MEASURES FOR ENERGY CONSERVATION IN NEW BUILDINGS 1983

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MEASURES FOR ENERGY CONSERVATION IN NEW BUILDINGS 1983

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PREFACE

This document is based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90A-1980, but modified in format and content to reflect Canadian objectives and conditions.

It contains in the Appendix much of the material from the Commentary on the Measures for Energy Conservation in New Buildings 1978, formerly published as a separate document.

A new simplified Section on houses facilitates the use of the requirements for housing by collecting them into one Section, either by duplicating the requirements from other Sections or by making reference to them.

The Measures provide a basis for improving the energy use characteristics of new buildings and are intended to be minimum requirements. They reflect in part optimum practice as determined by analysis based on certain assumptions as described in the Appendix. These assumptions will not necessarily be valid for all locations and circumstances. Depending on local construction and fuel costs, optimum requirements may be significantly higher than the minimum requirements herein.

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 justifiable deviations.

A table to convert SI units to imperial units can be found inside the back cover of this document.

Comments on this document are welcomed and will be considered during the preparation of the next edition. It is important for the further development of these Measures that difficulties encountered in their applications should be brought to the attention of the Associate Committee on the National Building Code. Comments 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, taking into account the specialized use of terms by the various trades and professions to which the terminology applies. (See Appendix.)

1.1.2. The words and terms in italics in these Measures have the following meanings: (See Appendix.)

*Appliance** means a device to convert fuel into energy and includes all components, controls, wiring and piping required to be part of the device by the applicable standard referred to in the National Building Code of Canada 1980.

*Authority having jurisdiction** means the governmental body responsible for the enforcement of any part of this Code or the official or agency designated by that body to exercise such a function.

*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.

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

Degree days means the summation of the differences between 18°C and the mean daily temperature for each day in the year when the mean daily temperature is below 18°C.

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 *suite* 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.

Heated space means any space within a *building* that is intended to be heated either directly or indirectly by a heating system.

*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.

*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 CAN4-S114-M80, "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.

*Occupancy, major** 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*.

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

*Plenum** means a chamber forming part of an air duct system.

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, and includes both the addition of heat in an air duct entering the zone and the addition of heat to the air within the zone.

*Residential occcupancy** 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 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.

*Suite** means a single room or series of rooms of complementary use, operated under a single tenancy, and includes *dwelling units*, individual guest rooms in motels, hotels, boarding houses, rooming houses and dormitories as well as individual stores and individual or complementary rooms for *business and personal services occupancies.*

Unheated space means any space within a *building* other than *heated space.* (See Appendix.)

SUBSECTION 1.2 ABBREVIATIONS OF NAMES AND ASSOCIATIONS

1.2.1. The abbreviations in these Measures for the names and associations shall have the meanings assigned to them in Subsection 1.4.1. of the National Building Code of Canada 1980 and the following:

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

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

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 Subsection 1.4.2. of the National Building Code of Canada 1980 and the following:

RSI .... Thermal resistance in SI Units ($m^2 \cdot °C/W$).

SECTION 2 GENERAL

SUBSECTION 2.1 APPLICATION

2.1.1. These Measures apply to the design and construction of *buildings* to limit subsequent energy use. (See Appendix.)

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 seasonal cottages or similar *buildings* that are not intended to be heated on a continuing basis during winter months, or to farm *buildings* other than *dwelling units*.

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*.

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. (See Appendix.)

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

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, such as described in the ASHRAE Handbooks, the HRAI Digest and the HI Manuals.

SUBSECTION 2.3 REFERENCE DOCUMENTS

2.3.1. Unless otherwise specified in these Measures, the documents referred to shall be those current as of January 1, 1983, together with all amendments, revisions and supplements effective to that date.

2.3.2. In the case of conflict between the requirements in these Measures and those of a referenced document, the requirements in these Measures shall govern.

2.3.3. Requirements in these Measures shall be carried out in conformance with the National Building Code of Canada 1980.

2.3.4. The climatic values required for the design of *buildings* under these Measures shall be the values established by the *authority having jurisdiction* or, in the absence of such data, with the climatic values in Chapter 1, "Climatic Information for Building Design in Canada" of the Supplement to the NBC 1980. (See Appendix.)

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 other than houses as described in Section 8. (See Appendix.)

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. (See Appendix.)

SUBSECTION 3.2 THERMAL RESISTANCE OF ASSEMBLIES

3.2.1. Except as provided in Articles 3.2.2. to 3.2.9., 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.)

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. (See Appendix.)

3.2.3. Article 3.2.2. for *building* assemblies incorporating thermal bridges does not apply where these bridges are insulated to restrict heat flow through them 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. (See Appendix.)

3.2.4. The thermal resistance of a *building* assembly may be reduced from that required in Articles 3.2.1. and 3.2.2. provided that the thermal resistance of other assemblies of the *building* are increased so 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 of Articles 3.2.1. or 3.2.2. (See Appendix.)

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

$$RSI_I = \frac{t_i - t_o}{18 - t_o} \cdot RSI$$

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

RSI 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 Articles 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 clearances for ventilation, 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. (See Appendix.)

Table 3.2.A.
Forming part of Article 3.2.1.

MINIMUM THERMAL RESISTANCE, RSI[1]				
Building Assembly	Maximum Number of *Degree Days*			
	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	3.0	3.6	4.1	4.5
Foundation wall assemblies separating *heated space* from *unheated space,* outside air or adjacent earth	2.2	2.2	2.2	2.2
Roof or ceiling assemblies separating *heated space* from *unheated space* or the exterior (a) if *combustible construction* is permitted (b) if *noncombustible construction* is required	 4.7 2.6	 5.6 3.1	 6.4 3.5	 7.1 3.9
Floor assemblies separating *heated space* from *unheated space* or the exterior (a) if *combustible construction* is permitted (b) if *noncombustible construction* is required	 4.7 2.6	 4.7 3.1	 4.7 3.5	 4.7 3.9
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 (b) slabs other than those described in (a)	 1.3 0.8	 1.7 1.3	 2.1 1.7	 2.5 2.1
Column 1	2	3	4	5

Note to Table 3.2.A.:

(1) (See Appendix.)

3.2.8. Where the number of *degree days* for a particular region is different from those listed in Table 3.2.A., interpolation between values or extrapolation for values below 3 500 may be made to obtain the minimum required thermal resistance values for that region. (See Appendix.)

3.2.9. 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. (See Appendix.)

3.2.10. Insulation applied to the exterior of a slab-on-ground floor shall extend down to at least 600 mm below the adjacent exterior ground level, or shall extend down and outward from the floor for a total distance of at least 600 mm, measured from the adjacent finished ground level. (See Appendix.)

3.2.11. Insulation applied to a basement foundation wall shall extend from the floor above such walls down to the basement floor, except that such insulation need not extend more than 2.4 m below the exterior adjacent ground level. (See Appendix.)

3.2.12. Insulation applied to a crawl space foundation wall shall extend from the floor above such walls down to not less than 600 mm below the exterior adjacent ground level, or to the floor of the crawl space, whichever is greater, except that where the insulation is of a type that may be damaged by water, a clearance of at least 50 mm shall be provided between the bottom of the insulation and the floor of the crawl space.

SUBSECTION 3.3 GLAZING

3.3.1. Except as provided in Articles 3.3.2., 3.3.5. and 3.4.4., all glass or other glazing material that separates *heated space* from *unheated space* or the exterior shall be double glazed with a spacing of at least 12 mm between the panes, or have a thermal resistance of at least 0.35 $m^2 \cdot °C/W$. (See Appendix.)

3.3.2. Except as provided in Article 3.3.5., where a *building* is located in a region where the number of *degree days* exceeds 6 500, all windows and skylights shall be triple glazed with spacings of at least 6 mm between the panes, or have a thermal resistance of at least 0.45 $m^2 \cdot °C/W$.

3.3.3. Where an enclosed *unheated space*, such as a sun porch, enclosed verandah or vestibule, is separated from a *heated space* by glass or other glazing material, the unheated enclosure may be considered to provide a thermal resistance of 0.16 $m^2 \cdot °C/W$ or the equivalent of 1 layer of glass.

3.3.4. Except as provided in Articles 3.3.5. and 3.3.6., the total area of glass or other glazing material, including glass 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 glass 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. (See Appendix.)

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

3.3.6. Except as provided in Article 3.3.7., the area of clear glass or other glazing material that has a shading coefficient of more than 0.70, that is unshaded in the winter at noon on December 21, 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 glass in Articles 3.3.4. and 3.3.5. provided the *building* is designed so that it is capable of distributing the solar heat gain from such glazed areas throughout the *building*.

3.3.7. Article 3.3.6. shall not apply where the *building* is designed to be cooled by the use of a refrigerating machine unless the glass or other glazing material described in Article 3.3.6. is shaded in the summer at noon on June 21 with exterior devices. (See Appendix.)

