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National Energy Code of Canada for Buildings 2011

Issued by the

Canadian Commission on Building and Fire Codes

National Research Council of Canada

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Preface

The National Energy Code of Canada for Buildings 2011, together with the National Building Code of Canada 2010, the National Plumbing Code of Canada 2010 and the National Fire Code of Canada 2010, is an objective-based National Model Code that can be adopted by provincial and territorial governments. The National Model Codes are developed by the Canadian Commission on Building and Fire Codes (CCBFC).

In Canada, provincial and territorial governments have the authority to enact legislation that regulates building design and construction within their jurisdictions. This legislation may include the adoption of the National Energy Code for Buildings (NECB) without change or with modifications to suit local needs, and the enactment of other laws and regulations regarding building design and construction, including the requirements for professional involvement.

The NECB is a model code in the sense that it helps promote consistency among provincial and territorial building codes. Persons involved in the design or construction of a building should consult the provincial or territorial government concerned to find out which construction requirements are applicable.

This edition of the NECB succeeds the 1997 edition of the Model National Energy Code of Canada for Buildings.

The development of the NECB 2011 has been a collaborative effort involving the National Research Council of Canada (NRC), Natural Resources Canada (NRCan) and other stakeholders. Through the Government of Canada's ecoENERGY initiatives, NRCan's contribution will improve the energy efficiency of new buildings and reduce greenhouse gas emissions. The NECB 2011 will contribute to long-term benefits for both Canada's economy and the environment.

Code Development

Development of the National Model Codes

The Canadian Commission on Building and Fire Codes (CCBFC) is responsible for the content of the National Model Codes. The CCBFC is an independent body made up of volunteers from across the country and from all facets of the code-user community. Members of the CCBFC and its standing committees include builders, engineers, skilled trade workers, architects, building owners, building operators, fire and building officials, manufacturers and representatives of general interests.

The CCBFC is advised on scope, policy and technical issues pertaining to the Codes by the Provincial/Territorial Policy Advisory Committee on Codes (PTPACC), which is a committee of senior representatives from provincial/territorial ministries responsible for the regulation of buildings, fire safety and plumbing in their jurisdictions. The PTPACC was created by the provinces and territories, with provision of guidance to the CCBFC as one of its main functions. Through the PTPACC and its subcommittees on building, fire and plumbing regulation, the provinces and territories are engaged in every phase of the model Code development process.

The Canadian Codes Centre of the National Research Council's Institute for Research in Construction provides technical and administrative support to the CCBFC and its

standing committees. The National Research Council publishes the National Model Codes and periodic revisions to the Codes to address pressing issues.

The broader code-user community also makes a significant contribution to the model Code development process by submitting requests for changes or additions to the Codes and by commenting on the collected proposed changes during the public reviews that precede each new edition.

The CCBFC takes into consideration the advice received from the provinces and territories as well as code users' comments at each stage of Code development. The scope and content of the Model Codes are determined on a consensus basis, which involves the review of technical, policy and practical concerns and debate on the implications of these concerns.

More information on the Code development process is available on the Internet at www.nationalcodes.ca. Printed copies of this information may also be requested from the Secretary of the CCBFC, whose address is provided at the end of this Preface.

Policy Context for the Development of a National Energy Code

The development of the NECB 2011 was initiated by the CCBFC in response to a request from numerous stakeholders regarding the addition of a new objective on energy efficiency to the National Model Codes. The establishment of new objectives must follow the Protocol for Addressing New Objectives in Model National Codes, which was developed in 2009 by the CCBFC in conjunction with the PTPACC. This Protocol outlines the steps required for considering and establishing a new objective to ensure that the result is responsive to provincial/territorial needs and transparent to all stakeholders.

The CCBFC used the Protocol to analyze the request for an energy efficiency objective and to develop policy goals through discussions with PTPACC, including work by a Joint CCBFC-PTPACC Task Group, consultants' reports, various federal/provincial/territorial policy documents, and discussions with key stakeholders in open meetings. The CCBFC then evaluated the effectiveness of various means available to provincial/territorial governments to encourage energy efficiency —regulations, product standards, voluntary programs, incentives/disincentives, market demand and education—and conducted an impact analysis for each option; a status quo option was also considered.

As a result of the analysis, the CCBFC determined that regulations were an effective tool to support the policy direction of increased energy efficiency for buildings. It also determined that a national model code on energy efficiency was justifiable to effectively address an overall objective related to the environment, with a sub-objective focused on resource conservation and future potential sub-objectives on reduced greenhouse gas emissions, infrastructure capacity and energy security, as well as to address the policy goal of harmonization of construction codes across Canada. It concluded that other tools, such as education, incentives and labeling programs, also contribute to the successful achievement of an overall energy efficiency policy.

The CCBFC thus submitted the proposed new principal objective, Environment, which comprises a second-level objective, Resources, and a sub-objective, Excessive Use of Energy, to public review. Pursuant to favourable comments, the new objective, sub-objectives and related functional statements were approved.

The broad definitions of the NECB objectives and their hierarchical structure provide the flexible framework that is necessary for the provinces and territories to adapt the NECB 2011 to meet their specific needs. Although the 2011 edition of the NECB was written to address only the efficient use of energy by the building, some provinces and territories may want to address other goals such as reduction of greenhouse gas emissions or promulgation of alternative energy sources. These additional priorities can easily be accommodated within the context of NECB's Environment objective by adding one or more applicable second-level objectives or sub-objectives. The flexible framework of the model NECB 2011 thus increases the potential for the harmonization of national, provincial and territorial codes.

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National Energy Code of Canada for Buildings 2011

The National Energy Code for Buildings (NECB) sets out technical provisions to address energy efficiency in the design and construction of new buildings and additions to existing buildings. In the context of the NECB, the use of the term "energy efficiency" shall be understood to mean "energy use efficiency."

Code provisions do not necessarily address all the characteristics of buildings that might be considered to have a bearing on the Code's objectives. Through the extensive consensus process used to develop and maintain the National Model Codes (see the section entitled Development of the National Model Codes), the code-user community has decided which characteristics should be regulated through the NECB.

Because the NECB is a model code, its requirements can be considered as the minimum acceptable measures required to adequately achieve the above-listed objective, as recommended by the Canadian Commission on Building and Fire Codes. They become minimum acceptable requirements once they are adopted and passed into law or regulation by an authority having jurisdiction: i.e. the requirements represent the minimum level of performance required to achieve the objective that is acceptable to the adopting authority.

Code users are also involved in the development of the NECB and they help determine the content. The Code development process is described in the section entitled Development of the National Model Codes.

The NECB is a model code which, when adopted or adapted by a province or territory, becomes a regulation. It is not a textbook on the design or construction of energy-efficient buildings. The design of a technically sound building depends upon many factors beyond simple compliance with building regulations. Such factors include the availability of knowledgeable practitioners who have received appropriate education, training and experience and who have some degree of familiarity with the principles of good building practice and experience using textbooks, reference manuals and technical guides.

The NECB does not list acceptable proprietary building products. It establishes the criteria that building materials, products and assemblies must meet. Some of these criteria are explicitly stated in the NECB while others are incorporated by reference to material or product standards published by standards development organizations. Only those portions of the standards related to the objective of this Code are mandatory parts of the NECB.

Code Requirements

The NECB establishes requirements that address one principal objective (OE), Environment, which comprises a second-level objective (OE1), Resources, and a sub-objective (OE1.1), Excessive Use of Energy. Every NECB requirement addresses sub-objective OE1.1.

In dealing with proposed changes or additions to any of the National Model Codes, the CCBFC considers many issues such as the following:

- Does the proposed requirement provide the minimum level of performance—and no more than the minimum—needed to achieve the Code's objectives?
- Will persons responsible for Code compliance be able to act on or implement the requirement using commonly accepted practices?
- Will enforcement agencies be able to enforce the requirement?
- Are the costs of implementing the requirement justifiable?
- Have the potential policy implications of the requirement been identified and addressed?
- Is there broad consensus on this requirement among Code users representing all facets of the design and construction industries as well as among provincial and territorial governments?

Guidelines for requesting changes to the NECB are available on the Internet at www.nationalcodes.ca. Printed copies of the guidelines may also be requested from the Secretary of the CCBFC, whose address is provided at the end of this Preface.

Objective-Based Code Format

This is the first edition of the NECB to be published in an objective-based code format. The principle to develop objective-based codes arose out of the strategic plan adopted by the Canadian Commission on Building and Fire Codes (CCBFC) in 1995.

The NECB comprises three Divisions:

- Division A, which defines the scope of the Code and contains the objectives, the functional statements and the conditions necessary to achieve compliance;
- Division B, which contains acceptable solutions (commonly referred to as "technical requirements") deemed to satisfy the objective and functional statements listed in Division A; and
- Division C, which contains administrative provisions.

A more complete description of this division-based structure is included in the section entitled Structure of Objective-Based Codes.

Each requirement in Division B is linked to three types of information:

- sub-objective OE1.1, Excessive Use of Energy,
- one or more functional statements (statements on the functions of the building that a particular requirement helps to achieve), and
- an intent statement (detailed statement on the specific intent of the provision).

Objectives

The NECB's objectives are fully defined in Section 2.2. of Division A.

The objectives describe, in very broad terms, the overall goals that the NECB's requirements are intended to achieve. They serve to define the boundaries of the subject areas the Code addresses. However, the Code does not deal with all the issues that might be considered to fall within those boundaries.

The objectives describe undesirable situations and their consequences, which the Code aims to avoid occurring in buildings. The wording of the definitions of the objectives includes two key phrases: "limit the probability" and "unacceptable effect." The phrase "limit the probability" is used to acknowledge that the NECB cannot entirely prevent the undesirable outcome from happening. The phrase "unacceptable effect" acknowledges that the NECB cannot eliminate all undesirable effects: the "acceptable effect" is the outcome potentially remaining once compliance with the Code has been achieved.

The objectives are entirely qualitative and are not intended to be used on their own in the design and approval processes.

Functional Statements

The NECB's functional statements are listed in Section 3.2. of Division A.

The functional statements are more detailed than the objectives: they describe conditions in the building that help satisfy the objectives. The functional statements and the objectives are interconnected: there may be several functional statements related to any one objective.

Like objectives, functional statements are entirely qualitative and are not intended to be used on their own in the design and approval processes.

The functional statements attributed to the requirements or portions of requirements in Division B are listed in tables at the end of each Part.

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Intent Statements

Intent statements explain, in plain language, the basic thinking behind each Code provision contained in Division B. Intent statements, each of which is unique to the provision with which it is associated, explain how requirements help to achieve their attributed sub-objective and functional statements. Like the objectives, the intent statements are expressed in terms of risk avoidance and expected performance. They offer insight into the views of the responsible standing committee on what the Code provisions are intended to achieve.

The intent statements serve explanatory purposes only and do not form an integral part of the Code provisions: as such, they are similar in function to appendix notes. Due to the sheer volume of intent statements, they are only published in the electronic version of the Code and as a separate document entitled "Supplement to the NECB 2011: Intent Statements," available on-line at www.nationalcodes.ca.

All this additional information—objectives and functional and intent statements—is intended to facilitate the implementation of the Code in two ways:

- Clarity of intent: The objectives, functional statements and intent statements linked to a Code requirement clarify the reasoning behind that requirement and facilitate understanding of what must be done to satisfy that requirement. This added information may also help avoid disputes between practitioners and officials over these types of issues.
- Flexibility: The additional information allows for flexibility in Code compliance. A person seeking to propose a new method or material not described or covered in the Code will be able to use the added information to understand the expected level of performance that their alternative solution must achieve to satisfy the Code.

Structure of Objective-Based Codes

The National Energy Code for Buildings (NECB) is organized into three Divisions.

Division A: Compliance, Objectives and Functional Statements

Division A defines the scope of the NECB and presents the objective that the Code addresses and the functions the building must perform to help to satisfy that objective.

Division A cannot be used on its own as a basis for designing and constructing a building, or for evaluating a building's compliance with the Code.

Division B: Acceptable Solutions

The term "acceptable solutions" refers to the technical provisions contained in the Code. It reflects the principle that codes establish an acceptable level of risk or performance and underlines the fact that a code cannot describe all possible valid design and construction options. The term provokes the question "To whom are these solutions considered acceptable?" As indicated previously in this Preface, the acceptable solutions represent the minimum level of performance that will satisfy the NECB's objective and that is acceptable to an authority that adopts the NECB into law or regulation.

The requirements in Division B—the acceptable solutions—are linked to the sub-objective, OE1.1, and to one or more functional statements found in Division A. These linkages play an important role in allowing objective-based codes to accommodate innovation.

It is expected that the majority of Code users will primarily follow the acceptable solutions given in Division B and that they will consult Division A only in cases where it may serve to clarify the application of Division B's requirements to a particular situation or when they are considering an alternative solution.

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Division C: Administrative Provisions

Division C contains administrative provisions relating to the application of the Code. Many provinces and territories establish their own administrative provisions upon adopting or adapting the NECB; having all the administrative provisions in one Division facilitates their customization to suit jurisdictional needs.

Relationship between Division A and Division B

Sentence 1.2.1.1.(1) of Division A is a very important sentence: it is a precise statement of the relationship between Divisions A and B and is central to the concept of objective-based codes.

1) Compliance with this Code shall be achieved by
a) complying with the applicable acceptable solutions in Division B (see Appendix A), or
b) using alternative solutions that will achieve at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the applicable acceptable solutions (see Appendix A).

Clause (a) makes it clear that the acceptable solutions in Division B are automatically deemed to satisfy the linked sub-objective and functional statements of Division A.

Clause (b) makes it clear that alternative solutions can be used in lieu of compliance with the acceptable solutions. However, to do something different from the acceptable solutions described in Division B, a builder, designer or building owner must show that their proposed alternative solution will perform at least as well as the acceptable solution(s) it is replacing. The sub-objective and functional statements attributed to the acceptable solution(s) identify the areas of performance where this equivalence must be demonstrated.

Additional Information

Numbering System

A consistent numbering system has been used throughout the National Model Codes. The first number indicates the Part of the Code; the second, the Section in the Part; the third, the Subsection; and the fourth, the Article in the Subsection. The detailed provisions are found at the Sentence level (indicated by numbers in brackets), and Sentences may be broken down into Clauses and Subclauses. This structure is illustrated as follows:

3	Part
3.5.	Section
3.5.2.	Subsection
3.5.2.1.	Article
3.5.2.1.(2)	Sentence
3.5.2.1.(2)(a)	Clause
3.5.2.1.(2)(a)(i)	Subclause

Meaning of the words “and” and “or” between the Clauses and Subclauses of a Sentence

Multiple Clauses and Subclauses are connected by the word “and” or “or” at the end of the second last Clause or Subclause in the series. Although this connecting word appears only once, it is meant to apply to all the preceding Clauses or Subclauses within that series.

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For example, in a series of five Clauses—a) to e)—in a Code Sentence, the appearance of the word "and" at the end of Clause d) means that all Clauses in the Sentence are connected to each other with the word "and." Similarly, in a series of five Clauses—a) to e)—in a Code Sentence, the appearance of the word "or" at the end of Clause d) means that all Clauses in the Sentence are connected to each other with the word "or."

In all cases, it is important to note that a Clause (and its Subclauses, if any) must always be read in conjunction with its introductory text appearing at the beginning of the Sentence.

Administration

A separate CCBFC document entitled Administrative Requirements for Use with the National Building Code of Canada 1985 is also published by the National Research Council. It is automatically adopted as per Article 2.2.1.1. of Division C if the adopting authority does not provide other administrative requirements.

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Contact Information

The CCBFC welcomes comments and suggestions for improvements to the National Energy Code for Buildings. Persons interested in requesting a change to an NECB provision should refer to the guidelines available on the Internet at www.nationalcodes.ca, where additional information is also presented.

Comments, suggestions and requests for printed copies of Internet material referred to in this Preface should be sent to:

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(2) Chair term commenced during the preparation of the 2011 Code.
(3) Term completed during the preparation of the 2011 Code.
(4) NRC-IRC staff who provided assistance to the Committee.
(5) NRC-IRC staff whose involvement with the Committee ended during the preparation of the 2011 Code.

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Errata

Issued by the Canadian Commission on Building and Fire Codes

The Change History table that follows describes errata and editorial updates that apply to the National Energy Code of Canada for Buildings 2011:

- Errata are corrections to existing text.
- Editorial updates are provided for information purposes only.

Code pages containing errata are identified with the words "Amended Page" in the footer; pages with editorial updates and index pages with changes are not flagged.

Contact your local authority having jurisdiction to find out if these errata apply in your province or territory.

Change History — National Energy Code of Canada for Buildings 2011

Division	Code Reference	Change	Date (Y-M-D)	Description of Change
B	Table 1.3.1.2.	erratum	2012-12-21	Entry was added for standard "DOE 10 CFR, Part 430-2011"
B	Table 1.3.1.2.	erratum	2012-12-21	Entry for NRCan standard was corrected to read "SOR/94-651-2008"
B	1.3.2.1.(1)	editorial update	2012-12-21	Entry was added for DOE
B	3.2.1.4.(1)	erratum	2012-12-21	Equations for FDWR values were modified for clarity
B	Table 3.5.1.1.	erratum	2012-12-21	Attributions for Sentences 3.2.4.4.(2) and (3) were deleted
B	4.2.3.1.(3)	erratum	2012-12-21	Sentence was corrected to read "... shall not be greater than the individual allowance for that application taken from Table 4.2.3.1.C. ..."
B	5.2.5.3.(5)	erratum	2012-12-21	Ratio was corrected to read "u2/u1"
B	5.2.5.3.(6)	erratum	2012-12-21	Ratio was corrected to read "u2/u1"
B	5.2.10.2.(2)	erratum	2012-12-21	Sentence was corrected to read "... that provides at least 80% of the dehumidification ..."
B	Table 5.2.12.1.	erratum	2012-12-21	Table Note (5) was added to entries for furnaces
B	Table 5.5.1.1.	erratum	2012-12-21	Attribution for Sentence 5.2.5.3.(2) was deleted
B	Table 6.2.2.1.	erratum and editorial update	2012-12-21	Under entry for gas-fired service water heaters, input value "22–117 kW" was deleted Table Note (5) was deleted
B	6.2.3.1.(2)	erratum	2012-12-21	Ratio was corrected to read "u2/u1"
B	6.2.3.1.(3)	erratum	2012-12-21	Ratio was corrected to read "u2/u1"
B	Table 6.2.3.1.	erratum	2012-12-21	Second value under column entitled "Mean Rating Temperature, °C" was corrected to read "38"
B	Table 6.5.1.1.	erratum	2012-12-21	Attribution was added for Sentence 6.2.1.1.(1)
B	7.2.4.1.(1)	erratum	2012-12-21	Reference in Sentence was corrected to read "... Tables 3 and 5 of CSA C390, ..."
B	Table 8.4.4.22.A.	erratum	2012-12-21	In entry for Furnace Part-Load Performance Curve(s), values listed for variable c under Condensing Furnace and Atmospheric Furnace were interchanged

Change History — National Energy Code of Canada for Buildings 2011 (Continued)

Division	Code Reference	Change	Date (Y-M-D)	Description of Change
B	Table 8.5.1.1.	erratum	2012-12-21	Functional Statement F99 was deleted from attribution for Clauses 8.4.4.20.(3)(b) and (c)
Index	Letter H	erratum	2012-12-21	Reference under Heaters/heating systems, recessed, was corrected to read “3.2.1.2.” Reference under Heating, ventilating and air-conditioning (HVAC) systems, baseboard heaters, was corrected to read “3.2.1.2.”

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Division A

Compliance, Objectives and Functional Statements

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Part 1 Compliance

Section 1.1. General

1.1.1. Application of this Code

1.1.1.1. Application of this Code

1) Except as provided in Sentence (2), this Code applies to the design and construction of all new *buildings* described in Sentence 1.3.3.2.(1) of Division A of the NBC and to *additions*. (See Appendix A.)

2) This Code does not apply to *farm buildings*.

1.1.1.2. Building Parameters Covered by this Code

1) This Code contains requirements for

a) the design and construction of the *building envelope*,
b) the design and construction or specification of systems and equipment for
   i) heating, ventilating or air-conditioning,
   ii) *service water* heating, and
   iii) lighting, and
c) the provision of electrical power systems and motors, excluding process loads.

1.1.1.3. Relationship to Other Building Regulations

1) This Code shall be used in conjunction with applicable federal, provincial or territorial regulations or municipal bylaws or, in the absence of such regulations or bylaws, in conjunction with the National Building Code of Canada 2010.

2) Where the requirements of this Code are in conflict with the requirements of the regulations or bylaws referred to in Sentence (1) or, where applicable, with the National Building Code of Canada 2010, the requirements providing the greatest performance level shall govern.

Section 1.2. Compliance

1.2.1. Compliance with this Code

1.2.1.1. Compliance with this Code

1) Compliance with this Code shall be achieved by

a) complying with the applicable acceptable solutions in Division B (see Appendix A), or
b) using alternative solutions that will achieve at least the minimum level of performance required by Division B in the areas defined by the objective and functional statements attributed to the applicable acceptable solutions (see Appendix A).

2) For the purposes of compliance with this Code as required in Clause (1)(b), the objective and functional statements attributed to the acceptable solutions in Division B shall be the objective and functional statements referred to in Subsection 1.1.2. of Division B.

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1.2.2. Materials, Appliances, Systems and Equipment

1.2.2.1. Characteristics of Materials, Appliances, Systems and Equipment

1) All materials, appliances, systems and equipment installed to meet the requirements of this Code shall possess the necessary characteristics to perform their intended functions when installed in a *building*.

1.2.2.2. Storage on the Building Site

1) All *building* materials, appliances and equipment on the *building* site shall be stored in such a way as to prevent the deterioration or impairment of their essential properties.

1.2.2.3. Used Materials, Appliances and Equipment

1) Unless otherwise specified, used materials, appliances and equipment are permitted to be reused when they meet the requirements of this Code for new materials and are satisfactory for the intended use.

Section 1.3. Divisions A, B and C of this Code

1.3.1. General

1.3.1.1. Scope of Division A

1) Division A contains the compliance and application provisions, objectives and functional statements of this Code.

1.3.1.2. Scope of Division B

1) Division B contains the acceptable solutions of this Code.

1.3.1.3. Scope of Division C

1) Division C contains the administrative provisions of this Code.

1.3.1.4. Internal Cross-references

1) Where the Division of a referenced provision is not specified in this Code, it shall mean that the referenced provision is in the same Division as the referencing provision.

1.3.2. Application of Division A

1.3.2.1. Application of Parts 1, 2 and 3

1) Parts 1, 2 and 3 of Division A apply to all *buildings* covered in this Code. (See Article 1.1.1.1.)

1.3.3. Application of Division B

1.3.3.1. Application of Parts 1 to 8

1) Parts 1 to 8 of Division B apply to all *buildings* covered in this Code. (See Article 1.1.1.1.)

1.3.4. Application of Division C

1.3.4.1. Application of Parts 1 and 2

1) Parts 1 and 2 of Division C apply to all *buildings* covered in this Code. (See Article 1.1.1.1.)

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Section 1.4. Terms and Abbreviations

1.4.1. Definitions of Words and Phrases

1.4.1.1. Non-defined Terms

1) Words and phrases used in this Code that are not included in the list of definitions in Article 1.4.1.2. shall have the meanings that are 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.

2) Where objectives and functional statements are referred to in this Code, they shall be the objectives and functional statements described in Parts 2 and 3.

3) Where acceptable solutions are referred to in this Code, they shall be the provisions stated in Parts 3 to 8 of Division B.

4) Where alternative solutions are referred to in this Code, they shall be the alternative solutions mentioned in Clause 1.2.1.1.(1)(b).

1.4.1.2. Defined Terms

1) The words and terms in italics in this Code shall have the following meanings:

Addition means any *conditioned space* that is added to an existing *building* and that increases the *building*'s *floor surface area* by more than 10 m^2 .

