plates in a room for ease of maintenance.

Use adhesive labels on lamacoids or custom made insert products.

Integral label products are cost effective and simple to use.

Electrical System Identification Table E-1 Labels and Lamacoids

Component	Type	Information
Main distribution centre Main breaker Sub distribution panel	A A A	Year installed, name of facility, names of electrical engineer and electrical contractor. Voltage, phase, amps. Name of panels it is feeding (i.e., Panel A, Panel B)
Panel boards	A	Panel designations (i.e., A,B,C or EA,EB,EC for panels fed from emergency power).
Terminal cabinets i.e., telephone, low voltage	B	Indicate equipment controlled (i.e., Telephone Rooms 1-12, Intercom Rooms 1-7)
Equipment i.e., motors, fans, pumps, etc.	-	SEE MECHANICAL IDENTIFICATION STANDARDS
Disconnect switches	B	Indicate equipment controlled and voltage.
Starters / contactors	B	Indicate equipment controlled and voltage.
Motor control centres	B	Indicate equipment controlled and voltage.
Transformers	B	Circuit and panel designations.
Relays	D	Circuit and panel designations.
Junction boxes, pull boxes	D	Circuit and panel designation for power. Contents for low voltage (i.e., TV rooms 1-12 or security rooms 1,2 & 7).
On/Off switches Fire alarm devices (i.e., pull stations, end of line)	C C	If it is not obvious, then indicate area being served (i.e., service spaces or grouped switches. Zone number and device number in that zone (i.e., Zone 1-#3, Zone 10 - #7)
Receptacles: • standard duplex • GFCI • surge suppression • special receptacles	 D D D D	Indicate: panel / circuit designation panel / circuit designation panel / circuit designation panel / circuit designation and voltage, phase, amps

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Electrical System Identification Table E-2

Label	Letter Height	Type	Colours
Type A	9.5 mm	riveted lamacoid	white lettering / black background
Type B	6.0 mm	riveted lamacoid	while lettering / black background
Type C	3.0 mm	adhesive lamacoid	white lettering / black background
Type D	3.0 mm	adhesive label	black lettering

Colours Table E-3

Component	Conductors or Cables	Raceways and Junction Boxes[1]	Receptacles	Other
Normal Power: • 120 / 208, 240 Volt • 347 / 600 Volt	 Code Code	 Gray Sand	 As specified by the Designer	
Emergency Power: • 120 / 208, 240 Volt • 347 / 600 Volt	 Code Code	 Orange Sand	 Red (see Note 3) n/a	
Low Voltage and Safety: • Switching / Controls • Emergency • Exit Lighting • Security / Panic • Mechanical Alarms	See Note 2	 Black Orange Orange Blue Amber		Exterior Strobe: Blue Amber
Fire Alarm:	Red	Red		Exterior Strobe: Red
Communications and Security: • Structured Wiring • Telephone • Intercom and Sound • Television and Cable • CCTV • Access Control • Intrusion Alarm	See Note 2 Blue Olive / Gray Brown Black Beige	 White White Brown Brown		

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IDENTIFICATION NOTES

1. *All junction box covers of a particular system must be painted according to the colour coding schedule. Color coding is not necessary for visible surface mounted junction boxes as they can be easily traced.*

2. *Low voltage cables can be purchased with various colors of the exterior jacket allowing quick identification for tracing of installed cabling for security, nurse call, intercom, data, video, telephone, television, CCTV, DDC cabling.*

3. *Only receptacles that form part of an Essential Power Supply are required to be red.*

K4 Power Supply

Electricity is supplied in most NWT communities by diesel generators operated by the NWT Power Corporation. Fuel is re-supplied annually and power costs are very high. Hydro power is currently available in only a few communities. Voltage fluctuations are typical, as are power outages. As a result, sensitive electronic equipment requires special design considerations. Three phase power and 347/600 volt service is not available in all communities. Power is supplied to consumers primarily by overhead services, with larger buildings being supplied by underground conductors from pad mounted transformers.

4.1 PUBLIC UTILITIES

Power is supplied and generally distributed by NWT Power Corporation, except that it is distributed by Northland Utilities in some communities. Some communities will only provide 120/208V 3 phase and 120/240V single phase. Only in very rare cases will it be deemed acceptable to provide 347/600V in communities where it is not regularly supplied. This will require careful coordination with the local utility.

4.1.1 Consumption Targets

See specific sections regarding energy consumption requirements (i.e., lighting, motors).

See General G6.1 Model National Energy Code.

4.1.2 Underground Service

Overhead services are preferred. However, if an underground service is necessary for safety reasons, teck cable is preferred. In non-permafrost areas, the cable needs to be placed below the frost especially if the soil is frost susceptible. In permafrost, or if the cable must be placed in the active layer, it must be surrounded by non-frost susceptible soil. This can be accomplished by surrounding the screened sand on all sides by gravel, which will ensure drainage of water out of the sand.

Overhead services are preferred as they are easy to repair and maintain. If the service is underground, teck cable is easier to install and less expensive compared to conduit, especially in cold weather. Teck cable is flexible enough to take the stress of frost heaving and installation over uneven or rocky ground. In permafrost areas, surrounding fill should be of a type that does not bond to the cables (because frozen soil tends to contract and crack, causing buried lines to pull apart when the line on each side of the crack is frozen tightly in the soil).

Underground service conductors over 75

By providing a PVC sleeve for long

meters shall be installed inside a PVC sleeve.

underground service runs the increased potential of movement from frost heaving will decrease the stress on the installed cable.

4.1.3 Service Sizing

Size main services & service transformers according to the connected load or estimated load, whichever is greater. Calculate connected load by using demand factors as dictated by the type of load plus an allowance for future load. Calculate estimated loads based on basic power loads plus additional loads anticipated for heavy power usage areas

4.2 AUXILIARY POWER

Reliability of power supply for equipment is more important in cold climates than in moderate climates because of the dire consequences of extended failure. Systems dependent on electricity include boilers, pumps, fire protection and heating controls. Power failures in northern communities are not uncommon due to extreme weather conditions or equipment failures, which can incapacitate the community generator. For this reason, generators are often required in public sector buildings where services must be maintained. Emergency generators, where required by NBC, need to meet stringent requirements. Standby power supplies are optional and sized according to desired load requirements determined on a project by project basis.

The importance of reliability is mentioned, not so much for community functions, but because of the dependence on electricity for building systems.

4.2.1 Where Required

Emergency power is to be provided where required by the National Building Code and to be provided to Post-disaster Buildings. Where the facility program drives the requirements for a generator, provide standby power.

Emergency power has specific code requirements above and beyond those for standby power. Post-disaster Building is essential to the provision of services in the event of a disaster and is the place where the emergency power is highly required in the case of losing the utility power.

4.2.2 CSA C282

This standard "Emergency Electrical Power Supplies for Buildings" is suitable as a guide for standby generation. Items such as fire resistance ratings that do not affect the general reliability of the system can be overlooked. For all backup generators, CSA C282 is to be followed.

The CSA standard was developed to cover installations where power is required on an emergency basis. In most GNWT facilities, standby power is provided as a backup for convenience, not safety, and shutdowns can be scheduled, making a manual by-pass unnecessary. Installing a "standby" or "auxiliary" generator to C282 maintains reliability.

4.2.3 Components Required

When generators are required, they shall be:

This is a requirement of C282.

- fuelled by a standalone dedicated day tank, located in the service room, capable of operating the generator under full load for 4 hours

Standalone tank required as base tanks introduce additional operational complexity.

- day tank to be fed from the fuel tank provided for the building

This assures fuel supply.

- liquid-cooled with mounted radiator fan and water pump (integral radiator only)

Remote radiators are problematic in harsh winter conditions.

- air-cooled with integral cooling fan and cooling ducting where conditions make an air-cooled generator practical

For some smaller installations, an air-cooled generator may be practical.
Example: park generators, or very small units in buildings.

skid mounted and come complete with:

Is easier to move if equipment needs to be repaired.

- glow plug and timer

This should be installed where required.

- steel springs and/or rubber pads as recommended by the manufacturer

This combats light and heavy vibrations.

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- remote annunciator package for critical functions

This practice helps to identify generator problems.

- thermostatically controlled recirculating block heater fed from boiler heat exchanger

Preferred over electric block heater systems for energy conservation. This practice ensures the generator is warm for easy starting.

- integral radiator

See above regarding remote radiators.

- hospital or critical grade muffler

This will assist in noise reduction.

- flexible exhaust section

To dampen generator vibration to the exhaust.

- battery, automatic battery charger, cable and rack

Starting system failures typically cause 85% of failures on emergency generators. Proper selection of battery and charger is particularly important.

- 12 volt electric start

Preferred over 24 volt systems for safety and maintenance.

4.2.4 Capacity

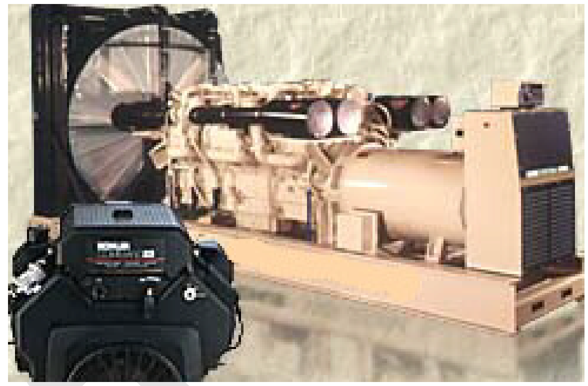
Where emergency generators are required by code, they must be sized to carry the following only:

- fire protection system (including fire pump and jockey pump)
- complete heating system including fuel pumps, controls, boilers and zone valves
- exit lighting
- domestic water pumps
- sanitary pumping
- selected lighting (including wash room

Besides code requirements, emergency generators allow buildings to continue operating with minimal disruption. In many instances size of the fire pump dictates the size of the installation, and thus the entire electrical system can function on emergency power as there is little cost or operational advantage to reducing lighting and receptacle capacities. In many cases it is desirable to shunt trip building load from the generator in the event that the fire pump is required to start. Refer to the facility program to determine which lighting and power loads are essential. Subject to emergency lighting design of specific building.

lighting in buildings where there are young children, the aged or the infirm)

- power loads deemed necessary by the program requirements
- loads required by the National Building Code to be powered from an emergency power supply


Sample emergency generator

4.2.5 Automatic Exercising

Automatic exercising of the emergency or standby generators is not required.

In the past there was concern that maintenance staff were either non-existent or untrained for testing the generator regularly. Consequently, time clocks were installed to ensure the generator was cycled regularly to ensure proper operation. With qualified maintainers in all communities and the requirement of CSA C282 and the Maintenance Management System (MMS) to record and log all instrument readings during a weekly test, the time clock is redundant.

4.2.6 Customer Metering

Provide digital customer meter where the generator size is in excess of 75 kVA that can provide consumption, demand, voltage and current information.

Digital metering is an excellent tool for troubleshooting, generator loading and a variety of general maintenance activities.

4.2.7 Location

Generators shall be installed in a room separated from other oil-fired equipment and with connecting door large enough to allow for changing the generator.

This ensures that generator operation does not consume boiler combustion air and provides a way to access for future maintenance requirements.

Generators located outdoors shall have a minimum clearance of 1.5 m (5 ft) between the generator and adjacent building opening or exit ways.

Emergency generator complete with day tank which meets item 7.3.13 in CSA B139, Installation code for oil-burning equipment.

4.2.8 Portable Generators

Portable generators are not recommended.

Where a generator is required, it should be permanently installed to ensure reliability and regular maintenance. If it were portable, there would be a good possibility that it would not be readily available when needed. Portable units can also be hazardous if improperly installed, grounded or exhausted.

4.2.9 Load Banks

Permanently connected, stepped load banks with customer metering to monitor generator loading is required for hospitals and correctional facilities.

Permanently connected stepped load banks provide a means for maintenance staff to properly exercise generators on a weekly and yearly basis avoiding "wetstacking" from small building loads.

Emergency, auxiliary or standby generators 300 Kw and over shall also have permanently installed stepped load banks.

Where the building load is not adequate for the yearly testing of code required emergency generators, means to safely install a portable load bank shall be provided.

This provision will provide a safe way of connecting portable load banks on a yearly basis.

Where an emergency generator set is required and a permanent load bank is not installed, then provide a suitable junction point between the generator and the transfer switch for the connection of a portable load bank. Connectors will be female type, and colours will be red for phase A, black for phase B, blue for phase C, white for neutral, and green for ground. Eaton Cam-Lok Single pole connectivity J-Series E106-1704BB and its accessories as required.

This provision will minimize disturbance to building operation and improve maintainability.

4.2.10 Generator Operation

The generator shall be started by any of the auto-transfer switches on loss of utility power if there is more than one auto-transfer switch installed in the facility.

Emergency loads are critical for facility operations. Any of the loads connected to emergency power shall be energized as soon as possible on loss of utility power.

The load bank shall be disconnected from the generator during any loss of utility power.

The load bank is sized based on the generator and it shall be prevented from overloading due to feeding the emergency loads and the load bank simultaneously.

The fire pump shall provide a shunt trip signal only when the fire pump is started.

The auto-transfer switch for the fire pump will start the generator on loss of utility power. Other connected emergency loads shall remain connected unless the fire pump needs to start At that time shunt trip will operate and other emergency loads will be shed as fire pump may require 6 times the fire pump load capacity

4.2.11 Timer

Provide a timer (holdover timer or "time delay, emergency to normal") with a minimum lag time of 10 minutes before retransfer from generator power to normal power after normal power restarts. This

This allows time for the normal power to stabilize. It is especially important when generators have a 'Warm- up" period of 3-5 minutes before accepting a load, as the effect of a second blackout would be a further delay feature is a component of the automatic transfer switch settings.

for power to resume. (The generator cycles through a cool-down period, then a warm-up cycle starts again).

4.3 RENEWABLE ENERGY (SUN, WIND)

The seasonal variation of solar in the North is often much higher than southern locations. Many renewable energy systems are designed for warmer climates and where technical staff is available for proper care and maintenance. Due to required maintenance, isolated or seasonal sites may increase the life cycle costs of these systems significantly. The trend of rising fuel prices and dropping costs for renewables, coupled with a desire to reduce greenhouse gas emissions make these systems more desirable. An analysis of whether or not to install these systems would be contingent on a life cycle cost analysis, as well as making considerations on the overall environmental impact or offset created.

4.3.1 Unsuitable Applications

.1 Where buildings can be connected to a hydro powered grid, energy technologies that generate electricity shall not be installed.

The hydro system provides a reliable clean source of electricity. It is unlikely that life cycle costing will be favorable for alternative energy sources. Note that this is based on cost information at publication; current costs should be considered when making a decision.