SUBSECTION 3.4 DOORS

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

3.4.2. Except for doors on enclosed unheated vestibules, the opaque portions of 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.

3.4.3. Glass inserts in doors need not provide the thermal resistance required in Article 3.3.2. provided they are double glazed and provided the overall heat loss does not exceed that which would occur if the door had the thermal resistance required in Article 3.4.3. over its entire area.

SUBSECTION 3.5 AIRTIGHTNESS

3.5.1. Windows separating *heated space* from *unheated space* or the exterior shall conform to the air leakage requirements in the applicable window standards listed in Part 9 of the National Building Code 1980.

3.5.2. Manually operated exterior sliding glass door assemblies that separate *heated space* from *unheated space* or the exterior shall conform to the air leakage requirements in CGSB 82-GP-2m(1977), "Doors, Glass, Aluminum Frame, Sliding, Medium-Duty."

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* and individually rented hotel and motel rooms and *suites* shall be designed to limit the rate of air leakage to not more than 2.54 L/s for each square metre of door area when tested in conformance with ASTM E 283-73, "Standard Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors."

3.5.4. Except for doors used primarily to facilitate the movement of vehicles or handling of material, 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 leakage to not more than 17.0 L/s for each metre of door crack when tested in conformance with ASTM E 283-73, "Standard Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors."

3.5.5. 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.

SECTION 4 ENCLOSURES FOR BUILDING 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 other than houses described in Section 8. (See Appendix.)

SUBSECTION 4.2 THERMAL RESISTANCE OF ASSEMBLIES

4.2.1. Except as permitted in Articles 4.2.2. to 4.2.9., 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.

4.2.2. Except as provided in Article 4.2.3., 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 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 these bridges are insulated to restrict heat flow through them 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 from that required in Articles 4.2.1. and 4.2.2. provided that the thermal resistance of other assemblies of the *building* are increased so 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 of Articles 4.2.1. and 4.2.2.

4.2.5. Where the indoor winter design temperature is less than 18°C, the minimum thermal resistance RSI_1 shall be determined in conformance with the formula

$$RSI_1 = \frac{t_i - t_o}{18 - t_o} \cdot RSI$$

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

RSI 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 values in Articles 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 clearances for ventilation, 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. Where the number of *degree days* for a particular region is different from those listed in Table 4.2.A., interpolation between values or extrapolation for values below 3 500 may be made to obtain the minimum required thermal resistance values for that region.

4.2.9. 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.

4.2.10. 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 3.2.10. to 3.2.12.

SUBSECTION 4.3 GLAZING

4.3.1. Glass or other glazing material that separates *heated space* from *unheated space* or the exterior shall conform to the appropriate requirements in Subsection 3.3., except that 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 glass may be used. (See Appendix.)

SUBSECTION 4.4 DOORS

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

Table 4.2.A.
Forming part of Article 4.2.1.

MINIMUM THERMAL RESISTANCE, RSI[1]				
Building Assembly	Maximum Number of *Degree Days*			
	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	2.4	3.0	3.6	4.1
Foundation wall assemblies separating *heated space* from *unheated space*, outside air or adjacent earth	2.2	2.2	2.2	2.2
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	2.1	2.6	3.1	3.5
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	2.1	2.6	3.1	3.5
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

Note to Table 4.2.A.:

[1] See Appendix Note to Table 3.2.A.

SUBSECTION 4.5 AIRTIGHTNESS

4.5.1. Measures shall be taken to control air leakage 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.

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. Deviations from requirements of this Section are permitted 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. (See Appendix.)

5.1.2. The requirements in this Section apply to *buildings* of all *occupancy* classifications other than houses except as provided in Section 8.

5.1.3. 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. (See Appendix.)

SUBSECTION 5.2 VENTILATION

5.2.1. Where mechanical ventilation is provided, the ventilating system shall incorporate controls which will allow the system to be operated with not more than the outdoor air quantities equal to that required in ASHRAE 62-81, "Ventilation for Acceptable Indoor Air Quality" where energy is required to either heat or cool the outdoor air.

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, complete with automatic reset to normal operation.

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. (See Appendix.)

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. (See Appendix.)

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. (See Appendix.)

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, complete with automatic reset to normal operation.

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*,
(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 L/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, air leakage 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 L/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, and except as provided in Articles 5.8.2. and 5.8.3., 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*.

5.8.2. Where pipe insulation has a thermal resistivity of less than 0.028 $m^2 \cdot$ °C/W mm, the thickness in Table 5.8.A. shall be increased by the ratio of 0.028/r where r is the measured thermal resistivity of the insulation.

5.8.3. Where pipe insulation has a thermal resistivity of more than 0.032 $m^2 \cdot$ °C/W mm, the thicknesses in Table 5.8.A. may be decreased by the ratio of 0.032/r where r is the measured thermal resistivity of the insulation.

5.8.4. The thermal resistivity of pipe insulation shall be determined in conformance with ASTM C177-76, "Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate."

SUBSECTION 5.9 DUCT INSULATION

5.9.1. Except as provided in Articles 5.9.3. and 5.9.4., where the design temperature difference between ambient air and air within a duct or *plenum* exceeds 15°C, the duct or *plenum* shall be thermally insulated if the heat loss or heat gain from the duct or *plenum* would increase the energy requirements of the *building*. (See Appendix.)

5.9.2. Thermal insulation required in Article 5.9.1. shall have a thermal resistance, expressed in $m^2 \cdot$ °C/W, numerically equal to at least 0.02 times the difference in temperature in °C between ambient air and air within the duct or *plenum*.

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

5.9.4. Supply and return ducts circulating heated or cooled air which 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.

Table 5.8.A.
Forming part of Article 5.8.1.

Fluid Temperature Range, °C	Minimum Insulation Thickness, mm (Thermal resistivity of 0.028 to 0.032$m^2 \cdot$ C/W · mm)			
	Nominal Pipe Size			
	1 in. and less	1¼-2 in.	2½-4 in.	5 in. and larger
151 - 240	64	64	76	89
121 - 150	51	64	64	76
96 - 120	38	38	51	51
50 - 95	25	25	38	38
5 - 13	13	19	25	25
Below 5	25	38	38	38
Column 1	2	3	4	5

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

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

5.10.2. 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.

5.10.3. 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.

5.10.4. 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.

5.10.5. 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.

5.10.6. Power assisted dampers required in Articles 5.10.3. to 5.10.5. shall be designed so that air flow with the damper in the closed position does not exceed 50 L/s for each square metre of cross sectional area at a pressure of 250 Pa. (See Appendix.)

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 so that they can be balanced.

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 system used.

SUBSECTION 5.12 GENERAL EQUIPMENT REQUIREMENTS

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

5.12.2. 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. (See Appendix.)

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, condensers and heat pumps)

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. (See Appendix.)

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	2.28	2.20
water cooled	3.98	3.40
Water chiller without condenser		
air cooled	—	2.78
water cooled	—	3.40
Compressors and condensing units 19 kW and over		
air cooled	—	2.50
water cooled	—	3.48
Column 1	2	3

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 total energy inputs to the component, expressed in the same energy units.

5.24.3. The coefficient of performance for a water chiller or for a water source heat pump in Article 5.14.1. shall be determined on the basis of the standard rating conditons shown in Table 5.14.B.

Table 5.14.B.
Forming part of Article 5.14.3.

TEMPERATURES FOR STANDARD RATING CONDITIONS FOR WATER CHILLERS AND HEAT PUMPS, °C			
Location of Measurements	Type of Water Chiller		Water-Source Heat-Pump
	Centrifugal or Self-Contained Reciprocating	Reciprocating Without Integral Condenser	
Water leaving chiller	6.7	6.7	—
Water entering chiller	12.2	12.2	—
Water leaving condenser	35.0	—	35.0
Water entering condenser	29.4	—	29.4
Air entering indoor portion of unit	—	—	26.7 dry bulb 19.4 wet bulb
Air entering condenser (air- or evaporative-cooled)	35.0 dry bulb 23.9 wet bulb	—	—
Refrigerant discharge from water-cooled or evaporative-cooled compressor	—	40.6[1]	—
Refrigerant discharge from air-cooled compressor	—	48.9[1]	—
Refrigerant liquid water-cooled or evaporative-cooled compressors	—	35.0	—
Refrigerant liquid in air-cooled compressors	—	43.3	—
Air surrounding unit	—	—	26.7
Column 1	2	3	4

Note to Table 5.14.B.:

[1] Saturation temperature at discharge pressure.