Air barrier assembly means the combination of air barrier materials and air barrier accessories within the environmental separator that are designed to act as a continuous barrier to the movement of air through the environmental separator.

Airflow control area means a portion of a *building* to which the flow of air from the heating, ventilating or air-conditioning air distribution system can be reduced or stopped without reducing or stopping the flow of air to other portions of the *building*.

Annual energy consumption means the annual sum of the lighting, *service water* heating and space-conditioning energy consumption of the proposed *building* design, as calculated in accordance with the requirements of Part 8 of Division B.

*Assembly occupancy** means the *occupancy* or the use of a *building*, or part thereof, by a gathering of persons for civic, political, travel, religious, social, educational, recreational or like purposes, or for the consumption of food or drink.

*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.

Boiler means an *appliance*† intended to supply hot water or steam for space or *service water* heating purposes, except *storage-type service water heaters*.

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

*Building area** means the greatest horizontal area of a *building* above *grade* within the outside surface of exterior walls or within the outside surface of exterior walls and the centre line of *firewalls*†.

Building energy target means the *annual energy consumption* of a hypothetical replica of the proposed *building*, using the same energy sources for the same functions and having the same environmental requirements, *occupancy*, climatic data and operation schedules as the proposed *building*, but made to comply with all applicable prescriptive requirements of this Code.

Building envelope means the collection of components that separate *conditioned space* from unconditioned space, the exterior air or the ground, or that separate *conditioned spaces* intended to be conditioned to temperatures differing by more than 10°C at design conditions. (See Appendix A.)

* The definition of this term is reproduced from the National Building Code of Canada 2010.

† The definition of this term can be found in the National Building Code of Canada 2010.

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*Building height** (in *storeys*) means the number of *storeys* contained between the roof and the floor of the *first storey*.

Ceiling height (CH) means the average height of the ceiling where there is a ceiling and the average height of the base of the installed luminaires where there is no ceiling.

Coefficient of performance (COP) means, for a heat pump in the heating mode, the ratio of the rate of net heat output to the total energy input expressed in consistent units and under designated rating conditions, as described in the standards referenced in this Code; for refrigerating equipment or a heat pump in the cooling mode, COP means the ratio of the rate of heat removal to the rate of energy input in consistent units and under designated rating conditions, as described in the standards referenced in this Code.

Combustion efficiency (E_c) means a measure of the efficiency of fuel-burning equipment in converting fuel to heat, as obtained through the procedures described in the standards referenced in this Code.

*Conditioned space** means any space within a *building*, the temperature of which is controlled to limit variation in response to the exterior ambient temperature by the provision, either directly or indirectly, of heating or cooling over substantial portions of the year.

*Dwelling unit** means a *suite* operated as a housekeeping unit, used or intended to be used by one or more persons and usually containing cooking, eating, living, sleeping and sanitary facilities.

Enclosed space means a volume substantially surrounded by solid surfaces such as full-height walls or *partitions*, floors, ceilings, and openable devices such as doors and operable windows.

Energy-efficiency ratio (EER) means, for refrigerating equipment or a heat pump in the cooling mode, the ratio of net cooling capacity in Btu/h to the total rate of electric input in watts, under designated operating conditions, as described in the standards referenced in this Code.

Energy factor (EF) means a measure of overall energy efficiency in terms of energy output compared to energy consumption over a 24-h usage cycle and is obtained as described in the standards referenced in this Code.

Exhaust duct means a duct through which air is conveyed from an interior space to the outdoors or to unconditioned space.

*Exit** means that part of a *means of egress*†, including doorways, that leads from the *floor area*† it serves, to a separate *building*, an open public thoroughfare, or an exterior open space protected from fire exposure from the *building* and having access to an open public thoroughfare.

Exterior entrance means a doorway used for entering, or for entering and exiting, a *building*, that leads from an exterior space to a space provided with *interior lighting*.

Exterior exit means a doorway used only for exiting from an area provided with *interior lighting* to an exterior space.

Exterior lighting means lighting other than *interior lighting*.

Facade lighting means lighting installed to highlight features of the principal front of a *building* or a face of a *building* that overlooks a street or open space and includes lighting installed on the facade and on constructed or natural surfaces in close proximity to the facade. *Facade lighting* does not include signage or other lighting installed on the facade that is intended to light exterior spaces or surfaces other than the facade.

*Farm building** means a *building* or part thereof that does not contain a *residential occupancy*† and that is associated with and located on land devoted to the practice of farming, and used essentially for the housing of equipment or livestock, or the production, storage or processing of agricultural and horticultural produce or feeds.

Fenestration means all *building envelope* assemblies, including their *frames*, that transfer visible light, such as windows, clerestories, *skylights*, translucent wall panels, glass

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blocks, transoms, sidelights, sliding, overhead or swinging glass doors, and glazed inserts in doors, etc.

*First storey** means the uppermost *storey* having its floor level not more than 2 m above *grade*.

Floor surface area means the area of a floor surface, including heated garages, measured from the interior surface of the perimeter walls at or near floor level, including the area occupied by columns, interior walls and openings in the floor.

*Foundation** means a system or arrangement of *foundation units*† through which the loads from a *building* are transferred to the supporting *soil*† or *rock*†.

Frame in a door, window or other glazed area means the associated head, jambs, sill and, where applicable, mullions which, when assembled, house the door, *sash* or fixed glazing.

*Furnace** means a *space-heating appliance*† using warm air as the heating medium and usually having provision for the attachment of ducts.

General lighting means lighting that provides primary illumination throughout an interior area. *General lighting* shall not include decorative lighting or lighting that provides a dissimilar level of illumination within that area to serve a specialized application or feature.

*Grade** means the lowest of the average levels of finished ground adjoining each exterior wall of a *building*, except that localized depressions need not be considered in the determination of average levels of finished ground. (See *First storey*.)

Gross lighted area means the total area served by *interior lighting*, including the areas occupied by *partitions* but excluding areas occupied by exterior enclosing assemblies and by elevator and service shafts. (See Appendix A.)

Heat trap means an energy-conserving arrangement of the water piping entering or leaving a *service water* heater constructed to counteract the convective forces of the hot water (thermosyphoning) during standby periods.

Installed interior lighting power means the power, in watts, used by all the lighting systems that are part of the complete *interior lighting* design.

Integrated coefficient of performance (ICOP) means a single-number figure of merit expressing cooling part-load COP efficiency for commercial unitary air-conditioning and heat pump equipment that is based on weighted operation at various load capacities of the equipment (analogous to IEER).

Integrated energy-efficiency ratio (IEER) means a single-number figure of merit expressing cooling part-load energy efficiency for air-conditioning and heat pump equipment that is based on weighted operation at various load capacities of the equipment, as described in the standards referenced in this Code.

Integrated part-load value (IPLV) means a single-number figure of merit based on part-load *energy-efficiency ratio* or *coefficient of performance* expressing part-load efficiency for air-conditioning and heat pump equipment that is based on weighted operation at various load capacities of the equipment, as described in the standards referenced in this Code.

Interior lighting means

(a) lighting installed in spaces that are within the *building envelope*, and
(b) lighting installed in unconditioned or *conditioned spaces* that are sheltered from the outdoor environment and intended to light only those spaces, except for lighting at *exterior entrances* and *exterior exits*.

(See Appendix A.)

Interior lighting power allowance means the maximum lighting power allowed to be provided to illuminate the interior of a *building*.

Landscape lighting means lighting installed to highlight landscape elements, such as trees, shrubs, rocks and pools. *Landscape lighting* does not include lighting of exterior spaces or walkways.

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

Occupant sensor means a device that detects the presence of people within an area and causes lighting, equipment or *appliances*† to be regulated accordingly.

Opaque building assembly means a *building* assembly that is part of the *building envelope*, other than doors, and does not admit light.

Overall thermal transmittance (U-value) means the rate, in W/(m²·K), at which heat is transferred through a *building* assembly that is subject to a temperature difference. It represents the amount of heat transferred through a unit area in a unit of time induced under steady-state conditions by a unit temperature difference between the environments on its two faces. The U-value reflects the capacity of all elements to transfer heat through the thickness of the assembly, as well as, for instance, through air films on both faces of above-ground components. Where heat is not transferred homogeneously across the area being considered, the *overall thermal transmittance* shall be determined. (See Appendix A.)

*Partition** means an interior wall one *storey* or part-*storey* in height that is not *loadbearing*†.

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

Primary system means the combination of equipment working as a system that converts electricity or fuel to heating or cooling and may distribute it to one or more *secondary systems* (e.g. *boilers* and chillers), where such equipment is not already defined as part of the *secondary system*.

*Repair garage** means a *building* or part thereof where facilities are provided for the repair or servicing of motor vehicles.

*Return duct** means a duct for conveying air from a space being heated, ventilated or air-conditioned back to the heating, ventilating or air-conditioning *appliance*†.

Sash means an assembly of secondary framing members that fits within the primary *frame* of a window and whose main purpose is to hold and support the glass in operable windows; however, a *sash* is often included in fixed windows to maintain a uniform appearance with operable windows.

Seasonal energy-efficiency ratio (SEER) means the total cooling, in Btu, provided by a central air conditioner or heat pump during its normal annual usage period for cooling, divided by its total electric power usage, in watt-hours, during that same period.

Secondary system means a system that provides air for the purposes of ventilating, heating and cooling a *thermal block* (e.g. fan system). *Secondary systems* may include dedicated equipment that converts electricity or fuel to heating or cooling. *Secondary systems* can be single-zone—serving only a single *thermal block*—or multiple-zone—serving one or more *thermal blocks*.

*Service room** means a room provided in a *building* to contain equipment associated with *building* services. (See Appendix A.)

Service water means water for plumbing systems, but not water for systems used exclusively for space-heating or -cooling, or for processes.

Sidelighting means the illumination of *building* interiors with daylight admitted through *fenestration* located on an exterior wall, such as windows.

Skylight means a form of *fenestration* that is inclined less than 60° from the horizontal.

*Space heater** means a *space-heating appliance*† for heating the room or space within which it is located, without the use of ducts.

Standby losses (SL) are the heat losses incurred by a *storage-type service water heater* under a stable condition when no water is withdrawn from the tank and the water temperature is held constant by the thermostats.

*Storage-type service water heater** means a *service water heater*† with an integral hot water storage tank.

*Storey** means that portion of a *building* that 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.

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*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*†. (See Appendix A.)

Supply air handler means that part of a heating, ventilating and air-conditioning system that conditions return air and/or outdoor air and delivers it to the *supply ducts*.

*Supply duct** means a duct for conveying air from a heating, ventilating or air-conditioning *appliance*† to a space to be heated, ventilated or air-conditioned.

Temperature-control zone means a space that is controlled by an individual temperature-control device.

*Theatre** means a place of public assembly intended for the production and viewing of the performing arts or the screening and viewing of motion pictures, and consisting of an auditorium with permanently fixed seats intended solely for a viewing audience.

Thermal block means a space or group of spaces that is considered as one homogeneous space for modeling purposes. A *thermal block* shall be:

(a) one *temperature-control zone*,

(b) a group of *temperature-control zones*

(i) that are served by the same *secondary system* or by systems that can be considered to be identical,

(ii) that are operated and controlled in the same way, and

(iii) whose space use and envelope characteristics are sufficiently similar that the heating and cooling energy consumption obtained by modeling the group of zones as a *thermal block* is not significantly different from what would be obtained by summing the results for the individual zones modeled separately, or

(c) a zone consisting entirely of indirectly *conditioned spaces*.

Thermal efficiency (E_t) means a measure of the efficiency of fuel-burning equipment in converting fuel to heat, as obtained through the procedures described in the standards referenced in this Code.

Toplighting means the illumination of *building* interiors with daylight admitted through *fenestration* located on the roof, such as *skylights* and rooftop monitors.

*Unit heater** means a suspended *space heater* with an integral air-circulating fan.

1.4.2. Symbols and Other Abbreviations

1.4.2.1. Symbols and Other Abbreviations

1) The symbols and other abbreviations in this Code shall have the meanings assigned to them in this Article and Article 1.3.2.1. of Division B.

A ..... ampere(s)

a ..... annum (year)

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

CH ..... *ceiling height*

COP ..... *coefficient of performance*

° ..... degree(s) (of an angle)

°C ..... degree(s) Celsius

°F ..... degree(s) Farenheit

db ..... dry bulb (temperature)

E_c ..... *combustion efficiency*

E_t ..... *thermal efficiency*

EER ..... *energy-efficiency ratio*

EF ..... *energy factor*

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gpm ..... gallon(s) per minute
> ..... greater than
≥ ..... greater than or equal to
h ..... hour(s)
HVAC ..... heating, ventilating and air-conditioning
ICOP ..... *integrated coefficient of performance*
IEER ..... *integrated energy-efficiency ratio*
IPLV ..... *integrated part-load value*
K ..... Kelvin
kg ..... kilogram(s)
kVA ..... kilovolt ampere(s)
kW ..... kilowatt(s)
< ..... less than
≤ ..... less than or equal to
L ..... litre(s)
lin ..... linear
LPD ..... lighting power density
lx ..... lux
m ..... metre(s)
max. ..... maximum
MBH ..... mega Btu/h
min. ..... minimum
mm ..... millimetre(s)
No. ..... number
o.c. ..... on centre
Pa ..... pascal(s)
% ..... per cent
R ..... thermal resistance value (imperial unit)
RSI ..... thermal resistance value (metric unit)
s ..... second(s)
SCOP ..... seasonal *coefficient of performance*
SEER ..... *seasonal energy-efficiency ratio*
SL ..... *standby losses*
Δt ..... temperature difference
US gal. ..... US gallon(s)
USGPM ..... US gallon(s) per minute
U-value ..... *overall thermal transmittance*
V ..... volt(s)
V_t ..... storage volume
W ..... watt(s)
wb ..... wet bulb (temperature)
wt ..... weight

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Section 1.5. Referenced Documents and Organizations

1.5.1. Referenced Documents

1.5.1.1. Application of Referenced Documents

1) The provisions of documents referenced in this Code, and of any documents referenced within those documents, apply only to the extent that they relate to

a) *buildings*,
b) *building* systems, and
c) the objective and functional statements attributed to the applicable acceptable solutions in Division B where the documents are referenced.

(See Appendix A.)

1.5.1.2. Conflicting Requirements

1) In the case of conflict between the provisions of this Code and those of a referenced document, the provisions of this Code shall govern.

1.5.1.3. Applicable Editions

1) Where documents are referenced in this Code, they shall be the editions designated in Subsection 1.3.1. of Division B.

1.5.2. Organizations

1.5.2.1. Abbreviations of Proper Names

1) The abbreviations of proper names in this Code shall have the meanings assigned to them in Article 1.3.2.1. of Division B.

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Part 2
Objectives

Section 2.1. Application

2.1.1. Application

2.1.1.1. Application

1) This Part applies to all *buildings* covered in this Code. (See Article 1.1.1.1.)

2.1.1.2. Application of Objectives

1) The objectives described in this Part apply
a) to all *buildings* covered in this Code (see Article 1.1.1.1.), and
b) only to the extent that they relate to compliance with this Code as required in Article 1.2.1.1.

Section 2.2. Objectives

2.2.1. Objectives

2.2.1.1. Objectives

1) The objectives of this Code are as follows (see Appendix A):

OE Environment
An objective of this Code is to limit the probability that, as a result of the design or construction of the *building*, the environment will be affected in an unacceptable manner.

OE1 Resources
An objective of this Code is to limit the probability that, as a result of the design or construction of the *building*, resources will be used in a manner that will have an unacceptable effect on the environment. The risks of unacceptable effect on the environment due to use of resources addressed in this Code are those caused by—

OE1.1 – excessive use of energy

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Part 3
Functional Statements

Section 3.1. Application

3.1.1. Application

3.1.1.1. Application

1) This Part applies to all *buildings* covered in this Code. (See Article 1.1.1.1.)

3.1.1.2. Application of Functional Statements

1) The functional statements described in this Part apply
a) to all *buildings* covered in this Code (see Article 1.1.1.1.), and
b) only to the extent that they relate to compliance with this Code as required in Article 1.2.1.1.

Section 3.2. Functional Statements

3.2.1. Functional Statements

3.2.1.1. Functional Statements

1) The objectives of this Code are achieved by measures, such as those described in the acceptable solutions in Division B, that are intended to allow the *building* or its elements to perform the following functions (see Appendix A):

F90 To limit the amount of uncontrolled air leakage through the *building envelope*.

F91 To limit the amount of uncontrolled air leakage through system components.

F92 To limit the amount of uncontrolled thermal transfer through the *building envelope*.

F93 To limit the amount of uncontrolled thermal transfer through system components.

F94 To limit the unnecessary demand and/or consumption of energy for lighting.

F95 To limit the unnecessary demand and/or consumption of energy for heating and cooling.

F96 To limit the unnecessary demand and/or consumption of energy for *service water* heating.

F97 To limit the unnecessary demand and/or consumption of energy for electrical equipment and devices.

F98 To limit the inefficiency of equipment.

F99 To limit the inefficiency of systems.

F100 To limit the unnecessary rejection of reusable waste energy.

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Appendix A
Explanatory Material

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A-1.1.1.1.(1) Application of this Code. This Code applies to buildings and their systems, components and assemblies at the time of their construction. Buildings within the scope of Part 9 of Division B of the NBC, as defined in Sentence 1.3.3.3.(1) of Division A of the NBC, are not covered by the NECB.

For the purpose of understanding the scope of this Code, an addition can be thought of as a new building that happens to be built contiguous to an existing building or as a new portion of an existing building.

A-1.2.1.1.(1)(a) Code Compliance via Acceptable Solutions. If a building design (e.g. material, component, assembly or system) can be shown to meet all provisions of the applicable acceptable solutions in Division B (e.g. it complies with the applicable provisions of a referenced standard), it is deemed to have satisfied the objective and functional statements linked to those provisions and thus to have complied with that part of the Code. In fact, if it can be determined that a design meets all the applicable acceptable solutions in Division B, there is no need to consult the objectives and functional statements in Division A to determine its compliance.

A-1.2.1.1.(1)(b) Code Compliance via Alternative Solutions. Where a design differs from the acceptable solutions in Division B, then it should be treated as an "alternative solution." A proponent of an alternative solution must demonstrate that the alternative solution addresses the same issues as the applicable acceptable solutions in Division B and their attributed objective and functional statements. However, because the objective and functional statements are entirely qualitative, demonstrating compliance with them in isolation is not possible. Therefore, Clause 1.2.1.1.(1)(b) identifies the principle that Division B establishes the quantitative performance targets that alternative solutions must meet. In many cases, these targets are not defined very precisely by the acceptable solutions—certainly far less precisely than would be the case with a true performance code, which would have quantitative performance targets and prescribed methods of performance measurement for all aspects of building performance. Nevertheless, Clause 1.2.1.1.(1)(b) makes it clear that an effort must be made to demonstrate that an alternative solution will perform as well as a design that would satisfy the applicable acceptable solutions in Division B—not "well enough" but "as well as."

In this sense, it is Division B that defines the boundaries between acceptable situations and the "unacceptable" situations referred to in the statements of the Code's objectives, i.e. the consequence remaining once the applicable acceptable solutions in Division B have been implemented represents the residual consequence deemed to be acceptable by the broad base of Canadians who have taken part in the consensus process used to develop the Code.

Level of Performance

Where Division B offers a choice between several possible designs, it is likely that these designs may not all provide exactly the same level of performance. Among a number of possible designs satisfying acceptable solutions in Division B, the design providing the lowest level of performance should generally be considered to establish the minimum acceptable level of performance to be used in evaluating alternative solutions for compliance with the Code.

Sometimes a single design will be used as an alternative solution to several sets of acceptable solutions in Division B. In this case, the level of performance required of the alternative solution should be at least equivalent to the overall level of performance established by all the applicable sets of acceptable solutions taken as a whole.

Each provision in Division B has been analyzed to determine to what it applies and what it is intended to achieve. The resultant intent statements clarify what undesirable results each provision seeks to preclude. These statements are not a legal component of the Code, but are advisory in nature, and can help Code users establish performance targets for alternative solutions. They are published in the electronic version of the Code and as a separate document entitled "Supplement to the NECB 2011: Intent Statements," which is available on-line at www.nationalcodes.ca.

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Areas of Performance

A subset of the acceptable solutions in Division B may establish criteria for particular types of designs (e.g. certain types of materials, components, assemblies, or systems). The acceptable solutions in Division B establish acceptable levels of performance for compliance with the Code only in those areas defined by the objective and functional statements attributed to the acceptable solutions.

Applicable Acceptable Solutions

In demonstrating that an alternative solution will perform as well as a design that would satisfy the applicable acceptable solutions in Division B, its evaluation should not be limited to comparison with the acceptable solutions to which an alternative is proposed. It is possible that acceptable solutions elsewhere in the Code also apply. The proposed alternative solution may be shown to perform as well as the most apparent acceptable solution which it is replacing but may not perform as well as other relevant acceptable solutions. For example, an innovative window assembly may perform adequately as an air barrier system but may not have adequate thermal properties. All applicable acceptable solutions should be taken into consideration in demonstrating the compliance of an alternative solution.

A-1.4.1.2.(1) Defined Terms.

Building Envelope Application

Several types of spaces can be unconditioned and thus need to be treated differently, e.g., mechanical rooms, crawl spaces, garages, loading docks.

There is also a need to consider components that separate spaces that are conditioned to substantially different temperatures (e.g., swimming pools, skating rinks).

Gross Lighted Area

Gross lighted area cannot be tied to the building envelope because the building envelope relates only to conditioned space. Gross lighted area is used in the calculation of interior lighting power allowance, which includes all interior lighting, whether the space is conditioned or not, and some lighting of exterior spaces; lighting in elevator and service shafts, if provided at all, is not factored in since it would not have a significant impact on the interior lighting power allowance.

Interior Lighting

Building envelope

Given the definition of building envelope, Clause (a) of the definition of interior lighting applies to lighting of all conditioned spaces.

Other sheltered spaces

Storage garages (parking garages), bus shelters and retail outlets (such as market stalls) are examples of interior spaces that are sheltered from the exterior environment and not necessarily conditioned where the interior lighting is intended only to illuminate that space.

The illumination of a covered exterior walkway may be considered exterior lighting or interior lighting, depending on whether the lighting is intended to light the area around the walkway or only the walkway itself. If only the covered walkway is illuminated, limits for lighting interior corridors would apply.

Overall Thermal Transmittance (U-value)

The overall thermal transmittance, U-value in $W/(m^2 \cdot K)$, is the inverse of the effective RSI in $m^2 \cdot K/W$. To convert RSI to an imperial R-value, use 1 $m^2 \cdot K/W$ = 5.678263 $h \cdot ft^2 \cdot °F/Btu$.

Service Room

Typical examples of service rooms include boiler rooms, furnace rooms, incinerator rooms, garbage-handling rooms, and rooms to accommodate air-conditioning or heating appliances, pumps, compressors and electrical equipment. Rooms such as elevator machine rooms and common laundry rooms are not considered to be service rooms.

Suite

Tenancy in the context of the term "suite" applies to both rental and ownership tenure. In a condominium arrangement, for example, dwelling units are considered separate suites even though they are individually owned. In order to be of complementary use, a series of rooms that constitute a suite must be in reasonably close proximity to each other and have access to each other either directly by means of a common doorway or indirectly by a corridor, vestibule or other similar arrangement.

The term "suite" does not apply to rooms such as service rooms, common laundry rooms and common recreational rooms that are not leased or under a separate tenure in the context of the Code. Similarly, the term "suite" is not normally applied in the context of buildings such as schools and hospitals, since the entire building is under a single tenure. However, a room that is individually rented is considered a suite. A warehousing unit in a mini-warehouse is a suite. A rented room in a nursing home could be considered as a suite if the room were under a separate tenure. A hospital bedroom, on the other hand, is not considered to be under a separate tenure, since the patient has little control of that space, even though he or she pays the hospital a per diem rate for the privilege of using the hospital facilities, which include the sleeping areas.

