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MEASURES FOR ENERGY CONSERVATION IN NEW BUILDINGS 1978

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ASSOCIATE COMMITTEE ON THE NATIONAL BUILDING CODE
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MEASURES FOR ENERGY CONSERVATION

IN NEW BUILDINGS

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SPECIAL NOTE

As this is the first Canadian attempt at preparing comprehensive measures for energy conservation in new buildings, it is to be expected that problems will arise during the initial stages of their application. These problems can be minimized through careful preplanning by those who wish to institute these measures. To assist with this process a Commentary is being prepared which will help to clarify the more complex areas by explaining the basis of their development and how they are intended to be applied.

The Committee responsible for developing the measures recognizes that, when used in a regulatory manner, the provisions will require a phasing-in period to ensure that the necessary enforcement mechanisms are in place before adoption. In the case of requirements affecting heating, ventilating and air-conditioning systems and lighting loads, the adoption authority may need to rely upon the stamp of a professional engineer as an aid in establishing compliance. There may also be a need to establish training courses for enforcement officials to ensure that they have a sufficient understanding of the energy conservation requirements which they are to administer.

The Committee is aware that conservation of energy in buildings depends as much upon operation as it does upon design. The Committee is also aware that, in the short term, energy used in existing buildings far exceeds that used in new buildings to which these measures are intended to apply. For these reasons, the Committee has begun studies to determine the factors which control the use of energy in buildings. These studies will be assisted by input from representatives of user groups with the object of developing realistic performance guidelines for various building categories based on annual energy budgets.

PREFACE

This is the first edition of Measures for Energy Conservation in New Buildings. It has been developed by the Standing Committee on Energy Conservation in Buildings under the auspices of the Associate Committee on the National Building Code. The document has been prepared using the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90-75 as a guide, but contains modifications to adapt the requirements to Canadian conditions. Additional modifications have been made as a result of public comment on the draft document.

The measures are intended to provide a basis for improving the energy use characteristics of new buildings. They are well within the technical capabilities of the competent designer and are intended for use either as a guide or as the basis for regulatory requirements for the design of new buildings. The measures have been developed so that compliance with them is determinable at the design stage through evaluations and analysis of design specifications, drawings and calculations. They are essentially prescriptive in nature, but some flexibility in their application has been introduced through the inclusion of trade-off provisions such as articles 2.1.6., 3.2.4. and 4.2.4., which permit deviations from certain requirements.

Wherever appropriate, the document makes reference to existing requirements in the National Building Code. The user is directed to the requirements of the National Building Code for additional information on occupancy classifications which are used to differentiate between building uses.

It will be noted that the measures dealing with combustion equipment in this document are relatively brief and do not cover a number of aspects which may have significant energy savings potential. A task group has been established to investigate what future course of action is necessary to develop such measures. This group includes members from the Canadian Standards Association, the Canadian Gas Association, industry and combustion research establishments as well as members who assisted in the development of this document. It is anticipated that, as a result of this group's activity, changes will be initiated to improve the current requirements governing combustion equipment.

It should also be noted that measures for the efficiency of cooling equipment are based on the values that appear in Standard 90-75, published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers for the period up to January 1, 1980. These values in ASHRAE 90-75 are to be increased after that date, and it is anticipated these increases will be reflected in future editions of this document.

The metric values used throughout the document are based on the International System of Units (SI) contained in "The Canadian Metric Practice Guide," CAN3-Z234.1-76, prepared by the Canadian Standards Association and issued as a National Standard of Canada. The

equivalent imperial values are shown in Appendix B of the document. They are calculated using the conversion factors found in the Metric Practice Guide.

The Associate Committee wishes to acknowledge the assistance provided by the many individuals who have contributed to the production of this edition and to express its appreciation to the Standards Writing Organizations whose standards are referenced in this document. In particular, the Associate Committee is indebted to the American Society of Heating, Refrigerating and Air-Conditioning Engineers for permission to use material from their ASHRAE Standard 90-75 in developing this document.

Comments on this document are welcomed and will be the basis for the improvement of the next edition. It is important for the further development of these measures that problems encountered in their application should be brought to the attention of the Associate Committee on the National Building Code. They should be directed to: The Secretary, The Associate Committee on the National Building Code, National Research Council of Canada, Ottawa, Ontario K1A 0R6.

Ce Document est disponible en français. On peut se le procurer en s'addressant au Secrétaire, Comité associé du Code national du bâtiment, Conseil national de recherches du Canada, Ottawa, Ontario K1A 0R6.

SECTION 1 DEFINITIONS AND ABBREVIATIONS

SUBSECTION 1.1 DEFINITIONS OF WORDS AND PHRASES

1.1.1. Words and phrases used in these Measures that are not included in the list of definitions in this Section shall have the meanings commonly assigned to them in the context in which they are used in these Measures taking into account the specialized use of terms by the various trades and professions to which the terminology applies. (The ASHRAE Handbook of Fundamentals 1977, Chapter 33 contains a list of terms common to heating, cooling and ventilating systems and is a useful source of information in this field.)

1.1.2. The words and terms that are italicized in these Measures shall have the following meanings:

Approved means approved by the *authority having jurisdiction*.

Authority having jurisdiction means

(a) with respect to the proclamation and amendment of these Measures, the adopting governmental body, or

(b) with respect to the administration of these Measures, the person (designated official) appointed by the adopting governmental body and any person authorized by him to administer these Measures.

Building means any structure used or intended for supporting or sheltering any use or *occupancy*.

Business and personal services occupancy means the *occupancy* or use of a *building* or part thereof for the transaction of business or the rendering or receiving of professional or personal services.

Closure means a device for shutting off an opening through a construction assembly, such as a door or a shutter, and includes all components such as hardware, closing devices, frames and anchors.

Combustible (as applying to an elementary building material) means that such material fails to conform to ULC-S114-1975, "Standard Method of Test for Determination of Non-Combustibility in Building Materials."

Combustible Construction means that type of construction that does not meet the requirements for *noncombustible construction*.

Dual duct system means an air-handling system in which air supplied by separate hot and cold air ducts is mixed at terminals to meet thermostatic demand.

Dwelling unit means a room or suite of rooms operated as a housekeeping unit, used or intended to be used as a domicile by 1 or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.

Floor surface area means the area of the floor surface measured from the interior surface of the perimeter walls at or near floor level, excluding any openings through the floor, but including the area occupied by columns and interior walls.

Institutional occupancy means the *occupancy* or use of a *building* or part thereof by persons who are involuntarily detained, or detained for penal or correctional purposes, or whose liberty is restricted, or require special care or treatment because of age, mental or physical limitations.

Major occupancy means the principal *occupancy* for which a *building* or part thereof is used or intended to be used and shall be deemed to include the subsidiary *occupancies* which are an integral part of the principal *occupancy*.

Mercantile occupancy means the *occupancy* or use of a *building* or part thereof for the displaying or selling of retail goods, wares or merchandise.

Noncombustible (as applying to an elementary *building* material) means that such material conforms to ULC-S114-1975, "Standard Method of Test for Determination of Non-Combustibility in Building Materials."

Noncombustible construction means that type of construction in which a degree of fire safety is attained by the use of *noncombustible* materials for structural members and other *building* assemblies.

Occupancy means the use or intended use of a *building* or part thereof for the shelter or support of persons, animals or property.

Owner means any person, firm or corporation controlling the property under consideration.

Permit means permission or authorization in writing by the *authority having jurisdiction* to perform work regulated by these Measures.

Reheat means the application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space by either mechanical refrigeration or the introduction of outdoor air to provide cooling.

Residential occupancy means the *occupancy* or use of a *building* or part thereof by persons for whom sleeping accommodation is provided but who are not harboured or detained to receive medical care or treatment or who are not involuntarily detained.

Service water heater means a device for heating water for plumbing services.

Storey means that portion of a *building* which is situated between the top of any floor and the top of the floor next above it, and if there is no floor above it, that portion between the top of such floor and the ceiling above it.

SUBSECTION 1.2 ABBREVIATIONS OF NAMES AND ASSOCIATIONS

1.2.1. The abbreviations in these Measures for the names and associations shall have the meaning assigned to them in this Subsection.

ACNBC - Associate Committee on the National Building Code
(National Research Council of Canada
Ottawa, Ontario K1A 0R6)

ARI - Air Conditioning & Refrigeration Institute
(1815 North Fort Myer Drive
Arlington, Virginia 22209 U.S.A.)

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
(345 East 47th Street
New York, New York 10017 U.S.A.)

ASTM - American Society for Testing and Materials
(1916 Race Street
Philadelphia, Pa. 19103 U.S.A.)

CGA - Canadian Gas Association
(55 Scarsdale Road
Don Mills, Ontario M3B 2R3)

CSA - Canadian Standards Association
(178 Rexdale Blvd.
Rexdale, Ontario M9W 1R3)

HI - Hydronics Institute
(35 Rusco Place
Berkeley Heights, New Jersey 07922 U.S.A.)

HRA - Heating, Refrigerating and Air Conditioning Institute of Canada
(Suite 267, 385 The West Mall
Etobicoke, Ontario M9C 1E7)

IES - Illuminating Engineering Society
(345 East 47th Street
New York, New York 10017 U.S.A.)

NBC - National Building Code of Canada
(National Research Council of Canada
Ottawa, Ontario K1A 0R6)

SMACNA - Sheet Metal and Air Conditioning Contractors
National Association Inc.
(1611 North Kent Street, Suite 200
Arlington, Va. 22209 U.S.A.)

ULC - Underwriters' Laboratories of Canada
(7 Crouse Road
Scarborough, Ontario M1R 3A9)

SUBSECTION 1.3 ABBREVIATIONS OF WORDS AND PHRASES

1.3.1. The abbreviations of words and phrases in these Measures shall have the meanings assigned to them in this Subsection.