.2 Systems using solar photovoltaic energy to provide lighting shall not be used when natural daylight can be used to provide adequate lighting.

In the summer months natural daylight is available. Solar panels are not effective in the winter due to short daylight hours.

4.3.2 Suitable Applications

.1 Solar energy technologies that generate electricity may be considered for remote and/or summer-use facilities such as: parks buildings, field research stations and fire towers.

The cost of operating and fueling generators in remote locations in the North is usually very expensive. Alternative energy is expensive also, but may be viable because it has very low operational costs. Yearly setup costs also need to be considered as equipment left on site may be subject to theft or vandalism.

.2 Renewable energy sources in locations with community diesel generators may be considered where life cycle costing shows it to be a viable alternative.

Seasonal availability of sunlight, and issues such as hoar-frosting make the availability and maintenance costs different from southern climates.

.3 All electrical loads need to be reduced to a minimum by using efficient installations, before considering renewable energy.

The initial cost of buying a renewable energy system is normally the largest component of the life cycle costs. As the initial cost is proportional to the size of the loads imposed on the system, reducing the loads will help minimize the life cycle costs of the system.

.4 Where wind turbines are installed, they will generally require a separate power source.

Most wind turbines are induction generators and require excitation from a separate power source.

.5 Batteries shall not be provided where connected to a community power grid.

Capital and maintenance cost of batteries are to be avoided.

Ensure compliance with Utility requirements for grid-tie connections.

Additional electrical safety precautions are necessary to protect electrical personnel.

4.3.3 Remote Sites

Remote sites are defined as those sites which must generate their own electricity on site, and do not have access to a local community power grid.

Remote sites should consider a hybrid power system that incorporates a small generator, a battery bank, a solar array and associated equipment as the electrical supply.

Electricity at remote sites is expensive to produce and most often relies on small, relatively inefficient diesel generators.

Electrical systems for seasonal sites must be simple to install and remove.

Seasonal sites are accessible year round and costs of equipment replacement can easily offset the yearly setup costs.

All reasonable measures shall be taken to reduce electrical loads.

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Propane shall be used whenever possible for stoves, ovens, and clothes dryers.

The cost of operating these propane appliances is roughly 1/3 that of operating electric models when electricity is diesel-generated.

Special emphasis shall be placed on the use of natural lighting.

Lighting can be easily accomplished during much of the day with ambient light. Sun tubes, skylights, and windows can significantly decrease electricity demand for lighting.

4.4 CONSUMER SERVICE AND DISTRIBUTION

4.4.1 Electrical Service Rooms

.1 Separate Room

A separate electrical room is recommended for all facilities that have services of 600 V and larger and/or 400 A and larger.

Services greater than 600 V and/or 400 A are of such a size that a separate room is desirable to consolidate electrical equipment. Separating it from the mechanical equipment generally ensures better access for maintenance operations, as well as provides a cleaner environment required for electrical equipment that often includes communications equipment, transformers, etc.

Wherever auxiliary power is provided, electrical panels and equipment may be located in the generator room noted in Electrical E4.2.7 above, with the exception of motor control centres, which are ideally located within sight of equipment being served.

As a separate room is already required for the generator, electrical equipment can be located there. Motor control centres are usually better placed in the mechanical room so the controls are within sight of many of the motors they control.

A separate electrical room is recommended in facilities where the mechanical space is expected to reach temperatures that will be higher than 30°C.

Electrical and electronic equipment, and in particular breakers are temperature sensitive and should not be located in spaces where their performance will be compromised.

Rooms that serve a dual function such as storage or corridor and electrical room shall be avoided.

Designers assume that electrical equipment is static and wish to use this "empty" space for other purposes such as pathways to other rooms. This can easily create a dangerous situation such as a door being opened into an electrician working on an open electrical enclosure.

.2 Working Space
Adequate space around electrical equipment is to be provided. Minimum working space around electrical equipment is 1.0 metres. Coordination with the other disciplines (especially mechanical) is essential.

Past experience with unacceptable clearances has resulted in need for on-site changes. We intend to ensure that safe working space is provided around electrical equipment (i.e., including space to stand beside panel boards while disconnecting breakers).

Entrance to and exit from the working space around electrical equipment must be kept clear of all obstructions.

Careful consideration during the design phase can help to anticipate and avoid the working space being used for storage space.

4.4.2 Service Size

Calculation of service shall be as per the CEC, with no oversizing of service, unless specific mention of future additions is made. Include calculation on drawings.

Service size calculations from the CEC are generally very conservative, with best practice margin errors adding to the CEC numbers. If a major renovation takes place in the future, and there is no spare capacity, then the service will need to be upgraded at that point in time.

Sizing and trip settings of the main service breaker must be considered carefully as the available fault current in many communities is very low, and as a result a fault may not clear within a reasonable time. Include available fault current at the service entrance on the single line diagram.

In some instances, utility fuses are tripping prior to main circuit breakers. Electrical hazards are based on the available fault current as well as the time to clear the fault. In most cases the fault current is very low, which is good, but the time to clear can be very long because of the low current, which is not good. Careful design when selecting the settings on the breakers will avoid this problem. Breakers equipped with adjustable instantaneous trip settings allow a breaker to be field adjusted to accommodate lower available fault current.

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4.4.3 Components

Standard of acceptance for power systems is Eaton Cutler Hammer, Schneider or Siemens.

This reduces inventory and allows maintenance staff to become familiar with the products.

Standard of acceptance for control equipment is Allen Bradley, Cutler Hammer, Schneider or Siemens.

4.4.4 Customer Metering

Provide a digital customer meter where service size is in excess of 200 kVA that can provide power quality metering, such as harmonic content, phase imbalance, transients, protection from phase reversal, over-voltage, under-voltage as well as Kwh consumption etc., capable of being tied into the building automation system.

This meter provides invaluable O&M data. This can be used to verify utility invoices, provide a quick history for maintenance person and allow for O&M staff to realize problems by reading through the data on their prescribed PM programs and logged evidence of power quality problems originating off site.

Provide digital customer meter where the service size is in excess of 75kVA that can provide consumption, demand, voltage and current information.

Digital metering is an excellent tool for troubleshooting and other general maintenance activities.

4.4.5 Power Quality

Ensure items prone to adding noise, such as a VFD are adequately isolated from the rest of the electrical system.

4.4.6 Uninterruptible Power Supplies (UPS)

Provide wall mounted shelves for UPS units that are supplying fixed wall mounted equipment.

Wall mounting above the floor surface allows ease of area cleaning procedures, and a more protected location.

When grouping computer or network equipment in a single room, consider

Regular servicing of a single larger unit can be more cost effective than servicing many smaller consolidating all UPS power requirements into a centralized unit feeding a small panel.

units. This also provides a higher level of protection from the electrical supply that may have variable quality.

Building systems such as telephone, public address, intrusion alarm systems, CCTV security systems, networking systems and etc. shall be fed from UPSs (or batteries), and also from the generator where a generator is available

Providing electrical redundancy to systems that are needed for proper operation of the building during utility power failures provides a greater level of reliability.

Where UPS is fed from a generator, provide a minimum of 15 minute back-up, where no generator is present, 1 hr shall be the minimum.

Generators do not always start, and this provides sufficient time to shut equipment down. Because of the frequency of outages, the larger capacity batteries will also last longer before requiring replacement.

4.4.7 Surge Suppression (TVSS)

Transient voltage surge suppression shall be provided on buildings with electronic equipment; however, surge arrestors for lightning strikes are generally not required.

Power quality though is not generally high, so some form of TVSS at the service entrance will reduce the exposure of equipment inside the building to harmful surges. The Northwest Territories has low incidence of lightning strikes, so surge arrestors would only be considered an asset on buildings where electrical reliability is critical.

Sensitive electronic equipment shall be protected from surges, both those generated from other equipment and those originating from the utility service. This can be accomplished at the service entrance, panel boards, and at receptacles.

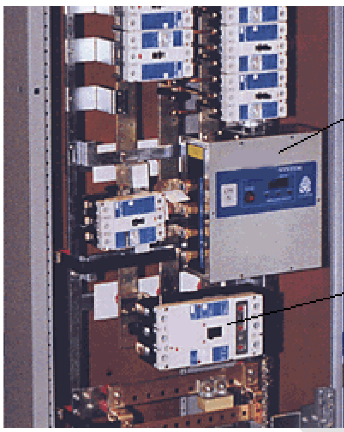
The rise in amount of sensitive electronics, and high powered switching devices such as VFD as well as the number of building systems that are sensitive to electrical noise (building automation systems, lighting controls) means that we have more harmonic content that can negatively affect the building systems. TVSS properly located will provide protection from internal sources of harmonics, voltage spikes, and transients.

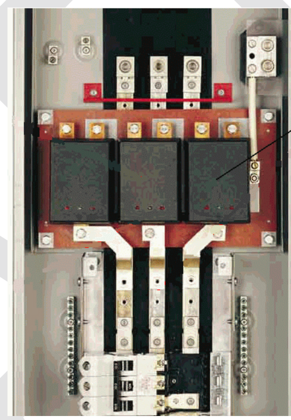
Evaluation of where to place TVSS will depend on the application.

Cost of providing TVSS is minimal compared to the potential of equipment and/or data lost due to poor power quality issues.

Point of use devices at workstations or integral to the receptacle may also be incorporated.

TVSS receptacles or within power bars is a relatively inexpensive method of providing good protection to single location equipment.





Sample Buss Mounted TVSS

4.4.8 Variable Frequency Drives

Provide drives complete with harmonic distortion line filters which limit total harmonic current distortion to less than IEEE 519 standard requirements where the drive terminals are the point of common coupling, but in no case more than 3%.

Additional line filtering is often required to reduce the propagation of harmonics and radio frequency interference (RFI) to other equipment.

Coordinate motor selections with mechanical to ensure inverter duty motors are provided.

These motors can withstand repetitive voltage spikes that are 3.1 times the rated RMS voltage.

Use pulse width modulated technology

Select drives with proven maintenance

drives. Locate drives within 7 meters of load.

capabilities.

4.4.9 Separation from Disturbance

Keep equipment that causes electrical disturbances (motors & VFDs Variable frequency drives in HVAC applications and Industrial pumping (water/waste water) electrically separated from electronic equipment susceptible to electrical disturbances (such as computers servers', terminals, monitors, printers, fax machines, telecom systems photocopiers and communication equipment etc.) Provide electrical protection and line power conditioning for affected equipment as follows:

Determine the extent and severity of electrical service disturbances including voltage sags, surges, short term and long term transients and outages. Consultation with the Utility in order to determine the likely incidence of these disturbances.

Identify electronic equipment and system likely to be affected by disturbances and the extent of protection necessary for normal operation

.1 Surge protectors: electronic or varistors surge arrestors for equipment affected by transients.

These motors can withstand repetitive voltage spikes that are 3.1 times the rated RMS voltage.

.2 Isolation transformers: electro statically shielded transformers for equipment affected by transients and noise.

Select drives with proven maintenance capabilities.

.3 Regulated power supplies: for equipment and systems affected by transients, noise, voltage sags and surges.

.4 Electronic filters: for equipment affected by power line noise.

.5 Uninterruptible power supplies: for equipment requiring continuity of service.

.6 All electronic based systems are to be on power conditioning UPSs

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4.4.10 Panel Boards – Spare Conduit

For flush mounted panels, stub 3 spare 21 mm conduit out to the accessible ceiling space and/or crawl space (whichever is accessible afterwards).

The intent is to provide ready access to the panel boards for future circuitry requirements

4.4.11 Breakers

Wherever possible, breakers shall be used rather than fuses unless specified by the owner.

Tripped breakers can be reset; burned-out fuses must be replaced. Replacement fuses are not readily available in most communities, which can lead to the serious consequences associated with loss of power in cold climates. Fuses may be specified only where a large interrupting rating is required.

4.4.12 Location of Receptacles

.1 Receptacles Facing Up
Receptacles must not be mounted facing up, either inside or on shelving units, work surfaces or counters. The only exception permitted is a floor box with a hinged cover.

Dirt accumulation or spilled substances could create problems (e.g., in home economic rooms and science rooms).

.2 Receptacles in Exterior Walls
Where possible, avoid locating outlets in exterior walls if the air-vapour barrier must be broken to accommodate the devices.

It is not always possible in large rooms with exterior walls (i.e., gyms, assembly halls), but the intent is to reduce the number of penetrations. (Note: this is not a concern where walls are built or strapped on the warm side of the air-vapour barrier). Careful attention to maintaining the vapour seal is required to avoid air and moisture infiltration.

.3 In addition to code required areas, general use receptacles in public waiting areas and primary school classrooms are required to be Tamper Resistant.

This reduces electrical shock exposure for younger children.

4.4.13 Provision of Branch Circuits

.1 Counter Receptacles
At least one 20 amp T slot receptacle shall be provided at counter work surfaces.

This will prevent the overloading of a circuit and allow a variety of equipment to be used on work counters. These requirements border on adequacy provisions, but experience shows that if there isn't a degree of adequacy in the electrical installation, they quickly become unsafe. Examples include classrooms, school lounges, office work counters etc.

.2 Fridge, Microwave, Freezer
Each receptacle installed for a refrigerator, microwave oven or freezer is to be supplied by a separate branch circuit.

Same as Electrical E4.5.10.1.

.3 Circ Pump, Heat Trace
Each water circulation pump and heat trace outlet is to be supplied by a separate branch circuit.

This prevents the freezing of the facility water supply due to a fault in other electrical equipment.

.4 Circuits feeding receptacles in a classroom shall not share a circuit with receptacles in other classrooms.

If a circuit trips in one classroom, it should leave other classrooms unaffected.

.5 Circuits feeding receptacles in common corridors for cleaning equipment shall not share the circuit with receptacles in other areas. Install 20 Amp T slot receptacles.

Modern cleaning equipment can overload circuits that are shared by other devices causing nuisance tripping. 20 Amp T slot receptacles can provide adequate power requirements for a variety of present or future labor saving cleaning equipment.

.6 A minimum of one circuit shall feed receptacles within an enclosed office space.

Initial design of circuitry and receptacles, if not adequate for future needs within an office may result in poor power quality, extension cord usage, or additional circuits having to be added at a future date. Personal use photocopiers and laser printers may be future requirements.

.7 Drinking Fountains shall be GFCI protected.

This reduces electrical shock exposure.

.8 The maximum number of receptacles per circuit shall be four (4) for office and workshops, and shall be eight (8) for corridors and crawl spaces.

This reduces a chance to be overloaded to a circuit.