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

SUBSECTION 5.15 HEAT-OPERATED COOLING EQUIPMENT

5.15.1. Except as provided in Article 5.15.4., heat operated cooling equipment, including absorption equipment, engine and turbine driven equipment shall have a coefficient of performance described in Article 5.15.2. of at least 0.48 in the case of direct fired (oil or gas) equipment and of at least 0.68 in the case of indirect fired equipment (steam or hot water). (See Appendix.)

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.

5.15.4. Heat operated cooling equipment which is driven by solar energy or by waste heat which cannot be used elsewhere in the *building* need not conform to the requirements of Article 5.15.1.

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.

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 2.5, except that where the heat pump operates from an air source and the standard rating conditions are a dry bulb temperature of minus 8.3°C and a wet bulb temperature of minus 9.4°C, the coefficient of performance shall be at least 1.5. (See Appendix.)

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 the 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.

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

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 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.

SUBSECTION 5.18 HEAT RECOVERY SYSTEMS

5.18.1. Except as provided in Articles 5.18.6. and 5.18.7., *buildings* with air systems exhausting to the outdoors shall be provided with heat recovery systems 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. (See Appendix.)

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 L/s,

t_e is the temperature (°C) of the exhaust air before passing through any heat recovery system, and

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

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 L/s, c is the specific heat of exhaust air at exhaust air conditions in kJ/kg · °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 2½ 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. (See Appendix.)

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. (See Appendix.)

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*.

5.18.7.(1) In *buildings* of *residential occupancy*, exhaust systems need not conform to the requirements of Articles 5.18.1. to 5.18.5. where each exhaust fan of that system

(a) is individually controlled from within the space served,
(b) serves only a single *suite*, and
(c) is of not more than 75 L/s rated capacity.

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.

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 Bt/h."

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 heat 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 such as those described in the Illuminating Engineering Society Lighting Handbook, sixth edition, and in the IES recommended practice booklets.

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, it 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 each 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 Illuminating Engineering Society Lighting Handbook, sixth edition, for the particular work function to be carried out in the area to be lighted. (See Appendix.)

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*. (See Appendix.)

SECTION 8 HOUSES

SUBSECTION 8.1 SCOPE

8.1.1. This Section applies to detached, semi-detached, duplex and row houses. (See Appendix.)

8.1.2. Sections 1 and 2 of these Measures shall apply to houses described in Article 8.1.1. in addition to the requirements in this Section.

SUBSECTION 8.2 THERMAL RESISTANCE

8.2.1. Except as provided in Articles 8.2.3. to 8.2.5., 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 8.2.A. (See Appendix Note to Article 3.2.1.)

Table 8.2.A.
Forming part of Article 8.2.1.

MINIMUM THERMAL RESISTANCE, RSI[1]					
Building Assembly	Maximum Number of *Degree Days*				
	3 000	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	2.8	3.0	3.6	4.1	4.5
Foundation wall assemblies separating *heated space* from *unheated space*, outside air or adjacent earth	2.2	2.2	2.2	2.2	2.2
Roof or ceiling assemblies separating *heated space* from *unheated space* or the exterior	4.4	4.7	5.6	6.4	7.1
Floor assemblies separating *heated space* from *unheated space* or the exterior	4.7	4.7	4.7	4.7	4.7
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	0.9	1.3	1.7	2.1	2.5
(b) slabs other than those described in (a)	0.4	0.8	1.3	1.7	2.1
Column 1	2	3	4	5	6

Note to Table 8.2.A.:

(1) See Appendix Note to Table 3.2.A.

8.2.2. Where metal framing or furring is used in an assembly, the thermal resistance values in Article 8.2.1. shall be modified in conformance with Articles 3.2.2. and 3.2.3.

8.2.3. Except for doors on enclosed unheated vestibules, the opaque portions of 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.

8.2.4. The thermal resistance of a *building* assembly may be reduced from that required in Article 8.2.1. provided the thermal resistance of other assemblies of the *building* are increased in conformance with Article 3.2.4.

8.2.5. The thermal resistance values in Article 8.2.1. 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 $m^2 \cdot °C/W$.

8.2.6. Where the number of *degree days* for a locality is different than the value in Table 8.2.A., the thermal resistance shall be calculated, assuming a proportional relationship between such values and the thermal resistance values listed in the Table. (See Appendix Note to Article 3.2.8.)

8.2.7. Every foundation wall 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.

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

8.2.9. Insulation applied to a basement foundation wall shall extend from the floor above such walls down to the basement floor, except that such insulation need not extend more than 2.4 m below the exterior adjacent ground level. (See Appendix Note to Article 3.2.9.)

8.2.10. Insulation applied to a crawl space foundation wall shall extend from the floor above such walls down to not less than 600 mm below the exterior adjacent ground level or to the floor of the crawl space, whichever is greater, except that where the insulation is of a type that may be damaged by water, a clearance of at least 50 mm shall be provided between the bottom of the insulation and the floor of the crawl space.

SUBSECTION 8.3 GLAZING

8.3.1. Except as provided in Articles 8.3.2. and 8.3.3., all glass or other glazing material that separates *heated space* from *unheated space* or the exterior shall be double glazed with a spacing of at least 12 mm between the panes, except that a 6 mm spacing is permitted for glass in doors. (See Appendix note to Article 3.3.1.)

8.3.2. Except as provided in Article 8.3.3., where a *building* is located in a region where the number of *degree days* exceeds 6 500, all windows and skylights shall be triple glazed with spacings of at least 6 mm between the panes.

8.3.3. Where the thermal resistance of glass or other glazing is different from that required in Articles 8.3.1. and 8.3.2., the area of glass may be adjusted in conformance with Article 3.3.5.

8.3.4. Where an enclosed *unheated space*, such as a sun porch, enclosed verandah or vestibule, is separated from a *heated space* by glass or other glazing material, the unheated enclosure may be considered to provide the equivalent of 1 layer of glass.

8.3.5. Except as provided in Article 8.3.6., the total area of glass or other glazing material, including glass 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.

8.3.6. Where glass or other glazing material faces a direction within 45° of due south, allowable glazed areas may be adjusted in conformance with Article 3.3.6.

SUBSECTION 8.4 AIRTIGHTNESS

8.4.1. Windows separating *heated space* from *unheated space* or the exterior shall conform to the air leakage requirements in the applicable window standards listed in Part 9 of the National Building Code of Canada.

8.4.2. Sliding glass door assemblies that separate *heated space* from *unheated space* or the exterior shall conform to the air leakage requirements in CGSB 82-GP-2M(1977), "Doors, Glass, Aluminum Frame, Sliding, Medium-Duty."

8.4.3. 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 shall conform to the air leakage requirements in Article 3.5.3.

8.4.4. 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.

SUBSECTION 8.5 HEATING, COOLING AND VENTILATING

8.5.1.(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.)

(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. (See Appendix note to Article 5.4.2.)

(3) Thermostats to control air temperatures for space cooling systems shall conform to Article 5.4.3.

(4) Thermostats designed to control air temperatures for both space heating and space cooling systems shall conform to Article 5.4.4.

8.5.2.(1) Supply and return ducts circulating heated or cooled air which are located outside of the insulated portion of the *building* shall be insulated as required in Article 8.2.1. for wall assemblies above ground level (other than foundation walls) separating *heated space* from *unheated space* or the outside air.

(2) Supply and return ducts for heated or cooled air located in *unheated spaces* or spaces outside of the *dwelling unit* shall have all joints sealed.

(3) Kitchen and bathroom exhaust ducts shall be equipped with backflow dampers to prevent air leakage when the exhaust fans are not in operation.

8.5.3. 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.

8.5.4. Heat pumps for heating shall conform to Article 5.12.2. and Subsection 5.17.

8.5.5. Where cooling equipment is used it shall conform to Article 5.12.2. and Subsections 5.13, 5.14 and 5.15.

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

8.5.7. Oil-, gas- and electric-heating systems in *dwelling units* shall be designed so that they can be balanced.

8.5.8. *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 system used.

SUBSECTION 8.6 SERVICE WATER HEATING

8.6.1. Equipment for service water heating shall conform to Section 6.

SUBSECTION 8.7 SWIMMING POOLS

8.7.1. Swimming pools shall conform to Subsection 6.4.

APPENDIX

Explanatory Material
for
Measures for Energy Conservation in New Buildings 1983

Article 1.1.1. Definitions

The ASHRAE Handbook of Fundamentals 1981, Chapter 35, contains a list of terms common to heating, cooling and ventilating systems and is a useful source of information in this field.

Article 1.1.2. National Building Code Definitions

An asterisk(*) following a defined word or term means that the definition for that word or term is taken from the National Building Code of Canada 1980.

Article 1.1.2. Definition of Unheated Spaces

Unheated space is any space the temperature of which in normal use would be subject mainly to the influence of outside temperature, and the temperature in that space would be nearer to outside than to inside air temperature. Although some space such as clothes closets, janitors' closets and washrooms may not have heat added directly to them, they would be indirectly heated from the surrounding area and would be considered to be "heated spaces."