°C ..... degree(s) Celsius

cm^3 ..... cubic centimetre(s)

dm^3 ..... cubic decimetre(s)

in. ..... inch(es)

J ..... joule(s)

k ..... kilo

kg ..... kilogram(s)

m ..... metre(s)

m^2 ..... square metre(s)

m^3 ..... cubic metre(s)

mm ..... millimetre(s)

Pa ..... pascal(s)

R ..... thermal resistance

s ..... second(s)

W ..... watt(s)

SECTION 2 GENERAL

SUBSECTION 2.1 APPLICATION

2.1.1. These Measures apply to the design and construction of *buildings* whereby energy use is to be limited.

2.1.2. Except as provided in Articles 2.1.3. to 2.1.5., these Measures apply to *buildings* as described in the scope of each of the Sections herein.

2.1.3. These Measures do not apply to cottages or similar *buildings* that are not intended to be heated on a continuing basis during winter months, or to farm *buildings* other than a *dwelling unit*.

2.1.4. These Measures do not apply to *buildings* that are not heated or cooled, or to *buildings* for which the maximum design rate of energy use for other than manufacturing or processing operations is less than 10 W/m^2 of *floor surface area*. (Normally, unheated warehouses, garages or sheds would be excluded.)

2.1.5. The *authority having jurisdiction* may exempt certain *buildings* from some requirements of these Measures where it can be shown that the nature of the *occupancy* makes it impractical to apply those requirements.

2.1.6. The *authority having jurisdiction* may permit deviations from any requirements in these Measures where it can be shown that the deviations will result in energy use that is not greater than would result by following the requirements in these Measures.

SUBSECTION 2.2 PLANS AND SPECIFICATIONS

2.2.1. Upon the application for a *permit*, the *owner* shall submit all plans, specifications and calculations to show in sufficient detail all relevant data and features of the *building*, including its systems, necessary to determine conformance with the requirements of these Measures.

2.2.2. Calculations for the design of heating and cooling systems, including the calculation of heat losses and gains, and the thermal resistance of *building* assemblies shall be made in conformance with good engineering practice.

(The procedures described in the ASHRAE Handbooks, the HRA Digest and the HI Manuals are considered to be good engineering practice.

SUBSECTION 2.3 ADMINISTRATION

2.3.1. (Reserved: this Subsection is intended to be completed by the adopting authority.)

SUBSECTION 2.4 REFERENCE DOCUMENTS

2.4.1. Unless otherwise specified in these Measures, the documents referred to shall be those current as of January 1, 1978 together with all amendments, revisions and supplements effective to that date.

2.4.2. In the case of conflict between the requirements in these Measures and those of a referenced document, requirements in these Measures shall govern, except that where there is a conflict between the requirements in these Measures and the NBC 1977, the requirements of the NBC 1977 shall govern.

2.4.3. The materials for, and the installation of thermal insulation and vapour barrier protection shall conform to the appropriate requirements in Subsections 4.8 and 9.26 of the NBC 1977.

2.4.4. Where insulation is installed in a *building* required to be of *noncombustible construction*, the insulation and any *combustible* material associated with the insulation shall conform to the requirements in Article 3.1.4.5. of the NBC 1977.

2.4.5. Foamed plastic thermal insulation shall be protected in conformance with the appropriate requirements in Articles 3.1.11.2. and 9.30.1.2. of the NBC 1977.

2.4.6. Foamed plastic thermal insulation for plenums and other parts of duct systems shall be protected in conformance with the requirements in Article 2.4.6. of the Canadian Heating, Ventilating and Air-Conditioning Code 1977.

2.4.7. The outdoor design temperature and degree day values specified in these Measures shall be those determined from NBC Supplement No. 1, "Climatic Information for Building Design in Canada 1977."

SECTION 3 ENCLOSURES FOR BUILDINGS WITH LOW ENERGY REQUIREMENTS FOR LIGHTING, FANS AND PUMPS

SUBSECTION 3.1 SCOPE

3.1.1. Except as provided in Article 3.1.2., this Section shall apply to *buildings* of all *occupancy* classifications.

(Normally, houses, low rise apartment *buildings*, nursing homes, motels and heated warehouses fall within the requirements of this Section.)

3.1.2. Where the *owner* can demonstrate that the total load of all wired-in interior lighting, plus the total rated power of all fans and water pumps, excluding standby equipment, exceeds an average of 25 W/m^2 of *floor surface area* in those parts of the *building* that are heated or cooled, the requirements in Section 4 may be used in lieu of the requirements in this Section.

SUBSECTION 3.2 THERMAL RESISTANCE OF ASSEMBLIES

3.2.1. Except as provided in Articles 3.2.2. to 3.2.7., and except for doors, windows, skylights and other *closures*, the thermal resistance of each *building* assembly through any portion that does not include framing or furring shall conform to Table 3.2.A. (See Appendix A for graphical illustration of thermal resistance values.)

3.2.2. Except as provided in Article 3.2.3., the thermal resistance of the insulated portion of a *building* assembly incorporating metal framing elements, such as steel studs and steel joists, that act as thermal bridges to facilitate heat flow through the assembly, shall be 20 per cent greater than the values shown in Table 3.2.A. unless it can be shown that the heat flow is not greater than the heat flow through a wood frame assembly of the same thickness.

3.2.3. Article 3.2.2. for *building* assemblies incorporating thermal bridges does not apply where the thermal bridges are insulated to restrict heat flow through the thermal bridges by a material providing a thermal resistance at least equal to 25 per cent of the thermal resistance required for the insulated portion of the assembly in Article 3.2.1.

3.2.4. The thermal resistance of a *building* assembly may be reduced by not more than 20 per cent from that required in Articles 3.2.1. and 3.2.2., and the amount of glazing may be increased to more than that permitted in Article 3.3.4., where it can be shown that the total calculated heat loss from the *building* enclosure does not exceed the heat loss that would result if the enclosure were constructed in conformance with the minimum thermal resistance requirements in Articles 3.2.1. and 3.2.2. and with the maximum amount of glazing permitted in Article 3.3.4., provided no allowance is made for solar heat gains or for the orientation of the glazing as described in Article 3.3.6.

Table 3.2.A.

Forming part of Article 3.2.1.

MINIMUM THERMAL RESISTANCE (R VALUE), $m^2 \cdot °C/W$				
Building Assembly	Maximum Number of Celsius Degree Days(1)			
	up to 3 500	5 000	6 500	8 000 and over
Wall assemblies above ground level (other than foundation walls) separating heated space from unheated space or the outside air	2.5	3.0	3.4	3.7
Foundation wall assemblies separating heated space from unheated space, outside air or adjacent earth(2)	1.6	1.6	1.6	1.6
Roof or ceiling assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	4.7	5.6	6.4	7.1
(b) if *noncombustible construction* is required	2.5	3.0	3.4	3.7
Floor assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	4.7	4.7	4.7	4.7
(b) if *noncombustible construction* is required	2.5	3.0	3.4	3.7
Perimeters of slab-on-ground floors that are less than 600 mm below adjacent ground level (insulation only)				
(a) slabs where heating ducts, pipes or resistance wiring are embedded in or beneath the slabs	1.3	1.7	2.1	2.5
(b) slabs other than those described in (a)	0.8	1.3	1.7	2.1
Column 1	2	3	4	5

Notes to Table 3.2.A.:

(1) Where the number of degree days for a particular area is different from those listed, interpolation between values shown in the Table may be made to obtain the minimum required thermal resistance values for that area.

(2) Every foundation wall face having more than 50 per cent of its area exposed to outside air and those parts of foundation walls of wood-frame construction above exterior ground level shall have a thermal resistance conforming to the requirements for wall assemblies above ground level.

3.2.5. Where the indoor winter design temperature is less than 18°C, the minimum thermal resistance R_1 shall be determined in conformance with the formula,

$$R_1 = \frac{t_i - t_o}{18 - t_o} \cdot R$$

where t_i is the indoor winter design temperature (°C),

t_o is the outdoor design temperature based on the 2½ per cent value for January (°C), and

R is the thermal resistance required in Article 3.2.1. or 3.2.2. ($m^2 \cdot °C/W$).

3.2.6. The thermal resistance values in Article 3.2.1. and 3.2.2. for roof or ceiling assemblies separating heated space from unheated space or the exterior may be reduced near the eaves to the extent made necessary by the roof slope and required ventilation clearances, except that the thermal resistance at the location directly above the inner surface of the exterior wall shall be at least 2.1 $m^2 \cdot °C/W$.

3.2.7. The thermal resistance values required in Article 3.2.1. may be reduced to take into account the effect of thermal inertia resulting from the mass of the *building* in conformance with Building Research Note No. 126, published by the Division of Building Research, National Research Council of Canada, January 1978.

3.2.8. Insulation applied to the exterior of a foundation wall or slab-on-ground floor shall extend down at least 600 mm below the adjacent exterior ground level or shall extend down and outward from the floor or wall for a total distance of at least 600 mm measured from the adjacent finished ground level.

3.2.9. Insulation applied to the interior of a foundation wall shall extend from the underside of the flooring above such walls, down to at least 600 mm below the exterior adjacent ground level, except as required in Article 9.26.5.6. of the NBC 1977.

SUBSECTION 3.3 GLAZING

3.3.1. Except as provided in Articles 3.3.2., 3.3.3 and 3.3.5., all glazing that separates heated space from unheated space or the exterior shall have a thermal resistance of at least 0.30 $m^2 \cdot °C/W$. (Double glazing with at least a 6-mm air space, or single glazing with a storm sash is considered to provide the required thermal resistance.)