A-1.5.1.1.(1) Application of Referenced Documents. Documents referenced in the NECB may contain provisions covering a wide range of issues, including issues that are unrelated to the objectives and functional statements stated in Parts 2 and 3 of Division A respectively. Sentence 1.5.1.1.(1) is intended to make it clear that, whereas referencing a document in the NECB generally has the effect of making the provisions of that document part of the Code, provisions that are unrelated to buildings or to the objective and functional statements attributed to the provisions in Division B where the document is referenced are excluded.

Furthermore, many documents referenced in the NECB contain references to other documents, which may also, in turn, refer to other documents. These secondary and tertiary referenced documents may contain provisions that are unrelated to buildings or to the objectives and functional statements of the NECB: such provisions—no matter how far down the chain of references they occur—are not included in the intent of Sentence 1.5.1.1.(1).

A-2.2.1.1.(1) Objectives. Where the term "the building" is used in the wording of the objectives, it refers to the building for which compliance with the NECB is being assessed.

A-3.2.1.1.(1) Listing of Functional Statements. There is a master list of functional statements covering the National Model Codes—the National Building Code, the National Fire Code, the National Plumbing Code and the National Energy Code for Buildings—but not all functional statements are pertinent to all Codes. The numbered functional statements are grouped according to functions that deal with closely related subjects.

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Division B

Acceptable Solutions

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Part 1
General

Section 1.1. General

1.1.1. Application

1.1.1.1. Application

1) This Part applies to all *buildings* covered in this Code. (See Article 1.1.1.1. of Division A.)

1.1.2. Compliance

1.1.2.1. Prescriptive, Trade-off or Performance Compliance

(See Appendix A.)

1) *Buildings* shall comply with
a) the prescriptive or trade-off requirements stated in Parts 3 to 7, or
b) the performance requirements stated in Part 8.

1.1.3. Objective and Functional Statements

1.1.3.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in Division B shall be the objective and functional statements identified in Sections 3.5., 4.5., 5.5., 6.5., 7.5. and 8.5. (See Appendix A.)

1.1.4. Basic Data and Calculation Methods

1.1.4.1. Climatic Values

1) The climatic values required for the design of *buildings* under this Code shall be in conformance with the values established by the *authority having jurisdiction* or, in the absence of such data, with the climatic values in Appendix C, Climatic and Seismic Information for Building Design in Canada, of the National Building Code of Canada for the location nearest to the *building* site. (See Appendix A.)

1.1.4.2. Calculation Procedures

1) Calculations carried out to ensure compliance with this Code and not described in the balance of this Subsection or in other Parts of the Code shall be carried out using procedures recognized for the particular purposes, such as those described in, but not limited to:
a) ASHRAE Handbooks, Standards and Guidelines,
b) HRAI Digest,
c) Hydronics Institute Manuals, and
d) ISO 13790 – Energy performance of buildings - Calculation of energy use for space heating and cooling.

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Section 1.2. Terms and Abbreviations

1.2.1. Definitions of Words and Phrases

1.2.1.1. Non-defined Terms

1) Words and phrases used in Division B that are not included in the list of definitions in Article 1.4.1.2. of Division A shall have the meanings that are 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.

2) Where objectives and functional statements are referred to in Division B, they shall be the objectives and functional statements described in Parts 2 and 3 of Division A.

3) Where acceptable solutions are referred to in Division B, they shall be the provisions stated in Parts 3 to 8.

1.2.1.2. Defined Terms

1) The words and terms in italics in Division B shall have the meanings assigned to them in Article 1.4.1.2. of Division A.

1.2.2. Symbols and Other Abbreviations

1.2.2.1. Symbols and Other Abbreviations

1) The symbols and other abbreviations in Division B shall have the meanings assigned to them in Article 1.4.2.1. of Division A and Article 1.3.2.1.

Section 1.3. Referenced Documents and Organizations

1.3.1. Referenced Documents

1.3.1.1. Effective Date

1) Unless otherwise specified herein, the documents referenced in this Code shall include all amendments, revisions, reaffirmations, reapprovals, addenda and supplements effective to 30 June 2010.

1.3.1.2. Applicable Editions

1) Where documents are referenced in this Code, they shall be the editions designated in Table 1.3.1.2. (See Appendix A.) (See also Appendix Note A-1.5.1.1.(1) of Division A.)

Table 1.3.1.2.
Documents Referenced in the National Energy Code of Canada for Buildings 2011
Forming Part of Sentence 1.3.1.2.(1)

Issuing Agency	Document Number[1]	Document Title[2]	Code Reference
AAMA	501.5-07	Thermal Cycling of Exterior Walls	3.2.4.3.(2)
AHAM	ANSI/AHAM RAC-1-1982	Room Air Conditioners	Table 5.2.12.1.
AHRI	ANSI/AHRI 210/240-2008	Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment	Table 5.2.12.1.
AHRI	ANSI/AHRI 340/360-2007	Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment	Table 5.2.12.1.
AHRI	365-2009	Commercial and Industrial Unitary Air-Conditioning Condensing Units	Table 5.2.12.1.
AHRI	ANSI/AHRI 390-2003	Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps	Table 5.2.12.1.

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Table 1.3.1.2. (Continued)

Issuing Agency	Document Number[1]	Document Title[2]	Code Reference
AHRI	ANSI/AHRI 1060-2005	Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation	5.2.10.1.(5)
AMCA	500-89	Louvers, Dampers and Shutters	5.2.4.2.(2)
ANSI/CSA	ANSI Z21.10.3-2004/ CSA 4.3-04	Gas Water Heaters – Volume III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous	Table 6.2.2.1.
ANSI/CSA	ANSI Z21.13-2004/ CSA 4.9-04	Gas-Fired Low Pressure Steam and Hot Water Boilers	Table 5.2.12.1.
ANSI/CSA	ANSI Z21.47-2006/ CSA 2.3-2006	Gas-Fired Central Furnaces	Table 5.2.12.1.
ANSI/CSA	ANSI Z21.56-2006/ CSA 4.7-2006	Gas-Fired Pool Heaters	Table 6.2.2.1.
ANSI/CSA	ANSI Z83.8-2006/ CSA 2.6-2006	Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-Fired Duct Furnaces	Table 5.2.12.1.
ASHRAE	2009	ASHRAE Handbook – Fundamentals	3.1.1.5.(4)
ASHRAE	ANSI/ASHRAE 127-2007	Rating Computer and Data Processing Room Unitary Air-Conditioners	Table 5.2.12.1.
ASHRAE	ANSI/ASHRAE 140-2007	Evaluation of Building Energy Analysis Computer Programs	3.3.4.4.(4) 8.4.2.2.(5)
ASME	PTC 4-2008	Fired Steam Generators - Performance Test Codes	Table 5.2.12.1.
ASME/CSA	ASME A112.18.1-05/ CAN/CSA-B125.1-05	Plumbing Supply Fittings	6.2.6.1.(1) 6.2.6.2.(1)
ASTM	C 177-10	Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus	3.1.1.5.(1)
ASTM	C 335/C 335M-05	Steady-State Heat Transfer Properties of Pipe Insulation	5.2.5.3.(7) 6.2.3.1.(4)
ASTM	C 518-10	Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus	3.1.1.5.(1)
ASTM	C 1363-05	Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus	3.1.1.5.(4) 3.1.1.5.(5)
ASTM	E 283-04	Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen	3.2.4.3.(2) 3.2.4.4.(1) to (3)
CCBFC	NRCC 53301	National Building Code of Canada 2010	1.1.1.1.(1)[3] 1.1.1.3.(1)[3] 1.1.1.3.(2)[3] 1.1.4.1.(1) 1.4.1.2.(1)[3] 3.1.1.5.(1) 3.2.2.1.(3) 5.2.1.1.(1) 5.2.2.1.(1) 5.2.2.8.(2) 5.2.5.1.(1) 5.2.10.4.(2)
CCBFC	NRCC 53302	National Plumbing Code of Canada 2010	6.2.1.1.(1)
CSA	AAMA/WDMA/CSA 101/I.S.2/A440-08	NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights	3.2.4.3.(3) 3.2.4.3.(4)
CSA	A440.2-09/A440.3-09	Fenestration Energy Performance/User Guide to CSA A440.2-09, Fenestration Energy Performance	3.1.1.5.(3)
CSA	CAN/CSA-B125.3-05	Plumbing Fittings	6.2.6.1.(1) 6.2.6.2.(1)
CSA	CAN/CSA-B140.4-04	Oil-Fired Warm Air Furnaces	Table 5.2.12.1.
CSA	CAN/CSA-B211-00	Energy Efficiency of Oil-Fired Storage Tank Water Heaters	Table 6.2.2.1.
CSA	B212-00	Energy Utilization Efficiencies of Oil-Fired Furnaces and Boilers	Table 5.2.12.1.
CSA	CAN/CSA-C191-04	Electric Storage Tank Water Heaters for Domestic Hot Water Service	Table 6.2.2.1.
CSA	CAN/CSA-C368.1-M90	Room Air Conditioners	Table 5.2.12.1.

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Table 1.3.1.2. (Continued)

Issuing Agency	Document Number(1)	Document Title(2)	Code Reference
CSA	C390-10	Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors	7.2.4.1.(1)
CSA	CAN/CSA-C439-09	Rating the Performance of Heat/Energy-Recovery Ventilators	5.2.10.4.(2)
CSA	C654-M91	Fluorescent Lamp Ballast Efficacy Measurements	4.2.1.2.(1) and (2)
CSA	CAN/CSA-C656-05	Split-System and Single-Package Central Air Conditioners and Heat Pumps	Table 5.2.12.1.
CSA	CAN/CSA-C743-09	Rating Packaged Water Chillers	Table 5.2.12.1.
CSA	ARI 310/380-2004/ CAN/CSA-C744-04	Packaged Terminal Air Conditioners and Heat Pumps (Bi-National Standard, with ARI 310/380-2004)	Table 5.2.12.1.
CSA	CAN/CSA-C745-03	Energy Efficiency of Electric Storage Tank Water Heaters and Heat Pump Water Heaters	Table 6.2.2.1.
CSA	CAN/CSA-C746-06	Rating Large and Single Packaged Vertical Air Conditioners and Heat Pumps	Table 5.2.12.1.
CSA	C748-94	Direct-Expansion (DX) Ground-Source Heat Pumps	Table 5.2.12.1.
CSA	CAN/CSA-C802.1-00	Minimum Efficiency Values for Liquid-Filled Distribution Transformers	7.2.3.1.(1)
CSA	CAN/CSA-C802.2-06	Minimum Efficiency Values for Dry-Type Transformers	7.2.3.1.(1)
CSA	CAN/CSA-C802.3-01	Maximum Losses for Power Transformers	7.2.3.1.(1)
CSA	CAN/CSA-C828-06	Thermostats Used with Individual Room Electric Space Heating Devices	5.2.8.5.(4)
CSA	CAN/CSA-C860-07	Internally Lighted Exit Signs	4.2.1.1.(1)
CSA	CAN/CSA-C13256-1-01	Water-Source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps (Adopted ISO 13256-1:1998, with Canadian Deviations)	Table 5.2.12.1.
CSA	CAN/CSA-C13256-2-01	Water-Source Heat Pumps - Testing and Rating for Performance - Part 2: Water-to-Water and Brine-to-Water Heat Pumps (Adopted ISO 13256-2:1998, with Canadian Deviations)	Table 5.2.12.1.
CSA	CAN/CSA-F379 SERIES-09	Packaged Solar Domestic Hot Water Systems (Liquid-to-Liquid Heat Transfer)	6.2.2.3.(1)
CSA	CAN/CSA-P.3-04	Measuring Energy Consumption and Determining Efficiencies of Gas-Fired Storage Water Heaters	Table 6.2.2.1.
CTI	201(04)	Certification of Water-Cooling Tower Thermal Performance	Table 5.2.12.1.
DOE	10 CFR, Part 430-2011	Energy, Energy Conservation Program for Consumer Products	Table 6.2.2.1.
HRAI	SAR-G1	HRAI Digest 2005	1.1.4.2.(1)
ISO	13790:2008	Energy performance of buildings – Calculation of energy use for space heating and cooling	1.1.4.2.(1)
NEMA	NEMA ANSI C82.11:2002	High-Frequency Fluorescent Lamp Ballasts	4.2.1.2.(2)
NFRC	100-2010	Determining Fenestration Product U-factors	3.1.1.5.(3)
NRCan	SOR/94-651-2008	Energy Efficiency Act and its Regulations	5.2.12.3.(1) 6.2.2.4.(1) 6.2.2.5.(1)
SMACNA	ANSI/SMACNA 006-2006	HVAC Duct Construction Standards – Metal and Flexible	5.2.2.3.(1) Table 5.2.2.3.
SMACNA	1985	HVAC Air Duct Leakage Test Manual	5.2.2.4.(1)

Notes to Table 1.3.1.2.:

(1) Some documents may have been reaffirmed or reapproved. Check with the applicable issuing agency for up-to-date information.

(2) Some titles have been abridged to omit superfluous wording.

(3) Code reference is in Division A.

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1.3.2. Organizations

1.3.2.1. Abbreviations of Proper Names

1) The abbreviations of proper names in this Code shall have the meanings assigned to them in this Article (the appropriate addresses of the organizations are shown in brackets).

AAMA ..... American Architectural Manufacturers Association (1827 Walden Office Square, Suite 550, Schaumburg, Illinois 60173-4268 U.S.A.; www.aamanet.org)

AHAM ..... Association of Home Appliance Manufacturers (111 19th Street, NW, Suite 402, Washington, D.C. 20036 U.S.A.; www.aham.org)

AHRI ..... Air-Conditioning, Heating and Refrigeration Institute (2111 Wilson Boulevard, Suite 500, Arlington, Virginia 22201 U.S.A.; www.ahrinet.org)

AMCA ..... Air Movement and Control Association (30 West University Drive, Arlington Heights, Illinois 60004 U.S.A.; www.amca.org)

ANSI ..... American National Standards Institute (25 West 43rd Street, 4th Floor, New York, New York 10036 U.S.A.; www.ansi.org)

ASHRAE ..... American Society of Heating, Refrigerating and Air-Conditioning Engineers (1791 Tullie Circle, NE, Atlanta, Georgia 30329 U.S.A.; www.ashrae.org)

ASME ..... American Society of Mechanical Engineers (Three Park Avenue, New York, New York 10016-5990 U.S.A.; www.asme.org)

ASTM ..... American Society for Testing and Materials International (100 Barr Harbor Drive, West Conshohoken, Pennsylvania 19428-2959 U.S.A.; www.astm.org)

CAN ..... National Standard of Canada designation

CCBFC ..... Canadian Commission on Building and Fire Codes (National Research Council of Canada, Ottawa, Ontario K1A 0R6; www.nationalcodes.ca)

CSA ..... Canadian Standards Association (5060 Spectrum Way, Suite 100, Mississauga, Ontario L4W 5N6; www.csa.ca)

CTI ..... Cooling Technology Institute (P.O. Box 73383, Houston, Texas 77273-3383 U.S.A.; www.cti.org)

DOE ..... Department of Energy (1000 Independence Avenue, SW, Washington, D.C. 20585 U.S.A.; http://energy.gov)

HRAI ..... Heating, Refrigeration and Air Conditioning Institute of Canada (2800 Skymark Avenue, Building 1, Suite 201, Mississauga, Ontario L4W 5A6; www.hrai.ca)

HVI ..... Home Ventilating Institute (1000 N. Rand Road, Suite 214, Wauconda, Illinois 60084 U.S.A.; www.hvi.org)

IESNA ..... Illuminating Engineering Society of North America (120 Wall Street, Floor 17, New York, New York 10005-4001 U.S.A.; www.iesna.org)

ISO ..... International Organization for Standardization (Standards Council of Canada, 270 Albert Street, Suite 200, Ottawa, Ontario K1P 6N7; www.iso.org)

NBC ..... National Building Code of Canada 2010 (see CCBFC)

NECB ..... National Energy Code of Canada for Buildings 2011

NEMA ..... National Electrical Manufacturers Association (1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209 U.S.A.; www.nema.org)

NFRC ..... National Fenestration Rating Council (6305 Ivy Lane, Suite 140, Greenbelt, Maryland 20770 U.S.A.; www.nfrc.org)

NPC ..... National Plumbing Code of Canada 2010 (see CCBFC)

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NRC ..... National Research Council of Canada (Ottawa, Ontario K1A 0R6; www.nrc-cnrc.gc.ca)

NRCan ..... Natural Resources Canada (www.nrcan.gc.ca)

SMACNA .... Sheet Metal and Air Conditioning Contractors' National Association (4201 Lafayette Center Drive, Chantilly, Virginia 20151-1219 U.S.A.; www.smacna.org)

TIAC ..... Thermal Insulation Association of Canada (1485 Laperrière Avenue, Ottawa, Ontario K1Z 7S8; www.tiac.ca)

U.S. Gov't .... U.S. Government Printing Office (732 North Capitol Street, NW, Washington, D.C. 20401-0001 U.S.A.; www.gpo.gov)

WDMA ..... Window & Door Manufacturers Association (401 N. Michigan Avenue, Suite 2200, Chicago, Illinois 60611 U.S.A.; www.wdma.com)

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Part 2
Reserved

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Part 3
Building Envelope

Section 3.1. General

3.1.1. General

3.1.1.1. Scope

1) This Part is concerned with the transfer of heat and air through
a) *building* materials, components and assemblies forming part of the *building envelope*, and
b) interfaces between *building* materials, components and assemblies forming part of the *building envelope*.

3.1.1.2. Application

1) This Part applies to the *building envelope* in *buildings*
a) that are equipped with space-conditioning systems or have provisions for the future installation of such systems (see Appendix A), and
b) whose heating and/or cooling system output capacity is equal to or greater than 10 W/m² of *floor surface area*.

3.1.1.3. Compliance

1) Compliance with this Part shall be achieved by following
a) the prescriptive path described in Section 3.2.,
b) the trade-off path described in Section 3.3., or
c) the performance path described in Section 3.4. (see Appendix A).

(See Appendix A.)

3.1.1.4. Definitions

1) Words that appear in italics are defined in Article 1.4.1.2. of Division A.

3.1.1.5. Thermal Characteristics of Building Assemblies

(See Appendix A.)

1) The thermal characteristics of *building envelope* materials shall be determined in accordance with the applicable product standards listed in the NBC or, in the absence of such standards or where such standards do not address the determination of thermal characteristics, in accordance with
a) ASTM C 177, "Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus," or
b) ASTM C 518, "Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus."

2) Calculations and tests performed in accordance with Sentence (1) shall be carried out at an average temperature of 24±2°C and under a temperature difference of 22±2°C.

3) Except as provided in Sentence (4), the *overall thermal transmittance* of *fenestration* and doors shall be determined for the reference sizes listed in accordance with
a) CSA A440.2/A440.3, "Fenestration Energy Performance/User Guide to CSA A440.2-09, Fenestration Energy Performance,"or
b) NFRC 100, "Determining Fenestration Product U-factors."

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4) The *overall thermal transmittance* of *fenestration* and doors that are not within the scope of the standards listed in Sentence (3) shall be determined from

a) calculations carried out using the procedures described in the ASHRAE Handbook – Fundamentals, or
b) laboratory tests performed in accordance with ASTM C 1363, "Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an indoor air temperature of 21±1°C and an outdoor air temperature of –18±1°C measured at the mid-height of the *fenestration* or door.

5) The thermal characteristics of *building* assemblies other than *fenestration* and doors shall be determined from

a) calculations, or
b) laboratory tests performed in accordance with ASTM C 1363, "Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an average temperature of 24±1°C and a temperature difference of 22±1°C.

3.1.1.6. Calculation of Fenestration and Door Areas

1) *Fenestration* and door areas shall be calculated to the rough opening in the wall and shall include all related *frame* and *sash* members. (See Appendix A.)

2) The *fenestration* area made of flat panes that are not all in the same plane or curved panes shall be measured along the surface of the glass. (See Appendix A.)

3) Except as provided in Sentence (4), in the calculation of allowable *fenestration* and door area, the gross wall area shall be calculated as the sum of the areas of all above-ground wall assemblies including *fenestration* and doors, but not including parapets, projected fins, ornamentation and appendages.

4) The calculation of allowable *fenestration* and door area in *additions* shall be based upon

a) the *addition* being considered by itself, or
b) the *addition* being considered together with the existing *building*, provided that the combined *overall thermal transmittance* of the *addition* and existing *building* meets the prescriptive or trade-off requirements.

5) In the calculation of allowable *skylight* area, the gross roof area shall be calculated as the sum of the areas of insulated roof including *skylights*.

3.1.1.7. Calculation of Overall Thermal Transmittance

1) In calculating the *overall thermal transmittance* of assemblies for purposes of comparison with the provisions in Section 3.2., the thermal bridging effect of closely spaced repetitive structural members, such as studs and joists, and of ancillary members, such as lintels, sills and plates, shall be accounted for as described in Article 1.1.4.2.

2) In calculating the *overall thermal transmittance* of assemblies for purposes of comparison with the provisions in Section 3.2., the thermal bridging effect of major structural members, such as columns and spandrel beams, that are parallel to the plane of the *building envelope* and partly penetrate that *building envelope* assembly need not be taken into account, provided they do not increase the *overall thermal transmittance* at the projected area of the member to more than twice that permitted in Section 3.2. (See Appendix A.)

3) In calculating the *overall thermal transmittance* of assemblies for purposes of comparison with the provisions in Section 3.2., pipes, ducts, equipment with through-the-wall venting, packaged terminal air conditioners or heat pumps, shelf angles, anchors and ties and associated fasteners, and other minor structural members that must completely penetrate the *building envelope* to perform their intended function need not be taken into account. (See Appendix A.)

4) In calculating the *overall thermal transmittance* of assemblies for purposes of comparison with the provisions in Section 3.2., major structural penetrations, such as

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balcony slabs, beams, girders, columns, and ornamentation or appendages that must completely penetrate the *building envelope* to perform their intended function need not be taken into account, provided that the sum of the cross-sectional areas at such major structural penetrations is limited to a maximum of 2% of the above-ground *building envelope* area. (See Appendix A.)

5) Where a component of the *building envelope* is protected by an enclosed unconditioned space, such as a sun porch, enclosed veranda or vestibule, the unconditioned enclosure may be considered to have an *overall thermal transmittance* of 6.25 W/(m²·K), which is equivalent to that of one layer of glass. (See Appendix A.)

6) For the purposes of this Article, roof assemblies shall be considered to include all related structural framing.

7) For the purposes of this Article, wall assemblies inclined less than 60° from the horizontal shall be considered as roof assemblies, and roof assemblies inclined 60° or more from the horizontal shall be considered as wall assemblies.

8) For the purposes of this Article, wall assemblies shall be considered to include all related structural framing and perimeter areas of intersecting interior walls but shall not include the perimeter areas where floor or roof slabs interrupt the wall's construction. (See Appendix A.)

9) For the purposes of this Article, floor assemblies shall be considered to include all related structural framing.

Section 3.2. Prescriptive Path

3.2.1. General

3.2.1.1. Protection of Insulation Materials

1) Except as provided in Sentence (2), the *building envelope* shall be designed to avoid increasing the *overall thermal transmittance* of the insulation material due to

a) air leakage or convection,
b) wetting, or
c) moisture bypassing the plane of thermal resistance.

(See Appendix A.)

2) Where any of the conditions described in Clauses (1)(a) to (c) occur as a result of the designed *building envelope* system, their effect on the *overall thermal transmittance* of the insulation material shall be calculated in accordance with Article 3.1.1.5.

3.2.1.2. Continuity of Insulation

1) Except as provided in Sentences (2) to (6), interior *building* components that intersect with components of the *building envelope* and major structural members that partly penetrate the *building envelope* shall not break the continuity of the insulation and shall not increase the *overall thermal transmittance* at their projected area to more than that permitted in Section 3.2. (See Appendix A.)