An enclosed exit stairshaft with 1 or more walls forming part of the building exterior wall which contains no equipment to supply heat to the stairshaft would tend to be cooler than adjoining occupied space, but would receive heat by means of thermal transfer through the enclosing interior walls. Provided that the exterior walls of the stairshaft were insulated in conformance with the requirements for a wall separating heated space from outside air, the stairshaft would be considered to be heated space, and walls separating it from adjacent occupied space would not need to be insulated. If the exterior walls of the same stairshaft were not insulated, the stairshaft would then be considered to be unheated space, and the walls separating it from adjacent heated space would have to be insulated.

An interior elevator shaft may terminate within an unheated garage located below heated space. The designer may treat the shaft either as heated space or as unheated space.

If the shaft is considered to be heated space, the walls and floor enclosing that part of the shaft located below the heated portion of the building would have to be insulated and, in addition, because the elevator doors would not limit infiltration into the shaft, a vestibule equipped with doors would be required at each garage level served by the elevator.

If the shaft is considered to be unheated space, the walls separating it from heated space would have to be insulated and, because the elevator doors would not limit infiltration from the shaft into the heated building, vestibules equipped with doors would be required at each heated floor served.

Article 2.1.1. General

The Measures are intended to apply to the materials used for the construction of the building and to systems which provide building heating, cooling, lighting, ventilation and service hot water, but are not intended to apply to equipment or systems used in processing or manufacturing activities within the building. However, where process equipment may incorporate a system to control the internal building environment, the Measures are intended to apply to that part of the system. For example, a paint spray booth serving an industrial process may incorporate an exhaust air system to remove objectionable odours and particles. The Measures apply to that exhaust air system, but do not apply to other components, such as the air compressor associated with the paint spray process.

If the building were heated by "waste heat" generated by a process such as an oven for industrial processes or by equipment in a telephone exchange, the Measures would not apply to this heat-generating equipment, but would apply to the equipment or system that was used to recover and to distribute the heat for building heating purposes.

The requirements are intended to apply to new construction, which, along with new buildings, also includes additions and alterations to existing buildings. The extent of application of these requirements to the alteration of existing buildings must be determined by the authority having jurisdiction. In making this determination, the extent to which the work will affect overall energy consumption and the practicality and economics of applying the requirements in whole or in part should be considered.

Article 2.1.5. Exemptions from Certain Requirements

In a few buildings, the intended use or occupancy may be such that compliance with some requirements could limit or prevent the building from performing its intended function. In such cases, the nature of the occupancy would be considered to make compliance impractical. This Article permits the authority having jurisdiction to review such special cases and to permit deviations. Only the nature of the occupancy, rather than economic or other factors, is to be considered in permitting such deviations.

For example, in buildings in which a continuous process may generate part or all of the heat required to meet building heat losses, requirements for thermal insulation could be relaxed. Some buildings such as smelters may not require any insulation throughout a large area of the building. Some telephone exchanges may require reduced insulation. Greenhouses or airport control towers require more than the permitted amount of glazed area because of the nature of the occupancy.

Article 2.1.6. Deviations Permitted

Article 2.1.6. has the effect of permitting the annual energy consumption of a building constructed to the requirements of this document to be used as an "energy budget," and of permitting deviations from these requirements provided other arrangements are made so that the energy budget is not exceeded. These other arrangements could include reduced energy consumption in other portions of the building, achieved by exceeding the minimum requirements, waste heat recovery in excess of that required or the use of solar energy.

It is expected that the owner would submit calculations of the annual energy loss from all those elements of the building affected by proposed deviations and compensations and, for comparison, calculations of the annual energy loss from the same elements of the building as if they were constructed to the minimum requirements.

For example, a deviation from the requirement that limits the maximum amount of glazed area may be desired for a building to take advantage of a spectacular view. The deviation may be permitted if it could be shown that complete compensation could be made for the calculated increase in annual heating energy due to the excess glazed area. To provide the compensating reductions in annual energy consumption, the thermal resistance value of some of the building assemblies could be increased to exceed the required thermal resistance value. If the design included heat storage and heat recovery from the kitchen, laundry or condenser water as a concession for having excess glazed area, the calculated annual energy saving from such equipment could be taken into consideration.

Article 2.4.4. Climatic Information

Data for municipalities not listed in the Supplement may be obtained by writing to: Head, Energy and Industrial Application Section, Canadian Climate Service, Environment Canada, 4905 Dufferin Street, Downsview, Ontario M3H 5T4.

Article 3.1.1. Application of Sections

Normally, low rise apartment buildings, nursing homes, motels and heated warehouses would fall within the scope of Section 3. Where a building may be designed for multi-use occupancy, it is intended that the total rated power for all occupancies that are heated or cooled should be divided by the total floor surface area of all such occupancies in order to determine whether the exception permitted under Article 3.1.2. applies. For example, a high-rise building containing shops, heated parking, offices and residential occupancies would be constructed either entirely to the requirements of Section 3 of the Measures or entirely to the requirements of Section 4. The residential occupancy would have thermal resistance values the same as those for the office occupancy.

Article 3.1.2. Calculation of Internal Energy

3.1.2. In calculating the average rated power of a building which may be subject to the requirements of Section 4 of the Measures, the interior lighting load to be considered is that only from wired-in fixtures. The intent of allowing only loads from wired-in fixtures and not those from portable lights is to permit easy verification of the lighting load from the drawings. Also, the occupant may decide against installing portable lighting, so that its contribution toward the power load cannot be recognized.

Article 3.2.1. Thermal Resistance Values

Thermal resistance values for building assemblies have been specified in terms of sections through the assemblies between framing. In other words the thermal resistance of an assembly is calculated, for purposes of determining compliance with the values in Table 3.2.A., by simply adding the individual resistances of the various finishes, sheathings and cladding components which make up the assembly, plus an appropriate allowance for surface air films. Except when metal framing elements are used, the effects of heat loss through framing in reducing the overall thermal resistance of the assembly need not be taken into account.

Calculating the effect of framing was considered to be too complex for the purposes of this document. While this effect should be taken into account by the designer of the heating equipment, it is not necessary to do so in the design of the building shell.

If the thermal resistance of the insulation were specified, it could restrict the flexibility of the requirements and would not be fair to those who may wish to use different combinations of materials in the building assembly.

Article 3.2.1. Thermal Resistance Versus Thickness

The thermal resistance (RSI value) of batt-type insulation is measured at a specified thickness. This value is marked on the batt for the specified thickness. Compressing the insulation reduces its total thermal resistance. Thermal resistance values of compressed batt-type insultation can be calculated in accordance with Figure 1. If a batt tested at a specified thickness of 100 mm had an RSI value of 2.1 and was then compressed into a 63 mm strapping space, the insulation would be 63/100 or 63 per cent of its original thickness and, according to Figure 1, would have an effective RSI value of 73 per cent of 2.1 = 1.5.

Articles 3.2.2. and 3.2.3. Effect of Steel Framing

The intent of these Articles is to require higher thermal insulation values for a building assembly to compensate for heat conducted by any metal framing which may be located within the thermal insulating portion of the building assembly. For instance, the steel studs used in an exterior wall assembly or the steel joists used to support a floor located above an unheated space may be located within the insulating material which provides the majority of the thermal resistance of the assembly. If 25 per cent of the required thermal resistance can be provided by those portions of the assembly located to the interior and exterior of the thermal bridge, no adjustment need be made to the required thermal resistance; but if 25 per cent of the required thermal resistance cannot be so provided, the required thermal resistance of the assembly must be increased to 120 per cent of that required if wood framing were used.

In the case of an assembly consisting of built-up roofing, rigid thermal insulation, roof deck, steel joist and suspended tee bar ceiling, at least 25 per cent of the required thermal resistance for the assembly would be provided by the outside air film, built-up roofing, rigid thermal insulation and roof deck. If the metal framing element is not within that portion of the building assembly which provides the required thermal resistance, and therefore does not act as a thermal bridge through it, the thermal resistance need not be increased.

Figure 2 illustrates the application of these Articles to an exterior wall assembly constructed with steel studs.