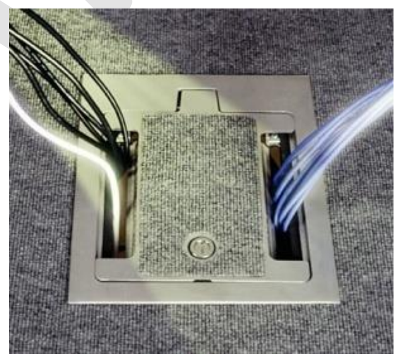
4.4.14 Electrical Boxes

.1 Sectional Boxes
Avoid ganging together of sectional boxes.

Joined sectional boxes can come apart during rough-in, which eliminates the grounding between boxes.

.2 Floor Boxes
Use floor-mounted receptacles only if there is no alternative to providing power to equipment. Unless a raised floor system has been installed, whose purpose is to provide floor mount receptacles.

Flush-mounted floor boxes with removable covers are undesirable because the covers are often misplaced, leaving the receptacle exposed (facing up), which is an electrical hazard.



If construction allows, they shall be flush-mounted type complete with hinged covers.

Floor boxes that are flush-mounted are less obtrusive and less of a tripping hazard compared to surface-mounted floor boxes and are able to accommodate both line voltage and low voltage wiring.

K5 GROUNDING AND BONDING

Grounding by connecting to municipal water mains, as is typical in most of urban Canada, is seldom possible for buildings in the NWT. In areas supplied by municipal water mains the water lines are insulated and not in contact with the ground due to the cold winter conditions. Buildings within most isolated communities are provided by individually tanked water and sewage systems. Means of adequately grounding these facilities are covered by the CEC; the preferences stated reflect Infrastructure experience with different situations encountered in Northern public sector buildings. Size all grounding conductors to carry the fault current necessary to trip the over current devices protecting the loads, panel boards, and feeders associated with the grounding system.

5.1 ORDER OF PRECEDENCE

Grounding System is required, in order of precedence as follows:

.1 Exothermic (cad) weld to a minimum of 4 steel pipe piles

The large surface area of a steel foundation system that is contact with the ground and commonly used in the north can provide the best ground possible in northern areas. Cad welding provides a permanent connection.

.2 Minimum 9.5 mm (3/8”) bolts (copper, bronze or brass) tapped and threaded to a minimum of 4 steel pipe piles.

The electrical resistance of the ground in arctic or subarctic areas is extremely variable (1 to 1000 ohms for a standard 19 mm by 3.0 m grounding rod). The resistivities of frozen ground are inadequate to meet the electrical code requirements. The choices given indicate the options in order of preference for providing the best possible ground system.

.3 A minimum of 3 rod electrodes for more than 200 A services.

.4 A minimum of 2 rod electrodes for not more than 200 A Service.

.5 Ufer ground.

.6 Plate electrodes.

Where low ground resistance is critical or standard means will not obtain a reasonably low ground resistance consider use of additives.

Consideration must be given at the design stage to pick the best possible system, avoiding dissimilar metals, and from galvanic action set up under certain soil conditions.

Additives will degrade over time, reducing the effectiveness of the grounding system, however they may be warranted in some situations.

5.2 CSA Z32 "Electrical Safety in Patient Care Areas"

Assume procedures as noted in Electrical E6.3.7.

K6 WIRING

6.1 USE OF CONDUIT

Infrastructure previously required all wiring to be run in conduit. This was viewed as a worthwhile investment as it simplified any unforeseen expansion or changes. In practice not all facilities make use of this feature over their lifetime. The need for conduit has now been reviewed and modified as noted below.

6.1.1 Conduit Use

.1 Surface-mounted conduit

Is acceptable in service buildings (i.e., garages, firehalls), in recreational buildings (arenas, etc.) and in spaces concealed from the public or not accessible.

This clarifies where surface conduit is acceptable.

Spaces such as service rooms and closets, plenums, crawlspaces etc., are not normally seen, so surface conduit use in these areas is acceptable.

.2 Concealed conduit

Install conduit concealed wherever possible to provide clean wall and ceiling surfaces.

Surface conduit should be avoided wherever possible to reduce wall and ceiling trim and painting requirements in new and renovated buildings and maintain visual appeal.

.3 Wood Frame Construction

.a Where a conduit is not required by the Code but is installed in a wood frame construction, the conduit may be terminated in junction boxes convenient to each room (i.e., above T-bar ceilings, in crawl spaces, etc.). NMD90 or armoured cable may then be used as wiring to the power outlets from this junction box.

The intent is to reduce construction costs and yet allow some flexibility in wood frame construction by providing a "grid" system of conduit and junction boxes.

Facilities where future electrical requirements are most likely to change include maintenance shops, open offices, and modular classrooms in schools.

.b Conduit is not required for long runs or where only a single circuit is used (i.e., exterior lights, exit lights, emergency battery pack remote heads).

Conduit to allow for expansion of electrical power systems is typically not required for residential facilities such as student residences or group homes, arena support space areas, gymnasiums or community halls, garages, warehouses or fire halls.

.4 Non-Combustible Construction

Conduit may be terminated in junction boxes convenient to each room (i.e., above T-bar ceilings, in crawl spaces, etc.) Armoured cable may then be used as wiring to the power outlets from this junction box.

The intent is to reduce construction costs and yet allow some flexibility in non-combustible construction by providing a "grid" system of conduit and junction boxes.

.5 In Slab Conduit

Ensure adequate depth in slab to avoid fasteners.

Conduits need to be protected from mechanical fasteners.

Coordinate with mechanical heating lines.

Proximity to in slab heating lines can result in de-rating of conductors.

6.1.2 Cable Tray

Cable tray is desirable where many structured wiring cables will be installed. Cable tray shall also be installed where there is a strong potential for frequent changes to structured wiring, or where multiple systems (ie: security, CCTV) may be added at a later date.

Cable tray allows for very fast installation and for ease of changes in the future. Data requirements are changing very quickly and the tray allows for a neat installation for retrofits.

Cable tray shall be designed for future additions.

A minimum of 21mm conduit from the Cable tray location shall be installed to the point of use.

A 21 mm conduit provides ample room for a variety of cables that may be terminated at one point of use within a room.

All cable trays, whether containing power or low tension cabling (Data, Voice, CCTV Security, Public Address, Nurse Call, Intrusion Alarm, Duress, etc.) shall comply with CEC section 12-2200.

Adequate working space shall be provided for access to cable trays to facilitate the installation and removal of installed cabling, and to maintain the system.

Of particular importance is maintenance of clearances as follows:

.a 1 300mm vertical clearance from the top of the cable tray to all ceilings, height ducts, and heating equipment and 150mm for short (less than 1m) obstructions.

.b .600mm horizontal clearance on at least one side.

6.1.3 J Hooks

It is also acceptable to branch off a cable tray system at right angles using J-hooks for support in concealed spaces (above T bar ceilings).

J-hooks provide an approved means of attachment for a variety of cables when few are required to a point of use. This cabling system also improves cabling organization above ceilings.

Install 21mm conduit sleeve within wall to allow for cable installation.

Conduit provision allows for ease of installation and future cabling upgrades.

6.1.4 Surface Mount Raceway

Preference is to concealed raceways, although areas that are being renovated, or frequently renovated, where the wall finish is not being removed, surface mount raceway may be used, provided the appearance is matched to other architectural finishes in the space.

Areas that experience frequent renovation the visual appearance of surface mount raceway can be offset by lower cost of renovations and the flexibility of surface mount.

Surface mount raceway would also be acceptable for short runs to feed non-permanent pieces of equipment such as intelligent whiteboards.

These installations are often changed, frequently require different connections than previous generations and are often installed by none electricians. Architecturally finished surface mount raceways provides a way to run cords in a tidy and inconspicuous manner.

6.1.5 Telephones

Telephone cabling shall be run in structured wiring type cable, and follow all applicable guidelines.

This allows for greatest flexibility in ever changing cable requirements, as each client department is often responsible for all wire installation. Structured wiring also allows for future changes to telephone technology.

Where twisted pair telephone lines are installed in a facility, cables shall be installed in conduit where exposed to mechanical injury.

The installation of conduit provides mechanical protection and for future changes within a building.

6.1.6 Owner Equipment

Group wiring and cables for centrally controlled or networked equipment in a common conduit or raceway. Conduit shall be sized to allow for some expansion.

Examples of systems where this should be applied include computer LANs, intercom systems (independent of telephone), sound systems, and television. Equipment and systems should be identified in facility programs.

6.1.7 Air / Vapour Barrier

Conduit penetrations through air/vapour barriers need to be sealed inside and outside of the conduit.

See Architectural A3.1, A3.3, A3.4, and A3.6. Sealing prevents air and moisture penetration that can detrimentally affect installed electrical systems and wiring.

6.2 WIRE AND CABLE

6.2.1 Type and Size

.1 Copper wiring only, thermoset type insulation R90, RW90 (XLPE).

Compared to TW or thermoplastic insulation, thermoset XLPE insulation provides a wider range of acceptable operational temperatures encountered in northern buildings. XLPE insulation is also more robust and thus not as susceptible to installation damage.

Cable types NMD90, AC90 or Teck90. All wiring to be minimum #12 gauge with the exception of control wiring and low voltage wiring.

#12 is specified to prevent voltage drop problems associated with #14. Heat (I2R) losses are reduced.

It is to be noted that NMD90 cabling is only

This note is provided for information

FT1 rated. It cannot be installed in a return air plenum or through fire penetrations.

purposes to ensure where NMD is installed in a wood structured building that it is not installed in a return air plenum.

.2 Control wiring and low voltage wiring (i.e., fire alarm) can be as per minimum code requirements.

This confirms that minimum code requirements are acceptable for control and low voltage wiring.

.3 FAS cable is acceptable for fire alarm systems in wood frame construction.

This confirms that minimum code requirements are acceptable for control and low voltage wiring.

.4 The use of aluminum wiring is not recommended. Aluminum wiring is permitted for service and distribution panel feeders, but not branch circuit wiring.

Connections require special procedures and application of antioxidant material. Also require annual inspections as they have a tendency to loosen.

.5 Structured wiring that does not meet the flame spread rating the NBCC requires shall be removed during renovations.

Older Cat 3 cables or non-plenum rated cables that have been installed in plenum spaces need to be removed to reduce fire load and smoke development.

Capacity and rating of cable shall be considered during schematic design.

Rapid changes in industry mean that any specific preference for capacity of structured cabling (ie: Cat 6) could easily be outdated prior to new GBP's being issued.

6.3 WIRING DEVICES

See Electrical E2.4 Standardization".

6.3.1 Grade

Wiring devices shall be "Specification Grade" or better for all applications.

Residential quality is not durable enough for public buildings.

The following set the Standard of Acceptance (or equivalent):

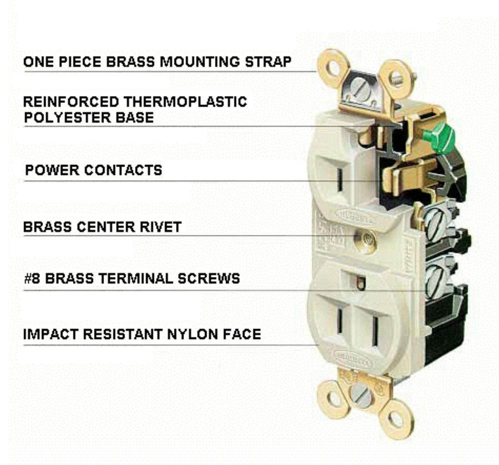
- Standard receptacle: Hubbell 5262 (15 Amp) or 5362 (20 Amp) Specification grade.
- Surge suppression receptacle: Hubbell

5260-SA c/w blue nylon face.

- Ground fault receptacle: Hubbell GF15ILA (15 Amp) or GF20ILA (20 Amp T slot)

- Tamper resistant receptacle: Cooper, Hubbell or Leviton specification grade.

- Standard switch: Cooper, Hubbell or Leviton specification grade.



6.3.2 Colour

Wiring devices (receptacles and switches) shall be of the same colour throughout the building. Preference is user defined. Exceptions:

- Surge protection outlets Blue
- Emergency outlets Red
- Isolated ground Orange

The intent is to standardize the colour for replacement and stocking purposes, yet allow some flexibility for the designer's choice (i.e., ivory, white, brown).

6.3.3 GFCI Outlets

Interior ground fault receptacles may be the receptacle type that have "test" and "reset" on face of receptacle.

GFCI receptacles are much less expensive than GFCI breakers, and also more likely to be tested regularly because the test is readily accessible.

Exterior ground fault receptacles will need to be protected by a GFCI breaker, not from within the receptacles itself.

GFCI's do not function properly in cold temperatures, and exterior receptacles that require GFCI protection must have GFCI protection in a warm location.

6.3.4 Cover Plates

Stainless steel, enamel finish metal is the preference; nylon receptacle plates will be considered.

Stainless steel plates are typically used in schools, health centres and detention facilities, as they are the least susceptible to damage. Enamel finish metal or nylon is acceptable for most other uses including student residences, offices, group homes and treatment centres.

Bakelite is not recommended.

Bakelite plates are not durable.

6.3.5 Crawl Space

Receptacles may be provided in all enclosed crawl spaces. Locate receptacles adjacent to all equipment or mount receptacles so that any point in the area is not more than 25 m horizontally from a receptacle.

The NBCC does not clearly cover requirements for crawl spaces, which are a common feature in buildings. These receptacles may be required to provide power for "trouble lights," pumps and/or repair equipment.

Regardless of enclosed crawlspace heights, do not install NMD cabling on bottom cord of floor joists. Provide protection by location of cabling or by mechanical means.

Enclosed crawlspaces are typically used for maintenance activities or material storage. NMD cabling is much more prone to mechanical damage than armored cable or conduit.

Install GFCI protection on crawl space receptacles with exposed earth.

Moisture and standing water can be found in many crawlspaces during seasonal variations. GFCI protection provides increased safety to maintenance personnel.

6.3.6 Outdoor Receptacles

Receptacles shall be provided if they are a program requirement.

Minimize the use of exterior electrical cables; keep outlets above snow level.

Flush mount exterior electrical outlets on the building unless otherwise stipulated, and ensure that they are mounted above the level of winter snow accumulation.

Flush mounting has been found to be less susceptible to vandalism. Mounting on buildings is also desirable because people tend to leave a walking space between the vehicle and the building in order to access the receptacle.

Parking rails with receptacles are preferred.

Install rails at or above vehicle grill height, as

Posts may be used only where necessary or unavoidable.

people will be a more cautious when approaching.

Parking outlets shall be split receptacles if they serve 2 parking stalls.

Vehicles in the North generally have a block heater, and battery blanket. Some vehicles may also have an oil pan heater. To avoid nuisance tripping a separate circuit is usually provided for each parking stall.

Where only a few exterior receptacles are required for vehicles, use intelligent receptacles that are programmable with a delayed response to initial connected load, are temperature sensitive and are individually adjustable.