2) Where an interior wall penetrates an exterior wall or insulated roof or ceiling and breaks the continuity of the *building envelope*, it shall be insulated

a) on both of its sides inward or outward from the *building envelope* for a distance equal to 4 times the uninsulated thickness of the penetrating wall, and
b) to an *overall thermal transmittance* no more than that required for the exterior wall.

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3) Where an ornamentation or appendage other than a balcony slab or canopy slab penetrates an exterior wall and breaks the continuity of the *building envelope*, it shall be insulated

a) on both of its sides inward or outward from the *building envelope* for a distance equal to 4 times the thickness of the penetrated wall, and
b) to an *overall thermal transmittance* no more than that required for the exterior wall.

4) Where *building envelope* assemblies in the same plane intersect but their respective expanses of insulation do not, one of the two expanses of insulation shall be extended beyond the intersecting assembly for a distance equal to at least 4 times the distance separating the two expanses of insulation. (See Appendix A.)

5) Where mechanical ducts and chases or electrical system components, such as pipes, ducts, conduits, cabinets, panels, or recessed heaters, are placed within and parallel to the *building envelope*, the *overall thermal transmittance* of the *building envelope* at the projected area of the mechanical or electrical system components shall not be increased.

6) Except as provided in Sentence (4), joints between components of the *building envelope*, such as expansion or construction joints or joints between walls and doors or *fenestration*, shall be insulated in a manner that provides continuity across such joints. (See Appendix A.)

3.2.1.3. Spaces Heated to Different Temperatures

1) The *overall thermal transmittance*, U_1, of *building* assemblies separating *conditioned spaces* that are intended to be heated to temperatures that differ by more than 10°C shall not be greater than that obtained with the following equation:

$$U_1 = [(t_2 - t_0) / (t_2 - 0.5 \cdot t_1 - 0.5 \cdot t_0)] \cdot U$$

where

t_1 = indoor heating design temperature of the colder *conditioned space*, in °C,
t_2 = indoor heating design temperature of the warmer *conditioned space*, in °C,
t_0 = outdoor 2.5% January design temperature as specified in Article 1.1.4.1., in °C, and
U = *overall thermal transmittance* required in Sentences 3.2.2.2.(1), 3.2.2.3.(2) and 3.2.2.4.(1), in W/(m²·K).

(See Appendix A.)

3.2.1.4. Allowable Fenestration and Door Area

1) The maximum allowable total vertical *fenestration* and door area to gross wall area ratio (FDWR), determined in accordance with Article 3.1.1.6., shall be as follows:

$$\text{FDWR} = 0.40 \text{ for } \text{HDD} \leq 4000,$$
$$\text{FDWR} = (2000 - 0.2 \cdot \text{HDD}) / 3000 \text{ for } 4000 < \text{HDD} < 7000 \text{ , and}$$
$$\text{FDWR} = 0.20 \text{ for } \text{HDD} \geq 7000,$$

where

HDD = the heating degree-days of the location of the *building* determined according to Sentence 1.1.4.1.(1).

(See Appendix A.)

2) The total *skylight* area shall be less than 5% of the gross roof area as determined in Article 3.1.1.6.

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3.2.2. Above-ground Components of the Building Envelope

3.2.2.1. Vestibules

1) Except as provided in Sentence (3), a door that separates *conditioned space* from the exterior shall be protected with an enclosed vestibule whose doors opening into and out of the vestibule are equipped with self-closing devices.

2) Except for doors equipped with power operators in barrier-free entrances, vestibules required in Sentence (1) shall be designed so that users passing through the vestibule are not required to open the interior and exterior doors at the same time.

3) A vestibule is not required for an exterior door that

a) is a revolving door,
b) is used primarily to facilitate vehicular movement or material handling,
c) is intended to be used as a service, emergency *exit*, or stairwell *exit* door only,
d) is intended to be used as a seasonal use door, such as a door leading to a patio,
e) opens directly from a *dwelling unit*,
f) opens directly from a retail space less than 200 m^2 in area or from a space less than 150 m^2 for other uses, or
g) is located in a *building* less than 5 *storeys* in *building height* in any area that has fewer than 3500 heating degree-days (°C) as listed in Appendix C of Division B of the NBC.

3.2.2.2. Thermal Characteristics of Above-ground Opaque Building Assemblies

1) Except as provided in Sentences (2) and (3) and in Sentence 3.2.1.3.(1), the *overall thermal transmittance* of above-ground *opaque building assemblies* shall be not more than that shown in Table 3.2.2.2. for the *building* or part thereof enclosed by the *opaque building assembly*, for the applicable heating-degree day category. (See Appendix A.)

Table 3.2.2.2.
Overall Thermal Transmittance of Above-ground Opaque Building Assemblies
Forming Part of Sentences 3.2.2.2.(1) and (2)

Above-ground *Opaque Building Assembly*	Heating Degree-Days of *Building* Location,[1] in Celsius Degree-Days					
	Zone 4:[2] < 3000	Zone 5:[2] 3000 to 3999	Zone 6:[2] 4000 to 4999	Zone 7A:[2] 5000 to 5999	Zone 7B:[2] 6000 to 6999	Zone 8:[2] ≥ 7000
	Maximum *Overall Thermal Transmittance*, in W/(m^2·K)					
Walls	0.315	0.278	0.247	0.210	0.210	0.183
Roofs	0.227	0.183	0.183	0.162	0.162	0.142
Floors	0.227	0.183	0.183	0.162	0.162	0.142

Notes to Table 3.2.2.2.:
[1] See Sentence 1.1.4.1.(1).
[2] See Appendix A.

2) The *overall thermal transmittance* of portions of a *foundation* wall that are above ground, where the top of a *foundation* wall is less than 0.4 m above the adjoining ground level, shall be not more than that shown in Table 3.2.2.2.

3) Where radiant heating cables or heating or cooling pipes or membranes are embedded in the surface of an above-ground *opaque building assembly*, this assembly shall have an *overall thermal transmittance* no greater than 80% of that required by Sentence (1). (See Appendix A.)

3.2.2.3. Thermal Characteristics of Fenestration

1) For the purposes of this Article, use of the term "*fenestration*" does not include doors, which are covered in Article 3.2.2.4.

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2) Except as provided in Sentences (3) and 3.2.1.3.(1), the *overall thermal transmittance* of *fenestration*, shall be not more than that shown in Table 3.2.2.3. for the applicable heating-degree-day category, as determined in accordance with Article 3.1.1.5.

3) *Skylights* whose *overall thermal transmittance* exceeds the values shown in Table 3.2.2.3. are permitted, provided that

a) the total area of such *skylights* does not exceed 2% of the gross roof area calculated in accordance with Article 3.1.1.6., and
b) the *overall thermal transmittance* of such *skylights* is not more than 3.4 W/(m²·K).

(See Appendix A.)

Table 3.2.2.3.
Overall Thermal Transmittance of Fenestration
Forming Part of Sentences 3.2.2.3.(2) and (3)

Component	Heating Degree-Days of *Building* Location,(1) in Celsius Degree-Days					
	Zone 4:(2) < 3000	Zone 5:(2) 3000 to 3999	Zone 6:(2) 4000 to 4999	Zone 7A:(2) 5000 to 5999	Zone 7B:(2) 6000 to 6999	Zone 8:(2) ≥ 7000
	Maximum *Overall Thermal Transmittance*, in W/(m²·K)					
All *fenestration*	2.4	2.2	2.2	2.2	2.2	1.6

Notes to Table 3.2.2.3.:
(1) See Sentence 1.1.4.1.(1).
(2) See A-Table 3.2.2.2. in Appendix A.

3.2.2.4. Thermal Characteristics of Doors and Access Hatches

1) Except as provided in Sentences (2), (4) and 3.2.1.3.(1), the *overall thermal transmittance* of doors shall be not more than that shown in Table 3.2.2.4. for the applicable heating-degree-day category, as determined in accordance with Article 3.1.1.5.

Table 3.2.2.4.
Overall Thermal Transmittance of Doors
Forming Part of Sentence 3.2.2.4.(1)

Component	Heating Degree-Days of *Building* Location,(1) in Celsius Degree-Days					
	Zone 4:(2) < 3000	Zone 5:(2) 3000 to 3999	Zone 6:(2) 4000 to 4999	Zone 7A:(2) 5000 to 5999	Zone 7B:(2) 6000 to 6999	Zone 8:(2) ≥ 7000
	Maximum *Overall Thermal Transmittance*, in W/(m²·K)					
All doors	2.4	2.2	2.2	2.2	2.2	1.6

Notes to Table 3.2.2.4.:
(1) See Sentence 1.1.4.1.(1).
(2) See A-Table 3.2.2.2. in Appendix A.

2) Doors need not comply with Sentence (1) where

a) their total area does not exceed 2% of the gross wall area calculated in accordance with Article 3.1.1.6., and
b) their *overall thermal transmittance* does not exceed 4.4 W/(m²·K).

3) Access hatches that are part of a *building envelope* shall be insulated to a nominal thermal transmittance of not more than 1.3 W/(m²·K), exclusive of stiffeners or edge construction.

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4) Storm doors, automatic sliding glass doors, revolving doors, and fire shutters need not comply with Sentence (1). (See Appendix A.)

3.2.3. Building Assemblies in Contact with the Ground

3.2.3.1. Thermal Characteristics of Walls in Contact with the Ground

1) Except as provided in Sentence (2), the *overall thermal transmittance* of walls or portions thereof that are below the exterior ground level and are part of the *building envelope* shall be not greater than that shown in Table 3.2.3.1. for the applicable heating-degree-day category.

Table 3.2.3.1.
Overall Thermal Transmittance of Building Assemblies in Contact with the Ground
Forming Part of Sentences 3.2.3.1.(1), 3.2.3.2.(1) and 3.2.3.3.(1) to (3)

Assembly in Contact with the Ground	Heating Degree-Days of *Building* Location,[1] in Celsius Degree-Days					
	Zone 4:[2] < 3000	Zone 5:[2] 3000 to 3999	Zone 6:[2] 4000 to 4999	Zone 7A:[2] 5000 to 5999	Zone 7B:[2] 6000 to 6999	Zone 8:[2] ≥ 7000
	Maximum *Overall Thermal Transmittance*, in W/(m²·K)					
Walls	0.568	0.379	0.284	0.284	0.284	0.210
Roofs	0.568	0.379	0.284	0.284	0.284	0.210
Floors	0.757 for 1.2 m	0.757 for 1.2 m	0.757 for 1.2 m	0.757 for 1.2 m	0.757 for 1.2 m	0.379 for full area

Notes to Table 3.2.3.1.:
(1) See Sentence 1.1.4.1.(1).
(2) See A-Table 3.2.2.2. in Appendix A.

2) Where radiant heating cables or heating or cooling pipes or membranes are embedded in the surface of a wall or portion thereof that is below the exterior ground level and that separates *conditioned space* from the ground, the wall shall have an *overall thermal transmittance* no greater than 80% of that required by Sentence (1). (See A-3.2.2.2.(3) in Appendix A.)

3) Insulation on walls or portions thereof that are in contact with the ground shall extend 2.4 m down from ground level or to the bottom of the wall, whichever is less. (See Appendix A.)

4) Where the top of the footing is less than 0.6 m below the exterior ground level, the same level of insulation stated in Sentence (1) shall be placed on the top or bottom surface of the floor for a distance not less than 1.2 m from the perimeter.

3.2.3.2. Thermal Characteristics of Roofs in Contact with the Ground

1) The *overall thermal transmittance* of below-ground roofs that are part of the *building envelope* and are less than 1.2 m below the exterior ground level shall be not greater than that shown in Table 3.2.3.1. for the applicable heating-degree-day category. (See Appendix A.)

3.2.3.3. Thermal Characteristics of Floors in Contact with the Ground

(See Appendix A.)

1) Except as provided in Sentence (3), the *overall thermal transmittance* of floors separating *conditioned space* from the ground that are less than 0.6 m below *grade* shall be not greater than that shown in Table 3.2.3.1. for the applicable heating-degree-day category.

2) Floors-on-ground with no embedded heating ducts, cables or heating or cooling pipes that are required to be insulated shall have insulation placed on their top or

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bottom surface for a distance of not less than 1.2 m from their perimeter or over their full area as shown in Table 3.2.3.1. for the applicable heating-degree-day category.

3) Floors-on-ground with embedded heating ducts or cables or heating and cooling pipes shall

a) have an *overall thermal transmittance* that is no greater than that shown in Table 3.2.3.1. for the applicable heating-degree-day category, and
b) be insulated under their full area.

4) Except where the wall insulation is placed on the outside of the *foundation* wall and extends down to the level of the bottom of the floor, the insulation for floors-on-ground that are required to be insulated shall extend vertically around the perimeter of the floor.

3.2.4. Air Leakage

3.2.4.1. General

1) The *building envelope* shall be designed and constructed with a continuous air barrier system comprised of *air barrier assemblies* to control air leakage into and out of the *conditioned space*.

3.2.4.2. Opaque Building Assemblies

1) All *opaque building assemblies* that act as environmental separators shall include an *air barrier assembly*.

3.2.4.3. Fenestration

1) For the purposes of this Article, use of the term "*fenestration*" does not include doors, which are covered in Article 3.2.4.4.

2) Metal and glass curtain walls that act as environmental separators shall have an air leakage rate not greater than 0.20 L/(s·m^2) when a specimen prepared in accordance with Clause 6 of AAMA 501.5, "Thermal Cycling of Exterior Walls," is tested in accordance with ASTM E 283, "Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen," at a pressure differential of 75 Pa.

3) Fixed windows and *skylights* that act as environmental separators shall have an air leakage rate not greater than 0.20 L/(s·m^2) when tested in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights," at a pressure differential of 75 Pa.

4) Operable windows and *skylights* that act as environmental separators shall have an air leakage rate not greater than 0.5 L/(s·m^2) when tested in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights," at a pressure differential of 75 Pa.

3.2.4.4. Doors

1) Except as provided in Sentences (2) and (3), doors that act as environmental separators shall have an air leakage rate not greater than 0.50 L/(s·m^2) when tested in accordance with ASTM E 283, "Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen," at a pressure differential of 75 Pa.

2) Revolving doors and automatic commercial sliding doors, including their respective fixed sections, as well as overhead doors that act as environmental separators shall have an air leakage rate not greater than 5.0 L/(s·m^2) when tested as a complete assembly in accordance with ASTM E 283, "Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen," at a pressure differential of 75 Pa.

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3) Main entry exterior doors that act as environmental separators are permitted to have an air leakage rate not greater than 5.0 L/(s·m²) when tested as a complete assembly in accordance with ASTM E 283, "Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen," at a pressure differential of 75 Pa, provided that the total area of such doors does not exceed 2% of the gross wall area calculated in accordance with Article 3.1.1.6.

4) Loading docks that interface with truck boxes shall have weather seals that seal the truck box to the *building*.

3.2.4.5. Fireplace Doors

1) Fireplaces shall be equipped with doors or enclosures to restrict air movement through the chimney when the fireplace is not in use.

Section 3.3. Trade-off Path

(See A-1.1.2.1. in Appendix A.)

3.3.1. General

3.3.1.1. Limitations

1) Trade-off calculations described in this Section shall be subject to the limitations described in Sentences (2) and (3).

2) The *overall thermal transmittance* of *building envelope* assemblies that have radiant heating cables or heating or cooling pipes or membranes embedded in them shall not be increased to more than the *overall thermal transmittance* permitted by Sentence 3.2.2.2.(3).

3) Where the construction techniques used result in increased performance compared to those required to be used by Articles 3.2.1.1. and 3.2.2.1. and Subsection 3.2.4., that difference in performance levels shall not be used in trade-off calculations. (See Appendix A.)

4) Where the *building envelope* components used are more energy-efficient than those prescribed in Section 3.2., the trade-off calculation is permitted to take this increased performance level into account, provided it can be quantified and is not dependent on occupant interaction.

3.3.1.2. Application

1) This Section applies only to *buildings* whose *occupancy* is known and for which sufficient information is known about their components that are covered by the scope of this Section.

2) If, during construction, conditions are found to be altered from those used in the original trade-off assessment, the *building* shall be reassessed for compliance with this Section.

3) Except as provided in Sentence (4), the procedures stated in this Section shall be applied to a single *building* at a time.

4) Where a structure is divided into multiple *buildings*, the whole structure is permitted to be treated as one *building*.

3.3.1.3. Calculation Procedures

1) For the purposes of this Section, "reference *building*" is defined as a *building* whose *building envelope* is constructed in accordance with Section 3.2.

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2) For the purposes of trade-off calculations described in this Section, the insulated surface areas of above-ground roof assemblies shall

a) be calculated along the plane of the insulation using dimensions measured to the interior surfaces of intersecting exterior walls, and
b) exclude openings for *skylights* and chimneys as measured to the surfaces of structural framing surrounding such openings.

3) For the purposes of trade-off calculations described in this Section, the insulated surface areas of exterior above-ground wall assemblies shall

a) be calculated using dimensions measured to the exterior surfaces of intersecting exterior walls and to the exterior ground level, exclusive of the perimeter areas where floor or roof slabs interrupt the wall construction (see A-3.1.1.7.(8) in Appendix A),
b) include perimeter areas of intersecting interior walls, and
c) exclude openings for doors and *fenestration*, as measured to the surfaces of structural framing surrounding such openings.

4) For the purposes of trade-off calculations described in this Section, the insulated surface areas of above-ground exterior floor assemblies shall be calculated using dimensions measured to the exterior surface of perimeter walls.

5) For the purposes of trade-off calculations described in this Section, the insulated surface areas of roof assemblies in contact with the ground shall be calculated along the plane of the insulation using dimensions measured to the exterior surfaces of intersecting exterior walls.

6) For the purposes of trade-off calculations described in this Section, the insulated surface areas of wall assemblies in contact with the ground shall be calculated using dimensions measured

a) horizontally to the exterior surfaces of perimeter wall assemblies in contact with the ground, and
b) vertically from the exterior ground level to the underside of intersecting floors in contact with the ground.

7) For the purposes of trade-off calculations described in this Section, the insulated surface areas of floor assemblies in contact with the ground shall be calculated using dimensions measured to the exterior surfaces of perimeter walls.

3.3.2. Compliance

3.3.2.1. General

1) Compliance with this Section shall be achieved by complying with

a) the simple trade-off provisions of Subsection 3.3.3., or
b) the detailed trade-off provisions of Subsection 3.3.4.

3.3.3. Simple Trade-off Path

3.3.3.1. Application

1) Subject to the limitations stated in this Article and Article 3.3.1.1., the simple trade-off path applies only to variations from the maximum *overall thermal transmittance* of above-ground assemblies and to the allowable *fenestration* and door areas prescribed in Section 3.2., provided it can be demonstrated using the equation in Article 3.3.3.2. that the *building envelope* will not transfer more energy than it would if all its components complied with that Section.

2) Except as provided in Sentence (1), this Subsection applies only to proposed *buildings* whose set-point temperature is 18°C or above.

3) This Subsection does not apply to *additions*.

4) Vertical above-ground portions of the *building envelope* are only permitted to be traded off against other vertical above-ground portions of the *building envelope*.

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5) Horizontal above-ground portions of the *building envelope* are only permitted to be traded off against other horizontal above-ground portions of the *building envelope*.

3.3.3.2. Simple Trade-off Calculations

1) For the purpose of simple trade-off calculations, the sum of the areas of all above-ground assemblies in the proposed *building* shall be equal to the sum of the areas of the corresponding above-ground assemblies in the reference *building*.

2) Compliance with Article 3.3.3.1. shall be determined using the equation that follows to demonstrate that the sum of the areas of all above-ground assemblies of the *building envelope* multiplied by their respective *overall thermal transmittance* is not more than it would be if all assemblies complied with Section 3.2.:

$$\sum_{i=1}^{n} U_{ip} A_{ip} \leq \sum_{i=1}^{n} U_{ir} A_{ir}$$

where

n = total number of above-ground assemblies,
U_{ip} = *overall thermal transmittance* of assembly i of the proposed *building*,
A_{ip} = area of assembly i of the proposed *building*,
U_{ir} = *overall thermal transmittance* of assembly i of the reference *building*, and
A_{ir} = area of assembly i of the reference *building*.

3.3.4. Detailed Trade-off Path

3.3.4.1. Scope

1) Subject to the limitations stated in Article 3.3.1.1., the thermal characteristics of one or more components of the *building envelope* of a single *building* are permitted to be less energy-efficient than otherwise prescribed by Section 3.2., provided it can be demonstrated that the *building envelope* will not transfer more energy than it would if all its components complied with that Section.

2) Subject to the limitations stated in Article 3.3.1.1., the allowable *fenestration* and door areas are permitted to be varied from those prescribed in Article 3.2.1.4., provided it can be demonstrated that the *building envelope* will not transfer more energy than it would if all its components complied with Section 3.2.

3) A semi-heated *building* is permitted to meet less stringent *building envelope* requirements if it can be shown that the total energy transferred through the *building envelope* of the proposed semi-heated *building* is less than or equal to the total energy transferred through the *building envelope* of the reference *building*, subject to the following limitations:

a) the reference *building*'s setpoint temperature is 18°C,
b) the proposed *building*'s setpoint temperature is that shown in the specifications, and
c) the capacity of the installed heating equipment is no more than the *building* heating load plus 5%.

(See A-3.3.4.1.(3) and 8.4.4.3.(2) in Appendix A.)

3.3.4.2. Compliance

1) In the establishment of the reference *building*'s *building envelope* energy target, *building* components must be accounted for in accordance with the requirements of Section 3.2. for the climatic zone under consideration.

2) Subject to the provisions of this Subsection, the *annual energy consumption* of the proposed *building*'s *building envelope*, as determined in accordance with this Subsection, shall not exceed the reference *building*'s *building envelope* energy target.

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3.3.4.3. Treatment of Additions

1) For the purpose of detailed trade-off compliance calculations, the assessment of *additions* shall be based upon

a) the *addition* being considered by itself, or
b) the *addition* being considered together with the existing *building*, in which case the thermal characteristics of the existing *building*'s *building envelope* shall be used in the calculation of the *annual energy consumption* of the proposed *building*'s *building envelope* and of the energy target of the reference *building*'s *building envelope* (see Appendix A).

2) Where the *addition* is being considered together with the existing *building*, the existing *building*'s vertical *fenestration* area, door area and gross wall area are permitted to be combined with the *addition*'s areas in calculating the *addition*'s total vertical *fenestration* and door area to gross wall area ratio (FDWR) to determine the *building envelope* energy target.

3) Where the *addition* is being considered together with the existing *building*, the existing *building*'s *skylight* area and gross roof area are permitted to be combined with the *addition*'s areas in calculating the *addition*'s total *skylight* area to gross roof area ratio to determine the *building envelope* energy target.

3.3.4.4. Compliance Calculations

1) Compliance with this Subsection shall be assessed through energy modelling that conforms to the specifications detailed in this Article and in Articles 3.3.4.5. to 3.3.4.10.

2) The energy model calculations shall be performed for a one-year period (8 760 hours) using time intervals no greater than one hour.

3) Schedules and climatic data input in the energy model shall be for a time interval no greater than one hour.

4) If a computer program is used to carry out the compliance calculations, the calculation methods employed in the energy model shall conform to ANSI/ASHRAE 140, "Evaluation of Building Energy Analysis Computer Programs," or an equivalent test method.

3.3.4.5. Climatic Data

1) The energy model calculations shall be performed using values of climatic data, including temperature, humidity and insolation, that are derived from measured climatic data and are shown to be good representations of climate at the *building* site compared to the average of at least 10 years of measured climatic data collected at the weather station nearest to the *building* site. (See A-8.4.2.3. in Appendix A.)

2) For urban regions with several climatic data sets and for locations where weather data are not available, the energy model calculations shall be performed using available weather data that best represent the climate at the *building* site. (See A-8.4.2.3. in Appendix A.)

3.3.4.6. Thermal Mass

1) The energy model calculations shall account for the effect of thermal mass.