3.3.2. Except as provided in Articles 3.3.3. and 3.3.5., where a *building* is located in a climate area where the number of Celsius degree days exceeds 6 500, all windows and skylights shall have a thermal resistance of at least 0.45 $m^2 \cdot °C/W$. (Triple glazing with at least 6-mm air spaces, or double glazing with at least 6-mm air space and with a storm sash is considered to provide the required thermal resistance.)

3.3.3. Where an enclosed unheated space, such as a sun porch, enclosed verandah or vestibule, is separated from a heated space by glazing, the unheated enclosure may be considered to provide a thermal resistance of 0.16 $m^2 \cdot °C/W$, or the equivalent of one layer of glazing.

3.3.4. Except as provided in Articles 3.3.5. and 3.3.6., the total area of glazing, including glazing for doors and skylights, that separates heated space from unheated space or the exterior shall not exceed 15 per cent of the *floor surface area* of the *storey* served by the glazed areas and shall not exceed 40 per cent of the total area of the walls of that *storey* separating heated space from unheated space or the exterior. (In the case of a sloping wall, the area of the opaque portion of the wall is calculated as its projected area on a vertical plane.)

3.3.5. Where the thermal resistance of glazing is different from that required in Articles 3.3.1. and 3.3.2., the area of such glazing for the purpose of applying Article 3.3.4. may be assumed as being equal to the actual area multiplied by the ratio of the required thermal resistance divided by the actual thermal resistance of the glazing (see Appendix A).

3.3.6. Except as provided in Article 3.3.7., the area of glazing that contains clear glass or that has a shading coefficient of more than 0.70 that is unshaded in the winter and faces a direction within 45°of due South may be assumed to be 50 per cent of its unshaded area in calculating the maximum area of glazing in Articles 3.3.4. and 3.3.5. provided the *building* is designed with a system that is capable of distributing the solar heat gain from such glazed areas throughout the *building*. (For the purpose of determining whether or not the glazing is shaded in the winter, the shading shall be calculated using the noon sun angles of December 21.)

3.3.7. Article 3.3.6. shall not apply where the *building* is designed to be cooled unless the glazing described in 3.3.6. is shaded in the summer with exterior devices. (For the purpose of determining whether or not the glazing is shaded in the summer, the shading shall be calculated using the noon sun angles of June 21.)

SUBSECTION 3.4 DOORS AND WINDOWS

3.4.1. Air curtains shall not be used in place of exterior doors.

3.4.2. Except for doors used primarily to facilitate the movement of vehicles or handling of material, infiltration around doors shall conform to the appropriate requirements in Subsection 3.5.

3.4.3. Except for doors on enclosed unheated vestibules and except for glazed portions of doors, all doors separating heated space from the outside shall have a thermal resistance of at least 0.7 $m^2 \cdot °C/W$ where a storm door is not provided.

3.4.4. Except as provided in Article 3.5.1., windows shall conform to the appropriate requirements of Section 9.7 of the NBC 1977.

SUBSECTION 3.5 INFILTRATION

3.5.1. Windows separating heated space from unheated space or the exterior shall be designed to limit the rate of air infiltration to not more than 0.775 dm^3/s for each metre of sash crack when tested at a pressure differential of 75 Pa in conformance with ASTM E283-73, "Standard Method of Test for Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors."

3.5.2. Manually operated exterior sliding glass door assemblies that separate heated space from unheated space or the exterior shall be designed to limit air infiltration to not more than 2.5 dm^3/s for each square metre of door area when tested in conformance with Article 3.5.1.

3.5.3. Except where the door is weather-stripped on all edges and protected with a storm door or by an enclosed unheated space, exterior swing type door assemblies for *dwelling units*, individually rented hotel and motel rooms and suites shall be designed to limit the rate of air infiltration to not more than 6.35 dm^3/s for each square metre of door area when tested in conformance with Article 3.5.1.

3.5.4. Door assemblies other than those described in Articles 3.5.2. and 3.5.3. that separate heated space from unheated space or the exterior shall be designed to limit the rate of air infiltration to not more than 17.0 dm^3/s for each metre of door crack when tested in conformance with Article 3.5.1.

3.5.5. Caulking material to reduce air infiltration shall conform to the requirements in Article 9.28.4.3. of the NBC 1977.

3.5.6. The junction between the sill plate and the foundation, joints between exterior wall panels and any other location where there is a possibility of air leakage into heated spaces in a *building* through the exterior walls, such as at utility service entrances, shall be caulked, gasketed or sealed to restrict such air leakage.

3.5.7. Air leakage between heated space and adjacent roof or attic space caused by the penetration of services shall be restricted in conformance with the requirements of Articles 9.26.6.6. to 9.26.6.14. of the NBC 1977.

SECTION 4 ENCLOSURES FOR BUILDINGS WITH HIGH ENERGY REQUIREMENTS FOR LIGHTING, FANS AND PUMPS

SUBSECTION 4.1 SCOPE

4.1.1. The requirements in this Section apply to *buildings* of all *occupancy* classifications that do not fall within the scope of Section 3. (Normally, large office, recreational, manufacturing, retail and educational *buildings*, hospitals and hotels fall within the requirements of this Section.)

SUBSECTION 4.2 THERMAL RESISTANCE OF ASSEMBLIES

4.2.1. Except as permitted in Articles 4.2.2. to 4.2.7., and except for doors, windows, skylights and other *closures*, the thermal resistance of each *building* assembly through any portion that does not include framing or furring shall conform to Table 4.2.A. (See Appendix A for graphical illustration of thermal resistance values.)

4.2.2. Except as provided in Article 4.2.3., the thermal reistance of the insulated portion of a *building* assembly incorporating metal framing elements, such as steel studs and steel joists, that act as thermal bridges to facilitate heat flow through the assembly, shall be 20 per cent greater than the values shown in Table 4.2.A., unless it can be shown that the heat flow is not greater than the heat flow through a wood frame assembly of the same thickness.

4.2.3. Article 4.2.2. for *building* assemblies incorporating thermal bridges does not apply when the thermal bridges are insulated to restrict heat flow through the thermal bridges by a material providing a thermal resistance at least equal to 25 per cent of the thermal resistance required for the insulated portion of the assembly in Article 4.2.1.

4.2.4. The thermal resistance of a *building* assembly may be reduced by not more than 20 per cent from that required in Articles 4.2.1. and 4.2.2., and the amount of glazing may be increased to more than that permitted in Article 4.3.1., where it can be shown that the total calculated heat loss from the *building* enclosure does not exceed the heat loss that would result if the enclosure was constructed in conformance with the minimum thermal resistance requirements in Articles 4.2.1. and 4.2.2. and with the maximum amount of glazing permitted in Article 4.3.1. provided no allowance is made for solar heat gains.

4.2.5. Where the indoor winter design temperature is less than 18°C, the minimum thermal resistance R_1 shall be determined in conformance with the formula

$$R_1 = \frac{t_i - t_o}{18 - t_o} \cdot R$$

where t_i is the indoor winter design temperature (°C),

t_o is the outdoor design temperature based on the 2½ per cent value for January (°C), and

R is the thermal resistance required in Article 4.2.1. or 4.2.2. ($m^2 \cdot °C/W$).

4.2.6. The thermal resistance value in Article 4.2.1. and 4.2.2. for roof or ceiling assemblies separating heated space from unheated space or the exterior may be reduced near the eaves to the extent made necessary by the roof slope and required ventilation clearances, except that the thermal resistance at the location directly above the inner surface of the exterior wall shall be at least 2.1 $m^2 \cdot °C/W$.

4.2.7. The thermal resistance values required in Article 4.2.1. may be reduced to take into account the effect of thermal inertia resulting from the mass of the *building* in conformance with Article 3.2.7.

4.2.8. Perimeter insulation for slab-on-ground floors and for foundation walls shall extend down below the adjacent exterior ground level to the same depth as required in Articles 3.2.8. and 3.2.9.

SUBSECTION 4.3 GLAZING

4.3.1. Glazing that separates heated space from unheated space or the exterior shall conform to the appropriate requirements in Subsection 3.3, except Article 3.3.6. shall not apply, and where exterior doors are protected by unheated vestibules described in Articles 4.5.2. and 4.5.3., or such doors are of the revolving type, single glazing may be used in such doors.

SUBSECTION 4.4 DOORS

4.4.1. Doors shall conform to the appropriate requirements of Subsection 3.4.

4.4.2. Doors shall be designed to reduce air infiltration in conformance with Subsection 4.5.

SUBSECTION 4.5 INFILTRATION

4.5.1. Measures shall be taken to control air infiltration into *buildings* in conformance with Subsection 3.5.

4.5.2. Except as provided in Article 4.5.4., a door that separates heated space from the exterior shall be protected with an enclosed vestibule with all doors opening into or out of the vestibule equipped with self-closing devices.

4.5.3. Vestibules required in Article 4.5.2. shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to be open at the same time.

Table 4.2.A.

Forming part of Article 4.2.1.

MINIMUM THERMAL RESISTANCE (R VALUE), $m^2 \cdot °C/W$				
Building Assembly	Maximum Number of Celsius Degree Days(1)			
	up to 3 500	5 000	6 500	8 000 and over
Wall assemblies above ground level (other than foundation walls) separating heated space from unheated space or the outside air	1.9	2.5	3.0	3.4
Foundation wall assemblies separating heated space from unheated space, outside air or adjacent earth(2)	1.6	1.6	1.6	1.6
Roof or ceiling assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	3.6	4.7	5.6	6.4
(b) if *noncombustible construction* is required	1.9	2.5	3.0	3.4
Floor assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	3.6	4.7	4.7	4.7
(b) if *noncombustible construction* is required	1.9	2.5	3.0	3.4
Perimeters of slab-on-ground floors that are less than 600 mm below adjacent ground level (insulation only)				
(a) slabs where heating ducts, pipes or resistance wiring are embedded in or beneath the slabs	0.8	1.3	1.7	2.1
(b) slabs other than those described in (a)	0.8	0.8	1.3	1.7
Column 1	2	3	4	5

Notes to Table 4.2.A.:

(1) Where the number of degree days for a particular area is different from those listed, interpolation between values shown in the Table may be made to obtain the minimum required thermal resistance values for that area.