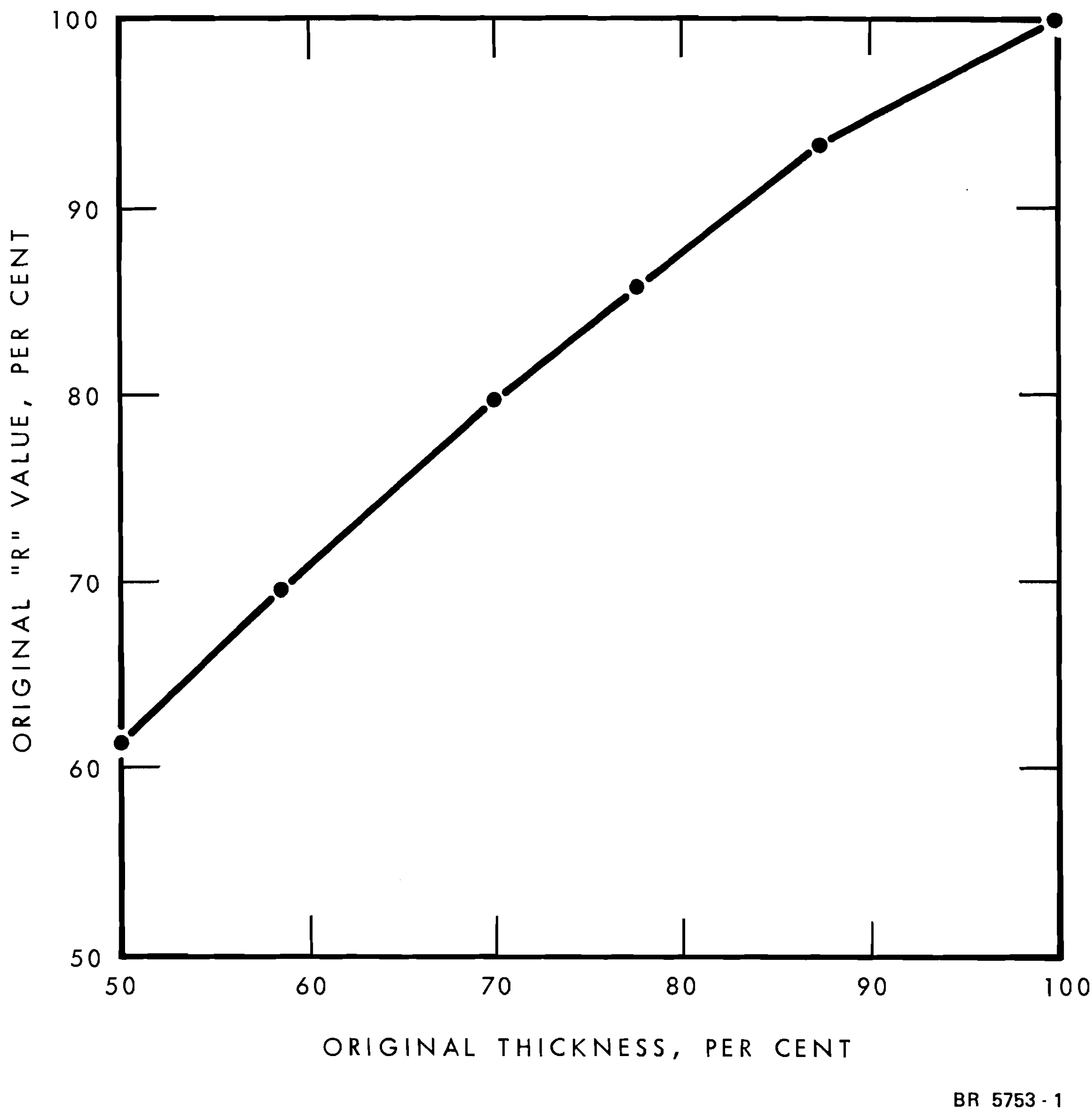
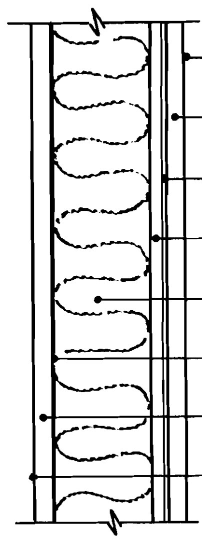


Figure 1 Effect on thermal resistance of compressing batt-type insulation

Articles 3.2.2. and 3.2.3. (Cont'd)



WALL SECTION

	Thermal resistances of components
Outside air film	0.030
Aluminum siding (no backing)	0.123
Building paper	0.001
6 mm plywood	0.055
R 2.1 batt	2.100
Vapour barrier	0.000
12.7 mm drywall	0.079
Inside air film	0.120
Thermal resistance of assembly	2.508

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Figure 2 Thermal resistance of a wall section containing steel studs

If the proposed wall is to be used in a degree day zone that would require, say, a minimum RSI value of 2.16, then 25 per cent of this would be 0.54. The thermal resistance of the elements on the outside and inside faces of the studs is equal to 2.508 − 2.100 = 0.408. Since this is less than 25 per cent of the *required* thermal resistance, then the required RSI through the insulated part of the wall would be 20 per cent more than 2.16 or about 2.59. The assembly in the sketch would, therefore, have to be modified, either by increasing the thermal resistance over the stud flanges by 0.54 − 0.408 = 0.13 units, or by increasing the overall insulation by 2.59 − 2.508 = 0.08 units.

Table 3.2.A. Determination of Thermal Resistance Requirements

Optimum thermal resistance values may be calculated from the formula

$$R = \sqrt{\frac{24 \cdot k \cdot P \cdot C \cdot D}{E \cdot F \cdot B}}$$

where R = optimum thermal resistance,
k = degree day adjustment factor,
C = cost of energy per unit quantity,
D = annual number of degree days,
P = present worth factor,
E = seasonal efficiency of heating system,
F = energy content of a unit quantity of fuel, and
B = incremental cost of adding insulation.

Table 3.2.A. (Cont'd)

In using this formula the seasonal efficiency, E, has to be estimated. For electric resistance heating E = 1.0. Electric heat pumps can have E values ranging from 1.2 to 1.8 depending on the climate.

Gas and oil systems are available with E values ranging from 0.6 to over 0.9.

The incremental cost of adding insulation varies with the type of insulation, the method of construction and the location of the insulation. It is expressed in cents per square metre for each unit of thermal resistance.

The degree day adjustment factor, k, relates the change in the required heating energy caused by a change in the thermal conductance of the building envelope to the severity of the climate as expressed by degree days. It was determined to be 0.83 by computing the purchased space heating requirement of a house with 4 different levels of insulation subjected to 10 different climate conditions. Since internal and solar heat gains were taken into account in determining k, it is not the same as the correction factor, C_D, given in Chapter 28 of the ASHRAE Handbook of Fundamentals 1981. (See Building Research Note 177, published by the Division of Building Research of the National Research Council of Canada for a fuller account of the derivation of k.)

The concept of a present worth factor, P, is best explained by an example. Suppose the annual cost of the heat loss through the building envelope were to increase according to the following schedule:

1st year – $300
\+ 1 year – $336
\+ 2 years – $376
\+ 3 years – $421
\+ 4 years – $472
\+ 9 years – $832
\+ 19 years – $2 584

It is possible to calculate a sum of money which, if deposited in a bank or invested in an annuity and withdrawn according to the above schedule to pay the annual heating costs, would just be consumed (both principal and interest) at the end of the period under consideration. This amount is called the present worth of those annual heating costs. It is calculated using the following equations:

$$PW = \frac{C\,[1 - (1 + a)^{-n}]}{a}$$

$$PW = C \times P$$

Where a is the effective interest rate $= \dfrac{i - e}{1 + e}$,

PW is the present worth of the heating costs over n years,
P is the present worth factor,
C is the annual heating cost in the first year,
a is the effective interest rate,
e is the rate at which energy costs are expected to increase,
i is the discount rate or cost of money, and
n is the number of years under consideration.
These last 2 factors require some further elaboration.

The discount rate can be a number of things. If the money were in fact deposited in a bank, the discount rate would be the interest rate offered by the bank. Another way to look at it would be to say that the cost of money is the interest that would be paid on the best investment an owner could make with the same amount of money if he did not invest in an energy conserving option.

The number of years to be considered is equally difficult to decide on. It might be the amortization period of a mortgage or other form of financing. However, it can be argued that it should be the life of the building, which might be in excess of 100 years. It can also be argued that many owners are unwilling to look beyond 10 years, so this should be used. Perhaps it is reasonable to use the economic life of the building, i.e. that period over which the building is likely to remain useful without further major renovations. This is in the region of 20 to 30 years in most cases.

In calculating RSI values in Table 3.2.A., theoretical values were not always found to be practicable, and adjustments to these values were made for a variety of reasons. In addition, the number of entries in the Table for the various systems of construction were kept to a minimum for the sake of simplicity. The physical limitations imposed by the system itself also imposed constraints on the theoretically determined values. The state of the art in calculating heat flow below ground level was another consideration that prevented theoretical optimum values from being used in all cases. Table 3.2.A., therefore, is a mixture of optimum values tempered where necessary by overriding practical considerations.