3.3.4.7. Space Temperature

1) The energy model calculations shall include dynamic calculation of indoor space temperatures.

3.3.4.8. Building Envelope Loads

1) The energy model shall calculate heat transfer through walls, roofs and floors, while accounting for the dynamic response due to thermal characteristics of the particular assembly.

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2) Calculations of heat transfer through walls and roofs shall account for the effect of solar radiation absorbed on their exterior surfaces, which depends on the orientation and absorptance of each surface.

3) The energy model calculations shall account for heat transfer through *fenestration*, including *skylights*, while accounting for both temperature difference and transmission of solar radiation through the glazing.

4) Calculations of cooling and heating loads due to the transmission of solar radiation through *fenestration* shall account for

a) orientation,
b) glazing solar-optic properties, and
c) dynamic response due to the effect of thermal characteristics of the *thermal block*.

3.3.4.9. Proposed Building Envelope Annual Energy Consumption Calculation

1) The proposed *building*'s *building envelope annual energy consumption* shall be calculated as described in this Article.

2) The energy model shall be consistent with the proposed *building*'s specifications, including its *fenestration* and door components and *opaque building assemblies* and their respective areas.

3) The following characteristics of the proposed *building* shall be input into the energy model using the *building*'s specifications:

a) the *overall thermal transmittance* and area of each type of
   i) above-ground wall,
   ii) wall in contact with the ground,
   iii) above-ground roof,
   iv) roof in contact with the ground,
   v) exposed floor,
   vi) floor in contact with the ground,
   vii) *fenestration*, and
   viii) door forming part of the *building envelope*,
b) the space-heating set-point temperature for each *thermal block* in accordance with Sentence (7),
c) where cooling is provided, the space-cooling set-point temperature for each *thermal block* in accordance with Sentence (8),
d) the floor-to-roof height,
e) the depth below *grade* of floors in contact with the ground,
f) the interior or exterior placement of insulation for below-grade walls, and
g) the geographic location of the *building*.

4) The following information on the *building envelope* assemblies shall be input into the energy model using the *building*'s specifications:

a) orientation or azimuth,
b) tilt angle of walls,
c) roof slope,
d) thermal mass (see Appendix A), and
e) solar heat gain coefficient (see A-8.4.3.4.(2) in Appendix A).

5) The solar absorptance of the *building envelope* assemblies shall be set at a constant value of 0.7.

6) Air leakage shall be set at a constant value of 0.25 L/(s·m^2) of gross above-ground wall and roof areas. (See A-8.4.3.4.(3) in Appendix A.)

7) The space-heating set-point shall be entered as

a) a schedule corresponding to a typical weekly profile using hourly values, or
b) a fixed value for each hour of the week.

8) Where cooling is provided, the space-cooling set-point shall be entered as

a) a schedule corresponding to a typical weekly profile using hourly values, or
b) a fixed value for each hour of the week.

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9) The occupant density, *interior lighting*, receptacle loads, *service water* heating loads and schedules of occupancy and equipment operation shall not be included.

10) The energy used by heating, cooling and distribution of ventilation and/or air circulation shall not be included.

11) Space-heating shall be set to electric resistance and sized for the peak heating load using the average heating set-point temperature for the weekly schedule or fixed set-point temperature that was entered at Sentence (7).

12) Where cooling is provided, space-cooling shall be set to electric direct expansion with a COP of 1.0 and sized for the peak cooling load using the average cooling set-point temperature for the weekly schedule or fixed set-point temperature that was entered at Sentence (8).

13) The energy used by exhaust fans shall not be included.

14) If the proposed *building* is an *addition*, the energy model calculations shall include both the existing *building* and the *addition*.

15) The energy model calculations shall follow the calculation procedures defined in Part 8 to determine the *annual energy consumption* of the proposed *building*'s *building envelope*.

3.3.4.10. Reference Building Envelope Energy Target Calculation

1) The reference *building*'s *building envelope* energy target shall be calculated as described in this Article.

2) The energy model shall be consistent with the proposed *building*'s specifications and shall match its physical size, shape, roof slope, floor to roof height, and orientation or azimuth, but shall set the *building envelope* component areas at the maximum allowable total vertical *fenestration* and door area to gross wall area ratio in Article 3.2.1.4. for all above-ground walls and using a 5% *skylight* area to gross roof area ratio for all above-ground roofs.

3) Walls, floors in contact with the ground, roofs and exposed floors shall be input in the energy model with the following characteristics:

a) area matching that of the proposed *building*, and
b) the *overall thermal transmittance* as prescribed in Section 3.2.

4) Each conditioned *thermal block* in the reference *building* shall match the proposed *building*'s characteristics as described in Sentence 3.3.4.9.(3).

5) The thermal mass shall be set to "light-weight," which corresponds to a framed exterior wall or a 51 mm concrete floor slab (150 kg/m^2 of floor area).

6) Except as stated in Sentence 3.3.4.1.(3), the space-heating set-point and schedule entered in the energy model shall match those identified in Sentence 3.3.4.9.(7).

7) The space-cooling set-point and schedule entered in the energy model shall match those identified in Sentence 3.3.4.9.(8).

8) The energy used by heating, cooling and distribution of ventilation and/or air circulation shall not be included.

9) Space heating shall be set to electric resistance and sized for the peak heating load of the *thermal block* using the average heating set-point temperature for the weekly schedule or fixed set-point temperature that was entered in Sentence 3.3.4.9.(7).

10) Where cooling is provided, space cooling shall be set to electric direct expansion with a COP of 1.0 and sized for the peak cooling load of the *thermal block* using the average cooling set-point temperature for the weekly schedule or fixed set-point temperature that was entered in Sentence 3.3.4.9.(8).

11) The energy used by exhaust fans shall not be included.

12) If the proposed *building* is an *addition*, the energy model calculations shall include all defined *thermal blocks*, including the existing *building*.

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13) The energy model calculations shall follow the calculation procedures defined in Part 8 to determine the reference *building*'s *building envelope* energy target.

Section 3.4. Performance Path

(See A-1.1.2.1. in Appendix A.)

3.4.1. General

3.4.1.1. Scope

1) Subject to the limitations stated in Article 3.4.1.2., where the *building envelope* does not comply with the requirements of Section 3.2. or 3.3., it shall comply with Part 8.

3.4.1.2. Limitations

1) The performance path described in this Section shall be subject to the following limitations:

a) the *overall thermal transmittance* of the *building envelope* assemblies that have radiant heating cables or heating or cooling pipes or membranes embedded in them shall not be increased to more than the *overall thermal transmittance* permitted by Sentence 3.2.2.2.(3), and

b) Article 3.2.1.1. shall apply.

Section 3.5. Objective and Functional Statements

3.5.1. Objective and Functional Statements

3.5.1.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in this Part shall be the objective and functional statements listed in Table 3.5.1.1. (See A-1.1.3.1.(1) in Appendix A.)

Table 3.5.1.1.
Objectives and Functional Statements Attributed to the Acceptable Solutions in Part 3
Forming Part of Sentence 3.5.1.1.(1)

Functional Statements and Objectives[1]	
3.1.1.5. Thermal Characteristics of Building Assemblies	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
(5)	[F92-OE1.1]
3.1.1.7. Calculation of Overall Thermal Transmittance	
(1)	[F92-OE1.1]
(6)	[F92-OE1.1]
(7)	[F92-OE1.1]
(8)	[F92-OE1.1]
(9)	[F92-OE1.1]

Table 3.5.1.1. (Continued)

Functional Statements and Objectives[1]	
3.2.1.1. Protection of Insulation Materials	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
3.2.1.2. Continuity of Insulation	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
(5)	[F92-OE1.1]
(6)	[F92-OE1.1]
3.2.1.3. Spaces Heated to Different Temperatures	
(1)	[F92-OE1.1]
3.2.1.4. Allowable Fenestration and Door Area	
(1)	[F92,F99-OE1.1]
(2)	[F92,F99-OE1.1]

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Table 3.5.1.1. (Continued)

Functional Statements and Objectives[1]	
3.2.2.1. Vestibules	
(1)	[F90-OE1.1]
(2)	[F90-OE1.1]
3.2.2.2. Thermal Characteristics of Above-ground Opaque Building Assemblies	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92,F95-OE1.1]
3.2.2.3. Thermal Characteristics of Fenestration	
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
3.2.2.4. Thermal Characteristics of Doors and Access Hatches	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
3.2.3.1. Thermal Characteristics of Walls in Contact with the Ground	
(1)	[F92-OE1.1]
(2)	[F92,F95-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
3.2.3.2. Thermal Characteristics of Roofs in Contact with the Ground	
(1)	[F92-OE1.1]
3.2.3.3. Thermal Characteristics of Floors in Contact with the Ground	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92,F95-OE1.1]
(4)	[F92-OE1.1]
3.2.4.1. General	
(1)	[F90-OE1.1]
3.2.4.2. Opaque Building Assemblies	
(1)	[F90-OE1.1]
3.2.4.3. Fenestration	
(2)	[F90-OE1.1]
(3)	[F90-OE1.1]
(4)	[F90-OE1.1]
3.2.4.4. Doors	
(1)	[F90-OE1.1]
(4)	[F90-OE1.1]
3.2.4.5. Fireplace Doors	
(1)	[F90-OE1.1]

Table 3.5.1.1. (Continued)

Functional Statements and Objectives[1]	
3.3.1.1. Limitations	
(2)	[F92,F95-OE1.1]
(3)	[F91,F92-OE1.1]
(4)	[F92-OE1.1]
3.3.1.2. Application	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
3.3.1.3. Calculation Procedures	
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
(5)	[F92-OE1.1]
(6)	[F92-OE1.1]
(7)	[F92-OE1.1]
3.3.3.1. Application	
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
(5)	[F92-OE1.1]
3.3.3.2. Simple Trade-off Calculations	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
3.3.4.1. Scope	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
3.3.4.2. Compliance	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
3.3.4.3. Treatment of Additions	
(1)	[F92-OE1.1]
3.3.4.4. Compliance Calculations	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
3.3.4.5. Climatic Data	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
3.3.4.6. Thermal Mass	
(1)	[F92-OE1.1]
3.3.4.7. Space Temperature	
(1)	[F92-OE1.1]

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Table 3.5.1.1. (Continued)

Functional Statements and Objectives[1]	
3.3.4.8. Building Envelope Loads	
(1)	[F92-OE1.1]
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
3.3.4.9. Proposed Building Envelope Annual Energy Consumption Calculation	
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
(5)	[F92-OE1.1]
(6)	[F90-OE1.1]
(7)	[F92,F99-OE1.1]
(8)	[F92-OE1.1]
(9)	[F92-OE1.1]
(10)	[F92-OE1.1]
(11)	[F92-OE1.1]
(12)	[F92-OE1.1]
(13)	[F92-OE1.1]
(14)	[F92-OE1.1]
(15)	[F92-OE1.1]
3.3.4.10. Reference Building Envelope Energy Target Calculation	
(2)	[F92-OE1.1]
(3)	[F92-OE1.1]
(4)	[F92-OE1.1]
(6)	[F92-OE1.1]
(7)	[F92-OE1.1]
(8)	[F92-OE1.1]
(9)	[F92-OE1.1]
(10)	[F92-OE1.1]
(11)	[F92-OE1.1]
(12)	[F92-OE1.1]
(13)	[F92-OE1.1]
3.4.1.2. Limitations	
(1)	[F92,F99-OE1.1]

Notes to Table 3.5.1.1.:

(1) See Parts 2 and 3 of Division A.

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Part 4
Lighting

Section 4.1. General

4.1.1. General

4.1.1.1. Scope

1) This Part is concerned with lighting components and systems for the applications listed in Article 4.1.1.2.

4.1.1.2. Application

1) Except as provided in Sentence (2), this Part applies to lighting components and systems that are connected to the *building*'s electrical service. (See Appendix A.)

2) This Part does not apply to the following lighting systems:
a) emergency lighting that is automatically off during normal hours of *building* operation,
b) lighting within *dwelling units*, and
c) lighting in *buildings* or parts of *buildings* and in certain exterior spaces associated with the *building* where it can be shown that the nature of the *occupancy* makes it impractical to apply these requirements (see Appendix A).

4.1.1.3. Compliance

1) Compliance with this Part shall be achieved by following
a) the prescriptive path described in Section 4.2.,
b) the trade-off path described in Section 4.3., or
c) the performance path described in Section 4.4. (see A-3.1.1.3.(1)(c) in Appendix A).

(See Appendix A.)

4.1.1.4. Definitions

1) Words that appear in italics are defined in Article 1.4.1.2. of Division A.

Section 4.2. Prescriptive Path

4.2.1. Interior Lighting Power

4.2.1.1. Exit Signs

1) Power requirements for lighting units for *exit* signs shall conform to CAN/CSA-C860, "Internally Lighted Exit Signs."

4.2.1.2. Fluorescent Lamp Ballasts

1) Fluorescent lamp ballasts shall conform to CSA C654, "Fluorescent Lamp Ballast Efficacy Measurements."

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2) Electronic fluorescent lamp ballasts that are not within the scope of CSA C654, "Fluorescent Lamp Ballast Efficacy Measurements," shall conform to NEMA ANSI C82.11, "High-Frequency Fluorescent Lamp Ballasts."

4.2.1.3. Limits to Installed Interior Lighting Power

(See Appendix A.)

1) The *installed interior lighting power* described in Article 4.2.1.4. shall not exceed the value of the *interior lighting power allowance* determined using

a) the *building* area method described in Article 4.2.1.5., or
b) the space-by-space method described in Article 4.2.1.6.

2) The individual power allowances in each space of the *building* do not have to be met, provided the total *installed interior lighting power* is not exceeded.

3) Only one of the methods described in Sentence (1) shall be selected for use within the same *building*.

4.2.1.4. Determination of the Installed Interior Lighting Power

1) Except as provided in Sentences (4) and (5), the *installed interior lighting power* shall include all power used by the luminaires, including lamps, ballasts, transformers, and control devices.

2) The determination of the *installed interior lighting power* shall include

a) connected lighting power for both permanently installed *interior lighting* and supplemental *interior lighting* provided by movable or plug-in luminaires, and
b) in cases where two or more independently operating lighting systems in a space are controlled to prevent simultaneous operation, the lighting system with the highest wattage.

(See Appendix A.)

3) Luminaire wattage to be included in *installed interior lighting power* shall be determined in accordance with the following criteria:

a) except as provided in Clause (b), the wattage of luminaires shall be the design operating input wattage of the lamp/auxiliary combination based on values provided by a recognized testing laboratory or, in the absence of such information, the maximum labeled wattage of the luminaire shall be used (see Appendix A),
b) the wattage of luminaires with ballasts designed for multiple wattages shall be the maximum labeled wattage of the luminaire,
c) for line-voltage lighting track and plug-in busway designed to allow the addition and/or relocation of luminaires without altering the wiring of the system, the wattage shall be
    i) the specified wattage of the luminaires included in the system with a minimum of 98 W/m,
    ii) the wattage limit of the system's circuit breaker, or
    iii) the wattage limit of other permanent current-limiting device(s) on the system,
d) the wattage of low-voltage lighting track, cable conductor, rail conductor, and other flexible lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the specified wattage of the transformer supplying the system, and
e) the wattage of all other miscellaneous lighting equipment shall be the specified wattage of the lighting equipment.

4) Lighting for the following functions, spaces or equipment need not be included in the calculation of *installed interior lighting power*:

a) display or accent lighting that is an essential element for the function it performs in galleries, museums, and monuments,
b) lighting that is integral to equipment or instrumentation and is installed by its manufacturer,
c) lighting specifically designed for use only during medical or dental procedures,

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d) lighting integral to both open and glass-enclosed refrigerator and freezer cases,
e) lighting integral to food warming and food preparation equipment,
f) lighting for plant growth or maintenance,
g) lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical or age-related issues,
h) lighting in retail display windows, provided the display area is enclosed by ceiling-height *partitions*,
i) lighting in interior spaces that have been specifically designated as a registered interior historic landmark,
j) lighting that is an integral part of advertising or directional signage,
k) *exit* signs,
l) lighting that is for sale or for lighting educational demonstration systems,
m) lighting for theatrical purposes, including performance, stage, and film and video production,
n) lighting for television broadcasting in sporting activity areas,
o) casino gaming areas,
p) mirror lighting in dressing rooms, and
q) accent lighting in religious pulpit and choir areas.

5) Lighting for functions, spaces or equipment need not be included in the calculation of *installed interior lighting power* where it can be shown that its inclusion will adversely affect the intended functions or the use of the space or equipment.

4.2.1.5. Calculation of Interior Lighting Power Allowance Using the Building Area Method

(See Appendix A.)

1) Calculation of *interior lighting power allowance* using the *building* area method as provided in this Article may be applied only where
a) the *interior lighting power allowance* is being determined for an entire *building*, and
b) the *building* type or an equivalent *building* type is identified in Table 4.2.1.5.

2) Except as provided in Sentence (3), *interior lighting power allowance* calculations shall be based on the primary use for which the *building* is intended.

3) Where 10% or more of the *gross lighted area* of the *building* can be classified as being of a *building* type other than the principal type for the *building*, the *interior lighting power allowance* shall be calculated using the space-by-space method described in Article 4.2.1.6.

4) Where the *building* is of a type other than those listed in Table 4.2.1.5. and no equivalent *building* type can be selected, the *interior lighting power allowance* shall be calculated using the space-by-space method described in Article 4.2.1.6.

5) The *interior lighting power allowance* using the *building* area method shall be calculated by multiplying the lighting power density, in W/m^2, for the *building* type provided in Table 4.2.1.5. by the *gross lighted area*, in m^2.

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Table 4.2.1.5.
Lighting Power Density by Building Type for Use with the Building Area Method
Forming Part of Sentences 4.2.1.5.(1), (4) and (5)

Building Type	Lighting Power Density, W/m²
Automotive facility	8.8
Convention centre	11.6
Courthouse	11.3
Dining:	
bar lounge/leisure	10.7
cafeteria/fast food	9.7
family	9.6
Dormitory	6.6
Exercise centre	9.5
Fire station	7.6
Gymnasium	10.8
Health-care clinic	9.4
Hospital	13.0
Hotel	10.8
Library	12.7
Manufacturing facility	11.9
Motel	9.5
Motion picture *theatre*	8.9
Multi-unit residential *building*	6.5
Museum	11.4
Office	9.7
Parking garage	2.7
Penitentiary	10.4
Performing arts *theatre*	15.0
Police station	10.3
Post office	9.4
Religious *building*	11.3
Retail area	15.1
School/university	10.7
Sports arena	8.4
Town hall	9.9
Transportation	8.3
Warehouse	7.1
Workshop	12.9

4.2.1.6. Calculation of Interior Lighting Power Allowance Using the Space-by-Space Method

1) The *interior lighting power allowance* using the space-by-space method shall be determined as follows:

a) the gross interior floor area of each *enclosed space* shall be determined based on the inside dimensions of the space,
b) the allowed lighting power density (LPD) for each *enclosed space* shall be determined using Table 4.2.1.6. for the exact space type or a space type that most closely represents the proposed use of each space,
c) the lighting power allowance for each *enclosed space* shall be calculated by multiplying the floor area determined in Clause (a) by the allowed LPD determined in Clause (b), and
d) the *interior lighting power allowance* for the entire *building* shall be calculated by summing the lighting power allowances of all *enclosed spaces* determined in Clause (c).

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Table 4.2.1.6.
Lighting Power Density Using the Space-by-Space Method
Forming Part of Sentences 4.2.1.6.(1) and 4.3.3.2.(1)

Common Space Types(1)	
Space Types	Lighting Power Density, W/m²
Atrium	
first 13 m in height	0.10 per m (height)
height above 13 m	0.07 per m (height)
Audience seating area – permanent	
for auditorium	8.5
for performing arts *theatre*	26.2
for motion picture *theatre*	12.3
Classroom/lecture/training	13.3
Conference area/meeting/multi-purpose	13.2
Corridor/transition area	
≥ 2.4 m wide	7.1
< 2.4 m wide	8.4
Dining area	
for bar lounge/leisure dining	14.1
for family dining	9.6
other	7.0
Dressing/fitting room for performing arts *theatre*	4.3
Electrical/Mechanical area	13.4
Food preparation area	10.7
Laboratory	
for classrooms	17.2
for medical/industrial/research	23.6
Lobby	
for elevator	6.9
for performing arts *theatre*	21.5
for motion picture *theatre*	5.6
other	9.7
Locker room	9.8
Lounge/recreation area	9.4
Office	
enclosed	11.9
open plan	11.0
Sales area	18.1
Stairway	7.4
Storage area	6.8
Washroom	10.5
Workshop	17.1
Building-Specific Space Types(1)	
Space Types	Lighting Power Density, W/m²
Automotive – *repair garage*	7.2
Bank – banking activity area and offices	14.9
Convention centre	
audience seating	8.8
exhibit space	15.6

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Table 4.2.1.6. (Continued)

Building-Specific Space Types[1]	
Space Types	Lighting Power Density, W/m^2
Courthouse/Police station/Penitentiary	
courtroom	18.5
confinement cell	14.8
judges' chambers	12.6
penitentiary – audience seating	4.6
penitentiary – classroom	14.4
penitentiary – dining	11.5
Dormitory – living quarters	4.1
Fire station	
engine room	6.0
sleeping quarters	3.4
Gymnasium/Fitness centre	
fitness area	9.8
gymnasium – audience seating	4.6
play area	12.9
Hospital	
corridor/transition area ≥ 2.4 m wide	9.6
corridor/transition area < 2.4 m wide	11.7
emergency	24.3
exam/treatment	17.9
laundry – washing	8.0
lounge/recreation	11.5
medical supply	13.7
nursery	9.5
nurses' station	9.4
operating room	20.3
patient room	6.7
pharmacy	12.3
physical therapy	9.8
radiology/imaging	14.2
recovery	12.4
Hotel/Motel	
hotel dining	8.8
hotel guest rooms	11.9
hotel lobby	11.4
highway lodging dining	9.5
highway lodging guest rooms	8.1
Library	
card file and cataloging	7.8
reading area	10.0
stacks	22.9
Manufacturing	
corridor/transition area ≥ 2.4 m wide	4.4
corridor/transition area < 2.4 m wide	5.5
detailed manufacturing	13.9
equipment room	13.4
extra high bay (> 15 m floor-to-ceiling height)	11.3
high bay (7.5 m to 15 m floor-to-ceiling height)	13.2
low bay (< 7.5 m floor-to-ceiling height)	12.8

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Table 4.2.1.6. (Continued)

Building-Specific Space Types[1]	
Space Types	Lighting Power Density, W/m²
Museum	
general exhibition	11.3
restoration	11.0
Parking garage – garage area	2.0
Post office – sorting area	10.1
Religious *building*	
audience seating	18.2
fellowship hall	6.9
worship pulpit, choir	18.2
Retail	
dressing/fitting room	9.4
mall concourse	11.8
sales area	18.1
Sports arena	
audience seating	4.6
court sports area – class 4	7.8
court sports area – class 3	12.9
court sports area – class 2	20.7
court sports area – class 1	32.4
ring sports area	28.8
Transportation	
air/train/bus – baggage area	8.2
airport – concourse	3.9
seating area	5.8
terminal – ticket counter	11.6
Warehouse	
fine material storage	10.2
medium/bulky material	6.3
medium/bulky material with permanent shelving that is > 60% of *ceiling height*	10.2

Notes to Table 4.2.1.6.:

(1) In cases where the same space is listed as both a common space type and a *building*-specific space type, the latter shall apply. See Appendix A.

4.2.2. Interior Lighting Controls

4.2.2.1. Automatic Lighting Shut-off Controls

(See Appendix A.)

1) Except as provided in Sentence (4), *interior lighting* in *buildings* shall be controlled with automatic control devices to shut off *building* lighting in all spaces.

2) The automatic control devices referred to in Sentence (1) shall be

a) time-of-day operated control devices that turn lighting off at scheduled times,

b) *occupant sensors* that turn lighting off within 30 minutes of a space being unoccupied, or

c) a signal from another control or alarm system that indicates the area is unoccupied.