Providing an intelligent receptacle can reduce energy costs due to unnecessary use.

Where intelligent programmable receptacles are installed provide a programmer.

When more than 10 automobile stalls or spaces are required, consider installing a control system that provides power to the outlets in the following manner:

This is required for energy conservation.

- Above -16°C: No power.
- -16°C to -32°C: Cycle power (i.e., 20-30 min on, 20-30 min off).
- Below -32°C: Continuous power.

The controller can be either a centralized panel or an intelligent receptacle.

When 10 or more outlets are provided, at set point temperatures between -16°C and -32°C, the outlets could be cycled in such a manner that only one-half of the outlets are energized at any given time.

This is required for energy conservation. It reduces demand charges.

A separate set of car plug controls needs to be designed for propane and diesel driven

Propane and diesel driven vehicles require more heating.

vehicles where these types of vehicles will be plugged in.

Mechanically protect exposed low temperature thermostat sensors so that they are exposed to the wind and isolated from sources of heat. (e.g., a wire mesh guard or similar device).

6.3.7 CSA Z32.2 "Electrical Safety in Patient Care Areas"

Receptacles need to conform to requirements as follows:

Clarification of application of the Standard. Terms used here are as defined in the Standard.

Hospital grade receptacles are identified by a green dot on the receptacle face. These receptacles shall only be installed in patient care areas to differentiate from receptacles installed outside of these basic, intermediate or critical care areas.

It is our intent to clearly identify receptacles that must be installed and tested to Z32 requirements, and thereafter tested on a regular basis by maintenance staff.

Classification of care areas with a Community Health Care Center must be confirmed with the appropriate authority prior to finalizing design.

Hospital grade receptacles that have not been installed to Z32 requirements should either be replaced with specification grade, or the wiring upgraded to meet Z32 installation requirements. This ensures medical staff are properly informed of the nature of the installed system.

6.3.8 Specialty Installations

Recess wall receptacles within gymnasiums approximately ½" from front wall surface.

This reduces impact forces on receptacles resulting in broken receptacles and bent cover plates that can become a safety hazard.

Use recessed duplex receptacles for shelf type microwave installations.

Provides additional space for microwave cord connection and protection for cord cap.

K7 LIGHTING AND LIGHTING DESIGN

This section deals with lighting not only as it relates to building electrical systems, but also as it relates to architectural and interior design. Lighting Design is defined in the Illuminating Engineering Society's Handbook as,

"Providing light for the visual tasks to be performed and creating a balanced, comfortable, and aesthetically appealing environment coordinated with the decorative and architectural theme."

7.1 INTERIOR LIGHTING

Artificial lighting requirements are not much different in the NWT than anywhere else in North America, although the potential for day lighting is more limited during winter months. The use of "energy saving" lamps, fixtures, and switching devices which allow discreet control, is important because lighting accounts for a large portion of electrical costs. The use of new and innovative products, however, shall be carefully considered in terms of cost, availability and maintenance on a Regional scale. The role played by lighting in enhancing the architectural setting, orientation and atmosphere is to be recognized.

7.1.1 Illumination Levels

Lighting intensity and quality shall be to the recommended minimum of the current edition of the Illuminating Engineering Society's (IES) Lighting Handbook and IES recommended practices for different facilities.

This is recognized as the industry standard. Facilities such as schools or health facilities have recommended practice documents that detail many considerations that should be made when designing lighting layouts beyond the simple intensity at the workplane.

7.1.2 Energy Efficiency

Designers are required to stay within the energy budgets for lighting as set out in ASHRAE 90.1. For guidance, refer to Appendices, which includes excerpts from the most recently updated National Energy Code for Buildings (NECB) which was based on ASHRAE 90.1.

Costs for electrical energy in the northern environment are high. The goal is energy efficiency. The National Energy Code for Buildings (NECB) 2015 addresses the efficient use of energy by building. An "energy effective" strategy is one that conserves energy while meeting all appropriate standards for lighting quality, so the most efficient fixture is not *always the best selection. A building-wide approach can best reduce your energy consumption.*

7.1.3 Daylight

Where daylight can contribute to illumination for a significant portion of the annual occupied hours in any room, the artificial lighting levels shall be adjustable to take advantage of day lighting as per ASHRAE 9.4.1.1(e) and 9.4.1.1(f).

Minimum lighting levels have to be calculated based on northern winter conditions when day lighting is not possible in most NWT communities. Where daylight can provide adequate illumination to a room or a portion of a room, there must be the capacity to turn off redundant electrical lighting, (by automatic control) if any energy savings are to be achieved. Large areas with rows of fixtures controlled by a single switch for example, do not normally allow the flexibility required. Refer to Section 7.1.11 on lighting controls.

Lifecycle costing shall be performed, as well as an attempt to outline the qualitative aspects of daylighting in justifications for daylighting.

Low angle sunlight and snow accumulation are items that affect northern buildings, and differentiate this from southern applications. In general, understanding of daylighting in northern building is poor, although it is clear that there is a benefit well beyond the economic benefits, this would include benefits to circadian cycles, Vitamin D.

7.1.4 Indirect Lighting

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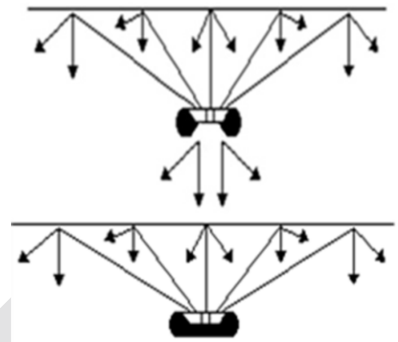
Indirect lighting shall only be considered where the quality of the lighting is the most important factor in the lighting design.



Fixtures that are a combination of direct and indirect lighting are preferred due to the high cost of energy in the north.

For most public sector buildings, the life cycle cost is the most important factor. Typical applications such as school gyms and entrance foyers should not be considered for indirect lighting unless the additional life cycle cost is insignificant (i.e., <5%).

Where indirect lighting is appropriate, reasonably uniform ceiling luminance is to be achieved.

If this is achieved, occupants may face in any direction without being subject to excessive ceiling reflections on the tasks.

7.1.5 Valence Lighting or Spot Lighting

Use valence Lighting or spot lighting only for task lighting, display cases and walls that are intended to be features or where dramatic lighting is important.

Minimize this practice because of poor lumen/watt ratio obtainable and the tendency to pick up irregularities of wall surfaces such as painted drywall.

7.1.6 Night Lights

Provide night lighting only where minimum lighting for safety or security is required at night and where light switches are not conveniently located.

The high cost of electricity limits the use of night lighting. Appropriate uses are group home hallways (for safety) or arena lobbies (for security) where switches are normally located at a central panel or in a closed-off room.

7.1.7 Fixtures

.1 Polycarbonate Fixtures

Are ideal for use in change rooms and ancillary washrooms.

There is a high potential for vandalism in some washrooms and change rooms (i.e., arenas, schools).

.2 Over-counter Lighting

Where required, provide separately switched task lighting over counters (i.e., valance lighting under cupboards).

Work at counter tops often requires good lighting for tasks (e.g., nursing stations - writing reports, kitchens - reading recipes) and helps in overcoming shadows cast by the body from general room lighting.

.3 Task Lighting

Wherever possible, provide built-in task lighting to supplement the ambient lighting for critical seeing tasks, rather than providing high ambient lighting. Balance the task and ambient lighting levels. The light levels supplemented by the task lighting should be no more than two times the light levels supplied by the ambient overhead system. For exhibit or display functions, this ratio can increase to 3-4 times task versus ambient. Office lighting designs that provide 300 lux ambient can be supplemented by an adjustable task light that can provide an additional 200 to 400 lux on the task and be within acceptable luminance ratios.

This assists in energy conservation and accommodates the need for higher lighting levels due to task visual difficulty, glare, etc. Typical applications are desks in student or senior residences, as well as airport control towers.

.4 Arena / Curling Fixtures

All luminaries in unventilated (less than 3 air changes / hour) arenas / curling rinks need to be suitable for use in wet locations.

High humidity due to flooding of rinks and the lack of mechanical ventilation causes severe condensation and frost build-up.

.5 Indirect T bar Fixtures

Provide improved optics and allow for easier installation.

Reduced glare, no lens shrinkage, reduced cleaning and design provides improved operating temperature.

7.1.8 LED Modules & Arrays

.1 LED Modules & Arrays

LED's are to be used throughout on all projects and shall meet LM-79 and LM-80 testing standards.

LED lighting is much more energy efficient than other types of lighting. Additionally, they last much longer and are more durable overall. LED lamps are particularly resilient to cold, temperatures, rapid switching, vibrations, and impacts. They are easier to use as dimmable lights and the do not emit IR or UV waves.

.2 LED's shall have a CRI >80 for general purpose interior applications. A CRI >90 shall be used in applications where accurate color discrimination is important (ie. Telehealth, museums, art galleries, high end retail, etc.).

The higher the CRI, the better the color rendering ability. Light sources with a CRI of 85 to 90 are considered good at color rendering. Light sources with a CRI of 90 or higher are excellent at color rendering and should be used for tasks requiring the most accurate color discrimination.

.3 LED's shall have a colour temperature of 3500K for general purpose applications. 4000K shall be used in areas where demanding visual tasks are performed. 3000K shall be used for residential and general purpose exterior lighting. Higher colour temperatures may be used where security is a concern, such as exterior parking lots.

Visual comfort is an important factor to consider in lighting design. Most people perceive higher colour temperatures as too bright, even if the lumen output of the fixture is the same as one with a lower colour temperature.

.4 LED's shall target a minimum luminous efficacy of 100 Lumens per Watt (Lm/W) for general purpose applications.

Higher Lumen per Watt ratios mean fewer fixtures required for the same amount of energy consumed.

.5 LED's shall target a minimum lumen maintenance (L70) of 100,000 hours for typical general purpose applications.

Higher L70 ratings mean luminaires maintain their initial lumen output for a longer period of time. Different luminaire types will have different L70 ratings. For example, pot lights may only have an L70 of 50,000 hours. Whereas high bay LEDs may be able to achieve an L70 of 200,000 hours or more.

7.1.9 Ballasts & Drivers

.1 Ballasts should not be specified unless special circumstances require them. If required, ballasts should be electronic rapid start, with a ballast factor of 0.88, and a TDH of <10%.

LED lighting shall be used unless otherwise noted and therefore fluorescent ballasts are no longer required.

.2 Electronic Drivers for LED's shall be 0-10V dimming down to 10% for typical general purpose applications. 1% dimming may be used in certain applications such as hospitality. Non-dimmable drivers may also be used where dimming is not required.

Dimmable LED drivers are standard on most LED fixtures; although non-dimmable might be the only option on some. 0-10V is most common but requires additional low-voltage control wires. Triac and ELV are also common dimming options that don't require additional control wires. The type of driver selected should always be coordinated with the type of controls used.

7.1.10 Plastic Luminous Panels

Use acrylic prismatic lenses with a minimum thickness of 0.125" (K12) mounted within a frame.

This identifies the standard of acceptance. A framed lens is not prone to falling out of the fixture due to lens shrinkage or vibration.

7.1.12 Lighting Controls

.1 Lighting controls shall meet the requirements of ASHRAE 9.4.1. This shall apply to all buildings defined in ASHRAE 9.1.1 with exceptions noted. Requirements of 9.4.1 shall also apply to lighting alterations defined in ASHRAE 9.1.2 with exceptions noted.

This is an adoption of requirements outlined in ASHRAE 90.1.

Controls do not need to be complicated in order to meet the requirements of ASHRAE. Off the shelf line voltage products are readily available that meet these requirements. Designers are encouraged to explore simple, low-cost solutions. Combinations of different types of controls may also be used to achieve these requirements.

The goal is energy efficiency.

.2 Lighting control devices and control systems shall be tested as per ASHRAE 9.4.3.

This ensures that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer's installation instructions. Testing shall be done by a 3rd party and provide documentation certifying the controls meet or exceed performance criteria.

7.1.13 Location of Controls

.1 Except as provided in 7.1.13.2 and 3, lighting controls shall be:

.a Provided in accordance with ASHRAE 9.4.1.1(a) Local Control.

.b Located next to the main entrance or entrances to the room or space whose lighting is controlled by those controls;

.c Located in such a way that there is a clear line of sight from the control to the area lighted; and

This is an adoption of requirements outlined in the National Energy Code for Buildings and ASHRAE 90.1. The goal is energy efficiency.

Requiring controls to be located at the entrances to the spaces served will not only encourage the use of the controls, but will reduce the likelihood that circuit breakers will be used for that purpose.

.d Readily accessible to persons occupying or using the space.

.2 Low voltage relay cabinets are ideally wall mounted next to electrical panels supplying lighting circuits.

This provides ease of access for maintenance, setting of controls, and wiring.

Provide web interface capability for remote programming and adjustments.

The ability to troubleshoot problems and make programming adjustments remotely is beneficial to maintenance staff and building operators.

7.1.14 Type of Controls

.1 Low Voltage Switching (LVS)
Consider LVS wherever there are multiple circuits and the switching is desirable from multiple locations.

This is not economical where there are few circuits. This is typically used in schools, health centres and correctional facilities.

Low voltage switching is recommended where 347 volt lighting fixtures are in use.

This provision limits access to increased hazards when cover plates are removed for painting or electrical maintenance.

Network panels in facilities with multiple low voltage control panels.

This provision allows ease of trouble shooting, programming/setting changes for maintenance staff.

.2 Motion Sensors
Passive Infrared Sensors (PIR) or dual technology sensors shall be used to control lighting in locations outlined in ASHRAE Table 9.6.1 for Automatic Partial or Full OFF control (i.e., classrooms/training rooms, offices, washrooms, utility/storage rooms, conference/meeting rooms, etc.) except for crawlspaces.

They provide energy efficiency and security. Motion sensors should be used when the reduced energy consumption makes the increased capital cost worthwhile. The cost of electricity, type of fixture and space function will determine when motion sensors should be used. Motion sensors are not acceptable where automatic shutoff would endanger the safety or security of room or building occupants or where lighting is required for 24/7 operation. Refer to the Exceptions to ASHRAE 9.4.1.

Keys are easily lost, and lights are then left on *unnecessarily resulting in wasteful energy consumption.*

.3 Key Operation
Keyed lighting switches are not recommended.

.4 Manual Control
Manual control should only be used where lighting is required for 24/7 continuous operation, lighting in spaces where patient care is rendered, or lighting in spaces where an automatic shutoff would endanger the safety or security of the room or building occupant as per ASHRAE 9.4.1.1.

This is an adoption of requirements outlined in ASHRAE 90.1.
The goal is energy efficiency.