One of the devices for keeping the Table of thermal resistance values reasonably simple was to assume a uniform unit energy cost, C, in all parts of the country. This cost does in fact vary considerably both regionally and for different energy sources.

The following examples are provided to show how fuel costs may affect the optimum RSI values.

Example: Electric Heating

C = 3.5¢/kWh, K = 0.83,
B = 542¢/m^2 for each unit of thermal resistance,
F = 1 000 Wh/kW · h, P = 18,
E = 1.0 (100 per cent efficiency),
D = 5 000 degree days,

$$R = \sqrt{\frac{24 \times 0.83 \times 18 \times 5\,000 \times 3.5}{1.0 \times 1\,000 \times 542}}$$

= 3.4.

Example: Oil Heating

C = 28¢/L, K = 0.83, B = 542¢/m^2
F = 10 800 W · h/L, E = 0.6 (seasonal efficiency of 60 per cent,)
P = 30, D = 5 000 degree days,

$$R = \sqrt{\frac{24 \times 0.83 \times 30 \times 5\,000 \times 28}{0.6 \times 10\,800 \times 542}}$$

= 4.9.

Example: Gas Heating

C = 17.6¢/m^3, K = 0.83, B = 542¢/m^2,
F = 10 400 W · H/m^3, E = 0.6,
P = 20, D = 5 000 degree days,

$$R = \sqrt{\frac{24 \times 0.83 \times 20 \times 5\,000 \times 17.6}{0.6 \times 10\,400 \times 542}}$$

= 3.2.

It can be seen from the preceding examples that if the incremental cost of adding insulation is constant in a given degree day zone, the optimum thermal resistance will be proportional to CP/EF. To compare the effect on RSI values due to fuel costs and types of fuel, thermal resistance adjustment factors may be calculated. If one wishes to determine how different fuel costs and types will affect RSI values in relation to electricity, one can do so by comparing CP/EF for those fuels to that of electricity.

This has been done in the following Table:

COMPARISON OF RSI FACTORS BASED ON ELECTRICITY AT 3½¢/kWh (Electricity at 3½¢/kWh = 1.00)					
Electricity E = 100% P = 18		Gas E = 60% P = 20		Oil E = 60% P = 30	
Unit Cost, ¢/kWh ·	Adjustment Factor	Unit Cost, ¢/m^3	Adjustment Factor	Unit Cost, ¢/L	Adjustment Factor
2	0.76	20	1.01	20	1.21
3	0.93	25	1.13	25	1.36
4	1.07	30	1.24	30	1.48
5	1.20	35	1.33	35	1.60
6	1.31	40	1.43	40	1.71
7	1.41	45	1.51	45	1.82
8	1.51	50	1.59	50	1.92
9	1.60	55	1.67	55	2.01
10	1.69	60	1.75	60	2.10
11	1.77	65	1.82	65	2.19
12	1.85	70	1.89	70	2.27
13	1.93	75	1.95	75	2.35
14	2.00	80	2.02	80	2.42
Column 1	2	3	4	5	6

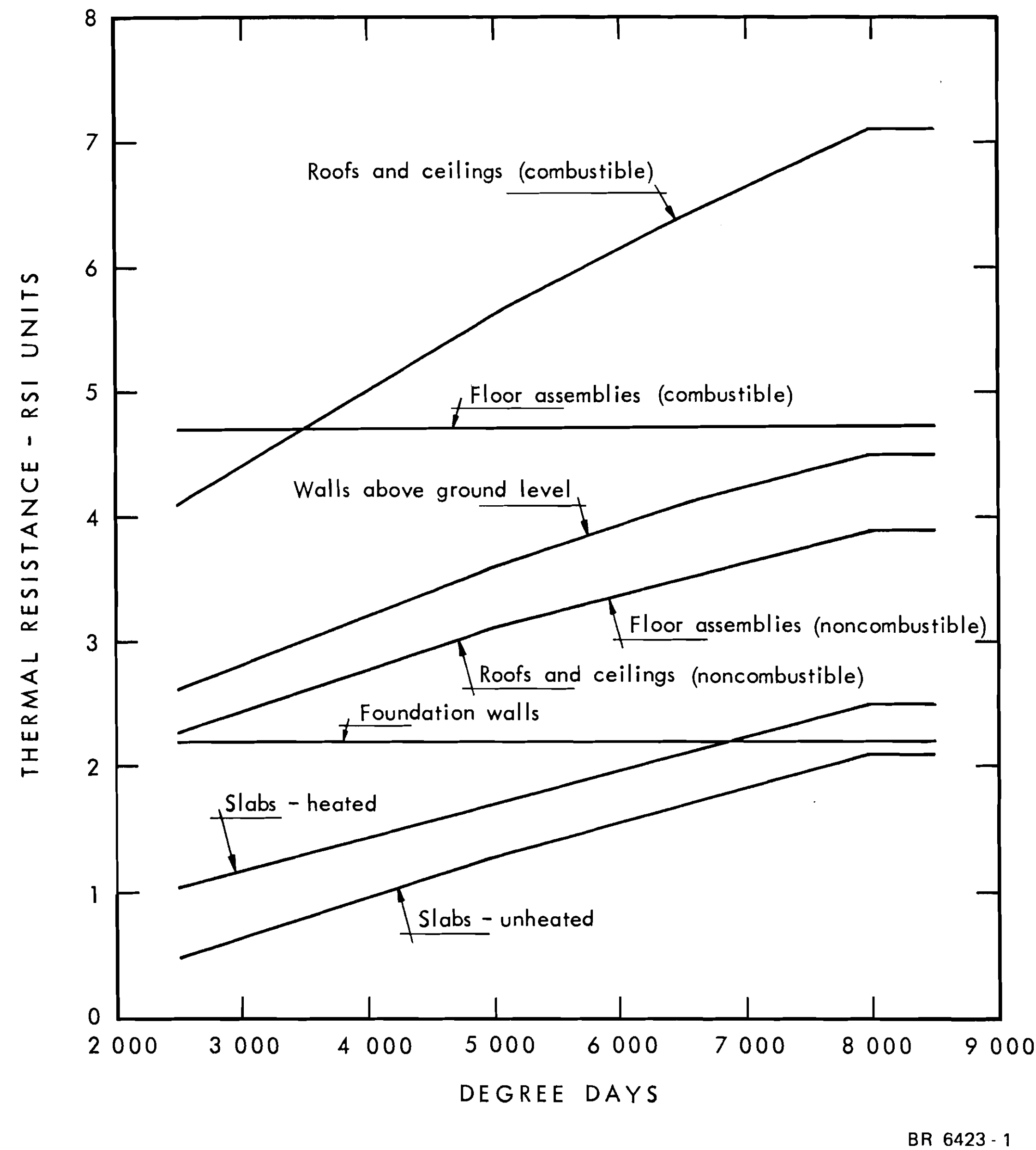
Article 3.2.4. Trade-offs

The intent of this Article is to permit trade-offs among elements of the building envelope provided that the calculated heat loss does not exceed a calculated heat loss "budget." The budget is the heat loss from a theoretical building having the same geometry, orientation, glazed area and outside grading as the proposed building, but which fully complies with the requirements for thermal resistance. Trade-offs or deviations from the requirements for glazed area and thermal resistance values are then permitted provided that the calculated heat loss from the design building does not exceed the heat loss budget. The designer must be prepared to substantiate such design variations by means of calculations if required by the authority having jurisdiction.

Article 3.2.7. Thermal Inertia

The reduction in "R" values permitted by this Article is intended to be in addition to that permitted by Article 3.2.4.

Article 3.2.8. Graphical Determination of Thermal Resistance



Articles 3.2.9. to 3.2.11. Foundation Wall Insulation

Insulation applied to a foundation wall restricts the loss of heat and causes the outside surface temperature of the wall to be colder than with insulated walls. This temperature may drop to the point where freezing of the soil may occur adjacent to the wall. Soil that is poorly drained may freeze against the foundation. Subsequent freezing as the frost penetrates deeper and deeper may cause foundation damage to occur. When this possibility exists, due to unfavourable soil or drainage conditions, insulation should be installed in a manner that will not restrict heat from reaching the footings, or measures should be taken to remedy the unfavourable soil or drainage conditions.

Article 3.3.1. Double Glazing

Operable shutters which would improve thermal performance of glazed openings are not recognized in the Measures. Such shutters are generally proprietary and their performance would have to be individually evaluated. In most cases, their performance is dependent upon manual daily adjustments which are not practicable to control through regulation.

Article 3.3.4. Maximum Glass Area

This Article regulates the maximum amount of glazing on each storey in relation to the floor area and the exterior wall area of that storey. The value of 15 per cent was selected to limit the use of very large amounts of glazed area, yet was considered to be consistent with current practice. Energy conserving improvements, such as the use of glazing having improved thermal performance (Article 3.3.5.) and south facing glazing (Article 3.3.6.), will permit the use of a larger total glazed area in buildings requiring such design features.