(2) Every foundation wall face having more than 50 per cent of its area exposed to outside air, and those parts of foundation walls of wood-frame construction above exterior ground level shall have a thermal resistance conforming to the requirements for wall assemblies above ground level.

4.5.4.(1) Exterior doors need not be protected with a vestibule where

(a) the door is a revolving door,
(b) the door is used primarily to facilitate vehicular movement or material handling,
(c) the door is not intended to be used as a general entrance door, or
(d) the door opens directly from an enclosed space of less than 150 m^2 in area.

SECTION 5 HEATING, COOLING AND VENTILATING

SUBSECTION 5.1 GENERAL

5.1.1. Space heating, space cooling and ventilating systems and equipment shall be designed and installed in conformance with the NBC 1977.

5.1.2. The *authority having jurisdiction* may permit deviations from some requirements of this Section where it can be shown that because of the nature of the *occupancy*, special design considerations must be taken into account that would make compliance with the requirements of this Section impractical.

5.1.3. Unless otherwise indicated herein, the requirements in this Section apply to *buildings* of all *occupancy* classifications.

5.1.4. For *buildings* within the scope of Section 4, the system designer's recommendations for efficient operation of the heating, cooling and ventilating systems shall be provided.

SUBSECTION 5.2 VENTILATION

5.2.1. Non-mechanical or natural ventilation of *buildings* shall conform to the requirements of the NBC 1977.

5.2.2. Where mechanical ventilation is provided, the design air quantities used for such ventilation shall be the minimum values permitted in ASHRAE Standard 62-73, "Standards for Natural and Mechanical Ventilation," except when otherwise required by the NBC 1977.

SUBSECTION 5.3 ENERGY FOR FAN OPERATION

5.3.1. The total design power input required to operate air moving fans in cooling systems shall not exceed 20 per cent of the total design rate of sensible heat removed from the space.

5.3.2. Except for *buildings* of *residential occupancy* or *institutional occupancy*, mechanically ventilated *buildings* shall be equipped with automatic controls to permit a reduction in fan energy requirements during periods when the *building* is not in use, and such controls shall permit manual override.

SUBSECTION 5.4 TEMPERATURE CONTROL

5.4.1. Except in a *dwelling unit* heated by a coal or wood burning appliance contained within the *dwelling unit*, the air temperature in those parts of a *building* that are designed to be heated or cooled shall be controlled by a thermostat in each temperature controlled zone (see Subsection 5.5).

5.4.2. Thermostats to control air temperatures for space heating systems only shall be capable of being set at least as low as 13°C and to not more than 24°C.

5.4.3. Thermostats to control air temperatures for space cooling systems only shall be capable of being set at least as high as 29°C and to not less than 24°C.

5.4.4. Thermostats designed to control air temperature for both space heating and space cooling shall conform to the requirements of Articles 5.4.2. and 5.4.3. and shall have at least a 1.5°C separation between the operation of the heating and cooling equipment.

5.4.5. Except for *buildings* of *residential occupancy* or *institutional occupancy*, heated *buildings* shall be equipped with temperature controls to permit an automatic reduction in heating energy demands during periods when the *building* is not in use and such controls shall permit manual override.

SUBSECTION 5.5 TEMPERATURE CONTROLLED ZONES

5.5.1. Each *dwelling unit* shall be considered to be a separate temperature controlled zone.

5.5.2.(1). Except as provided in Article 5.5.1., a *building* that is designed to be heated or cooled shall be designed so that there is a separate temperature controlled zone provided for

(a) each separate heating or cooling system,
(b) each *storey*, except that in multi *storey buildings* where the perimeter system is designed to balance only the thermal losses of the exterior wall, more than one *storey* of the perimeter system may be included in the same zone where the combined *storeys* have uniform exposure conditions,
(c) each suite or every enclosed space under a separate tenancy,
(d) other grouping of rooms or enclosed spaces where the heating or cooling requirements are sufficiently similar to permit similar comfort conditions to be maintained by a single thermostat, and
(e) each vestibule with forced flow heating equipment.

5.5.3. Where more than one of the requirements in Article 5.5.2. may apply, the requirements that provide the greatest number of temperature controlled zones shall govern.

SUBSECTION 5.6 SIMULTANEOUS HEATING AND COOLING

5.6.1. An air system that serves more than one temperature controlled zone shall not serve both an interior zone which does not require heating and a perimeter zone that does require heating.

5.6.2. A system that serves only one temperature controlled zone shall be equipped with controls to prevent simultaneous heating and cooling.

5.6.3. Except as permitted in Article 5.6.6., heating and cooling systems that use *reheat* and which serve more than one temperature controlled zone shall be equipped with controls that will automatically reset the temperature of the cold air supply to the highest temperature that will satisfy the temperature zone normally requiring the coolest air.

5.6.4. Except as permitted in Article 5.6.6., air systems that serve more than one temperature zone, such as multi-zone and *dual-duct systems*, shall be provided with controls that will automatically reset the temperature of the cold air supply to the highest temperature that will satisfy the temperature controlled zone normally requiring the coolest air and reset the temperature of the hot air supply to the lowest temperature that will satisfy the temperature controlled zone normally requiring the warmest air.

5.6.5. Except as permitted in Article 5.6.6., systems in which heated air is cooled to provide the desired temperature in a temperature controlled zone shall be provided with controls that will automatically reset the temperature to which the supply air is heated to the lowest temperature that will satisfy the zone normally requiring the warmest air.

5.6.6. Systems for reheating or recooling having a capacity of less than 2 500 dm^3/s need not conform to the temperature reset requirements in Articles 5.6.3. to 5.6.5.

5.6.7. Concurrent operation of independent heating and cooling systems serving the same space shall be minimized by providing sequential temperature control of both the heating and cooling in each temperature controlled zone, or by limiting the heating energy input by automatically resetting the energy input rate to the minimum value required to balance heat losses due to transmission, infiltration and ventilation of that space.

SUBSECTION 5.7 COOLING WITH OUTDOOR AIR

5.7.1. Except as permitted in Articles 5.7.3. and 5.7.4., each system having an air handling capacity of more than 1 200 dm^3/s or 20 kW of total cooling capacity shall be designed to introduce outdoor air up to the total capacity of the system when the introduction of the outdoor air would result in an overall decrease in energy consumption.

5.7.2. The introduction of outdoor air for cooling as required in Article 5.7.1. shall be initiated automatically upon the signal of an outdoor air enthalpy sensor or dry bulb temperature sensor.

5.7.3. Article 5.7.1. does not apply where all space cooling is accomplished by dissipating the heat to the outdoor air by means of a cooling tower or other heat dissipating system without the use of a refrigerating system.

5.7.4. Article 5.7.1. does not apply where the heat recovered from the cooling system is used for other purposes and results in the use of less total energy on an annual basis.

SUBSECTION 5.8 PIPE INSULATION

5.8.1. Except for piping in heated spaces in a *dwelling unit* that serves only that unit, or piping located within heating equipment or cooling equipment, piping carrying a fluid with a temperature of less than 13°C or more than 50°C shall be provided with thermal insulation in conformance with Table 5.8.A. when the heat loss or heat gain from the piping will increase the energy requirements of the *building*.

SUBSECTION 5.9 DUCT INSULATION

5.9.1. Except as provided in Articles 5.9.2. and 5.9.3., where the design temperature difference between ambient air and air within a plenum or duct exceeds 15°C, the duct or plenum shall be insulated to provide a thermal resistance, expressed in $m^2 \cdot °C/W$, numerically equal to at least 0.02 times the difference in temperature in °C where the heat loss or heat gain from the duct would increase the energy requirements of the *building*.

5.9.2. Ducts located in heated spaces in *dwelling units* need not conform to insulation requirements in Article 5.9.1.

5.9.3. Ducts that circulate heated air or cooled air and are located outside of the insulated portion of the *building* shall be insulated as required in Article 3.2.1. for "wall assemblies above ground level (other than foundation walls) separating heated space from unheated space or the outside air."

5.9.4. Sufficient insulation shall be provided on cold air supply ducts to prevent surface condensation on the duct or duct insulation.

5.9.5. Insulation on cold air supply ducts shall be provided with vapour barrier protection where necessary to prevent condensation within the insulation.

SUBSECTION 5.10 DUCT CONSTRUCTION

5.10.1. Ducts shall be constructed in conformance with the NBC 1977.

5.10.2. Except for ducts located in heated space in *dwelling units*, supply ducts located outside of the space to be served by such ducts shall have all joints sealed with *approved* mastic or tape.

5.10.3. Ducts with air velocities exceeding 10 m/s or pressures exceeding 500 Pa shall be pressure tested in conformance with SMACNA, "High Pressure Duct Construction Standard," third edition, 1975, and the rate of air leakage shall not exceed the value specified in that Standard.

Table 5.8.A.

Forming part of Article 5.8.1.