.5 Lighting Schedule Controllers
Scheduled shutoff of lighting as required by ASHRAE 9.4.1.1(i) can be accomplished by a time-of-day operated control device (ie. lighting schedule controllers) that automatically turns the lighting off at specific programmed times.

This is an adoption of requirements outlined in ASHRAE 90.1.
The goal is energy efficiency.

Alternatively, a signal from another automatic control device or alarm/security system can be used.

Where an intrusion alarm security system is installed, it is preferable to provide automatic shutoff via auxiliary contacts connected to the alarm panel such that when the security system is armed at the end of the day, the lights are automatically shut off.

Any manual control installed to provide override of the scheduled shutoff control shall not turn the lighting on for more than two (2) hours.

Controllers required in 7.1.13.5 shall be of the electronic type capable of being programmed for 7 days and for seasonal schedule variations.

The intent is to allow flexibility within various types of facilities.

Schedule controllers should be of a type that does not derive its time base from

The small isolated utility power systems in all NWT communities typically have poor the AC power line frequency.

frequency stability that is not suitable for clock time bases.

All lighting schedule controllers shall be equipped with back-up provisions to keep time synchronization during a power outage of at least 4 hours.

Power outages occur relatively frequently and maintaining the schedule is desirable for appropriate operation.

Schedule controllers shall be capable of automatic adjustments for Daylight Savings.

This reduces maintenance costs.

.6 Service Space Lighting
Wherever lighting is provided in typically unoccupied spaces, (i.e., crawl spaces) a pilot light, indicating whether service lights are "on", may be conveniently located at the entrance to the service space.

Lights can be left on inadvertently for extended periods of time, and nobody would be aware, because that space is not normally used.

7.1.15 Protection of Light Fixtures

.1 Wire Guards
Luminaries require wire guards if located in areas where they are subject to damage.

Protection of luminaries in such locations is necessary to prevent fixtures from being damaged by moving objects during games or during storage of equipment, and to prevent subsequent injury to persons. Guards may be required in gyms, service areas, storage areas, industrial arts classrooms, locker rooms and for exterior lights.

.2 Safety Chains/Cables
Suspended fixtures in recreational / sports facilities must not rely on support directly from an outlet or box or fixture hanger; provide safety chains / cables.

This is required to ensure that luminaries cannot fall when impacted by moving objects.

7.2 EXTERIOR LIGHTING

Exterior lighting shall be provided for safety and security reasons only (i.e., only install exterior lighting where they are required by code or by function as determined by the facility program). The high cost of electricity in the NWT makes the use of any decorative lighting undesirable.

7.2.1 Fixtures

Polycarbonate fixtures are well suited for all exterior lights. For all facilities consider the use of vandal resistant fixtures.

This reduces breakage due to high potential of vandalism. Some facilities experience very high rates of vandalism and it may be warranted to install fixtures and metal guards that will stand up to significant abuse.

Fixtures shall be IESNA dark sky compliant and layout to avoid light trespass.

Reduces energy costs.

7.2.2 LED Modules & Arrays

Refer to 7.1.8.

7.2.3 Lighting Controls

Refer to 7.1.11.

Locate PEC on north side of building.

If networked low voltage control systems are employed in a facility, integrate the exterior lighting controls.

The goal is energy efficiency.

Provide local, integral motion sensor for all person door fixtures.

This provision will simplify operational and maintenance requirements.

7.3 EMERGENCY LIGHTING

7.3.1 Emergency Lighting Locations

Emergency lighting shall be installed in areas required by the NBCC, including service spaces (i.e., electrical/mechanical rooms, accessible crawl spaces), corridors, and stairwells as well as washrooms.

This will enhance safety in service areas when power supply fails; as well as providing lighting for egress from service areas, crawl spaces, corridors, stairwells and washrooms.

Where Emergency generators provide lighting ensure that emergency battery powered lamps are provided in the generator room and the transfer switch location, minimum of 2 hours supply for all generator installations.

This is a requirement of C282.

Even if emergency generators provide lighting, install battery powered emergency lighting as required by NBCC.

The provision of lighting via battery powered emergency lighting even if a generator is provided reduces need for separate life safety transfer switch and associated distribution as well as providing instantaneous illumination.

7.3.2 Types of Emergency Lighting

Integral battery backup may be used in select fixtures to satisfy NBCC requirements. This is recommended in public corridors of schools, health care facilities, office buildings, etc.

This eliminates additional wiring and is more aesthetically pleasing in public areas.

Mini-Inverters may be used to provide emergency power to designated emergency lighting fixtures in areas that are difficult to illuminate such as gymnasiums or auditoriums. Mini-Inverters can be located in service areas where they are accessible for testing and servicing if required.

Some areas are difficult to meet minimum NBC requirements for illumination levels with traditional emergency lighting methods.

Battery Packs may be used in service spaces or other spaces easily accessible to O&M staff.

Battery packs must be frequently tested and should not be located in areas where they may *be subject to vandalism, such as a school washroom.*

Where remote heads are used, the emergency lighting battery pack feeding them should be placed in a central location.

This ensures DC wiring is minimized.

Ensure battery packs located in cold storage areas and/or buildings are rated for operation in -40°C. Do not provide self-powered exit signs in these areas unless rated for operation in -40°C.

NEMA 4X battery units will have a cold weather option available down to -40°C. These are necessary to ensure proper DC operation in cold temperatures.

7.3.3 Auto-test

Automated self-diagnostic circuitry card (auto-test) should be provided for emergency lighting in facilities with centralized battery pack unit(s).

The auto-test system automatically tests a centralized battery pack unit. Failed lamps are automatically sensed to indicate replacement required. The auto-test system is economical on central battery pack systems.

7.3.4 Remote Heads

If located in gymnasiums, provide securely mounted and adequate protection around remote heads with cages or polycarbonate lenses.

High impact sports require not only strong wire guards covering fragile devices, but these guards need adequate backing to prevent damage to wall finishes.

However, it is recommended that mini-inverters are used for fixtures in gymnasiums.

7.4 EXIT SIGNS

7.4.1 LED's

The exit sign should be illuminated with LED's, with no external transformer required, a 25 year life expectancy, a 10 year warranty, self-powered for a minimum of 60 minutes and a power consumption of less than 3 watts total.

All exit signs are to meet the CAN/CSA C860 standard.

This is acceptable because of its low energy consumption.

Self-powered exit signs eliminate DC wiring to central battery packs.

7.4.2 Guards

When located in gymnasiums provide securely mounted and adequate protection for fixture with cages or polycarbonate lenses.

High impact sports require not only strong wire guards covering fragile devices, but these guards need adequate backing to prevent damage to wall finishes.

K8 OWNER / COMMUNICATION EQUIPMENT

Telephones and computers are typically anticipated during building design. Current and future equipment requiring cable or special wiring must be routinely considered during design. Cable tray may be suitable for projects to consolidate all low voltage cable requirements. Figure 8-1 is provided below to encourage consolidation of head end equipment within a single location to limit floor space, and mechanical ventilation requirements.

All communication systems including communication services for telephone system and data system shall be prepared and shall be ready for use to the facility before the substantial completion. It is the contractor's responsibility to coordinate it with the utility company, the owner, and GNWT TSC in advance.

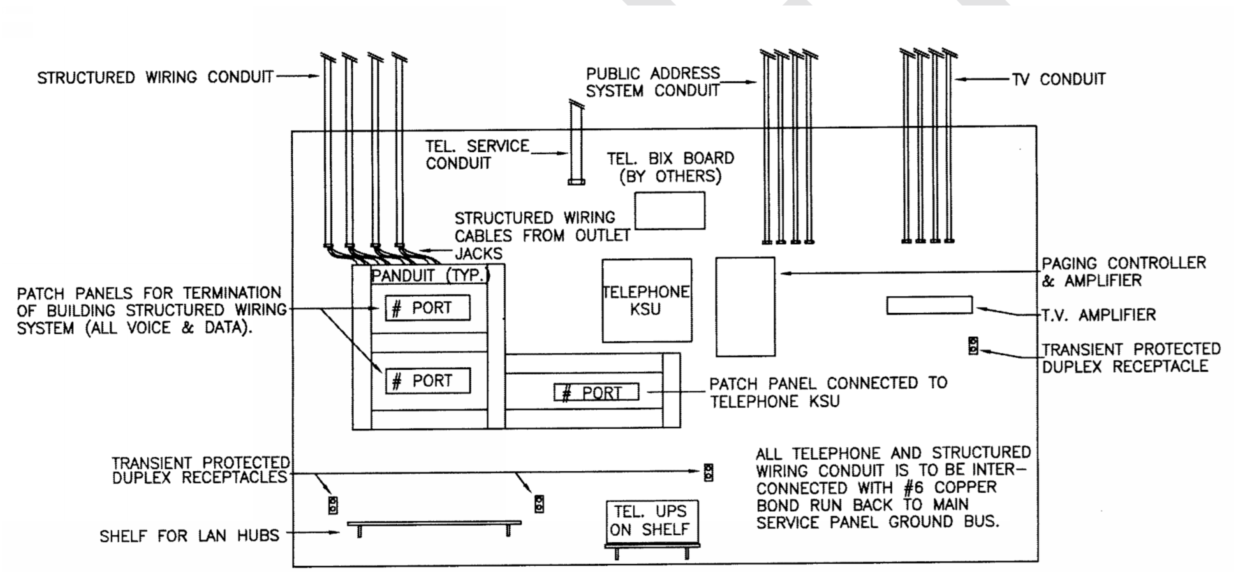


Figure 8-1 Typical Layout for Communication Equipment

8.1 TELEPHONES AND INTERCOMS

Northwestel provides telephone services across the NWT. The utility provider's responsibility is generally to the demarcation point (lightning protection block) usually located within a building. This is the point of interconnection between the utility service wiring, and the property owner's internal wiring and equipment. Communication systems vary from simple two or three line telephone distribution systems to multiple-phone use with teleconferencing and video capability. VoIP (Voice over Internet Protocol) use is also gaining popularity.

8.1.1 Telephone Requirements

Supply and installation of cabling beyond the demarcation point located at the utility providers entrance to the building is the building owners or tenants responsibility.

The telephone system shall be compatible with maintenance support by Northwestel.

Maintenance support is more readily obtained by Northwestel in remote communities.

8.1.2 Pathways

Pathways are to be provided as outlined in the Canadian Electrical Code, and EIA\TIA 568 and 569. Cabling is to terminate at a backboard in a service room with a dedicated duplex outlet.

This is done to ensure that a telephone service and pathway system is installed within every building and that a consistent location is chosen for terminations.

The duplex outlet is for a UPS power supply. (A quad receptacle shared with the Cable TV is not acceptable as the size of plugs c/w transformers restricts plugging both power supplies into a quad outlet.)

8.1.3 Communication Rooms

Separate communications rooms should be provided only when the complexity of the communications systems warrants it.

Health centres may require space for video conferencing and associated equipment for medical and educational support.

The following are guidelines for space requirements:

Modern telephone equipment can withstand a wide range of environmental conditions. Small and medium-sized key systems can operate in almost any interior environment.

.1 Buildings with 10 or fewer phone lines:
  - .a minimum 600 mm x 600 mm wood backboard. It can be installed in a mechanical or electrical room.

.2 Buildings with more than 10 phone lines:
  - .a min. 1200 x 2400 mm wood backboard. It can be installed in a mechanical or electrical room.

Large systems, especially Private Branch Exchange (PBX) with many tie lines, require a more controlled operating environment.

.3 Ensure adequate space is provided for future growth of network equipment, RF amplifiers, Security equipment, Sound amplification etc.

.4 All patch panels shall be placed on racks as below:** Add in condensed TSC requirements.

.a A full size data communication rack of 30 " w x 36" d x 84" h for the computer room.

.b Wall mount enclosure (refer to slim-jim) on plywood or 36" or 48"tall floor mount cabinet for Data communication closet.

.c Minimum of two (2) 5-20R (T-Slot) duplex receptacles with two (2) separate circuits for communication equipment near racks.

8.1.4 Installation

.1 All cables for telephone systems shall be terminated at the patch panel on racks in LAN room.

.2 Use star topology for wiring layout.

Simplest system to trouble shoot and administrate. Problems with wiring are isolated to specific outlet.

Figure 8-2 is provided to illustrate a star topology, and suitable termination blocks for multi conductor and device applications. Type of terminations may vary for various systems.

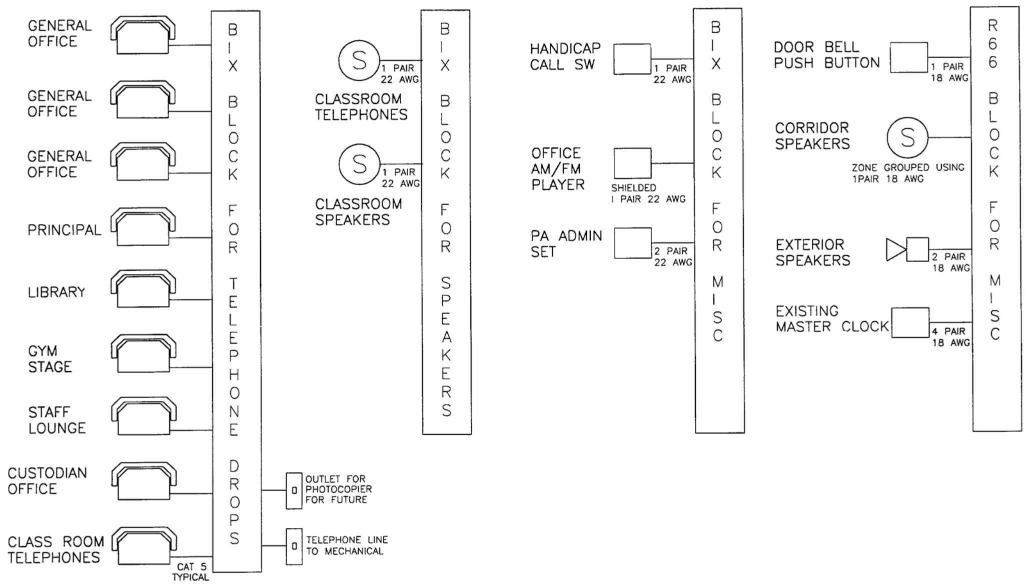


Figure 8-2: Typical Schematic for Analog School Communications Layout

8.1.5 Power Requirements for Telephone and Public Address Systems

The community telephone distribution system has power backup for continued operation through utility power failures. This system provides the power needed for line connected handsets to continue to function.

Wireless handset head end equipment requires a UPS or emergency power to continue operation.

Building owned equipment that is operated and maintained by various departments requires carefully designed UPS for continued operation.