For buildings having very large floor surface areas, the limit of 15 per cent would permit excessive glazed areas. Thus, the further restriction of limiting glazed areas to 40 per cent of wall areas is provided for such buildings.

In the case of a sloping wall, the area of the opaque portion of the wall is calculated as the projected area on a vertical plane.

Article 3.3.5. Adjustment for Thermal Resistance of Glass

Example of how this 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 = 0.35).

Problem: What is the total amount of glass permitted?

Solution:

Total area of double glazing permitted
= 0.15 x 150 = 22.5 m^2.
Equivalent area of 10 m^2 of triple glazing

$$= \frac{0.35 \times 10}{0.45} = 6.67 \text{ m}^2.$$

Additional area of double glazing permitted
= 22.5 - 6.67 = 15.83 m^2.
Total glass area = 15.83 + 10 = 25.83 m^2.

Article 3.3.6. South Facing Glass

Where the allowance permitted by this Article is used to increase the area of south facing glass, it is intended that the heat gain from such glass should be used to heat the building, and that such glass should not be shaded during the heating season by overhangs or similar exterior obstructions. These requirements, which are suitable for most applications, represent a simplification of a more detailed and rigorous treatment of this subject. The solar heat gained from such glazing may be distributed by a forced air system installed for building heating or ventilating, or a house with passive solar features may have other design features for the distribution of such heat gain that may be acceptable. The solar altitude angles for every 2 degrees of latitude for major Canadian cities are provided in "Tables of Solar Altitude, Azimuth, Intensity and Heat Gain Factors for Latitudes from 43 to 55 Degrees North," available from the National Research Council of Canada, Division of Building Research, Technical Paper No. 243, Ottawa, 1967 (NRC 9528).

Article 3.3.6. (Cont'd)

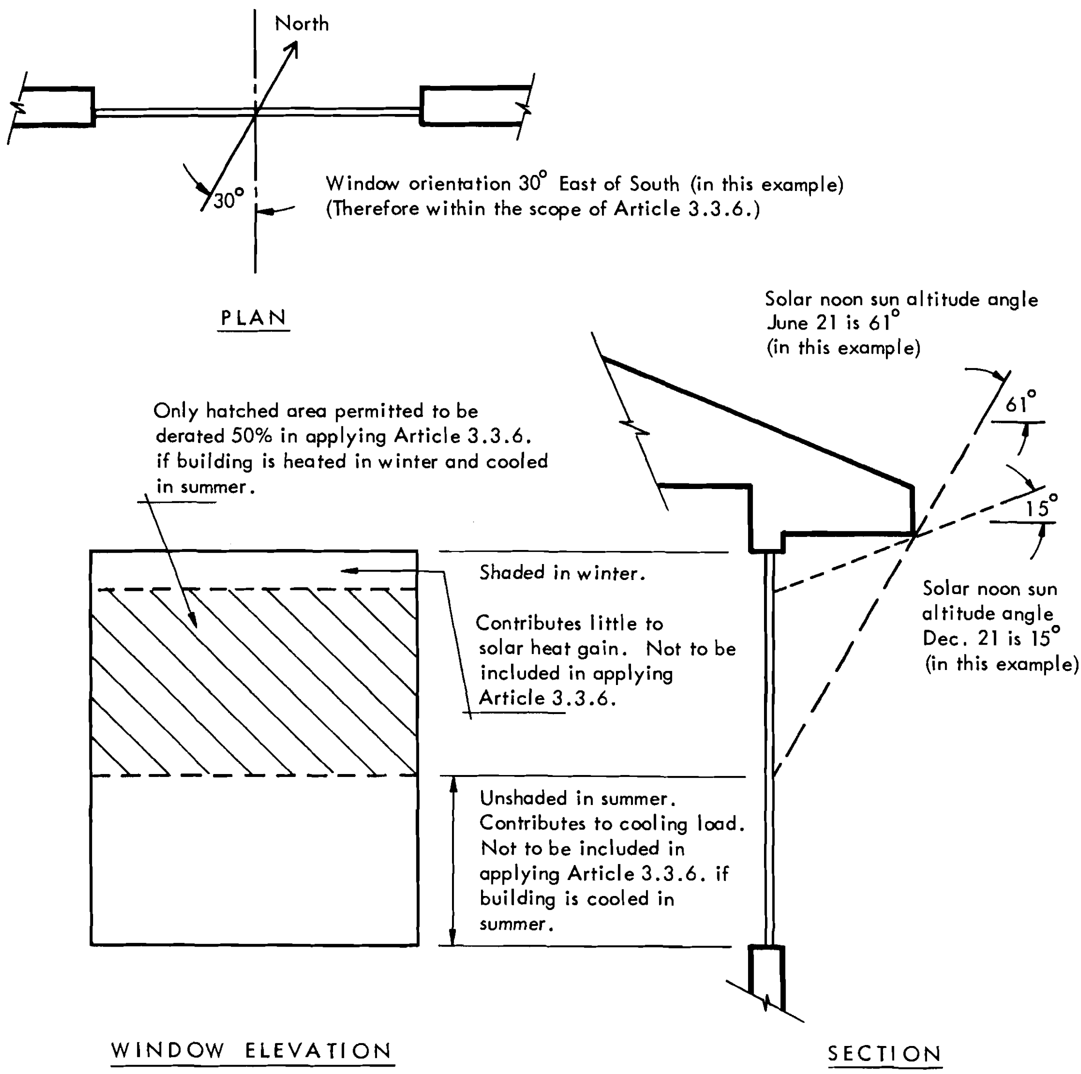


Figure 3 Summer and winter shading of glazed areas

Assume that, at the latitude for which a building is designed, the solar noon sun altitude angle is 15° in December and 61° in June and that a window faces 30° east of south. Knowing these angles, the shaded area of the glass can be determined by calculation or by scale drawings for both December and June as in Figure 3.

Article 3.3.7. Summer Shading

If the building is designed to be cooled, the increased area of south facing glass permitted in Article 3.3.6. would contribute to the summer cooling load and thus may consume part or all of the amount of heating energy saved unless the glazing is shaded in summer. Sun screens, awnings, overhangs and louvres are some examples of exterior shading devices which would be acceptable.

Article 4.1.1. Scope of Section 4

Normally, large office, recreational, manufacturing, retail and educational buildings, hospitals and hotels fall within the scope of this Section. Buildings within the scope of this Section are characterized by internal heat loads due to lights, fans and water pumps that are in excess of $25 W/m^2$ of floor surface area, and portions of such buildings usually require year-round cooling. It was recognized that in such buildings a higher proportion of the heat loss would be made up by the internal heat gains and hence the optimum R value would be lower. The effect of the internal heat gain has been taken into account, therefore, by assuming that the ambient climate is warmer than it actually is by an amount equivalent to a reduction of 1 500 degree days. This is a simple way of compensating for internal heat gains.

Article 4.3.1. South Facing Glass

In a building with high internal heat gains, some system of transferring interior heat to the perimeter should be considered in order to reduce the perimeter heating load. In a building having such high internal heat gains, the heating benefit of south facing glass would not be as useful as it is for a residence. Therefore, the increased area permitted under Article 3.3.6. has not been permitted for this type of building.

Article 5.1.1. Exemptions for Certain Buildings

In a few buildings, the intended use or occupancy may be such that compliance with some requirements of Section 5 could limit or prevent the building from performing its intended function. In such cases, the nature of the occupancy would be considered to make compliance impractical. This Article permits the authority having jurisdiction to review such special cases and to permit deviations. Only the nature of the occupancy, rather than economic or other factors, is to be considered in permitting such deviations.

Some medical treatment rooms, for example, may require very low temperatures. Because of the nature of the occupancy, a deviation from the requirement of Article 5.4.3. may be permitted, and the cooling thermostat may be set lower than the minimum of 24°C permitted under Section 5. Similarly, the heating thermostat in a senior citizens' residence may have to be set higher than the maximum of 24°C permitted under Article 5.4.2., again because of the nature of the occupancy.

Article 5.1.3. Designer's Operating Instructions

This Article requires that the designer prepares recommendations which would enable the systems in the building to be operated in an efficient manner.

Such recommendations may include descriptive information about each system detailing its function, design capability, performance characteristics and distribution arrangement; schematic and control diagrams; start/stop and adjustment procedures; changeover, startup and shutdown sequences; inspection, maintenance and operating schedules; and equipment data.

Articles 5.4.2. to 5.4.4. Thermostat Settings

The following is a schematic illustration of the intent of these Articles.