Fluid Temperature Range, °C	INSULATION THICKNESS,(1) mm				
	Nominal Pipe Size				
	1 in. and less	1¼-2 in.	2½-4 in.	5-6 in.	8 in. and larger
151 - 240	38	51	64	89	89
121 - 150	38	51	64	76	76
96 - 120	25	38	38	51	51
50 - 95	19	25	25	25	38
5 - 13	13	19	25	25	25
Below 5	25	38	38	38	38
Column 1	2	3	4	5	6

Note to Table 5.8.A.:

(1) Table 5.8.A. is based on insulation with a thermal resistance per metre of thickness of 30 $m^2 \cdot °C/W$, where the thermal resistance is determined from the thermal conductivity measured in conformance with ASTM C177-76, "Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate." For insulation having a thermal resistance per metre other than 30 $m^2 \cdot °C/W$, the thickness of thermal insulation is determined by multiplying the thickness values in the Table by 30/R, where R is the actual thermal resistance of the insulation per metre of thickness.

5.10.4. Every exhaust duct or exhaust opening discharging air to the outdoors, and every outside air intake duct or air intake opening, except those for combustion air, shall be equipped with a power assisted damper located near the *building* exterior, and shall be designed to close automatically when the system is not in operation, except that where the size of a duct does not exceed 0.1 m^2 in cross sectional area, the damper in the supply duct or opening may be manually operated, and the damper in the exhaust duct or opening may consist of a backflow damper.

5.10.5. Air heating equipment located outside of the insulated portion of the *building* shall be equipped with power assisted dampers at the fresh air intake openings and exhaust air openings, and the dampers shall be designed to close automatically when the system is not in operation.

5.10.6. Equipment used only for air cooling or ventilation and located outside of the insulated portion of the *building* shall be equipped with power assisted dampers located in the supply and return ducts at or near the insulated portion of the *building*, and the dampers shall be designed to close automatically when the system is not in operation.

5.10.7. Power assisted dampers required in Articles 5.10.4. to 5.10.6. shall be designed so that air flow with the damper in the closed position does not exceed 50 dm^3/s for each square metre of cross sectional area at a pressure of 250 Pa.

SUBSECTION 5.11 BALANCING

5.11.1. Oil, gas and electric heating systems in *dwelling units* and all heating, cooling and ventilating systems not located within *dwelling units* shall be designed with a means for balancing the systems.

5.11.2. *Dwelling units* that are heated by gas, oil or electricity shall be provided with a means to reduce the heating of each room by automatic devices or by means of manually operated dampers, valves or switches as appropriate for the heating system used.

SUBSECTION 5.12 GENERAL EQUIPMENT REQUIREMENTS

5.12.1. When requested by the *authority having jurisdiction*, evidence of the performance characteristics necessary to determine compliance of such equipment with the requirements of Subsections 5.13 to 5.18 shall be provided for all heating, cooling, ventilating and heat recovery equipment.

5.12.2. Where equipment requires periodic servicing to maintain efficient operation, the necessary maintenance instructions shall be provided with the equipment.

5.12.3. The coefficient of performance of equipment systems and components specified in Articles 5.13.1., 5.14.1., 5.15.1. and 5.17.1. shall be determined at an atmospheric pressure of 101.3 kPa.

SUBSECTION 5.13 ELECTRICALLY OPERATED UNITARY OR PACKAGED EQUIPMENT FOR AIR COOLING

5.13.1. Except as provided in Article 5.13.3., unitary cooling equipment, including air-cooled, water-cooled and evaporative-cooled types, packaged terminal air-conditioners and room air-conditioners shall have a coefficient of performance in cooling as described in Article 5.13.2. of at least 1.8 when the standard rating capacity of the cooling equipment is less than 19 kW and at least 2.0 when the standard rating capacity is 19 kW or more where the energy input for cooling is entirely electrical.

5.13.2. For the purpose of this Subsection the coefficient of performance shall mean the ratio of the change in enthalpy between room air entering and conditioned air leaving the equipment, without *reheat*, to the total electrical energy input to all elements of the air-cooling system including compressors, pumps, supply-air fans, return-air fans, condenser-air fans, cooling tower fans and the system equipment control circuit expressed in the same energy units.

5.13.3. Unitary heat pumps for cooling shall conform to CSA C273.3-M1977, "Performance Standard for Unitary Heat Pumps."

5.13.4. The coefficient of performance for system equipment in Article 5.13.1. shall be determined on the basis of the standard rating conditions shown in Table 5.13.A. and Article 5.14.3. for the particular equipment.

Table 5.13.A.

Forming part of Article 5.13.4.

Heating or Cooling Medium	Air Temperature,°C		Water Temperature,°C
	Dry Bulb	Wet Bulb	
Air, entering equipment	26.7	19.4	---
Air, condenser ambient (air cooled)	35	23.9	---
Water, condenser inlet	---	---	29.4
Water, condenser outlet	---	---	35
Column 1	2	3	4

SUBSECTION 5.14 ELECTRICALLY OPERATED COOLING SYSTEM COMPONENTS (WATER CHILLERS AND CONDENSERS)

5.14.1. Heating, cooling and ventilating system components, the energy input of which is entirely electrical, shall have a coefficient of

performance in cooling as described in Article 5.14.2. of not less than the values shown in Table 5.14.A.

5.14.2. For the purpose of this Subsection, the coefficient of performance shall mean the ratio of the difference in total heat content of the water or refrigerant entering and leaving the component to the combined energy inputs to all elements and accessories of the component, including compressors, internal circulating pumps, condenser-air fans, evaporative condenser cooling water pumps, purgers and the system component control circuit expressed in the same energy units.

Table 5.14.A.

Forming part of Article 5.14.1.

MINIMUM COEFFICIENT OF PERFORMANCE OF SYSTEM COMPONENTS FOR COOLING		
Item	Centrifugal Compressor Design	Reciprocating Compressor Design
Water Chiller with Condenser		
air cooled	2.2	2.1
water cooled	3.8	3.2
Water Chiller without Condenser		
air cooled	---	2.6
water cooled	---	3.2
Compressors and Condensing Units 19 kW and over		
air cooled	---	2.3
water cooled	---	3.3

5.14.3. The coefficient of performance for water chillers in Article 5.14.1. shall be determined on the basis of the standard rating conditions shown in Table 5.14.B.

5.14.4. The coefficient of performance for compressor and condensing units in Article 5.14.1. shall be determined in conformance with Section 6 and Table 4 of ARI Standard 520-74, "Standard for Positive Displacement Refrigerant Compressor and Condensing Units."

SUBSECTION 5.15 HEAT OPERATED COOLING EQUIPMENT

5.15.1. Heat operated cooling equipment, including absorption equipment, engine driven equipment and turbine driven equipment shall have a coefficient of performance described in Article 5.15.2. of at least 0.40

Table 5.14.B.

Forming part of Article 5.14.3.

TEMPERATURES FOR STANDARD RATING CONDITIONS(1) FOR WATER CHILLERS, °C		
Location of Measurements	Type of Water Chiller	
	Centrifugal or Self-Contained Reciprocating	Reciprocating Without Integral Condenser
Water temperature leaving chiller	6.7	6.7
Water temperature entering chiller	12.2	12.2
Water temperature leaving condenser	35.0	---
Water temperature entering condenser	29.4	---
Condenser ambient (Air or evaporative cooled)	35.0 dry bulb 23.9 wet bulb	---
Saturation temperature at discharge pressure, for water cooled or evaporative cooled compressors	---	40.6
Saturation temperature at discharge pressure, for air cooled compressors	---	48.9
Column 1	2	3

Note to Table 5.14.B.:

(1) Standard rating conditions for water chillers shall include a water fouling factor for tubes equal to 0.00018 $m^2 \cdot °C/W$, except that when non-ferrous tubes are used the factor may be reduced to 1/2 this value. No fouling factor is necessary for refrigerant.

in the case of direct fired (oil or gas) equipment and of at least 0.65 in the case of indirect fired equipment (steam or hot water).

5.15.2. For the purpose of this Subsection, the coefficient of performance shall be the ratio of the net cooling output of the equipment divided by the total heat input, exclusive of electrical auxiliary inputs.

5.15.3. The coefficient of performance required in Article 5.15.1. shall be determined at standard rating conditions appropriate for the equipment.

SUBSECTION 5.16 COMBUSTION EQUIPMENT FOR SPACE HEATING

5.16.1. Oil burning and gas burning equipment for space heating shall conform to the appropriate Canadian Standards Association or Canadian Gas Association standards for that equipment.

5.16.2. Combustion air for fuel-burning equipment shall be provided in conformance with the requirements in the Canadian Heating, Ventilating and Air-Conditioning Code 1977, as described in the Tables in Appendix B relating to Sentence 2.5.3.(2) of that Code.

SUBSECTION 5.17 HEAT PUMPS FOR HEATING

5.17.1. Except as provided in Article 5.17.4., heat pumps used for heating, including heat pumps in the packaged terminal unit forms and room unit forms, shall have a coefficient of performance of at least 2.2, except that where the heat pump operates from an air source and the standard rating conditions are a dry bulb temperature of -8.3°C and a wet bulb temperature of -9.4°C, the coefficient of performance shall be at least 1.2.

5.17.2. For the purpose of this Subsection, the coefficient of performance shall be the ratio of the change in enthalpy of the air entering and leaving the equipment, exclusive of supplementary heat, divided by the total energy input to all elements of the heat pump including compressors, pumps, supply-air fans, return-air fans, outdoor-air fans and cooling tower fans, and the equipment control circuit, but not including supplementary heaters, all expressed in the same energy units.

5.17.3. The coefficient of performance required in Article 5.17.1. shall be determined at the standard rating conditions appropriate for the equipment but not less than the values shown in Table 5.17.A.

5.17.4. Unitary heat pumps for heating shall conform to CSA C273.3-M1977, "Performance Standard for Unitary Heat Pumps."

5.17.5. Every heat pump used for heating shall be equipped with controls to prevent the operation of supplementary electrical heaters when the heat pump capacity is sufficient to meet the heating demands without the operation of the heaters, except that provision may be made to permit such

Table 5.17.A.