Key service units (KSU) which provides onsite telephone exchange and an interface with utility service provider requires a UPS for power filtering and backup during power failures. VoIP networking equipment also requires its own power supply for continued operation.

8.2 COMPUTERS

Computers require power, and/or networking cables and possibly telephone line connections to allow communication by modem. Electrical design should ensure the system can accommodate future expansion without significantly increasing construction costs.

8.2.1 Networking

If data service is via fiber optic cable, it shall be run in a dedicated conduit of 103mm.

To reduce chances of damaging cable.

If data service is provided via the GNWT Technical Service Centre (TSC), single-mode fibre optic cable run in conduit is required between the demarcation point and LAN room.

Multi-mode fibre optic cable is not compatible with the single-mode fibre optic service to the building by Northwestel.

Fibre optic cable shall be terminated at SC fibre optic patch panels located at both ends and will be placed on the top rack in LAN room.

TSC prefers a fiber optic patch panel placed on the top of rack. TSC will supply and install the Data Switch and fibre cross connects. Refer to Figure 8-3.

Wherever computers are identified as a current or future requirement in a facility program, allow for expansion using conduit or cable tray as outlined in E6.1.

This allows for changes and future expansion.

Where conduit is used, a minimum 21mm conduit linking computer work stations to hub or cable tray locations.

Conduit infrastructure allows for a wide variety of cable requirements i.e., from a basic single twisted pair of wires, a 4 pair cable, a coaxial cable, or a fiber optical cable from each workstation.

A 21mm conduit from the cross connect to the communication backboard is recommended.

8.2.2 Structured Cabling

Structured cabling for data and telephone drops to be Category 6. Drops to be terminated at jacks and patch panels.

Category 6 cabling is the current standard of acceptance for horizontal wiring. Category 6A or fiber should only be used where required on a specialized basis (i.e. Video Conferencing, Telehealth, Network Backbone etc).

8.2.3 Installation

All cables for data systems shall be terminated at patch panels on racks in the LAN room.

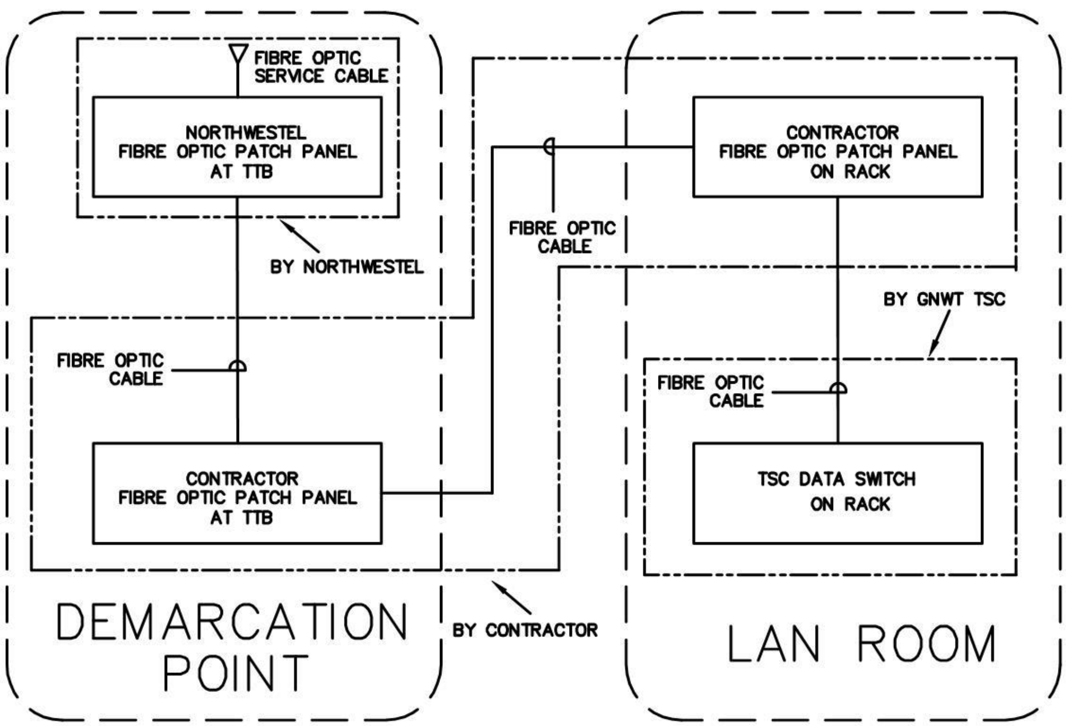


Figure 8-3: Typical Fibre Optic Connection Diagram

8.2.4 Telecommunication Outlets

Telecommunication outlets to be grouped. (i.e. combination Data/Voice Jacks)

Provides a more economical and compact installation when devices are grouped.

8.2.5 Wireless Networking

Where wireless systems are to be used, allow for wireless access points consisting of wired LAN drops with adjacent power receptacles located to ensure adequate signal strength.

This allows for accommodation of repeater stations to propagate network signals.

Initial construction should allow for provision of required physical infrastructure for future wireless system.

Wireless network setup and security provisions are to be installed and maintained by the building's users.

The open nature of wireless networking poses a risk that requires ongoing user intervention to ensure security is maintained.

8.3 TELEVISION AND CABLE

8.3.1 Cable Installation

Where televisions or television monitors are identified as a current or potential future requirement in a facility program, assume cable connection may be required and allow for capacity in common conduit as outlined in Electrical E6.1.

Typically used in classrooms, visitor centres and museums, group homes or detention facilities.

Wherever cable television is identified as a current or future requirement, it is required that individual RG 6 cables are run to each TV outlet from splitter boxes at the main television service backboard located in a service room (demarcation point), c/w a separate circuit duplex receptacle.

The intent is to ensure that the required television service will be installed at a consistent location and to identify that a conduit system is not always required, but that cables are not to be looped to outlets (to prevent a cable malfunction affecting more than one outlet). The duplex receptacle is required for a plug-in transformer or RF (radio frequency) amplifier.

Labeling of cabling is required at both ends of all cable runs.

Cable labeling provides ease of cable management and troubleshooting.

8.3.2 Television Distribution Diagram

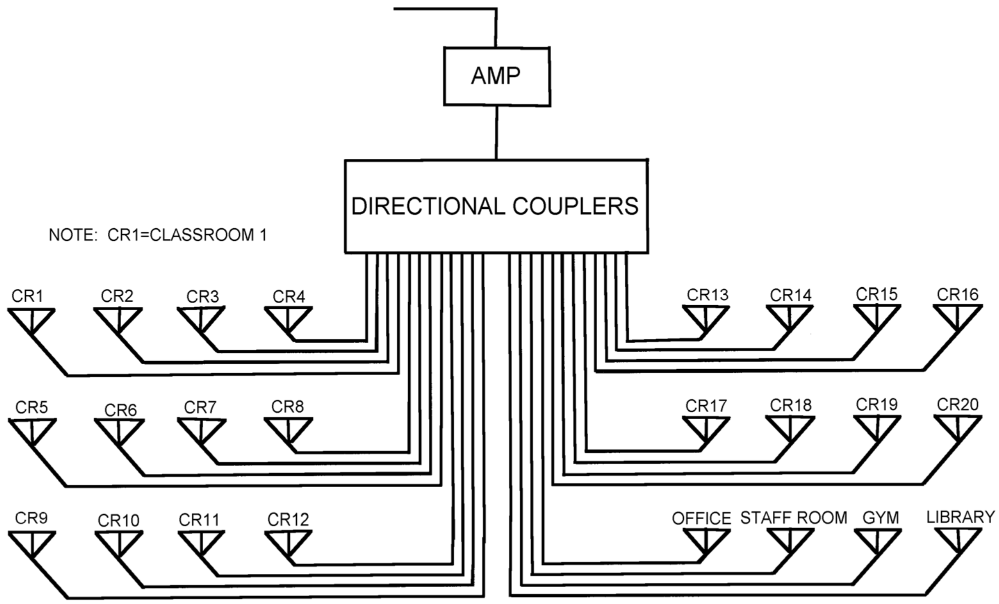


Figure 8-4: Typical School RFTV Distribution System

8.4 CLOCKS

Battery powered clocks are preferred. Class change signal clocks may be powered by an AC source, but should not derive the time base from the AC line frequency.

Power outages and the frequency of fluctuations in cycles/second (Hertz) of diesel generated power adversely affect the accuracy of 120 volt clocks.

K9 ALARM SYSTEMS

The primary purpose of an alarm is to issue a warning, preferably before any major damage occurs. Although fire and security alarms are typical across Canada, mechanical system alarms are also commonly used in the NWT. Alarm systems must be suited to the community and its resources: in some communities resident maintainers may be able to respond quickly when alerted; in other communities residents are expected to notify the Hamlet or Band Office, who in turn can notify the area maintainer, who may have to fly or drive in. Arctic Alarm Ltd is the only monitoring company for digital autodialler alarms in the NWT and all devices related to monitoring alarms shall meet Arctic Alarm Ltd's requirements and shall be installed to their requirements.

9.1 FIRE ALARM SYSTEMS

See the references below to News Bulletins issued from the Office of the Fire Marshal. Where clarification is required on fire alarm systems, consult with the NWT Fire Marshal early in design. Systems should be as simple as possible (i.e., factory service technician should not be needed to program the fire alarm system).

9.1.1 Product Manufacturers

Fire alarm systems should be supplied by one of the following suppliers:

- Simplex
- Notifier

Substitutions are not permitted without written authorization from the GNWT.

To ensure suitable maintainability, competitive bidding, yet limit the number of systems and replacement parts, the GNWT has specified 2 suppliers.

9.1.2 Types of Fire Alarm Systems

Fire alarm systems should not exceed the requirements of the NBC.

This keeps the systems as simple as possible, and meets minimum Code requirements.

Exception: Buildings designated as emergency shelters must have a fire alarm system, although not necessarily required by Code.

People may be required to sleep overnight or longer in an emergency shelter, which necessitates a safe haven.

Exception: Smoke alarms shall be placed in all server rooms and electrical rooms – this

Additional response time for alarms.

includes local smoke alarms in the case where a fire alarm system is not required.

If programming is required, it must be site programmable with a non-volatile memory (i.e., lithium battery back-up for programming).

This maintains programming memory in the event of loss of normal and battery power.

Addressable systems may be capable of remote programming.

This feature is useful for replacement of any devices without incurring the cost of air travel.

9.1.3 Strobes / Sirens

See Electrical F9.6.

9.1.4 Manual Pull Station

Install in every floor area near every required exit, including crawl space exits.

This is a clarification of the Code requirements.

Manual pull stations in gymnasiums must be fully recessed.

The intent is to prevent injury to people and damage to pull stations in gyms.

9.1.5 Fire Alarm Notification Devices

Horn strobe devices should be used in place of bells. Devices need not be red.

The intent is to ensure audibility and visibility where required. Red horn/strobes often take away from the architectural look.

9.1.6 Fire Alarm Verification

Verification is to be carried out in accordance with Can/ULC-S537 and Office of the Fire Marshal.

This will clarify verifying agent qualifications.

9.1.7 Central Monitoring Stations

The fire alarm system shall be monitored via a central Monitoring Station.

This is intended to clarify which projects require central monitoring with a DACT (Digital Alarm Communicator Transmitter).

9.1.8 Auto Dialers

For local fire alarm notification, digital dialers described in F9.5 may be used to dial local

In emergency fire situations, local people need to be contacted immediately. Many OPX (Off fire phone systems. It is to be noted that these dialers do not meet Central Monitoring Station requirements.

Premise Exchanges) fire phone systems address this requirement for quick response.

9.2 COMMUNITY FIRE SIRENS

9.2.1 Standard of Acceptance

Federal Signal Corporation for items listed below:

Most of the community fire alarm sirens in the NWT are now of this type and this manufacturer.

- Sirens
- Model No. STH 10A (3ø) or equivalent.
- Controls
- PGA (Predetermined General Alarm) timer or equivalent.
- Motor Starter
- Use RC5 Motor Starter (heavy duty relays, capable of handling the operating current) or equivalent.
- Exercise Clock
- Model 75 or equivalent.

The experience has been that this motor driven siren has given the fewest problems if exercised daily.

9.3 MECHANICAL SYSTEM ALARMS

Failures of mechanical systems can have serious consequences during the long, cold, winter months. The sooner maintainers can be alerted to a problem, the sooner they can make repairs or switch the building over to standby systems while effecting repairs.

9.3.1 Mechanical Alarm Annunciators

Locate the primary annunciator panel in the mechanical room.

The intent is to ensure that information is provided for building operators and maintainers.

The secondary, remote panel is required to alert building users to mechanical problems.

Typically required in schools, community halls, large residential facilities, and health centres where responsible users can notice and alert maintainers. Not required in fire halls, garages, or seasonal use facilities.

9.3.2 Nuisance Tripping

Ensure mechanical alarms are not initiated by a power interruption of less than 30 seconds.

False alarm signals produced during a power interruption have created a nuisance both for local staff and personnel contacted by the auto dialler.

9.3.3 Auto Diallers

Mechanical alarms shall be monitored by a monitoring company via an auto-dialer.
See Electrical F9.5 for other information.

9.3.4 Alarm Lights and Audible Alarms

See Electrical 9.6.

9.4 SECURITY SYSTEMS

9.4.1 Intrusion Alarm Systems

Where a security system is a program requirement, monitor entrances, exits, corridors, and accessible openings.

Intrusion alarms are installed for a variety of end purposes including when there is a danger of burglaries because of building contents, or as a means of reducing incidences of vandalism.

Monitor rooms with high value or controlled contents.

Computer labs, specialized equipment storage or pharmacies require controlled access.

.1 Device Wiring

Provide each device with individual home run conductors to main security panel.

Separate wiring allows isolation of failed individual devices rather than total failure of the system. It also provides identification of individual device status for troubleshooting purposes.

.2 Door contacts

Mount within door frame during new construction.

Mounting door contacts within frame provides excellent mechanical protection to door contact devices.

Install door contacts for all exterior doors.

Motion sensors do not confirm door position. Experience has shown that motion sensors can be repositioned and not noticed until after incidents. Door contacts are not as easily defeated.

.3 Alarm Signal

If there is a sound system within the facility, connect the alarm to the tone generator to sound a continuous tone upon receiving an intrusion alarm signal.

The sound system tone generator, if available, is a desirable deterrent.

.4 Partitionable

Provide partitions to allow separation of areas within a building. This provides access to one area, while continuing to secure other areas. For example, schools with night use requirements (i.e., gyms).

Many communities make good use of schools/gyms in the evening, and therefore, access to some areas is required at night without setting off the intrusion alarm.

.5 Enabling Systems

Time clocks or internal time settings may

This provision ensures the facility is secured be used to automate the arm and disarm process for buildings that have regular schedules.

through the normally unoccupied times.