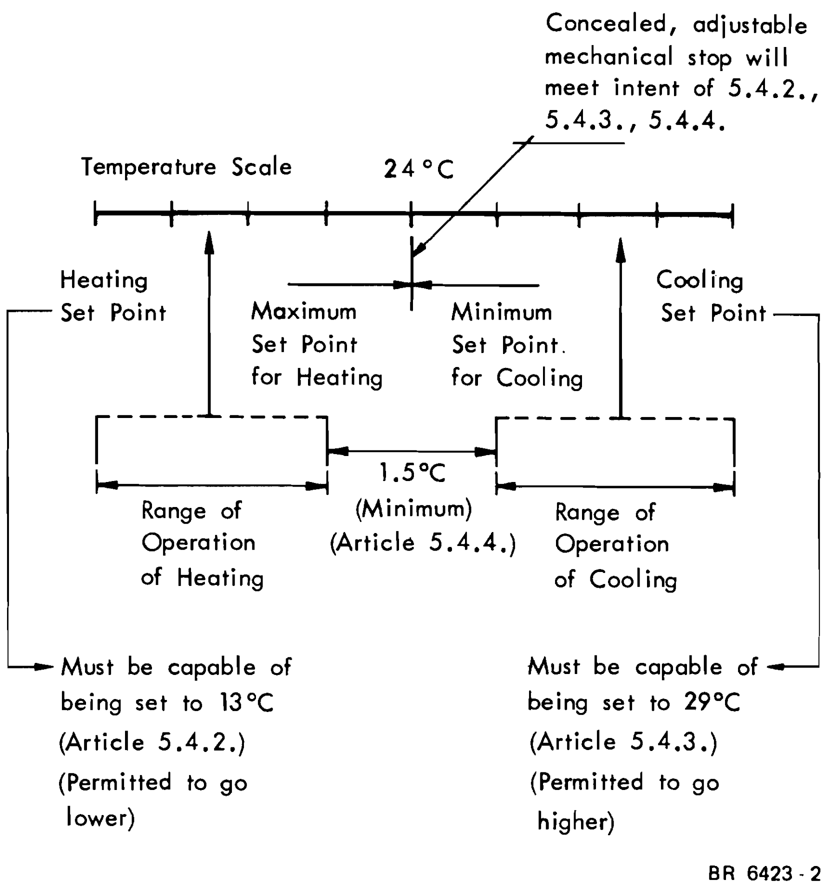


Figure 4 Illustration of intent of Articles 5.4.2., 5.4.3. and 5.4.4.

Article 5.9.1. Duct Insulation

Assume an air supply duct containing air at 13°C passes through a return air ceiling plenum in which an ambient temperature of 27°C was expected. Because the difference in temperature between the air inside and outside the duct does not exceed 15°C, no thermal insulation would be required. If the ambient air temperature of this same installation was expected to be 29°C, the duct would have to be thermally insulated because the design temperature difference (29°C − 13°C = 16°C) exceeds 15°C. The thermal insulation must have a thermal resistance of at least

$$0.02 \times (29 - 13) = 0.32 \text{ m}^2\text{C/W}.$$

Where a cold air supply duct passes through a space having an ambient temperature more than 15°C higher than the cold air in the duct, use of the uninsulated duct would in most cases require the expenditure of more energy than if the duct were insulated. Thus, in general, cold air supply ducts in which the design temperature difference between the air inside and outside the duct equals or exceeds 15°C would require thermal insulation. Note that all the ductwork carrying the cold air at the design temperature must be insulated. Because of duct pickup, the temperature of air inside long runs of supply air duct may increase to a point where the temperature difference across the duct wall would be less than 15°C. It is intended that the cold air supply duct downstream from that point need not be insulated.

A warm air heating duct passing through heated space would usually have a temperature difference between the air inside and outside the duct in excess of 15°C. Because the heating air is ducted to specific areas, any heat loss from the duct would result in less heat being delivered to the desired

Article 5.9.1. (Cont'd)

areas. If the air from the heated space can be recirculated, the heat loss from the duct may result in higher return air temperatures, thus requiring less heat input for the supply air and thus may not result in increased energy requirements for the building. However, if the air from the heated space were exhausted, heat which was lost from the duct and which did not reach areas where heating was required would result in increased energy requirements for the building. Heat loss from an un-insulated warm air heating duct located near the roof of a space would result in higher air temperatures at the underside of the roof assembly, thereby increasing the heat loss through the roof assembly. Since this would result in increased energy requirements for the building, that duct would have to be thermally insulated.

Article 5.10.6. Dampers for Air Cooling Units

Dampers in air-handling units that are used only for cooling or ventilating are required to be located at the insulated plane of the building because this equipment may not be used during the heating season and may not be thermally insulated to the same level as the building. Without dampers located at the insulated plane of the building, there would be excessive heat loss from the unit due to warm air from the building entering the unit.

Articles 5.13.1., 5.14.1., 5.15.1. and 5.17.1. Coefficient of Performance

The coefficient of performance of equipment under these Articles can be determined from the manufacturers' data sheets which relate to the equipment that was specified by the designer. Since the standard rating conditions of these Articles are the same as are used in the industry standards, such as the Air Conditioning and Refrigeration Institute and the American National Standards Institute, manufacturers' data sheets which show that the equipment has been rated in accordance with such standards will relieve the adopting authority from having to confirm the rating conditions.

Article 5.17.5. Two Stage Thermostat

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.

Article 5.18.1. Heat Recovery Systems

The requirements of this Article apply to all systems exhausting air from buildings, whether the air was used for environmental control or for process purposes. Such exhaust systems include toilets, kitchens, garages, storage rooms, janitor rooms, electrical vaults, elevator machine rooms, swimming pools, factory ventilation systems, and others.

Article 5.18.4. Efficiency of Heat Recovery Systems

It is not intended that all exhaust air from the building must pass through a heat reclaim unit provided that 40 per cent of the total sensible heat is recovered. Most heat reclaim units can recover more than 40 per cent of the sensible heat from the exhaust air, but because it may not be cost effective to reclaim heat from all exhaust air systems, the overall recovery requirement was set at 40 per cent.

Article 5.18.5. Heat Recovery Systems for Air-Cooling Equipment

The maximum amount of heat that can be recovered is equal to the theoretical heat rejection of the condenser water. The efficiency with which the heat recovery system performs need not be considered.

Article 6.2.4. HEAT INPUT CALCULATION

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

Article 7.3.1. ILLUMINATION LEVELS

The illumination levels in the Illuminating Engineering Society Lighting Handbook are used by some authorities as the minimum permitted design lighting levels for the purpose of regulations governing working conditions. In order to meet these levels and to permit a degree of design latitude without causing excessive energy use, an allowance of 10 per cent above the recommended IES levels has been permitted.

Article 7.3.2. LIGHTING LOAD LEVELS

The intent of this Article is to discourage the use of high overall lighting levels and to encourage the design of lighting systems which provide required levels of illumination by the use of efficient lamps and fixtures located within the task area to be illuminated.

Where plug-in lighting is intended to be used to meet the illumination levels required but is not shown on plans submitted for a building permit, the inspector may use the lighting designer's calculations, the air-conditioning designer's calculations or electrical distribution drawings to determine the intended electrical load due to lighting and its associated ballasts and controls. Because plug-in lighting is so easy to delete or relocate, there is no point in the inspector checking it on site.

The individual retail sales area mentioned in this Article refers to the room or rooms in which merchandise is displayed and sold. It does not include separate storage rooms, service rooms, lavatories or other separate rooms that may be ancillary to the merchandising function. Within such individual retail sales areas, lighting loads in excess of 85 W/m^2 may be required for some areas such as a jewellery sales area, but the total electrical load due to all lighting in that individual retail sales area, when averaged over it floor surface area, must not exceed 85 W/m^2.

Section 8 REQUIREMENTS FOR HOUSES

Section 8 is a simplified presentation of the requirements in the Measures as they relate to houses. These requirements are the same as those found elsewhere in the Measures for buildings with relatively low internal heat generation. Only those requirements that affect houses as they are commonly constructed are repeated in this section. Where requirements are of the type that would not affect the majority of houses, the requirement is called up by reference to other sections of the Measures. Similarly, where certain trade-offs are permitted which may require certain calculations to be performed, they are also called up by reference to other sections in an attempt to keep Section 8 as simple as possible. Requirements that involve a substantial amount of detail, but which would not be ordinarily the subject of on-site inspection or testing procedures, are also called up by reference to other sections.

CONVERSION FACTORS		
To Convert	**to**	**Multiply by**
m	ft	3.28
m^2	sq ft	10.764
mm	in.	0.0394
Pa	in. of water	0.0040
kPa	psi	0.1450
RSI	R	5.678
kW	Btu/hr	3412
W/m^2	Btu/hr sq ft	0.3172
L/S	cfm	2.12
Degree days °C	Degree days °F	1.8
°C	°F	1.8 and add 32