3) A time-of-day operated control device provided in accordance with Clause (2)(a) shall not have the capability of being overridden by more than two hours.

4) The requirements of Sentence (1) shall not apply to

a) lighting required round the clock due to operational requirements,

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b) lighting in spaces where patient care is rendered, and
c) lighting in spaces where an automatic shut-off would endanger the safety or security of its occupants.

4.2.2.2. Lighting Controls in Enclosed Spaces

1) Each *enclosed space* shall have at least one control device that allows the independent control of *general lighting* within
a) a maximum area of 250 m² in the case of an *enclosed space* that is 1 000 m² or less in area, or
b) a maximum area of 1 000 m² in the case of an *enclosed space* greater than 1 000 m² in area.

2) Except as provided in Sentence (3), the control device required in Sentence (1) shall be
a) an *occupant sensor* that automatically extinguishes lighting in the following *enclosed spaces* within 30 minutes of their being unoccupied:
   i) classrooms and lecture halls, excluding shop and laboratory classrooms,
   ii) conference, meeting, and training rooms,
   iii) employee lunch and break rooms,
   iv) storage and supply rooms up to 100 m²,
   v) rooms used for document copying and printing,
   vi) office spaces up to 25 m²,
   vii) washrooms, and
   viii) dressing, locker, and fitting rooms, or
b) a control device that is activated either manually by an occupant or automatically by a sensor in all other *enclosed spaces* not listed in Clause (a).

3) Bathrooms in guest rooms of commercial temporary lodgings shall have a control device installed that automatically extinguishes the bathroom lighting, except for night lighting not exceeding 5 W, within 60 minutes of being unoccupied. (See Appendix A.)

4.2.2.3. Additional Requirements for Lighting Controls

1) Except as provided in Sentences (2) and (4) to (7), lighting controls provided in accordance with Articles 4.2.2.1. and 4.2.2.2. shall be
a) located next to the main entrance or entrances to the room or space whose lighting they control,
b) located such that there is a clear line of sight from the controls to the lighted area, and
c) readily accessible to persons occupying or using the room or space.

2) Lighting controls are permitted to be installed in remote locations where
a) controls are automatic,
b) controls are programmable, or
c) it is desirable, for security or safety reasons, that lighting be under the control of staff or *building* management (see Appendix A).

3) Lighting controls installed in remote locations shall have
a) an indicator pilot light that is part of or next to the control device, and
b) a label clearly identifying which lighting they control.

4) Supplemental task lighting, including permanently installed undershelf or undercabinet lighting, shall have a control device that is
a) integral to the luminaires, or
b) readily accessible and located so that the occupant can see the controlled lighting.

(See Appendix A.)

5) Guest rooms in commercial temporary lodgings shall have one or more control devices at the entrance door that collectively control all permanently installed luminaires, except those in the bathroom(s). (See Appendix A and A-4.2.2.2.(3) and 4.2.2.3.(5) in Appendix A.)

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6) Hotel *suites* shall have control devices meeting the requirements of Sentence (5)
a) at the entrance to each room, or
b) at the primary entrance to the *suite*.
(See Appendix A.)

7) The following lighting applications shall have separate control devices:
a) display or accent lighting,
b) lighting in cases used for display purposes,
c) lighting for non-visual applications, such as plant growth and food warming, and
d) lighting equipment that is for sale or for demonstrations in lighting education (see Appendix A).
(See Appendix A.)

8) Where lighting controls are grouped, each control shall be labelled to indicate which area it controls.

4.2.2.4. Automatic Daylighting Controls for Toplighting

(See Appendix A.)

1) Except as provided in Sentence (2), when the total daylighted area under *skylights*, as determined in accordance with Article 4.2.2.5., plus the total daylighted area under rooftop monitors, as determined in accordance with Article 4.2.2.6., in an *enclosed space* exceeds 400 m², the electric *general lighting* over the daylighted area shall be separately controlled by at least one multi-level photocontrol having the following characteristics:
a) the light sensor for the photocontrol shall be remote from where calibration adjustments are made,
b) the means for calibration adjustments shall be readily accessible, and
c) the multi-level photocontrol shall reduce electric *general lighting* in response to available daylight with at least two control levels, one being greater than or equal to 35% and less than 70% of design lighting power and the other being less than 35%, including off, of design lighting power.
(See Appendix A.)

2) The requirements of Sentence (1) shall not apply to
a) daylighted areas under *skylights* where it can be demonstrated that existing adjacent *buildings* or natural objects block direct beam sunlight for more than 1 500 daytime hours per year between 8 a.m. and 4 p.m. local time,
b) daylighted areas where the *skylight* effective aperture, as determined in accordance with Article 4.2.2.7., is less than 0.006 (0.6%), and
c) *enclosed spaces* less than 800 m² in area in *buildings* located above the 55°N latitude.

4.2.2.5. Determination of Daylighted Area Under Skylights

1) The daylighted area under *skylights* shall refer to the combined daylighted area under each *skylight* without double-counting overlapping areas. (See Appendix A.)

2) The daylighted area under each *skylight* shall be calculated as the area of the *skylight*'s projection from the ceiling onto the floor plus the horizontal distances extending from that projection assessed separately in each direction using the smallest of the following values:
a) 70% of the *ceiling height*,
b) the distance to any primary sidelighted area, as determined in accordance with Article 4.2.2.9., or the daylighted area under rooftop monitors, or
c) the distance to the front face of any vertical obstruction where any part of the obstruction is farther away than 70% of the distance between the top of the obstruction and the ceiling.
(See Appendix A.)

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4.2.2.6. Determination of Daylighted Area Under Rooftop Monitors

(See Appendix A.)

1) The daylighted area under rooftop monitors shall refer to the combined daylighted area under each rooftop monitor without double-counting overlapping areas. (See A-4.2.2.5.(1) and 4.2.2.6.(1) in Appendix A.)

2) The daylighted area under each rooftop monitor shall be calculated as the product of the width of the vertical glazing above the ceiling and the smallest of the following horizontal distances measured inward from the bottom edge of the glazing:

a) the monitor's sill height, which is the vertical distance from the floor to the bottom edge of the monitor's glazing,
b) the distance to the edge of any primary sidelighted area, as determined in accordance with Article 4.2.2.9., or
c) the distance to the front face of any vertical obstruction where any part of the obstruction is farther away than the difference between the height of the obstruction and the monitor's sill height.

(See Appendix A.)

4.2.2.7. Calculation of Skylight Effective Aperture

(See Appendix A.)

1) The *skylight* effective aperture shall be calculated using the following equation:

$$\textit{skylight}\ \text{effective aperture} = \frac{0.85 \cdot \text{glazing area} \cdot \text{glazing VT} \cdot \text{WF}}{\text{daylighted area under } \textit{skylight}}$$

where

glazing area = total glazing area of *skylights*,
glazing VT = area-weighted average visible transmittance of *skylight* glazing, and
WF = area-weighted average well factor, where well factor is 0.9 if light well depth is less than 0.6 m, or 0.7 if light well depth is 0.6 m or greater (light well depth is measured vertically from the underside of the lowest point on the *skylight* glazing to the ceiling plane under the *skylight*).

4.2.2.8. Automatic Daylighting Controls for Primary Sidelighted Areas

(See Appendix A.)

1) Except as provided in Sentence (2), when the combined primary sidelighted areas, as determined in accordance with Article 4.2.2.9., in an *enclosed space* exceed 100 m^2, the electric *general lighting* over the primary sidelighted area shall be separately controlled by at least one multi-level photocontrol having the following characteristics:

a) the light sensor for the photocontrol shall be remote from where calibration adjustments are made,
b) the means for calibration adjustments shall be readily accessible, and
c) the multi-level photocontrol shall reduce electric *general lighting* in response to available daylight with at least two control levels, one being greater than or equal to 35% and less than 70% of design lighting power and the other being less than 35%, including off, of design lighting power.

(See A-4.2.2.4.(1) in Appendix A.)

2) The requirements of Sentence (1) shall not apply to

a) primary sidelighted areas where the tops of the existing adjacent *buildings* are at least twice as high above the windows as their distance away from the windows,
b) primary sidelighted areas where the *sidelighting* effective aperture, as determined in accordance with Article 4.2.2.10., is less than 0.1 (10%), and
c) retail spaces.

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4.2.2.9. Determination of Primary Sidelighted Areas

(See Appendix A.)

1) The total primary sidelighted area shall refer to the combined primary sidelighted areas without double-counting overlapping areas. (See Appendix A.)

2) Each primary sidelighted area, which is the floor area directly adjacent to vertical glazing below the ceiling, shall be calculated as the product of the width of the primary sidelighted area, as determined in Sentence (3), and its depth, as determined in Sentence (4).

3) The width of the primary sidelighted area shall be calculated as the width of the window plus, on each side, the smaller of the following values:

a) 0.6 m, or
b) the distance to any vertical obstruction that is 1.5 m or more in height.

4) The depth of the primary sidelighted area shall be calculated as the horizontal distance perpendicular to the glazing that is the smaller of the following values:

a) one window head height, which is the distance from the floor to the top of the glazing, or
b) the distance to any vertical obstruction that is 1.5 m or more in height.

4.2.2.10. Calculation of Sidelighting Effective Aperture

(See Appendix A.)

1) The *sidelighting* effective aperture shall be calculated using the following equation:

$$\textit{sidelighting}\ \text{effective aperture} = \frac{\sum \text{glazing area} \cdot \text{glazing VT}}{\text{total primary sidelighted area}}$$

where
glazing area = total glazing area of windows, and
glazing VT = area-weighted average visible transmittance of glazing in windows.

4.2.3. Exterior Lighting Power

4.2.3.1. Exterior Lighting

1) *Exterior lighting* allowances shall be based on the lighting zone in which the *building* is located, as determined from Table 4.2.3.1.A.

Table 4.2.3.1.A.
Lighting Zones Used to Determine Exterior Lighting Allowances
Forming Part of Sentence 4.2.3.1.(1)

Lighting Zone	Description
0	Undeveloped areas within national, provincial or territorial parks, forest land, and rural areas, and other undeveloped areas
1	Developed areas within national, provincial or territorial parks, and rural areas
2	Areas predominantly consisting of residential zoning, neighbourhood business districts, light industrial areas with limited nighttime use, and residential mixed-use areas
3	All other areas
4	High-activity commercial districts

2) The basic site allowance to be applied in the calculation of maximum connected *exterior lighting* power in Sentences (3) and (4) shall not exceed the limits specified in Table 4.2.3.1.B. for the applicable lighting zone.

3) Except as provided in Sentence (5), the connected *exterior lighting* power for each specific *building* exterior application listed in Table 4.2.3.1.C. that is to be

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illuminated shall not be greater than the individual allowance for that application taken from Table 4.2.3.1.C. for the applicable lighting zone plus any unused power applied from the basic site allowance listed in Table 4.2.3.1.B. (See Appendix A.)

Table 4.2.3.1.B.
Basic Site Allowances for Exterior Lighting
Forming Part of Sentences 4.2.3.1.(2) and (3)

Basic Site Allowance According to Lighting Zone				
Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
No allowance	500 W	600 W	750 W	1300 W

4) Except as provided in Sentence (5), the connected *exterior lighting* power for all general *building* exterior applications not listed in Table 4.2.3.1.C. that are to be illuminated shall not be greater than the sum of the individual allowances for these applications provided in Table 4.2.3.1.D. for the applicable lighting zone plus any remaining basic site allowance not used in compliance with Sentence (3). (See Appendix A.)

Table 4.2.3.1.C.
Lighting Power Allowances for Specific Building Exterior Applications
Forming Part of Sentences 4.2.3.1.(3) and (4)

Exterior Application	Lighting Power Allowances According to Lighting Zone				
	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Building facades (*facade lighting*)	A single luminaire of 60 W or less may be installed for each roadway or parking entry, trail head, and toilet facility, or other locations approved by the *authority having jurisdiction*	No allowance	1.1 W/m² for each illuminated wall or surface, or 8.2 W/m for each illuminated wall or surface length	1.6 W/m² for each illuminated wall or surface, or 12.3 W/m for each illuminated wall or surface length	2.2 W/m² for each illuminated wall or surface, or 16.4 W/m for each illuminated wall or surface length
Automated teller machines (ATM) and night depositories		270 W per location plus 90 W per additional ATM per location			
Entrances and gatehouse inspection stations at guarded facilities		8.1 W/m² of covered and uncovered area			
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles		5.4 W/m² of covered and uncovered area			
Drive-up windows and doors		400 W per drive-through			
Parking near 24-hour retail entrances		800 W per main entry			

5) The following *exterior lighting* applications need not comply with Sentences (1) to (4) where the lighting is equipped with an independent control device that complies with the requirements of Subsection 4.2.4.:

a) specialized signal, directional, and marker lighting associated with transportation,
b) lighting for advertising and directional signage,
c) lighting integral to equipment or instrumentation and installed by its manufacturer,
d) lighting for theatrical purposes, including performance, stage, film and video production,
e) lighting for athletic activity areas,

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f) temporary lighting,
g) lighting for industrial production, material handling, transportation sites, and associated storage areas for industrial sites,
h) lighting for theme elements in theme/amusement parks, and
i) lighting used to highlight features of art objects, public monuments and designated national or provincial historic sites.

Table 4.2.3.1.D.
Lighting Power Allowances for General Building Exterior Applications
Forming Part of Sentence 4.2.3.1.(4)

Exterior Application	Lighting Power Allowances According to Lighting Zone				
	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Uncovered Parking Areas					
Parking areas and drives	No allowances	0.4 W/m²	0.7 W/m²	1.1 W/m²	1.4 W/m²
Building Grounds					
Walkways less than 3 m wide	No allowances	2.3 W/m	2.3 W/m	2.6 W/m	3.3 W/m
Walkways 3 m wide or greater, plaza areas, special feature areas		1.5 W/m²	1.5 W/m²	1.7 W/m²	2.2 W/m²
Stairways		8.1 W/m²	11.0 W/m²	11.0 W/m²	11.0 W/m²
Pedestrian tunnels		1.6 W/m²	1.6 W/m²	2.2 W/m²	3.2 W/m²
Landscape lighting		0.4 W/m²	0.5 W/m²	0.5 W/m²	0.5 W/m²
Exterior Entrances and *Exterior Exits*					
Main entries	No allowances	66 W/m of door width	66 W/m of door width	98 W/m of door width	98 W/m of door width
Other doors		66 W/m of door width	66 W/m of door width	66 W/m of door width	66 W/m of door width
Entry canopies		2.7 W/m²	2.7 W/m²	4.3 W/m²	4.3 W/m²
Sales Canopies					
Free-standing and attached	No allowances	6.5 W/m²	6.5 W/m²	8.6 W/m²	11.0 W/m²
Outdoor Sales					
Open areas (including vehicle sales lots)	No allowances	2.7 W/m²	2.7 W/m²	5.4 W/m²	7.5 W/m²
Street frontage for vehicle sales lots in addition to “open area” allowance		No allowance	33 W/m	33 W/m	98 W/m

4.2.4. Exterior Lighting Controls

4.2.4.1. Requirements

1) Except as provided in Sentences (2) and (3), *exterior lighting* shall be controlled by
a) astronomical time controls,
b) photosensors,
c) a combination of photosensors and timer shut-off switch, or
d) other types of controls that perform the same function as those referred to in Clauses (a) to (c).

2) Except as provided in Sentence (3), *exterior lighting* designated for dusk-to-dawn operation shall be controlled by
a) astronomical time controls, or
b) photosensors.

3) *Exterior lighting* for covered vehicle *exterior entrances* or *exterior exits* from *buildings* or parking structures need not comply with Sentences (1) and (2) where it is required for safety, security, or eye adaptation. (See Appendix A.)

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4) All lighting schedule controllers shall be equipped with backup provisions to retain programming and the time setting for at least 10 h during a power outage.

Section 4.3. Trade-off Path

(See A-1.1.2.1. in Appendix A.)

4.3.1. General

4.3.1.1. Application

1) Subject to the limitations stated in Article 4.3.1.2., this Section applies to *interior lighting* and lighting controls.

4.3.1.2. Limitation

1) Notwithstanding the requirements of this Section, lighting and lighting controls shall comply with Articles 4.2.1.1. and 4.2.1.2. and Subsections 4.2.3. and 4.2.4.

4.3.1.3. Compliance

1) *Interior lighting* shall be deemed to comply with this Section if the installed *interior lighting* energy (IILE) in the proposed *building* calculated in accordance with Subsection 4.3.2. is less than or equal to the *interior lighting* energy allowance (ILEA) calculated in accordance with Subsection 4.3.3.

4.3.2. Installed Interior Lighting Energy

4.3.2.1. Determination of Installed Interior Lighting Energy

1) The installed *interior lighting* energy, IILE, in (W·h)/a, which is the total annual energy consumption of *interior lighting* in all spaces of the proposed *building*, shall be calculated using the following equation:

$$IILE = \sum_{i=1}^{N} E_{i,proposed}$$

where

i = counter for spaces,
N = total number of spaces in the proposed *building*, and
$E_{i,proposed}$ = annual energy consumption of *interior lighting* in a space, in (W·h)/a, calculated in accordance with Sentence (2).

2) The annual energy consumption of *interior lighting* in a space, $E_{i,proposed}$, in (W·h)/a, shall be calculated using the following equation:

$$E_{i,proposed} = p_i \cdot [A_{DL,i} \cdot (t_{eff,day,DL,i} + t_{eff,night,i}) + A_{NDL,i} \cdot (t_{eff,day,NDL,i} + t_{eff,night,i})]$$

where

p_i = lighting power density in the space, in W/m², determined in accordance with Article 4.3.2.2.,
$A_{DL,i}$ = daylighted area, in m², determined in accordance with Article 4.3.2.3.,
$A_{NDL,i}$ = non-daylighted area, in m², determined in accordance with Article 4.3.2.4.,
$t_{eff,day,DL,i}$ = effective annual daytime operational time of daylighted area, in h/a, determined in accordance with Article 4.3.2.5.,
$t_{eff,day,NDL,i}$ = effective annual daytime operational time of non-daylighted area, in h/a, determined in accordance with Article 4.3.2.5., and
$t_{eff,night,i}$ = effective annual nighttime operational time, in h/a, determined in accordance with Article 4.3.2.5.

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4.3.2.2. Determination of Lighting Power Density

1) The lighting power density for a space, p_i, in W/m², shall be calculated using the following equation:

$$p_i = \frac{P_i}{A_i}$$

where

P_i = lighting power in the space, in W, and
A_i = gross interior floor area of that space, in m².

4.3.2.3. Determination of Daylighted Area

1) Subject to the limitations stated in Sentence (2), the daylighted area of a space, $A_{DL,i}$, in m², shall be determined in accordance with Articles 4.2.2.5. (*skylights*) and 4.2.2.6. (rooftop monitors) for *toplighting* and Article 4.2.2.9. for *sidelighting*.

2) Where a space is illuminated by both *sidelighting* and *toplighting*, the daylighted area provided by only one of these daylight supplies shall be determined and used in the daylighting calculations in this Section. (See Appendix A.)

4.3.2.4. Determination of Non-Daylighted Area

1) The non-daylighted area of a space, $A_{NDL,i}$, in m², shall be calculated using the following equation:

$$A_{NDL,i} = A_i - A_{DL,i}$$

where

A_i = gross interior floor area of the space, in m², and
$A_{DL,i}$ = daylighted area of that space, in m².

4.3.2.5. Determination of Effective Annual Operational Times

1) The effective annual daytime operational time of the daylighted area, $t_{eff,day,DL,i}$, in h/a, shall be calculated using the following equation:

$$t_{eff,day,DL,i} = t_{day,i} \cdot F_{DL,i} \cdot F_{occ,i} \cdot F_{pers,i}$$

where

$t_{day,i}$ = annual operational time of the space during daytime, in h, determined in accordance with Article 4.3.2.6.,
$F_{DL,i}$ = factor for daylight harvesting determined in accordance with Article 4.3.2.7.,
$F_{occ,i}$ = factor for occupancy control determined in accordance with Article 4.3.2.10., and
$F_{pers,i}$ = factor for personal control determined in accordance with Article 4.3.2.10.

2) The effective annual daytime operational time of the non-daylighted area, $t_{eff,day,NDL,i}$, in h/a, shall be calculated using the following equation:

$$t_{eff,day,NDL,i} = t_{day,i} \cdot F_{occ,i} \cdot F_{pers,i}$$

where

$t_{day,i}$ = annual operational time of the space during daytime, in h, determined in accordance with Article 4.3.2.6.,
$F_{occ,i}$ = factor for occupancy control determined in accordance with Article 4.3.2.10., and
$F_{pers,i}$ = factor for personal control determined in accordance with Article 4.3.2.10.

3) The effective annual nighttime operational time, $t_{eff,night,i}$, in h/a, shall be calculated using the following equation:

$$t_{eff,night,i} = t_{night,i} \cdot F_{occ,i} \cdot F_{pers,i}$$

where

$t_{night,i}$ = annual operational time of the space during nighttime, in h, determined in accordance with Article 4.3.2.6.,
$F_{occ,i}$ = factor for occupancy control determined in accordance with Article 4.3.2.10., and
$F_{pers,i}$ = factor for personal control determined in accordance with Article 4.3.2.10.

4.3.2.6. Determination of Operational Times

1) Except as provided in Sentence (3), the annual operational time of each space during daytime, $t_{day,i}$, shall be determined using Table 4.3.2.6.A.

2) Except as provided in Sentence (3), the annual operational time of each space during nighttime, $t_{night,i}$, shall be determined using Table 4.3.2.6.B.

3) If the *building* operates for more or less than the default 250 days per year, the data provided in Tables 4.3.2.6.A. and 4.3.2.6.B. shall be linearly adjusted using the following equation:

$$t_{adjusted} = t_{base} \cdot \frac{d_{operation}}{250}$$

where

$t_{adjusted}$ = adjusted operational time to be used in the trade-off path, in h,
t_{base} = base operational time provided in Table 4.3.2.6.A. or 4.3.2.6.B., and
$d_{operation}$ = actual number of annual days of operation of the *building*, in days.