.6 Access Means
Access may be provided by a variety of means; key switch, keypads, key fobs, card access etc.

Keys may be used to reduce the number of people in the community knowing the access codes and will simplify installation.

.7 Auto Dialers
Intrusion Alarm System shall be monitored by a monitoring company via an auto-dialer.

.8 Installation
All cables for Intrusion Alarm System shall be terminated at the patch panel on racks in LAN room.

9.4.2 Video Monitoring

.1 Privacy
Before installing a CCTV system, check local laws regarding privacy and recording. Provide software based privacy screening for exterior cameras facing residential areas.

Never install video surveillance anywhere there is a reasonable expectation of privacy such as in bathrooms, locker rooms, changing rooms, medical examination rooms etc.

.2 Cameras

.a Outdoor cameras may require infrared illuminators to allow night vision and shall be rated for cold weather. For pan/tilt/zoom cameras, provide a heated enclosure as required to operate properly in a northern environment.

Each application requires a specific type of camera that will provide satisfactory image quality.

.b Interior cameras that are exposed to brightly lit and dark areas will require a wide dynamic range and dual shutter speeds for picture clarity.

.c Aisle cameras may require a long range lens, positioned to face away from light sources.

.d Large open areas may require day/night cameras with wide angle lens.

.3 Recording and Monitor
A monitor located in reception areas shall be installed for monitoring cameras with proper zone identification.

Operational environment will affect the durability of the installed equipment.

Digital Video Recorders (DVR) allow greater flexibility for recording space and network access from remote locations. Ensure equipment is located in a ventilated, secure environment suitable for continuous operation.

Setup recording to only save images when motion is detected.

This feature will allow for considerable extra recording backup time.

.4 Installation
All cables for CCTV System shall be terminated at the patch panel on racks in LAN room.

9.4.3 Access Control Systems

Proximity type sensors are acceptable. Preference is given to door strike hardware. Magnetic door locks are to be avoided wherever possible.

Access control systems simplify the process of ensuring secure access to various parts of a building. This can easily be done using the system's database. This has significant advantages over key and lock, but in small centers, it may become a nuisance that is simply bypassed.

Access control should not be used outside of the larger centres in the NWT.

Maintenance of these systems requires a level of expertise not commonly found within isolated communities.

Copies of the control diagrams should be located within enclosures designed for such and an additional copy provided within the appropriate section of the O&M manual.

This provision is to assist future maintenance requirements.

All cables for Access Control System shall be terminated at the patch panel on racks in LAN room.

9.4.4 Patient Wandering Systems & Nurse Call System

Locate wiring diagrams and sequence of operation within front cover of main panel as well as O&M manuals.

This provision is to assist future maintenance requirements.

Ensure patient wandering detection ranges are configured with the assistance of the building user.

This ensures proper operation in accordance with facility requirements.

All cables for Patient Wandering & Nurse Call Systems shall be terminated at the patch panel on racks in the LAN room.

9.4.5 Panic Alarm Systems

Where panic alarm systems are a program requirement, they must be c/w a strategically placed audible alarm connected to the auto dialer. Call buttons should be of industrial quality.

Typically, panic alarms are installed in health centres where a member of staff may be alone with clients and may require immediate assistance in case of emergency.

Copies of the control diagrams should be located within enclosures designed for such and an additional copy provided within the appropriate section of the O&M manual.
Panic Alarm System shall be monitored by a monitoring company via an auto-dialer.

This provision is to assist future maintenance requirements.

All cables for Panic Alarm System shall be terminated at the patch panel on racks in LAN room.

9.4.6 Public Address System

All cables for Public Address System shall be terminated at the patch panel on racks in LAN room.

9.4.7 Strobes/Sirens

See Electrical F9.6.

9.5 AUTO DIALERS

Where an auto dialer is not required by Code but is a program requirement, digital voice or digital dialer types are required as noted below:

Auto dialers are the best method available to provide a signal of potential problems where there is a possibility of life or property loss (i.e., schools, health centres).

Simplicity of programming is very desirable.

To be able to talk an untrained person through programming over a phone connection to a remote community is very cost effective.

A minimum 3 channel, digital voice, site programmable dialer is required.

Some dialers may have remote programming capabilities, which may be desirable in some Regions.

Appropriate authorities to ensure all messages meet their requirements.

Do not include low domestic water or high sewage alarms on auto dialer.

Low water or high sewage alarms do not signify conditions that warrant after-hours attention by maintainers.

9.6 ALARM LIGHTS AND AUDIBLE ALARMS

9.6.1 Exterior Alarm Lights

.1 Lights or strobes should be located on high point of buildings, clearly visible from the roadway.

Lights can be used either to indicate a building condition, or to act as an alarm indicating a critical condition requiring immediate attention. Intended as a supplement to the *auto dialer.*

Exception: Strobe alarm lights are not to be installed on arctic airports.

The intent is to avoid confusion with landing lights, vehicle lights, etc.

.2 Colour of lights

- Fire alarm: red
- Mechanical alarm: amber
- Security/panic: blue
- See 3.4.1 Table E-2

Colour coding is standardized on public sector buildings. Blue strobes are typically used for security systems and panic systems in health centres and correctional facilities, where staff may be alone with clients and could require immediate assistance.

9.6.2 Sirens/Horns

Exterior audible alarms are required for fire alarm systems and security systems.

Audible alarms can unnecessarily disturb the entire community. However, a fire condition is a critical condition that makes this disturbance necessary. Security system audible alarms are a deterrent as it draws attention to the building and the people nearby.

A siren is not required for mechanical systems.

With auto dialers and the strobe lights, the audible is not as necessary for mechanical systems (e.g., while air handling unit low temperature is a problem, it does not require disturbing the community).

9.6.3 "High Water" Light

High water level in a holding tank is indicated by using an illuminated light mounted close to the water fill pipe. Water fill indicating lights should be LED type with 25 year life and provide adequate illumination to be clearly visible.

LED lights have low energy consumption and low maintenance requirements.

Install a two lamp fixture.

This provision ensures at least one lamp will illuminate in the event of a lamp failure.

Locate in a visible location convenient to the operator.

Water delivery pumps are controlled at the vehicle. The light indicates that the tank is full and that the driver should stop pumping.

K10 MOTORS

10.1 CHARACTERISTICS

Motors must meet the specified minimum efficiencies in the Model National Energy Code for Buildings (MNECB) unless it can be shown that a lower efficiency motor will yield lower life cycle costs.

This is done for energy conservation.

Installation of high efficiency motors should be installed where life cycle costs may be demonstrated.

Match voltage rating of motor with supply voltages, i.e., use 200 V motors for 208 V services.

Although 230V and 240V motors may function on 208 V, experience has shown that their life expectancy is greatly reduced compared to 200 V motors.

10.1.1 Motor Starters - 3 Phase

.1 Provide single phase protection for all motors 5 hp or larger with magnetic starters c/w solid state adjustable overload sections offering phase loss protection.

This prevents costly motor replacement of large motors due to single phasing.

.2 Provide "Hand" option and "Running" indicator to allow for ease of O&M. If DDC is present, use CT's to indicate motor status in DDC.

These functions may be used rarely but are invaluable for troubleshooting and trending purposes.

.3 Where number of 3 phase starters in a given location will exceed four, give strong consideration to installation of an MCC.

.4 Where multiple 600 volt motors are

This ensures that the failure of one starter installed, provide full sized motor starters within an MCC.

does not detrimentally affect other starters in the same enclosure, and provides improved maintenance safety.

.5 Copies of the control diagrams should be located within enclosures designed for such and an additional copy provided within the appropriate section of the O&M manual.

This provision is to assist future maintenance requirements

.6 All motor starters to be combination c/w lockable disconnect.

This provision provides increased safety during any future maintenance requirements.

10.1.2 Motor Starters – Fractional Horsepower

.1 Provide thermal motor protection switches for fractional horsepower motor loads serving pumps.

Although many motors have built in motor protection, this provision assists in notifying maintenance staff of equipment status.

.2 Provide a pilot light on all thermal motor protection switches.

This provision provides a visible indication of power and state of thermal element.

.3 Provide lockable toggle plates.

This provision provides an increased measure of safety during maintenance requirements.

.4 Use hinged lockable covers on suitably sized junction boxes to enclose control and motor relays and/or sensors. If mounting thermal motor protection switch in junction box cover, mount independent of switch cover.

Secure mounting of the motor protection switch allows safe access to the thermal elements.

.5 Do not use float switches to interrupt motor current where long distances from storage tanks to motors loads are required.

Installation of a motor control relay may reduce voltage drop to motor loads during start up, providing them with the proper operating voltage.

10.1.3 Motor Terminations

Stranded wire should be used where wiring to motors ends in a terminal strip.

This is required because solid wiring to terminal strips in motors tend to become loose due to motor vibrations.

10.1.4 Variable Frequency Drives (VFD)

Install in conjunction with Direct Digital Control systems for mechanical loads where variable control is determined beneficial by the designer, or where energy savings can be proven (e.g., heat circulation pumps).

The intent is to allow for energy conservation.

Provide line and load side reactors.

This provision reduces harmonic distortion from feeding back into the power system.

Ensure motor matches VFD and is suitable for inverter duty.

Provide integral bypass for all VFD's.

This allows for equipment operation in the case of VFD failure.

10.1.5 Soft Starters

Large motors with frequent start/stop should have soft starters, especially in smaller communities.

Frequent start/stop can have a significant effect on the electrical supply in small communities, where a large motor starting can cause voltage fluctuations.

10.1.6 Power Factor Correction

Power factor correction of motor loads should be considered and applied if the nature of the load is supportive of correction, and the designer can show an acceptable cost payback.

Power factor correction can lower overall power and demand charges from the utility.

10.2 DISCONNECTS

A lockable manual disconnecting means to isolate a motor should be located within sight of and within 9m of the motor and the machinery driven thereby.

The intent is to permit safe operation and maintenance.

All disconnect switches shall be non-fusible type.

Improved maintainability in remote communities.

10.2.1 Motor Disconnects in Public Areas

Motor disconnect switches in public areas should be:

.1 installed at 2.1 m above the floor, or above ceiling tile close to equipment servicing

This prevents young children from shutting off motors (e.g., cabinet unit heaters in vestibules) that must operate to prevent property damage (e.g., prevent sprinkler heads from freezing and busting).

.2 provided with a ventilated lockable cover or within manufacturers equipment where possible.

Protecting the switches by location is preferred over lockable covers to avoid the cost and inconvenience of keyed covers.

10.3 SPRINKLER PUMPS

Sprinkler jockey pump must be fed by the generator.

Ensures operation of the jockey pump during utility power failures.

K11 MISCELLANEOUS

11.1 AUTOMATIC DOOR OPENERS

See Architectural A4.3.2 and A4.3.3.

11.2 HEAT TRACE

Where possible, hydronic heat trace should be installed instead of electrical heat trace.

Where heat trace is required, if available, hydronic provides the greatest energy efficiency.

All electric heat trace is to be controlled by a temperature controller that limits its operation during high ambient conditions.

Even self-limiting heat trace only regulates its temperature within a narrow range and, if allowed to run in a high-ambient environment, can cause overheating of the cable and possibly ignite adjacent materials. A temperature controller is a requirement of the NWT Electrical / Mechanical Safety Section.

Where heat trace is required for water and sewer connections, it should be the self-limiting type.

This is required for energy efficiency and premature failures of heat trace cable.

If used on polyethylene pipe, the heat trace must be T-rated for such application.

This applies to the typical heat trace system for standard GNWT water and sewer connections in permafrost areas to ensure "melt-down" does not occur.

For water re-circulation lines, where heat trace is used as a back-up, the heat trace should be activated upon a loss of flow.

This prevents freeze-up when the circulation pump fails. The heat trace should be sized to ensure that it will be of a sufficient size to thaw the pipe.

A pilot light should be used to indicate the heat trace is on.

The intent is to alert/confirm operation.

11.3 SMART CAR RECEPTACLES

Where appropriate provide smart car receptacles.

Some manufacturers have specific receptacle configurations; in addition, temperature/timer controlled receptacles are not desirable as they would interrupt charging cycles.

ENERGY EFFICIENCY

INTRODUCTION

Energy use has a significant cost both for the environment and for building owners. Fuel cost and fossil fuel utilization are both high in the North, and buildings consume a large portion of total northern energy.

The goal of energy efficient-buildings should be to use less energy, both fossil fuel and electrical, and to use it as efficiently as possible. The GNWT's overarching objective in reference to energy is to reach a secure, affordable and sustainable energy system that is less dependent on fossil fuels, and contributes to the economic, social and environmental wellbeing of the Territory and its residents. The GNWT's *2030 Energy Strategy* outlines these strategic objectives further.

If an existing building is to be made more energy-efficient, the quantity of energy it uses for various functions and the duration of those functions, and whether the functions can be reduced or altered, must be determined. Equipment and system efficiencies must be studied and improved. For a new building, the components, systems and operations must be chosen to complement each other, work efficiently and be easily maintained.

Greenhouse gas emissions reduction is a priority for the GNWT. Some reduction will naturally occur as less fuel is used. Fuel sources which emit lower quantities of greenhouse gases during combustion are recommended to be used whenever possible. Some electricity within the territories is generated from hydro, and thus produces no greenhouse gas emissions. This makes the task of finding the right systems and balancing economics against environmental impact more challenging.

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L1 ENERGY DESIGN CONSIDERATIONS

1.1 CHOICE OF ENERGY SOURCE

Energy source options must be determined early in the building design process.

Oil has traditionally been the default heating fuel in northern communities, but other options are recommended to be considered. Natural gas and propane, available in certain areas, can be more economical to burn and do produce fewer greenhouse gas emissions than oil. Biomass heating systems using wood pellet fuel are recommended in locations where pellets may be delivered economically. In small buildings, residential type wood pellet appliances or woodstoves may be considered, and wind may be a possible energy source to use, particularly at remote sites. Geothermal or ground source heat energy may be considered where electricity is hydro-generated and can present an environmentally sustainable thermal energy source.

Available waste heat from diesel generator plants, data centres, or other sources are practical to consider as a primary source or supplementary source for building heating energy.

District or common heating systems between two or more buildings might be considered where there are several new or renovated buildings located close to each other. Large scale biomass district heating systems are recommended. It may be economically practical to add to an existing district heating system if there is surplus or unused capacity, or if the central system or components have been upgraded.

Electricity is required in all northern buildings. Where cheaper rate interruptible power is available or likely to be developed, electricity can be considered a primary heating fuel source, when a permanent backup heating system is provided. Photo-voltaic and small scale wind generation can provide small environmentally benign supplementary electric power for controls and building system condition monitoring. {Add info about CHPs}

1.2 BUILDING DESIGN AND SYSTEMS OPERABILITY

Detailed building design and construction quality have a major effect on building energy efficiency. Building envelopes must be air tight and well-insulated, with properly-installed vapour and air barriers with minimal thermal bridging.