Forming part of Article 5.17.3.

STANDARD RATING CONDITIONS FOR HEAT PUMPS USED FOR HEATING			
Location of Temperature Measurement	Air Source		Water Source
	Condition No. 1	Condition No. 2	
Air entering equipment	21.1°C dry bulb temperature	21.1°C dry bulb temperature	21.1°C dry bulb temperature
Outdoor unit ambient	8.3°C dry bulb and 6.1°C wet bulb temperature	-8.3°C dry bulb and -9.4°C wet bulb temperature	---
Water entering equipment	---	---	15.6°C
Column 1	2	3	4

extra heating capacity over short periods of time to achieve a faster response to temperature demands such as during start-up, change in thermostat temperature setting and during periods of defrost.

(A 2-stage room thermostat that controls the supplementary electrical heaters on its second stage may be used to meet this requirement, where the setting to actuate the compression heating operation is higher than the setting for the operation of the supplementary heaters.)

SUBSECTION 5.18 HEAT RECOVERY SYSTEMS

5.18.1. Except as provided in Article 5.18.6., *buildings* with air systems exhausting to the outdoors shall be provided with a heat recovery system when the sensible heat content of the total quantity of exhaust air calculated in conformance with Articles 5.18.2. and 5.18.3. exceeds 300 kW.

5.18.2. When the exhaust air temperature does not exceed 30°C the sensible heat content of exhaust air in kilowatts shall be calculated as

$$0.00123Q\ (t_e - t_o)$$

where Q is the rated capacity of the *building* exhaust air system at normal exhaust air temperature in dm^3/s,
t_e is the temperature (°C) of the exhaust air before passing through any heat recovery systems, and
t_o is the outdoor design temperature based on the 2½ per cent value for January (°C).

5.18.3. When the exhaust air temperature exceeds 30°C, the sensible heat content of the exhaust air in kilowatts shall be calculated as

$$\frac{Q \cdot c \cdot (t_e - t_o)}{1\ 000v}$$

where Q is the rated capacity of the *building* exhaust air system in dm^3/s,
c is the specific heat of exhaust air at exhaust air conditions in $kJ/kg \cdot °C$,
t_e is the temperature (°C) of the exhaust air before passing through any heat recovery systems,
t_o is the outdoor design temperature (°C) based on the $2\frac{1}{2}$ per cent value for January, and
v is the specific volume of exhaust air at exhaust air conditions in m^3/kg.

5.18.4. Heat recovery systems required in Article 5.18.1. shall be capable of recovering at least 40 per cent of the total sensible heat content of the air exhausted from the *building*, calculated in Articles 5.18.2. and 5.18.3.

5.18.5. Except as provided in Article 5.18.6., *buildings* with air cooling systems shall be designed to recover heat that would otherwise be rejected by condenser water where the maximum amount of heat that can be recovered exceeds 600 kW.

5.18.6. Heat recovery systems described in Articles 5.18.1. and 5.18.5. may be reduced in capacity from that required provided they are sized to recover as much heat as can be effectively used in the *building*.

SECTION 6 SERVICE WATER HEATING

SUBSECTION 6.1 GENERAL

6.1.1. This Section applies to service water heating systems for all *buildings* within the scope of these Measures.

6.1.2. Service water heating systems shall be designed and installed in conformance with the NBC 1977.

SUBSECTION 6.2 PERFORMANCE EFFICIENCY

6.2.1. The stand-by loss for storage tanks for electric *service water heaters* shall not exceed the stand-by loss permitted in CSA C191-1973, "Performance Requirements for Electric Storage-Tank Water Heaters," but in no case shall it be greater than 43 W/m^2 of tank surface.

6.2.2. Storage tanks for gas-fired and oil-fired *service water heaters* shall have an hourly stand-by loss of not more than 4.3 + 0.25/v, expressed as a percentage, where "v" is the tank volume in cubic metres.

6.2.3. Gas-fired and oil-fired *service water heaters* shall have a thermal recovery efficiency of not less than 70 per cent.

6.2.4. The stand-by loss percentage and the thermal recovery efficiency in Articles 6.2.2. and 6.2.3. shall be determined in conformance with the method described in CAN1-4.1-77, "Gas-Fired Automatic Storage Type Water Heaters with Inputs Less than 75,000 Btuh."

(In the case of oil-fired *service water heaters*, the heat input, Q × H, referred to in the Standard shall be determined by multiplying the total volume of oil used in the test by the heating value of the oil.)

SUBSECTION 6.3 INSULATION

6.3.1. Except as required in Articles 6.2.1. and 6.2.2., hot water storage tanks shall be insulated in conformance with the requirements for pipe insulation in Article 5.8.1. for pipe sizes 8 in. and larger.

6.3.2. Piping for recirculating service water heating systems shall be insulated to meet the requirements of Article 5.8.1. for pipes containing fluids at a temperature of between 50°C and 95°C.

SUBSECTION 6.4 SWIMMING POOLS

6.4.1. Heated swimming pools, other than those used for therapeutic purposes, shall be equipped with controls to shut off the supply of oil, gas and electricity used for heating the pool water when the pool temperature reaches 27°C.

6.4.2. Unenclosed heated pools shall be designed so that the supply of oil, gas and electricity used for heating the pool water is automatically shut off whenever the outdoor air temperature is below 10°C.

6.4.3. Except for swimming pools located within a *dwelling unit*, indoor heated pools shall be provided with heat recovery equipment designed to preheat the make-up water to within 5°C of the discharge water temperature.

SECTION 7 ELECTRIC LIGHTING

SUBSECTION 7.1 GENERAL

7.1.1. This Section applies to all *occupancies* except for *dwelling units*.

7.1.2. Calculations for the design of lighting levels shall be in conformance with good engineering practice.

(The procedures described in the IES Handbook and in the IES Recommended Practice Booklets are considered to be good engineering practice.)

SUBSECTION 7.2 LIGHTING SWITCHING

7.2.1. Except for enclosed stairways and corridors used by the public, switches shall be provided in accessible locations within sight of the lights controlled.

7.2.2. Where task lighting is installed other than in the ceiling, such lighting shall be provided with switches located adjacent to the work station served.

7.2.3. Where lighting switches are grouped, they shall be suitably identified to indicate the area controlled by the switch.

SUBSECTION 7.3 LIGHTING LEVELS

7.3.1. Design task lighting levels shall not exceed by more than 10 per cent the values recommended in the IES Lighting Handbook, fifth edition, for the particular work function to be carried out in the area to be lighted.

7.3.2.(1) The electrical load of all wired-in and plugged-in lighting fixtures required to meet the design lighting levels specified in Article 7.3.1., including ballast and other control gear, shall not exceed an average of

(a) 22 W/m^2 of *floor surface area* for *major occupancies* classified as *business and personal services occupancies*, libraries, schools and colleges, and

(b) 50 W/m^2 of *floor surface area* for *major occupancies* classified as *mercantile occupancies*, except that the electrical load of all lighting fixtures in any individual retail sales area shall not exceed an average of 85 W/m^2 of *floor surface area*.