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Table 4.3.2.6.A.
Number of Operational Hours of the Building During Daytime, $t_{day,i}$, for Various Start and End Times
Forming Part of Sentences 4.3.2.6.(1) and (3)

Operation Start Time	Operation End Time																							
	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	12 p.m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	12 a.m.
	$t_{day,i}$, in h/a																							
12 a.m.	0	0	0	0	0	35	155	363	613	863	1,113	1,363	1,613	1,863	2,113	2,363	2,580	2,743	2,879	2,979	3,014	3,014	3,014	3,014
1 a.m.	-	0	0	0	0	35	155	363	613	863	1,113	1,363	1,613	1,863	2,113	2,363	2,580	2,743	2,879	2,979	3,014	3,014	3,014	3,014
2 a.m.	-	-	0	0	0	35	155	363	613	863	1,113	1,363	1,613	1,863	2,113	2,363	2,580	2,743	2,879	2,979	3,014	3,014	3,014	3,014
3 a.m.	-	-	-	0	0	35	155	363	613	863	1,113	1,363	1,613	1,863	2,113	2,363	2,580	2,743	2,879	2,979	3,014	3,014	3,014	3,014
4 a.m.	-	-	-	-	0	35	155	363	613	863	1,113	1,363	1,613	1,863	2,113	2,363	2,580	2,743	2,879	2,979	3,014	3,014	3,014	3,014
5 a.m.	-	-	-	-	-	35	155	363	613	863	1,113	1,363	1,613	1,863	2,113	2,363	2,580	2,743	2,879	2,979	3,014	3,014	3,014	3,014
6 a.m.	-	-	-	-	-	-	119	327	577	827	1,077	1,327	1,577	1,827	2,077	2,327	2,545	2,708	2,843	2,944	2,979	2,979	2,979	2,979
7 a.m.	-	-	-	-	-	-	-	208	458	708	958	1,208	1,458	1,708	1,958	2,208	2,425	2,588	2,724	2,825	2,860	2,860	2,860	2,860
8 a.m.	-	-	-	-	-	-	-	-	250	500	750	1,000	1,250	1,500	1,750	2,000	2,217	2,380	2,516	2,617	2,652	2,652	2,652	2,652
9 a.m.	-	-	-	-	-	-	-	-	-	250	500	750	1,000	1,250	1,500	1,750	1,967	2,130	2,266	2,367	2,402	2,402	2,402	2,402
10 a.m.	-	-	-	-	-	-	-	-	-	-	250	500	750	1,000	1,250	1,500	1,717	1,880	2,016	2,117	2,152	2,152	2,152	2,152
11 a.m.	-	-	-	-	-	-	-	-	-	-	-	250	500	750	1,000	1,250	1,467	1,630	1,766	1,867	1,902	1,902	1,902	1,902
12 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	250	500	750	1,000	1,217	1,380	1,516	1,617	1,652	1,652	1,652	1,652
1 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	250	500	750	967	1,130	1,266	1,367	1,402	1,402	1,402	1,402
2 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	500	717	880	1,016	1,117	1,152	1,152	1,152	1,152
3 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	467	630	766	867	902	902	902	902
4 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	217	380	516	617	652	652	652	652
5 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	163	299	400	434	434	434	434
6 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	136	237	271	271	271	271
7 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	136	136	136	136
8 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	35	35	35
9 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
10 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
11 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0

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Table 4.3.2.6.B.
Number of Operational Hours of the Building During Nighttime, $t_{night,i}$, for Various Start and End Times
Forming Part of Sentences 4.3.2.6.(2) and (3)

Operation Start Time	Operation End Time																							
	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	12 p.m.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	12 a.m.
	$t_{night,i}$, in h/a																							
12 a.m.	250	500	750	1,000	1,250	1,465	1,595	1,637	1,637	1,637	1,637	1,637	1,637	1,637	1,637	1,637	1,670	1,757	1,871	2,021	2,236	2,486	2,736	2,986
1 a.m.	-	250	500	750	1,000	1,215	1,345	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,420	1,507	1,621	1,771	1,986	2,236	2,486	2,736
2 a.m.	-	-	250	500	750	965	1,095	1,137	1,137	1,137	1,137	1,137	1,137	1,137	1,137	1,137	1,170	1,257	1,371	1,521	1,736	1,986	2,236	2,486
3 a.m.	-	-	-	250	500	715	845	887	887	887	887	887	887	887	887	887	920	1,007	1,121	1,271	1,486	1,736	1,986	2,236
4 a.m.	-	-	-	-	250	465	595	637	637	637	637	637	637	637	637	637	670	757	871	1,021	1,236	1,486	1,736	1,986
5 a.m.	-	-	-	-	-	215	345	387	387	387	387	387	387	387	387	387	420	507	621	771	986	1,236	1,486	1,736
6 a.m.	-	-	-	-	-	-	131	173	173	173	173	173	173	173	173	173	205	292	407	556	771	1,021	1,271	1,521
7 a.m.	-	-	-	-	-	-	-	42	42	42	42	42	42	42	42	42	75	162	276	425	640	890	1,140	1,390
8 a.m.	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	33	120	234	383	598	848	1,098	1,348
9 a.m.	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	33	120	234	383	598	848	1,098	1,348
10 a.m.	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	33	120	234	383	598	848	1,098	1,348
11 a.m.	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	33	120	234	383	598	848	1,098	1,348
12 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	33	120	234	383	598	848	1,098	1,348
1 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	33	120	234	383	598	848	1,098	1,348
2 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	33	120	234	383	598	848	1,098	1,348
3 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	33	120	234	383	598	848	1,098	1,348
4 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	120	234	383	598	848	1,098	1,348
5 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87	201	350	566	816	1,066	1,316
6 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	114	263	479	729	979	1,229
7 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	149	364	614	864	1,114
8 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	215	465	715	965
9 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	500	750
10 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	500
11 p.m.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250

4.3.2.7. Determination of Factor for Daylight Harvesting

1) Except as provided in Sentence (2), the factor for daylight harvesting, $F_{DL,i}$, shall be calculated using the following equation:

$$F_{DL,i} = 1 - C_{DL,sup,i} \cdot C_{DL,ctrl,i} \cdot C_{EL,ctrl,i}$$

where

$C_{DL,sup,i}$ = daylight supply factor determined in accordance with Sentences (3) and (4),
$C_{DL,ctrl,i}$ = daylight system control factor determined in accordance with Sentence (5), and
$C_{EL,ctrl,i}$ = daylight-dependent control factor for electric lighting determined in accordance with Sentence (6).

2) For spaces with no daylight supply, the factor for daylight harvesting, $F_{DL,i}$, shall be 0.

3) For spaces where *sidelighting* is the primary daylight supply, the daylight supply factor, $C_{DL,sup,i}$, shall be determined in accordance with Article 4.3.2.8.

4) For spaces where *toplighting* is the primary daylight supply, the daylight supply factor, $C_{DL,sup,i}$, shall be determined in accordance with Article 4.3.2.9.

5) The daylight system control factor, $C_{DL,ctrl,i}$, shall be selected from Table 4.3.2.7.A.

6) The daylight-dependent control factor for electric lighting, $C_{EL,ctrl,i}$, shall be selected from Table 4.3.2.7.B.

Table 4.3.2.7.A.
Daylight System Control Factor, $C_{DL,ctrl,i}$
Forming Part of Sentences 4.3.2.7.(5) and 4.3.3.7.(5)

Daylight System Control	$C_{DL,ctrl,i}$
Manual	0.5
Automatic	0.86

Table 4.3.2.7.B.
Daylight-Dependent Control Factor for Electric Lighting, $C_{EL,ctrl,i}$
Forming Part of Sentences 4.3.2.7.(6) and 4.3.3.7.(6)

Daylight-Dependent Control System	$C_{EL,ctrl,i}$
Dimming	1
Bi-level switching	0.99
Switching	0.82
Manual	0.51

4.3.2.8. Determination of the Daylight Supply Factor for Sidelighting

1) For spaces where *sidelighting* is the primary daylight supply, the daylight supply factor, $C_{DL,sup,i}$, shall be calculated using the following equation:

$$C_{DL,sup,i} = \tau_{eff,i} \cdot C_{DL,sup,raw,i} \cdot f_{obst,i}$$

where

$\tau_{eff,i}$ = effective luminous transmittance of the *fenestration* providing *sidelighting* calculated in accordance with Sentence (2),
$C_{DL,sup,raw,i}$ = raw daylight supply factor for the rough opening (opening without *fenestration*) calculated in accordance with Sentence (3), and
$f_{obst,i}$ = factor to account for horizontal obstructions calculated in accordance with Sentence (4).

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2) The effective luminous transmittance of the *fenestration* providing *sidelighting*, $\tau_{eff,i}$, shall be calculated using the following equation:

$$\tau_{\mathrm{eff,i}} = \tau_{\mathrm{D65,i}} \cdot \mathrm{k}_{1,\mathrm{i}} \cdot \mathrm{k}_{2,\mathrm{i}} \cdot \mathrm{k}_{3,\mathrm{i}}$$

where

$\tau_{D65,i}$ = luminous transmittance of the glazing for standard illuminant D65,
$k_{1,i}$ = factor to account for framing defined as the ratio of glazed area to overall area of the opening including area of framing,
$k_{2,i}$ = factor to account for dirt accumulation (if unknown, value shall be set to 0.8), and
$k_{3,i}$ = factor to account for non-perpendicular light incidence (if unknown, value shall be set to 0.85).

3) The raw daylight supply factor for the rough opening, $C_{DL,sup,raw,i}$, shall be determined using Table 4.3.2.8.

4) The factor to account for horizontal obstructions, $f_{obst,i}$, shall be calculated using the following equation:

$$\text{For } \gamma_{\mathrm{obst,i}} < 60^{\circ}, \mathrm{f}_{\mathrm{obst,i}} = \cos\left(1.5 \cdot \gamma_{\mathrm{obst,i}}\right), \text{ and}$$
$$\text{For } \gamma_{\mathrm{obst,i}} \geq 60^{\circ}, \mathrm{f}_{\mathrm{obst,i}} = 0$$

where

$\gamma_{obst,i}$ = angle from the centre of the *fenestration* to the top of the horizontal obstruction, in degrees.

Table 4.3.2.8.
Raw Daylight Supply Factors for Rough Opening, $C_{DL,sup,raw,i}$
Forming Part of Sentence 4.3.2.8.(3)

Design Illuminance, in lx[1]	Orientation of *Fenestration* Providing *Sidelighting*			
	North	East	South	West
	$C_{DL,sup,raw,i}$			
300	0.72	0.72	0.74	0.73
500	0.59	0.62	0.66	0.64
750	0.50	0.55	0.60	0.57
1000	0.44	0.49	0.55	0.52

Notes to Table 4.3.2.8.:
(1) See Appendix A.

4.3.2.9. Determination of the Daylight Supply Factor for Toplighting

1) For spaces where *toplighting* is the primary daylight supply, the daylight supply factor, $C_{DL,sup,i}$, shall be determined using Table 4.3.2.9.A.

2) The mean daylight factor for *toplighting*, D_i, shall be calculated using the following equation:

$$\mathrm{D_i} = \tau_{\mathrm{D65,i}} \cdot \mathrm{k}_{\mathrm{skyl,1,i}} \cdot \mathrm{k}_{\mathrm{skyl,2,i}} \cdot \mathrm{k}_{\mathrm{skyl,3,i}} \cdot \frac{\sum \mathrm{A}_{\mathrm{Rb,i}}}{\mathrm{A}_{\mathrm{RG,i}}} \cdot \eta_{\mathrm{R,i}}$$

where

$\tau_{D65,i}$ = luminous transmittance of the roof glazing for standard illuminant D65,
$k_{skyl,1,i}$ = factor to account for framing defined as the ratio of glazed area to overall area of the opening including area of framing (if unknown, value shall be set to 0.7),

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$k_{skyl,2,i}$ = factor to account for dirt accumulation (if unknown, value shall be set to 0.9),
$k_{skyl,3,i}$ = factor to account for non-perpendicular light incidence (if unknown, value shall be set to 0.85),
$A_{Rb,i}$ = area of the openings providing *toplighting* (area of rough opening), in m^2,
$A_{RG,i}$ = area of the space, in m^2, and
$\eta_{R,i}$ = utilization factor determined using Table 4.3.2.9.B.

3) The room cavity ratio, RCR, shall be calculated using the following equation:

$$RCR = \frac{5 \cdot H \cdot (L + W)}{[L \cdot W]}$$

where
H = height of the space, in m,
L = length of the space, in m, and
W = width of the space, in m.

Table 4.3.2.9.A.
Daylight Supply Factors for Toplighting, $C_{DL,sup,i}$
Forming Part of Sentence 4.3.2.9.(1)

Design Illuminance, in lx	Classification of the Daylighting Supply		
	Low (2% ≤ D_i < 4%)(1)	Medium (4% ≤ D_i < 7%)(1)	Good (D_i ≥ 7%)(1)
	$C_{DL,sup,i}$		
300	0.81	0.86	0.88
500	0.75	0.82	0.85
750	0.67	0.77	0.82
1000	0.59	0.73	0.79

Notes to Table 4.3.2.9.A.:
(1) See Sentence (2) to calculate the mean daylight factor for *toplighting*, D_i. For D_i < 2%, $C_{DL,sup,i}$ = 0.

Table 4.3.2.9.B.
Utilization Factor, $\eta_{R,i}$, as a Function of Room Cavity Ratio, RCR
Forming Part of Sentence 4.3.2.9.(2)

RCR(1)	Utilization Factor,(2) $\eta_{R,i}$
0	1.00
0.5	0.98
1	0.95
1.5	0.89
2	0.84
2.5	0.79
3	0.74
4	0.65
5	0.57
6	0.52
7	0.47
8	0.41
9	0.35
10	0.29

Notes to Table 4.3.2.9.B.:
(1) See Sentence (3) to calculate the room cavity ratio, RCR.
(2) The utilization factors are derived based on room reflectances of 70 pc (ceiling cavity)/50 pw (walls)/20 pf (floor cavity).

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4.3.2.10. Determination of Factors for Occupancy Control and Personal Control

1) The factor for occupancy control, $F_{occ,i}$, shall be calculated using the following equation:

$$F_{occ,i} = 1 - C_{A,i} \cdot C_{occ,ctrl,i}$$

where

$C_{A,i}$ = factor to account for the relative absence of occupants in the space determined using Table 4.3.2.10.A., and

$C_{occ,ctrl,i}$ = factor to account for the occupancy-sensing mechanism determined using Table 4.3.2.10.B.

2) The factor for personal control, $F_{pers,i}$, shall be calculated using the following equation:

$$F_{pers,i} = 1 - C_{pers,ctrl,i}$$

where

$C_{pers,ctrl,i}$ = factor to account for personal control determined using Table 4.3.2.10.A.

Table 4.3.2.10.A.
Factors for Relative Absence of Occupants and Personal Control According to Space Type
Forming Part of Sentences 4.3.2.10.(1) and (2) and 4.3.3.10.(1)

Common Space Types		
Space Types	Factors	
	Relative Absence of Occupants, $C_{A,i}$	Personal Control, $C_{pers,ctrl,i}$
Atrium		
first 13 m in height	0	0
height above 13 m	0	0
Audience seating area – permanent		
for auditorium	0.3	0
for performing arts *theatre*	0	0
for motion picture *theatre*	0	0
Classroom/lecture/training	0.5	0
Conference area/meeting/multi-purpose	0.5	0
Corridor/transition area		
≥ 2.4 m wide	0	0
< 2.4 m wide	0	0
Dining area		
for bar lounge/leisure dining	0	0
for family dining	0	0
other	0	0
Dressing/fitting room for performing arts *theatre*	0.4	0
Electrical/Mechanical area	0.9	0
Food preparation area	0	0
Laboratory		
for classrooms	0.4	0.1
for medical/industrial/research	0	0

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Table 4.3.2.10.A. (Continued)

Common Space Types		
Space Types	Factors	
	Relative Absence of Occupants, $C_{A,i}$	Personal Control, $C_{pers,ctrl,i}$
Lobby		
for elevator	0	0
for performing arts *theatre*	0	0
for motion picture *theatre*	0	0
other	0	0
Locker room	0.5	0
Lounge/recreation area	0	0
Office		
enclosed	0.3	0.1
open plan	0.2	0.1
Sales area	0	0
Stairway	0	0
Storage area	0.6	0
Washroom	0.5	0
Workshop	0	0
Building-Specific Space Types		
Space Types	Factors	
	Relative Absence of Occupants, $C_{A,i}$	Personal Control, $C_{pers,ctrl,i}$
Automotive – *repair garage*	0	0
Bank – banking activity area and offices	0	0
Convention centre		
audience seating	0.2	0
exhibit space	0	0
Courthouse/Police station/Penitentiary		
courtroom	0.2	0
confinement cell	0	0
judges' chambers	0.3	0.1
penitentiary – audience seating	0	0
penitentiary – classroom	0.5	0
penitentiary – dining	0	0
Dormitory – living quarters	0	0
Fire station		
engine room	0.5	0
sleeping quarters	0	0
Gymnasium/Fitness centre		
fitness area	0	0
gymnasium – audience seating	0	0
play area	0	0

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Table 4.3.2.10.A. (Continued)

Building-Specific Space Types		
Space Types	Factors	
	Relative Absence of Occupants, $C_{A,i}$	Personal Control, $C_{pers,ctrl,i}$
Hospital		
corridor/transition area ≥ 2.4 m wide	0	0
corridor/transition area < 2.4 m wide	0	0
emergency	0	0
exam/treatment	0.3	0
laundry – washing	0	0
lounge/recreation	0	0
medical supply	0.5	0
nursery	0	0
nurses' station	0	0
operating room	0.1	0
patient room	0.1	0.1
pharmacy	0	0
physical therapy	0.2	0
radiology/imaging	0	0
recovery	0	0
Hotel/Motel		
hotel dining	0	0
hotel guest rooms	0	0
hotel lobby	0	0
highway lodging dining	0	0
highway lodging guest rooms	0	0
Library		
card file and cataloging	0	0
reading area	0	0
stacks	0	0
Manufacturing		
corridor/transition area ≥ 2.4 m wide	0	0
corridor/transition area < 2.4 m wide	0	0
detailed manufacturing	0	0
equipment room	0.2	0
extra high bay (> 15 m floor-to-ceiling height)	0	0
high bay (7.5 m to 15 m floor-to-ceiling height)	0	0
low bay (< 7.5 m floor-to-ceiling height)	0	0
Museum		
general exhibition	0.2	0
restoration	0.3	0
Parking garage – garage area	0.4	0
Post office – sorting area	0	0

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Table 4.3.2.10.A. (Continued)

Building-Specific Space Types		
Space Types	Factors	
	Relative Absence of Occupants, $C_{A,i}$	Personal Control, $C_{pers,ctrl,i}$
Religious *building*		
audience seating	0.3	0
fellowship hall	0.3	0
worship pulpit, choir	0.1	0
Retail		
dressing/fitting room	0.4	0
mall concourse	0	0
sales area	0	0
Sports arena		
audience seating	0	0
court sports area – class 4	0	0
court sports area – class 3	0	0
court sports area – class 2	0	0
court sports area – class 1	0	0
ring sports area	0	0
Transportation		
air/train/bus – baggage area	0	0
airport – concourse	0	0
seating area	0	0
terminal – ticket counter	0	0
Warehouse		
fine material storage	0.5	0
medium/bulky material	0.5	0
medium/bulky material with permanent shelving that is > 60% of *ceiling height*	0.5	0

Table 4.3.2.10.B.
Factor to Account for Occupancy-Sensing Mechanism, $C_{occ,ctrl,i}$
Forming Part of Sentences 4.3.2.10.(1) and 4.3.3.10.(1)

Occupancy-Sensing Mechanism	$C_{occ,ctrl,i}$
Manual	0.30
Automatic	0.67

4.3.3. Interior Lighting Energy Allowance

4.3.3.1. Determination of Interior Lighting Energy Allowance

1) The *interior lighting* energy allowance, ILEA, in (W·h)/a, which is the maximum allowed annual energy consumption of all *interior lighting* complying with the prescriptive lighting power densities determined using the space-by-space method in

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Article 4.2.1.6. and with the prescriptive lighting controls in Subsection 4.2.2., shall be calculated using the following equation:

$$ILEA = \sum_{i=1}^{N} E_{i,prescriptive}$$

where

i = counter for spaces,
N = total number of spaces in the proposed *building*, and
$E_{i,prescriptive}$ = annual energy consumption for lighting in a space, in (W·h)/a, calculated in accordance with Sentence (2).

2) The annual energy consumption for lighting in each space, $E_{i,prescriptive}$, in (W·h)/a, shall be calculated using the following equation:

$$E_{i,prescriptive} = LPD_i \cdot [A_{DL,i} \cdot (t_{eff,day,DL,i} + t_{eff,night,i}) + A_{NDL,i} \cdot (t_{eff,day,NDL,i} + t_{eff,night,i})]$$

where

LPD_i = lighting power density for the space, in W/m², determined in accordance with Article 4.3.3.2.,
$A_{DL,i}$ = daylighted area, in m², determined in accordance with Article 4.3.3.3.,
$A_{NDL,i}$ = non-daylighted area, in m², determined in accordance with Article 4.3.3.4.,
$t_{eff,day,DL,i}$ = effective annual daytime operational time in daylighted area, in h/a, determined in accordance with Article 4.3.3.5.,
$t_{eff,day,NDL,i}$ = effective annual daytime operational time in non-daylighted area, in h/a, determined in accordance with Article 4.3.3.5., and
$t_{eff,night,i}$ = effective annual nighttime operational time, in h/a, determined in accordance with Article 4.3.3.5.

4.3.3.2. Determination of Lighting Power Density

1) The lighting power density for a space, LPD_i, shall be determined using Table 4.2.1.6.

4.3.3.3. Determination of Daylighted Area

1) The daylighted area of a space, $A_{DL,i}$, in m², shall be determined in accordance with Articles 4.2.2.5. (*skylights*) and 4.2.2.6. (rooftop monitors) for *toplighting* and Article 4.2.2.9. for *sidelighting*.

4.3.3.4. Determination of Non-Daylighted Area

1) The non-daylighted area of a space, $A_{NDL,i}$, in m², shall be calculated using the following equation:

$$A_{NDL,i} = A_i - A_{DL,i}$$

where

A_i = gross interior floor area of the space, in m², and
$A_{DL,i}$ = daylighted area of that space, in m².

4.3.3.5. Determination of Effective Annual Operational Times

1) The effective annual daytime operational time of the daylighted area, $t_{eff,day,DL,i}$, in h/a, shall be calculated using the following equation:

$$t_{eff,day,DL,i} = t_{day,i} \cdot F_{DL,i} \cdot F_{occ,i} \cdot F_{pers,i}$$

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where

$t_{day,i}$ = annual operational time of space during daytime, in h, determined in accordance with Article 4.3.3.6.,
$F_{DL,i}$ = factor for daylight harvesting determined in accordance with Article 4.3.3.7.,
$F_{occ,i}$ = factor for occupancy control determined in accordance with Article 4.3.3.10., and
$F_{pers,,i}$ = factor for personal control determined in accordance with Article 4.3.3.10.

2) The effective annual daytime operational time of the non-daylighted area, $t_{eff,day,NDL,i}$, in h/a, shall be calculated using the following equation:

$$t_{eff,day,NDL,i} = t_{day,i} \cdot F_{occ,i} \cdot F_{pers,i}$$

where

$t_{day,i}$ = annual operational time of space during daytime, in h, determined in accordance with Article 4.3.3.6.,
$F_{occ,i}$ = factor for occupancy control determined in accordance with Article 4.3.3.10., and
$F_{pers,,i}$ = factor for personal control determined in accordance with Article 4.3.3.10.

3) The effective annual nighttime operational time, $t_{eff,night,i}$, in h/a, shall be calculated using the following equation:

$$t_{eff,night,i} = t_{night,i} \cdot F_{occ,i} \cdot F_{pers,i}$$

where

$t_{night,i}$ = annual operational time of the space during nighttime, in h, determined in accordance with Article 4.3.3.6.,
$F_{occ,i}$ = factor for occupancy control determined in accordance with Article 4.3.3.10., and
$F_{pers,,i}$ = factor for personal control determined in accordance with Article 4.3.3.10.

4.3.3.6. Determination of Operational Times

1) Annual operational times, $t_{day,i}$ and $t_{night,i}$, shall be determined in accordance with Article 4.3.2.6.

4.3.3.7. Determination of Factor for Daylight Harvesting

1) Except as provided in Sentence (2), the factor for daylight harvesting, $F_{DL,i}$, shall be determined using the following equation:

$$F_{DL,i} = 1 - C_{DL,sup,i} \cdot C_{DL,ctrl,i} \cdot C_{EL,ctrl,i}$$

where

$C_{DL,sup,i}$ = daylight supply factor determined in accordance with Sentences (3) and (4),
$C_{DL,ctrl,i}$ = daylight system control factor determined in accordance with Sentence (5), and
$C_{EL,ctrl,i}$ = daylight-dependent control factor for electric lighting determined in accordance with Sentence (6).

2) For spaces with no daylight supply, the factor for daylight harvesting, $F_{DL,i}$, shall be 0.

3) For spaces where *sidelighting* is the primary daylight supply, the daylight supply factor, $C_{DL,sup,i}$, shall be determined in accordance with Article 4.3.2.8.

4) For spaces where *toplighting* is the primary daylight supply, the daylight supply factor, $C_{DL,sup,i}$, shall be determined in accordance with Article 4.3.2.9.

5) The daylight system control factor, $C_{DL,ctrl,i}$, shall be determined using Table 4.3.2.7.A. based on the minimum requirement for the applicable space according to the prescriptive path.