Siting, orientation, day lighting, solar gain and shading features of a building are recommended to be optimized.

Building systems need to be selected for simplicity and ease of operation. The use of systems and controls which could conflict with each other, such as simultaneous heating and cooling, should be avoided.

If operators are comfortable with their building systems, it is much more likely that buildings will be operated efficiently. If systems are too complicated, energy saving potential can be lost due to energy saving subsystems, components or control features being turned off or ignored. Conversely, informed and energy-conscious occupants and operators can also a positive impact on.

Electrical energy usage is to be minimized within the building by the use of energy-efficient fixtures, the use of day lighting and occupancy sensors for lighting, and variable speed drives, efficient motors, and similar features. Electrical demand charges are to be considered in the energy cost budget projections.

Ventilation systems are one of the largest consumers of heating energy. The required amount of fresh air and total airflow may be minimized while maintaining sufficient quantities of outdoor air through the use of displacement ventilation air supply or other efficient systems. The use of heat recovery devices, such as heat wheels, glycol run-around loops, and similar heat recapture devices on exhaust air systems is recommended to be evaluated during design.

More detailed information on architectural, mechanical and electrical systems and their energy efficiency and implementation of specific energy control measures may be found in the applicable sections of *Good Building Practice for Northern Facilities.*

1.3 ENERGY-EFFICIENT DESIGN GUIDELINES USED BY THE GNWT

There are a number of design guidelines for building energy efficiency. Energy conservation measures shall not reduce system performance below that required by codes and standards.

- National Energy Code of Canada for Buildings (NECB 2015)
- Good Building Practice for Northern Facilities
- ANSI/ASHRAE.IESNA, Standard 90.1-2016 – Energy Standard for Buildings Except Low-Rise Residential Buildings.
- ASHRAE Handbooks and Guidelines

This GNWT publication *Good Building Practice for Northern Facilities* considers building energy efficiency, construction, maintenance and operation. Use of this recommended technical best practice guidebook has been shown to ensure that buildings meet or exceed targeted energy efficiency for buildings developed and operated by the GNWT. It provides practical energy utilization benchmarking for all northern buildings.

The National Energy Code of Canada for Buildings (NECB 2015) sets out the minimum acceptable measures for energy efficiency in design and construction of new buildings and additions to existing buildings. NECB 2015 includes both prescriptive and performance requirements. It outlines how an energy efficient building should be designed, and as such should be considered as an important reference document.

1.4 ENERGY MODELLING

New GNWT projects are required to undergo Energy Modelling Workshops, depending on the size of the project. The purpose of the workshop is to evaluate and analyze efficiency options so as to arrive at an optimum cost benefit package within project budget. The building annual energy consumption shall be at least 10% less than that of a similar building modeled to the requirements of the 2011 National Energy Code for Canada, while meeting or exceeding the requirements of the GBP. In some cases, simple adherence to set or prescriptive design criteria listed in the *National Energy Code of Canada for Buildings (NECB 2015)* will ensure good building energy performance. For very simple buildings, a hand calculation can be used to estimate the annual energy consumption with a reasonable degree of accuracy.

For the vast majority of buildings, computerized energy simulation programs are recommended to be used to properly simulate building energy consumption and performance over time. Computerized energy use simulation programs are meant to supplement, not replace, the use of prescriptive design features which incorporate tried and true energy saving assemblies, equipment, or practices into a building design.

There are numerous computerized energy use simulation programs available to analyze energy use in buildings. Although buildings will be evaluated on a case by case basis, most technical design narratives will outline the requirement for an energy modeling workshop for new capital projects or additions and retrofits to existing GNWT assets.
~~** DETAIL TYPICAL ENERGY MODELING REQUIREMENTS~~

1.5 ENERGY AUDITS

An energy audit should include costs, savings and payback period. It can be done for the entire building or for specific systems. An individual systems audit is best suited for instances where funding is limited, where energy savings are needed quickly or where management are aware of energy and performance problems with respect to a major energy-using system. A full building audit is recommended if a building is complex or is older and scheduled for major renovation. It will make it possible to determine the combination of measures that provides the greatest return on investment. By accurately predicting the impact of measures including their interaction with other building systems, this indicates what systems are in need of upgrading and what those upgrades should be.

A full energy audit of the building includes reviewing historical energy consumption data, the establishment of new consumption baselines and the identification of any anomalies. A full audit will outline baseline energy consumption levels at the outset of the program so that comparisons with future consumption levels can be used to measure the success of the program. Energy consumption data averaged for a two-year period is usually sufficient to establish baselines. Weather-dependent components of the energy consumption should be adjusted to reflect normal conditions and adjustments can also be made to reflect changes to the building equipment or occupancy schedules that may have occurred during the baseline period.

1.6 ENERGY MONITORING AND BENCHMARKING

The first step in reducing energy use in existing buildings, or to check performance of newly built or recently renovated buildings, is to track energy use. All buildings are recommended to be provided with the means to monitor electricity and fuel use.

In most cases, energy use can be determined from fuel delivery records, or fuel and electrical meter readings. Electrical meters and fuel meters are normally installed on the electrical and fuel supply to each building.

However, if fuel or electricity is used for two or more significant purposes in a building, it may be helpful to meter fuel or electrical use at each large piece of equipment to identify the pattern of energy use.

During the building design phase, theoretical building energy efficiency can be predicted and optimized with the help of design tools such as the operational program, technical design guidelines, and computer modeling. Energy consumption targets may be useful to benchmark desired performance for a particular type of building. For example, the targets will vary for a school versus a health centre.

1.6.1 Ongoing Monitoring

Once the building is built and commissioned, it must be operated in accordance with the operational program. Monitoring of the actual building operation and energy usage after occupancy is vital, to ensure that the building is performing in accordance with predicted energy use efficiency. Noted anomalies or inefficiencies can then be investigated and operationally corrected.

Over the design service life of a building, its energy consumption cost may amount to more than the initial cost of construction. It makes economic as well as environmental sense to minimize operating costs and energy consumption.

1.6.2 Building Energy Performance Index (BEPI)

Energy monitoring allows building owners and operators to compare energy use in one facility to that in other facilities with similar uses. Energy use is normalized with regard to factors such as floor area, number of occupants, or heating degree days. The result is a Building Energy Performance Index (BEPI) that can be used to compare buildings of different sizes, different numbers of occupants, or which are located in different climate zones. The BEPI is most often given in mega joules, (MJ), or kilowatt-hours, (kWh), per year per square metre of gross floor area. Having such a benchmark value for a particular type of building allows operators and owners to identify inefficient buildings and to focus their energy conservation and efficiency retrofit efforts on those buildings.

1.6.3 Building Energy Cost Index (BECI)

The BECI is another normalized index: total energy costs in dollars per square metre per year. Building energy costs are high in the northern climate and vary greatly by community. Variance in energy costs and energy sources means that different building systems and energy-efficient technologies may be selected in different communities to optimize energy utilization.

1.7 COMMISSIONING

Durability and quality assurance can be assessed in advance of building operation commencement by commissioning. Commissioning of northern buildings is recommended for assuring the building can perform adequately in the harsh climate conditions of the northern environment. Commissioning tests and verifies the operation and performance of building systems, subsystems and components at the completion of construction, but actually commences early in the development, design and construction process.

“Commissioning GNWT Funded Buildings”, an advisory document explaining commissioning, is a good example of recommended commissioning procedures developed to meet northern conditions and can be found at

(https://www.inf.gov.nt.ca/sites/inf/files/commissioning_gnwt_funded_buildings.pdf).

1.8 SIMPLICITY AND EFFICIENCY

Available funding dictates "lean" buildings. It is recommended all building design solutions strive to:

- Minimize enclosed volumes and building perimeter for the required floor areas;
- Provide efficient program delivery by careful planning of related activity areas using uncomplicated floor plan layouts;
- Provide adequate and well-planned but efficient service and circulation areas;
- Plan for future expansion as simply as possible without major disruption to building users.

In terms of detailed development, the building design solution is recommended to:

- be kept simple to improve the speed of construction in a curtailed construction season and to offer greater opportunity for employment of local trades persons and labourers;
- incorporate materials and methods that will permit quality construction under adverse environmental conditions in a curtailed construction season;
- limit the variety of materials and minimize the number of specialized trades required on the project;
- ensure procedures needed to operate and maintain the building can be put into practice using readily available labour, maintenance products and equipment.

HAZARDOUS BUILDING MATERIAL ASSESSMENT

INTRODUCTION

Prior to renovations, building additions, new construction or de-construction and O&M, it is necessary to understand what we are getting into regarding the potential presence of hazardous materials and/or environmental pollution in the building.

The assessment available to ascertain presence and volume of potential contaminants, all of which have specific testing and remediation requirements is Hazardous Building Material Assessment (HBMA) / Designated Site Survey (DSS).

In order to understand and manage the risk, and to avoid extras and cost overruns, we need to understand this tool which to use, and when. In the following section this tool is explained regarding procedures, and uses.

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M1 HAZARDOUS BUILDING MATERIAL ASSESSMENT (HBMA)

The objective of the Hazardous Building Material Assessment (HBMA) is to determine if hazardous materials are present at subject buildings, so that health and safety protocols for workers can be established.

1.1 SCOPE OF WORK

The work consists of the completion of a HBMA at the subject facility. The first phase includes a review of all previous environmental reports, building condition reports, as-built drawings, construction drawings, and legal site plans. Reviews will be followed by coordination of a site inspection, sampling for designated substances or hazardous building materials. Sampling shall be as per the number of samples suggested by the various WSCC codes of practice at each subject building based on area, and reporting of the results.
The work will include a room by room intrusive investigation focusing on the hazardous building materials listed in Hazardous Building Material Assessment section below.

1.2 HEALTH AND SAFETY

Prior to commencing work, the assessor will complete a Job Safety Plan for the project. This plan may include, but not be limited to, the following:

- on-site hazards;
- project-specific personal protection equipment;
- safety training;
- location of the nearest medical facility; and
- emergency contact information for off-site staff.

During the assessments, the Job Safety Plan will be made available to all workers at all times while on site. At the start of the work, the assessor will review the scope of services, job hazards, safe work practices, and emergency procedures. The work will be completed in compliance with the appropriate general requirements of applicable occupational health and safety (WSCC) legislation and regulations.

1.3 HAZARDOUS BUILDING MATERIAL ASSESSMENT

A DSS and a HBMA are the same thing, a DSS being the term used in the eastern part of Canada. HBMA are to be used to protect workers' health and safety when conducting renovations and/or demolitions (deconstruction), or additions and O&M to existing structures. The HBMA will focus on a review of any environmental reports, building condition reports, construction drawings and/or as built drawings. Following the review of reports the assessor will coordinate with a building representative for a site visit complete with sampling of potential Hazardous Building Materials in applicable architectural, mechanical, electrical and civil applications such as:

- Asbestos-containing materials (ACM's);
- Lead Amended products (LBP);
- Polychlorinated Biphenyls (PCB's);
- Chlorofluorocarbons (CFC's);
- Lead (Pb);
- Mercury (Hg);
- Urea-formaldehyde foam insulation (UFFI);
- Ozone Depleting Substances (ODS's);
- Aboveground Storage Tanks (AST's); and
- Inventory of any fuels, chemicals and cleaners on site.

Field blind duplicates shall be collected according to Quality Assurance/Quality Control (QA/QC) protocols.

The HBMA shall focus on the following construction systems.

1.3.1 Architectural

Sampling will include all architectural finishes including, but not limited to: drywall, drywall taping compound, various applications of paint finishes, various flooring finishes, ceiling textures, ceiling tiles, mastics, and other suspect materials as determined by the assessor.

1.3.2 Mechanical

Sampling will include all mechanical insulation, Heating Ventilation and Air Conditioning (HVAC), mastic, duct insulation, flexible duct joints, piping insulation as well as joints, compressor and air handling systems, refrigeration systems and other suspect materials as determined by the assessor.

1.3.3 Electrical

Sampling will include electrical applications of ACMs and visual inspection to confirm the presents of PCBs, mercury in thermostatic controls and radioactive sources in heat/fire detection systems. Where wiring is exposed to full view, and where the system is confirmed to not be energized, sample and/or assess the following: textile wire coverings, visual identification of fluorescent light ballasts, and thermostatic controls.

1.3.4 Civil

Sampling will include exterior finishes including roofing, siding, window putty and other suspect materials as determined by the assessor.

The number of samples for ACM and LBP samples for a HBMA will be based on the estimated square footage as per the various WSCC code of practice.

Should additional sampling be required, the samples shall be collected during the field investigation, but analysis will only proceed following consultation and confirmation with the client (re: additional laboratory costs).

1.4 ANALYTICAL LABORATORY

Laboratories shall hold accreditation with the National Voluntary Accreditation Laboratory Program (NVLAP). Asbestos samples shall be analyzed by type and percentage content under Polarized Light Microscopy using dispersion staining in accordance with EPA method 600/R-93/116. Asbestos can be disposed of in a landfill in the NWT with the written authorization of the landfill operator, typically it will need to be buried and covered with a minimum of 600 mm of cover.

Materials sampled for lead, (LBP) will be analyzed for lead content in accordance with the requirements of the Environmental Protection Agency (EPA) analytical method 200.8 – Elements by Inductively Coupled Plasma (ICP). Samples that exceed 600 mg/kg Pb will have a Toxic Characteristic Leaching Procedure (TCLP) analysis performed on the sample to determine if the lead is leachable. LBP in exceedance of 600 mg/kg cannot be disposed of in the NWT and the TCLP will determine if it can be disposed of in a class 1 or 2 landfill outside of the NWT.

1.5 REPORTING

Upon concluding a HBMA a comprehensive report for each Subject property, the reports, drawings and tables shall be supplied to the client. Draft reports will be given to the client for review and comment. Upon receipt of the client's comments, final reports will be submitted and final payment initiated.
Finally the Reports shall provide a Class C estimate1[1] and brief work plan for the abatement work.

1.6 UTILIZATION of HBMA

HBMA's are to be used to protect workers' health and safety when conducting renovations and/or demolitions (deconstruction) or additions, as well as O&M to existing structures. It would be also be prudent to conduct a HBMA when acquiring an existing structure. Do not refer to a HBMA as a modified ESA. Refer to the job by what it is.

[1] Class C estimate is based on American Association of Cost Engineers (AACE) ANSI (Z94.0), which is equivalent to the Class 5 estimate; accurate to -30 percent (%) on the low side, and up to +50% on the high side.