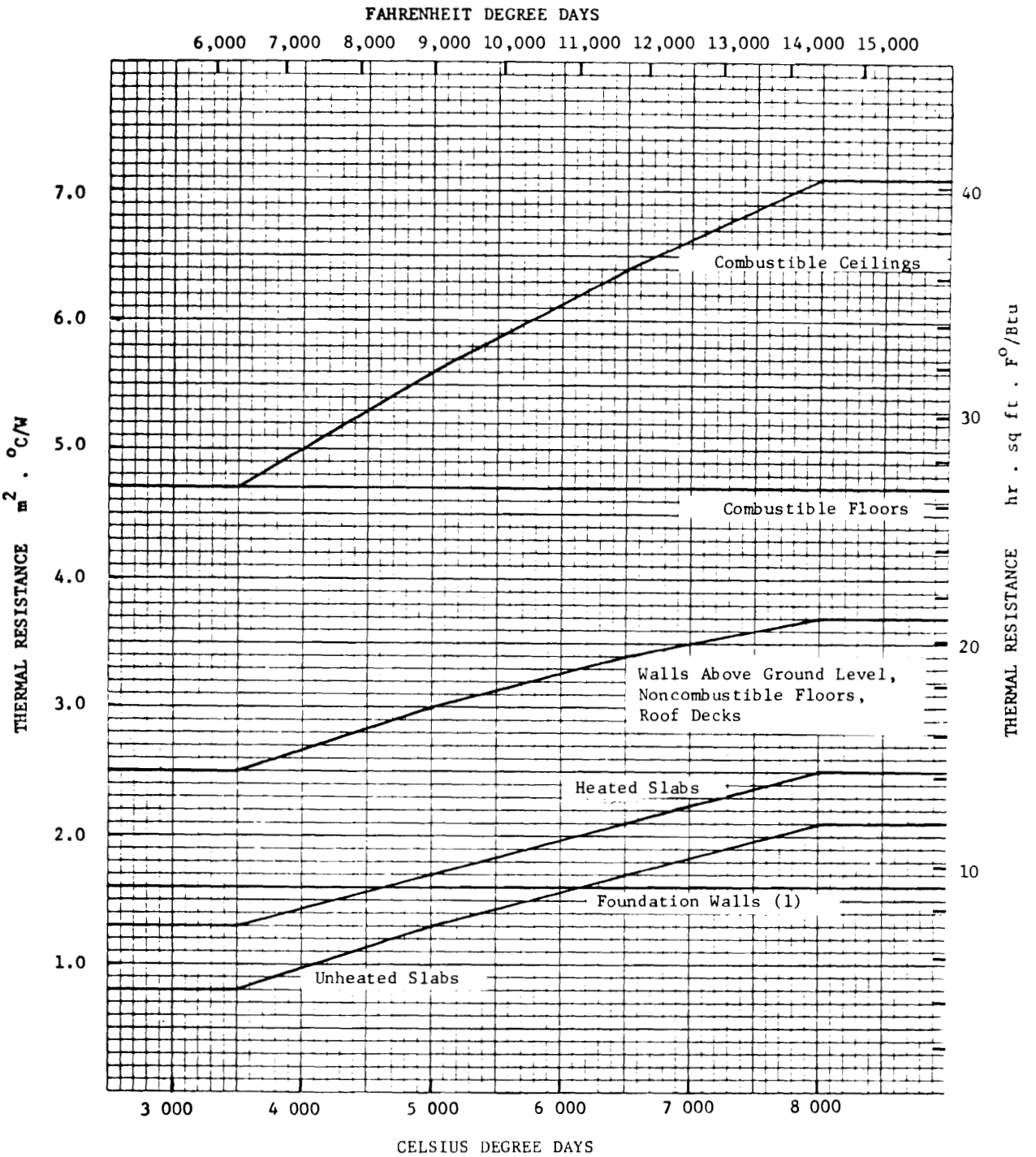
A P P E N D I X A

Explanatory Material

for

Measures for Energy Conservation in New Buildings

Article 3.2.1. Minimum Thermal Resistance Values



NOTE: (1) Every foundation wall face having more than 50 per cent of its area exposed to the outside air, and those parts of foundations walls of wood-frame construction above exterior ground level shall have a minimum thermal resistance conforming to the requirements for wall assemblies above ground level.

(Article 3.3.5.)

Example of how article is to be applied.

Assume floor surface area of storey = 150 m^2

Assume house is in a 6 000 °C degree day area

Assume owner wishes to use 10 m^2 of triple glazing (R = 0.45) and the remainder double glazing (R = 0.30)

Problem: What is the total amount of glass permitted?

Solution:

Total area of double glazing permitted

$$= 0.15 \times 150 = 22.5 \text{ m}^2$$

Equivalent area of 10 m^2 of triple glazing

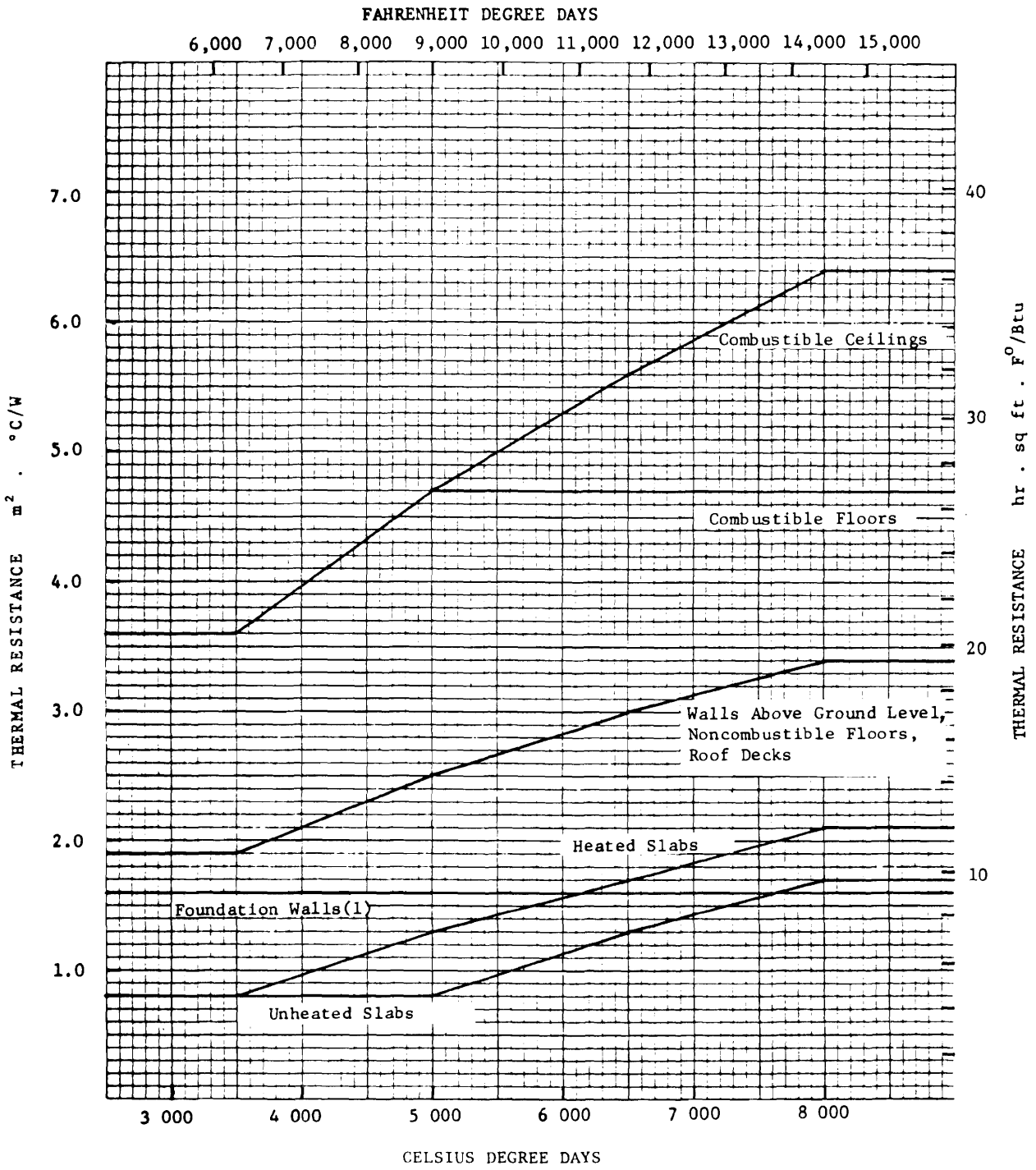
$$= \frac{0.30 \times 10}{0.45} = 6.67 \text{ m}^2$$

Additional area of double glazing permitted

$$= 22.5 - 6.67 = 15.83 \text{ m}^2$$

Total glass area = 15.83 + 10 = 25.83 m^2.

Article 4.2.1. Minimum Thermal Resistance Values



NOTE: (1) Every foundation wall face having more than 50 per cent of its area exposed to the outside air, and those parts of foundations walls of wood-frame construction above exterior ground level shall have a minimum thermal resistance conforming to the requirements for wall assemblies above ground level.

A P P E N D I X B

Imperial Equivalents of Metric Values

APPENDIX B

Imperial units equivalent to Metric units used in these Measures.

Abbreviations of Words and Phrases used in Appendix B

Btu.....British thermal unit(s)

cfm.....cubic foot (feet) per minute

cu ft.....cubic foot (feet)

°F.....degree(s) Fahrenheit (Temperature)

F°.....Fahrenheit degree(s) (Temperature difference)

hr.....hour(s)

in. .....inch(es)

lb.....pound(s)

psi.....pound(s) per square inch

R.....thermal resistance

sq ft.....square foot (feet)

W.....watt(s)

Reference	Metric Units	Equivalent Imperial Units	Remarks
2.1.4.	10 W/m^2	3.17 Btu/hr • sq ft	
3.1.2.	25 W/m^2	7.93 Btu/hr • sq ft	
Table 3.2.A.	---	---	See Appendix C
3.2.5.	18°C	64.4°F	
3.2.5.	$R_1 = \frac{t_i - t_o}{18 - t_o} \cdot R$	$R_1 = \frac{t_i - t_o}{64.4 - t_o} \cdot R$	
3.2.5.	°C	°F	
3.2.5.	$m^2 \cdot °C/W$	hr • sq ft • F°/Btu	
3.2.6.	2.1 $m^2 \cdot °C/W$	11.9 hr • sq ft • F°/Btu	
3.2.8.	600 mm	23.6 in.	
3.2.9.	600 mm	23.6 in.	
3.2.9.	50 mm	2.0 in.	
3.3.1.	0.30 $m^2 \cdot °C/W$	1.70 hr • sq ft • F°/Btu	
3.3.1.	6 mm	0.24 in.	
3.3.2.	Celsius degree days	Fahrenheit degree days	
3.3.2.	6 500	11,700	
3.3.2.	0.45 $m^2 \cdot °C/W$	2.56 hr • sq ft • F°/Btu	
3.3.2.	6 mm	0.24 in.	
3.3.3.	0.16 $m^2 \cdot °C/W$	0.91 hr • sq ft • F°/Btu	
3.4.3.	0.7 $m^2 \cdot °C/W$	4.0 hr • sq ft • F°/Btu	
3.5.1.	0.775 dm^3/s for each metre	0.50 cfm for each foot	
3.5.1.	75 Pa	0.30 in. of water	
3.5.2.	2.5 dm^3/s for each square metre	0.49 cfm for each sq ft	
3.5.3.	6.35 dm^3/s for each square metre	1.25 cfm for each sq ft	
3.5.4.	17.0 dm^3/s for each metre	11.0 cfm for each foot	
4.2.5.	18°C	64.4°F	
4.2.5.	$R_1 = \frac{t_i - t_o}{18 - t_o} \cdot R$	$R_1 = \frac{t_i - t_o}{64.4 - t_o} \cdot R$	
4.2.5.	°C	°F	

Reference	Metric Units	Equivalent Imperial Units	Remarks
4.2.5.	$m^2 \cdot °C/W$	hr • sq ft • F°/Btu	
4.2.6.	2.1 $m^2 \cdot °C/W$	11.9 hr • sq ft • F°/Btu	
Table 4.2.A.	---	---	See Appendix C
4.5.4.(1)(d)	150 m^2	1,615 sq ft	
5.4.2.	13°C	55.4°F	
5.4.2.	24°C	75.2°F	
5.4.3.	29°C	84.2°F	
5.4.3.	24°C	75.2°F	
5.4.4.	1.5°C	2.7 F°	
5.6.6.	2 500 dm^3/s	5,300 cfm	
5.7.1.	1 200 dm^3/s	2,540 cfm	
5.7.1.	20 kW	68,200 Btu/hr	
5.8.1.	13°C	55.4°F	
5.8.1.	50°C	122°F	
Table 5.8.A.	---	---	See Appendix C
5.9.1.	15°C	59°F	
5.9.1.	0.02 times the difference in temperature in °C	0.067 times the difference in temperature in F°	expressed in hr•sq ft•F°/Btu
5.10.3.	10 m/s	1,970 ft/min	
5.10.3.	500 Pa	2.0 in. of water	
5.10.4.	0.1 m^2	1.1 sq ft	
5.10.7.	50 dm^3/s for each square metre	9.8 cfm for each sq ft	
5.10.7.	250 Pa	1.0 in. of water	
5.12.3.	101.3 kPa	14.7 psi	
5.13.1.	19 kW	64,800 Btu/hr	
Table 5.13.A.	---	---	See Appendix C
Table 5.14.A.	19 kW	64,800 Btu/hr	
Table 5.14.B.	---	---	See Appendix C
5.17.1.	-8.3°C	17°F	
5.17.1.	-9.4°C	15°F	
Table 5.17.A.	---	---	See Appendix C

Reference	Metric Units	Equivalent Imperial Units	Remarks
5.18.1.	300 kW	1,024,000 Btu/hr	
5.18.2.	30°C	86°F	
5.18.2.	kilowatts	Btu/hr	
5.18.2.	$0.00123Q\ (t_e - t_o)$ where Q is rated capacity in dm^3/s t_e is in °C t_o is in °C	$1.10Q\ (t_e - t_o)$ **where Q is rated capacity** **in cfm** **t_e is in °F** **t_o is in °F**	
5.18.3.	30°C	86°F	
5.18.3.	kilowatts	Btu/hr	
5.18.3.	$\frac{Q \cdot c \cdot (t_e - t_o)}{1\ 000v}$ where Q is rated capacity in dm^3/s c is specific heat in kJ/kg °C v is specific volume in m^3/kg	$60Q \cdot \frac{c}{v}(t_e - t_o)$ where Q is rated capacity in cfm c is specific heat in Btu/lb·F° v is specific volume in cu ft/lb	
5.18.5.	600 kW	2,047,000 Btu/hr	
6.2.1.	43 W/m^2	4 W/sq ft	
6.2.2.	4.3 + 0.25/v cubic metres	4.3 + 56/v Canadian gallons	
6.3.2.	50°C to 95°C	122°F to 203°F	
6.4.1	27°C	80.6°F	
6.4.2.	10°C	50°F	
6.4.3.	5°C	9 F°	
7.3.2.(a)	22 W/m^2	2.04 W/sq ft	
7.3.2.(b)	50 W/m^2	4.65 W/sq ft	
7.3.2.(b)	85 W/m^2	7.9 W/sq ft	

A P P E N D I X C

Imperial Equivalents of Tabular Values

Table 3.2.A.

Forming part of Article 3.2.1.

MINIMUM THERMAL RESISTANCE (R VALUE), hr · sq ft · F°/Btu				
	Maximum Number of Fahrenheit Degree Days(1)			
Building Assembly	up to 6,300	9,000	11,700	14,400 and over
Wall assemblies above ground level (other than foundation walls) separating heated space from unheated space or the outside air	14.2	17.0	19.3	21.0
Foundation wall assemblies separating heated space from unheated space, outside air or adjacent earth(2)	9.0	9.0	9.0	9.0
Roof or ceiling assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	26.7	31.8	36.3	40.3
(b) if *noncombustible construction* is required	14.2	17.0	19.3	21.0
Floor assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	26.7	26.7	26.7	26.7
(b) if *noncombustible construction* is required	14.2	17.0	19.3	21.0
Perimeters of slab-on-ground floors that are less than 23.6 in. below adjacent ground level (insulation only)				
(a) slabs where heating ducts, pipes or resistance wiring are embedded in or beneath the slabs	7.4	9.7	11.9	14.2
(b) slabs other than those described in (a)	4.5	7.4	9.7	11.9
Column 1	2	3	4	5

Notes to Table 3.2.A.:

(1) Where the number of degree days for a particular area is different from those listed, interpolation between values shown in the Table may be made to obtain the minimum required thermal resistance values for that area.

(2) Every foundation wall face having more than 50 per cent of its area exposed to outside air and those parts of foundations walls of wood-frame construction above exterior ground level shall have a thermal resistance conforming to the requirements for wall assemblies above ground level.

Table 4.2.A.

Forming part of Article 4.2.1.

MINIMUM THERMAL RESISTANCE (R VALUE), hr • sq ft • F°/Btu				
	Maximum Number of Fahrenheit Degree Days(1)			
Building Assembly	up to 6,300	9,000	11,700	14,400 and over
Wall assemblies above ground level (other than foundation walls) separating heated space from unheated space or the outside air	10.8	14.2	17.0	19.3
Foundation wall assemblies separating heated space from unheated space, outside air or adjacent earth(2)	9.0	9.0	9.0	9.0
Roof or ceiling assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	20.4	26.7	31.8	36.3
(b) if *noncombustible construction* is required	10.8	14.2	17.0	19.3
Floor assemblies separating heated space from unheated space or the exterior				
(a) if *combustible construction* is permitted	20.4	26.7	26.7	26.7
(b) if *noncombustible construction* is required	10.8	14.2	17.0	19.3
Perimeters of slab-on-ground floors that are less than 23.6 in. below adjacent ground level (insulation only)				
(a) slabs where heating ducts, pipes or resistance wiring are embedded in or beneath the slabs	4.5	7.4	9.7	11.9
(b) slabs other than those described in (a)	4.5	4.5	7.4	9.7
Column 1	2	3	4	5

Notes to Table 4.2.A.:

(1) Where the number of degree days for a particular area is different from those listed, interpolation between values shown in the Table may be made to obtain the minimum required thermal resistance values for that area.

(2) Every foundation wall face having more than 50 per cent of its area exposed to outside air and those parts of foundation walls of wood-frame construction above exterior ground level shall have a thermal resistance conforming to the requirements for wall assemblies above ground level.

Table 5.8.A.

Forming part of Article 5.8.1.

Fluid Temperature Range, °F	Insulation Thickness,(1) in.				
	Nominal Pipe Size				
	1 in. and less	1¼-2 in.	2½-4 in.	5-6 in.	8 in. and larger
304 - 464	1.5	2.0	2.5	3.5	3.5
250 - 303	1.5	2.0	2.5	3.0	3.0
204 - 249	1.0	1.5	1.5	2.0	2.0
122 - 203	0.75	1.0	1.0	1.0	1.5
41 - 55	0.5	0.75	1.0	1.0	1.0
Below 41	1.0	1.5	1.5	1.5	1.5
Column 1	2	3	4	5	6

Note to Table 5.8.A.:

(1) Table 5.8.A. is based on insulation with a thermal resistance per inch of thickness of 4.3 hr•sq ft•°F/Btu, where the thermal resistance is determined from the thermal conductivity measured in conformance with ASTM C177-76, "Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate." For insulation having a thermal resistance per inch other than 4.3 hr•sq ft•°F/Btu, the thickness of thermal insulation is determined by multiplying the thickness values in the Table by 4.3/R, where R is the actual thermal resistance of the insulation per inch of thickness.

Table 5.13.A.

Forming part of Article 5.13.4.

Heating or Cooling Medium	Air Temperature, °F		Water Temperature, °F
	Dry Bulb	Wet Bulb	
Air, entering equipment	80	67	---
Air, condenser ambient (air cooled)	95	75	---
Water, condenser inlet	---	---	85
Water, condenser outlet	---	---	95
Column 1	2	3	4

Table 5.14.B.

Forming part of Article 5.14.3.

TEMPERATURES FOR STANDARD RATING CONDITIONS(1) FOR WATER CHILLERS, °F		
Location of Measurements	Type of Water Chiller	
	Centrifugal or Self-Contained Reciprocating	Reciprocating Without Integral Condenser
Water temperature leaving chiller	44	44
Water temperature entering chiller	54	54
Water temperature leaving condenser	95	---
Water temperature entering condenser	85	---
Condenser ambient (Air or evaporative cooled)	95 dry bulb 75 wet bulb	---
Saturation temperature at discharge pressure, for water cooled or evaporative cooled compressors	---	105
Saturation temperature at discharge pressure, for air cooled compressors	---	120
Column 1	2	3

Note to Table 5.14.B.:

(1) Standard rating conditions for water chillers shall include a water fouling factor for tubes equal to 0.0010 hr·sq ft·F°/Btu, except that when non-ferrous tubes are used the factor may be reduced to 1/2 this value. No fouling factor is necessary for refrigerant.

Table 5.17.A.

Forming part of Article 5.17.3.

STANDARD RATING CONDITIONS FOR HEAT PUMPS USED FOR HEATING			
Location of Temperature Measurement	Air Source		Water Source
	Condition No.1	Condition No.2	
Air entering equipment	70°F dry bulb temperature	70°F dry bulb temperature	70°F dry bulb temperature
Outdoor unit ambient	47°F dry bulb and 43°F wet bulb temperature	17°F dry bulb and 15°F wet bulb temperature	--- ---
Water entering equipment	---	---	60°F
Column 1	2	3	4