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6) The daylight-dependent control factor for electric lighting, $C_{EL,ctrl,i,}$ shall be determined using Table 4.3.2.7.B. based on the minimum requirement for the applicable space according to the prescriptive path.

4.3.3.8. Reserved

4.3.3.9. Reserved

4.3.3.10. Determination of Factors for Occupancy Control and Personal Control

1) The factor for occupancy control, $F_{occ,i,}$, shall be calculated using the following equation:

$$F_{occ,i} = 1 - C_{A,i} \cdot C_{occ,ctrl,i}$$

where

$C_{A,i}$ = factor to account for the relative absence of occupants in the space determined using Table 4.3.2.10.A., and

$C_{occ,ctrl,i}$ = factor to account for the occupancy-sensing mechanism determined using Table 4.3.2.10.B. based on the minimum requirement for the applicable space according to the prescriptive path.

2) The factor for personal control, $F_{pers,i,}$ shall be set to 1.

Section 4.4. Performance Path

(See A-1.1.2.1. in Appendix A.)

4.4.1. General

4.4.1.1. Scope

1) Where the lighting system does not comply with the requirements of Section 4.2. or 4.3., it shall comply with Part 8.

Section 4.5. Objective and Functional Statements

4.5.1. Objective and Functional Statements

4.5.1.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in this Part shall be the objective and functional statements listed in Table 4.5.1.1. (See A-1.1.3.1.(1) in Appendix A.)

Table 4.5.1.1.
Objectives and Functional Statements Attributed to the Acceptable Solutions in Part 4
Forming Part of Sentence 4.5.1.1.(1)

Functional Statements and Objectives[1]	
4.2.1.1. Exit Signs	
(1)	[F94-OE1.1]
4.2.1.2. Fluorescent Lamp Ballasts	
(1)	[F94,F98-OE1.1]
(2)	[F94,F98-OE1.1]

Table 4.5.1.1. (Continued)

Functional Statements and Objectives[1]	
4.2.1.3. Limits to Installed Interior Lighting Power	
(1)	[F94-OE1.1]
(3)	[F94-OE1.1]
4.2.1.4. Determination of the Installed Interior Lighting Power	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]

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Table 4.5.1.1. (Continued)

Functional Statements and Objectives[1]	
4.2.1.5. Calculation of Interior Lighting Power Allowance Using the Building Area Method	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
(4)	[F94-OE1.1]
(5)	[F94-OE1.1]
4.2.1.6. Calculation of Interior Lighting Power Allowance Using the Space-by-Space Method	
(1)	[F94-OE1.1]
4.2.2.1. Automatic Lighting Shut-off Controls	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
4.2.2.2. Lighting Controls in Enclosed Spaces	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
4.2.2.3. Additional Requirements for Lighting Controls	
(1)	[F94-OE1.1]
(3)	[F94-OE1.1]
(4)	[F94-OE1.1]
(5)	[F94-OE1.1]
(6)	[F94-OE1.1]
(7)	[F94-OE1.1]
(8)	[F94-OE1.1]
4.2.2.4. Automatic Daylighting Controls for Toplighting	
(1)	[F94-OE1.1]
4.2.2.5. Determination of Daylighted Area Under Skylights	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.2.2.6. Determination of Daylighted Area Under Rooftop Monitors	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.2.2.7. Calculation of Skylight Effective Aperture	
(1)	[F94-OE1.1]
4.2.2.8. Automatic Daylighting Controls for Primary Sidelighted Areas	
(1)	[F94-OE1.1]
4.2.2.9. Determination of Primary Sidelighted Areas	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
(4)	[F94-OE1.1]

Table 4.5.1.1. (Continued)

Functional Statements and Objectives[1]	
4.2.2.10. Calculation of Sidelighting Effective Aperture	
(1)	[F94-OE1.1]
4.2.3.1. Exterior Lighting	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
(4)	[F94-OE1.1]
4.2.4.1. Requirements	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(4)	[F94-OE1.1]
4.3.1.3. Compliance	
(1)	[F94-OE1.1]
4.3.2.1. Determination of Installed Interior Lighting Energy	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.3.2.2. Determination of Lighting Power Density	
(1)	[F94-OE1.1]
4.3.2.3. Determination of Daylighted Area	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.3.2.4. Determination of Non-Daylighted Area	
(1)	[F94-OE1.1]
4.3.2.5. Determination of Effective Annual Operational Times	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
4.3.2.6. Determination of Operational Times	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.3.2.7. Determination of Factor for Daylight Harvesting	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
(4)	[F94-OE1.1]
(5)	[F94-OE1.1]
(6)	[F94-OE1.1]
4.3.2.8. Determination of the Daylight Supply Factor for Sidelighting	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
(4)	[F94-OE1.1]

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Table 4.5.1.1. (Continued)

Functional Statements and Objectives[1]	
4.3.2.9. Determination of the Daylight Supply Factor for Toplighting	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
4.3.2.10. Determination of Factors for Occupancy Control and Personal Control	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.3.3.1. Determination of Interior Lighting Energy Allowance	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
4.3.3.2. Determination of Lighting Power Density	
(1)	[F94-OE1.1]
4.3.3.3. Determination of Daylighted Area	
(1)	[F94-OE1.1]
4.3.3.4. Determination of Non-Daylighted Area	
(1)	[F94-OE1.1]
4.3.3.5. Determination of Effective Annual Operational Times	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(3)	[F94-OE1.1]
4.3.3.7. Determination of Factor for Daylight Harvesting	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]
(5)	[F94-OE1.1]
(6)	[F94-OE1.1]
4.3.3.10. Determination of Factors for Occupancy Control and Personal Control	
(1)	[F94-OE1.1]
(2)	[F94-OE1.1]

Notes to Table 4.5.1.1.:

(1) See Parts 2 and 3 of Division A.

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Part 5
Heating, Ventilating and Air-conditioning Systems

Section 5.1. General

5.1.1. General

5.1.1.1. Scope

1) This Part is concerned with the systems used for heating, ventilating and air-conditioning of *buildings* covered by this Code.

5.1.1.2. Application

1) Except as permitted in Sentences (2) and (3), and except for systems and equipment used exclusively for the control of smoke in the event of a fire, this Part applies to heating, ventilating and air-conditioning systems and equipment.

2) A heating, ventilating or air-conditioning system or part thereof may be exempted from some or all of the requirements in this Part where it can be shown that the nature of the *occupancy* or the type of heating, ventilating or air-conditioning equipment used makes it impractical to apply these requirements. (See Appendix A.)

3) This Part does not apply to the existing components of systems that are extended to serve *additions*.

5.1.1.3. Compliance

1) Except as provided in Sentence (2), compliance with this Part shall be achieved by following

a) the prescriptive path described in Section 5.2.,
b) the trade-off path described in Section 5.3., or
c) the performance path described in Section 5.4. (see A-3.1.1.3.(1)(c) in Appendix A).

(See Appendix A.)

2) Back-up systems shall comply with the prescriptive requirements stated in Section 5.2.

5.1.1.4. Definitions

1) Words that appear in italics are defined in Article 1.4.1.2. of Division A.

Section 5.2. Prescriptive Path

5.2.1. Equipment Sizing

5.2.1.1. Load Calculations

1) Heating, ventilating and air-conditioning systems shall be sized in accordance with good engineering practice such as that prescribed in the NBC. (See Appendix A.)

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5.2.2. Air Distribution Systems

5.2.2.1. Design and Installation of Ducts

1) Ducts shall be designed and installed in accordance with the NBC. (See Appendix A.)

5.2.2.2. Provision for Balancing

1) All air distribution systems shall be designed so that they can be balanced. (See Appendix A.)

5.2.2.3. Duct Sealing

1) Except as provided in Sentences (2) to (5), air-handling ducts and *plenums* forming part of a heating, ventilating or air-conditioning system shall be constructed, installed and sealed as described in the ANSI/SMACNA 006, "HVAC Duct Construction Standards – Metal and Flexible," and in accordance with Table 5.2.2.3. (See Appendix A.)

2) Air-handling ducts and *plenums* that do not conform to Sentence (1) shall be tested to meet the requirements of Article 5.2.2.4.

3) *Return ducts* located within *conditioned space* or in spaces used as return air *plenums* need not comply with Sentence (1).

4) Except for *supply ducts* located upstream of zone coils, mixing boxes, variable-air-volume boxes and diffusers with integral variable-air-volume controls, *supply ducts* located within the *conditioned space* to which they supply air need not comply with Sentence (1). (See Appendix A.)

5) Sealing tape shall not be used as the primary sealant for air-handling ducts and *plenums*.

Table 5.2.2.3.
Sealing of Ducts
Forming Part of Sentence 5.2.2.3.(1)

Static Pressure Class(1)	Seal Class(1)
≤ 2	C
> 2 and < 4	B
≥ 4	A

Notes to Table 5.2.2.3.:

(1) The Static Pressure and Seal Classes are taken from ANSI/SMACNA 006, "HVAC Duct Construction Standards – Metal and Flexible." The Static Pressure Classes (inches, water gauge) shown do not refer to actual design static pressure and include both negatively and positively pressurized ducts.

5.2.2.4. Leakage Testing of Ducts

1) Where ducts are not constructed, installed and sealed in accordance with Sentence 5.2.2.3.(1), they shall be tested for leakage in conformance with the SMACNA 1985, "HVAC Air Duct Leakage Test Manual" and shall meet the requirements of Sentence (2). (See Appendix A.)

2) For ducts tested in accordance with Sentence (1), the maximum permitted leakage shall be calculated as follows:

$$L_{max} = \left(C_L \cdot (P)^{0.65}\right) / 720$$

where

L_{max} = maximum permitted leakage, in L/s/100 m² of duct surface area,
C_L = leakage class taken from Table 5.2.2.4., and

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P = maximum operating static pressure, in Pa.

Table 5.2.2.4.
Leakage Classes, C_L
Forming Part of Sentence 5.2.2.4.(2)

Shape of Duct	Maximum Operating Static Pressure, Pa		
	< 500	500-750	> 750
	C_L		
Rectangular	24	12	6
Round	12	6	3

5.2.2.5. Duct and Plenum Insulation

1) Except as provided in Sentences (2) to (5), all air-handling ducts, *plenums* and run-outs forming part of a heating, ventilating, or air-conditioning system shall be thermally insulated in accordance with Table 5.2.2.5.

Table 5.2.2.5.
Insulation of Ducts
Forming Part of Sentence 5.2.2.5.(1)

Temperature Difference,(1) °C	Minimum Thermal Resistance of Ducts and *Plenums*, $m^2 \cdot °C/W$	Minimum Thermal Resistance of Run-outs,(2) $m^2 \cdot °C/W$
< 5	0	0
5 to 22	0.58	0.58
> 22	0.88	0.58

Notes to Table 5.2.2.5.:

(1) Refers to the temperature difference at design conditions between the space within which the duct is located and the design temperature of the air carried by the duct. Where a duct is used for both heating and cooling purposes, the larger temperature difference shall be used.

(2) Refers to ducts not exceeding 3 m in length that connect to terminal grilles or diffusers.

2) *Exhaust ducts*, *return ducts* and *plenums* located within *conditioned space* need not comply with Sentence (1).

3) Ducts and *plenums* located within *conditioned space* in a *dwelling unit* and serving only that *dwelling unit* need not comply with Sentence (1).

4) Except for relief and outside air ducts and except as provided in Sentence (5), all air-handling ducts and *plenums* forming part of a heating, ventilating, or air-conditioning system that are located outside the *building envelope* shall be insulated to the same level as required for walls in Subsection 3.2.2.

5) Factory-installed *plenums* and ducts provided as part of equipment tested and rated in accordance with Article 5.2.12.1. need not comply with Sentences (1) and (4), provided they are insulated to a thermal resistance not less than 0.58 $m^2 \cdot °C/W$.

6) Insulation material required in Sentence (1) shall be installed in accordance with good practice. (See A-5.2.2.5.(6) and 5.2.5.3.(8) in Appendix A.)

5.2.2.6. Protection of Duct Insulation

1) Insulation on cold-air *supply ducts* shall be provided with vapour barrier protection to prevent condensation, where the surface temperature of the duct is below the dew point of the air surrounding the duct.

2) Duct insulation installed in areas where it may be subject to mechanical damage or weathering shall be protected.

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5.2.2.7. Cooling with Outdoor Air

1) Except for HVAC systems serving only *dwelling units* or hotel or motel rooms, each system that incorporates mechanical cooling and has an air-handling capacity of more than 1 500 L/s or a cooling capacity of more than 20 kW shall be designed to use outdoor air to reduce mechanical cooling energy by one of the means covered in Articles 5.2.2.8. and 5.2.2.9.

5.2.2.8. Cooling by Direct Use of Outdoor Air (Air Economizer System)

1) HVAC systems that use less mechanical cooling energy by direct use of outdoor air shall be capable of mixing return air with up to 100% outdoor air to produce the temperature required to condition the space. (See Appendix A.)

2) Systems described in Sentence (1) shall be designed to automatically revert to the minimum outdoor airflow required for acceptable indoor air quality as prescribed by the NBC, when either the return air temperature is less than the outdoor air temperature or the return air enthalpy is less than the outdoor air enthalpy. (See Appendix A.)

3) Except as provided in Sentence (6), systems described in Sentence (1) shall be designed to mix outdoor air and return air to a temperature as near as possible to that required to condition the space, even when mechanical cooling is provided.

4) Systems described in Sentence (1) with cooling capacities of 70 kW or more shall incorporate cooling equipment that can operate at less than full capacity, with the lowest stage providing no more than 25% of the full capacity of each system.

5) Systems described in Sentence (1) with cooling capacities of more than 25 kW but less than 70 kW shall incorporate cooling equipment that can operate at less than full capacity, with the lowest stage providing no more than 50% of the full capacity of each system.

6) Direct expansion HVAC systems are permitted to include controls to reduce the quantity of outdoor air at the lowest stage of cooling equipment output as necessary to permit proper operation of the equipment. (See Appendix A.)

5.2.2.9. Cooling by Indirect Use of Outdoor Air (Water Economizer System)

1) HVAC systems that reduce mechanical cooling energy use by using outdoor air to chill cooling distribution fluid by direct evaporation, indirect evaporation, or both, shall be capable of cooling supply air so as to provide 100% of the cooling load when the outdoor air wet-bulb temperature is 7°C or lower.

2) HVAC systems that reduce mechanical cooling energy use by using outdoor air to chill cooling distribution fluid by sensible heat transfer shall be capable of cooling supply air so as to provide 100% of the cooling load when the outdoor air dry-bulb temperature is 10°C or lower.

5.2.3. Fan System Design

5.2.3.1. Application

1) Except for equipment covered by Article 5.2.12.1. and whose minimum performance includes fan energy, this Subsection applies to all fan systems

a) that are used for comfort heating, ventilating or air-conditioning, or any combination thereof, and
b) for which the total of all fan motor nameplate ratings is 10 kW or more (see A-5.2.3.1.(2) in Appendix A).

2) For the purposes of this Subsection, the power demand of a fan system shall be the sum of the demand of all fans required to operate at design conditions to supply air to the *conditioned space*. (See Appendix A.)

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5.2.3.2. Constant-Volume Fan Systems

1) Where fans produce a constant airflow rate whenever the system is operating, the power demand required by the motors for the combined supply and return fan system at design conditions shall not exceed 1.6 W per L/s of supply air delivered to the *conditioned space*, calculated using the following equation:

$$W = 0.001 \cdot F \cdot SP/\eta$$

where

W = power demand, in watts,
F = design flow rate, in L/s,
SP = design static pressure across the fan, in Pa, and
η = combined fan-drive-motor efficiency, expressed as a decimal fraction.

(See Appendix A.)

5.2.3.3. Variable-Air-Volume Fan Systems

1) For fan systems through which airflow varies automatically as a function of load, the power demand required by the motors for the combined supply and return fan system, as calculated using the equation in Sentence 5.2.3.2.(1), shall not exceed 2.65 W per L/s of supply air delivered to the *conditioned space* at design conditions. (See Appendix A.)

2) In variable-air-volume systems, any individual supply, relief or return fan with a power demand greater than 7.5 kW and less than 25 kW, as calculated using the equation in Sentence 5.2.3.2.(1), shall incorporate controls and devices such that, if air delivery volume is reduced to 50% of design air volume, the corresponding fan power demand will be no more than 55% of design wattage, based on the manufacturer's test data.

3) In variable-air-volume systems, any individual supply, relief or return fan with a power demand equal to or greater than 25 kW, as calculated using the equation in Sentence 5.2.3.2.(1), shall incorporate controls and devices necessary to prevent the fan motor from demanding more than 30% of design wattage at 50% of design air volume, based on the manufacturer's test data.

5.2.4. Air Intake and Outlet Dampers

5.2.4.1. Required Dampers

1) Except as provided in Sentences (2) to (4), every duct or opening intended to discharge air from a *conditioned space* to the outdoors or to unconditioned space, and every outdoor air intake duct or opening shall be equipped with a motorized damper.

2) Where dampers are not permitted by other regulations, air intakes and outlets need not comply with Sentence (1).

3) Air intakes and outlets serving HVAC systems required to operate continuously need not comply with Sentence (1).

4) Where the duct or opening does not exceed 0.08 m² in cross-sectional area, air intake dampers required by Sentence (1) are permitted to be manually operated and air outlet dampers required by Sentence (1) are permitted to consist of gravity or spring-operated backflow dampers.

5.2.4.2. Type and Location of Dampers

1) Except as provided in Sentences (3) and (4), dampers required by Article 5.2.4.1. shall be

a) located as near as possible to the plane of the *building envelope*, and
b) designed to close automatically when the HVAC system is not in operation.

2) Motorized dampers required in Sentence 5.2.4.1.(1) shall be designed so that, when the damper is in the closed position, airflow does not exceed 15 L/s per m² of

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cross-sectional area at a pressure differential of 250 Pa, when tested in accordance with AMCA 500, "Louvers, Dampers and Shutters."

3) Dampers required in Article 5.2.4.1. are permitted to be located inboard of the *building envelope*, provided the portion of the duct between the damper and the *building envelope* is insulated in conformance with Sentence 5.2.2.5.(4) for ducts located outdoors.

4) Dampers in air intakes and outlets serving air-heating or -cooling equipment located outside of the *building envelope* are permitted to be located within the equipment.

5.2.5. Piping for Heating, Ventilating and Air-conditioning Systems

5.2.5.1. Design and Installation of Piping

1) HVAC piping shall be designed and installed in accordance with the NBC.

5.2.5.2. Provision for Balancing

1) All hydronic systems shall be designed so that they can be balanced. (See Appendix A.)

5.2.5.3. Piping Insulation

1) Except as provided in Sentences (2) to (5), piping forming part of an HVAC system shall be thermally insulated in accordance with Table 5.2.5.3.

2) Except for suction-line piping of direct expansion systems, piping located within *conditioned space* in a *dwelling unit* and serving only that *dwelling unit* need not comply with Sentence (1).

3) HVAC piping located outside the *building envelope* shall be insulated to the level specified in Table 5.2.5.3. for heating system piping conveying fluid with design operating temperatures above 177°C.

4) HVAC piping that conveys fluids with design operating temperatures greater than 13°C and less than 41°C need not comply with Table 5.2.5.3.

5) Where piping insulation has a thermal conductivity that is greater than the ranges given in Table 5.2.5.3., the insulation thickness given in the Table shall be increased by the ratio u2/u1, where u1 is the value at the higher end of the conductivity range for the operating temperature and u2 is the measured thermal conductivity of the insulation at the mean rating temperature.

6) Where piping insulation has a thermal conductivity that is lower than the ranges given in Table 5.2.5.3., the insulation thickness given in the Table may be decreased by the ratio u2/u1, where u1 is the value at lower end of the conductivity range for the operating temperature and u2 is the measured thermal conductivity of the insulation at the mean rating temperature.

7) The thermal conductivity of piping insulation at a mean rating temperature shall be determined in conformance with ASTM C 335/C 335M, "Steady-State Heat Transfer Properties of Pipe Insulation."

8) Insulation material required in Sentence (1) shall be installed in accordance with good practice. (See A-5.2.2.5.(6) and 5.2.5.3.(8) in Appendix A.)

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Table 5.2.5.3.
Minimum Thickness of Piping Insulation
Forming Part of Sentences 5.2.5.3.(1) and (3) to (6)

Type of System	Design Operating Temperature Range, °C	Thermal Conductivity of Insulation		Nominal Pipe Diameter, inches (mm)				
		Conductivity Range, W/m·°C	Mean Rating Temperature, °C	Runouts[1] ≤ 2 (51)	≤ 1 (25.4)	1¼ to 2 (32 to 51)	2½ to 4 (64 to 102)	≥ 5 (127)
				Minimum Thickness of Piping Insulation, mm				
Heating Systems (Steam, Steam Condensate and Hot Water)	> 177	0.046-0.049	121	38.1	63.5	63.5	76.2	88.9
	122-177	0.042-0.045	93	38.1	50.8	63.5	63.5	88.9
	94-121	0.039-0.043	65	25.4	38.1	38.1	50.8	50.8
	61-93	0.036-0.042	52	25.4	25.4	25.4	38.1	38.1
	41-60	0.035-0.040	38	25.4	25.4	25.4	25.4	38.1
Cooling Systems (Chilled Water, Brine and Refrigerant)[2]	5-13	0.033-0.039	24	25.4	25.4	25.4	25.4	25.4
	< 5	0.033-0.039	24	25.4	25.4	38.1	38.1	38.1

Notes to Table 5.2.5.3.:

(1) Refers to runouts to individual terminal units not exceeding 3.7 m in length.

(2) The required minimum thicknesses of insulation do not take into consideration water vapour transmission and condensation; additional insulation, vapour barriers, or both, may be required to limit these.

5.2.5.4. Protection of Piping Insulation

1) Insulation on piping conveying chilled fluid shall be provided with vapour barrier protection to prevent condensation, where the surface temperature of the pipe is below the dew point of the air.

2) Piping insulation installed in areas where it may be subject to mechanical damage or weathering shall be protected.

5.2.6. Pumping System Design

5.2.6.1. Application

1) This Subsection applies to HVAC pumping systems with a total pump system motor nameplate power of 7.5 kW or greater determined in accordance with Sentence (2).

2) For the purposes of this Subsection, the total pump system motor nameplate power shall be the sum of the nameplate power of all pumps required to operate at design conditions to supply fluid to a *conditioned space*.

5.2.6.2. Variable-Flow Pumping Systems

1) Except as provided in Sentence (2), HVAC pumping systems that serve control valves designed to modulate or to open and close in steps as a function of load shall be

a) designed for variable fluid flow, and
b) capable of reducing system flow to 50% or less of design flow.

(See Appendix A.)

2) Sentence (1) does not apply to systems

a) in which a minimum flow greater than 50% of the design flow is required for the proper operation of primary equipment serving the system, such as chillers and *boilers*,
b) with a single control valve, or
c) that include controls to reset the fluid supply temperature based on either outdoor temperature or system loads.

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5.2.7. Equipment Installed Outdoors

5.2.7.1. Manufacturer's Designation

1) Equipment installed outdoors or in an unconditioned space shall be designated by the manufacturer for such installation.

5.2.8. Temperature Controls

5.2.8.1. Temperature Controls

1) Each heating, ventilating or air-conditioning system intended to provide comfort heating or cooling shall include at least one automatic space temperature control device that is accurate to within 1°C.

2) Each *dwelling unit* shall be controlled by at least one thermostatic control device.

5.2.8.2. Temperature Control within Dwelling Units

1) *Dwelling units* shall be provided with manually operated or automatic devices as a means to reduce the heating of each room, as appropriate for the heating system used.

2) Where *dwelling units* are provided with a mechanical cooling system, they shall be provided with manually operated or automatic devices as a means to reduce the cooling of each room, as appropriate for the cooling system used.

5.2.8.3. Installation of Thermostats

1) Except as otherwise stated in the manufacturer's instructions and as required in barrier-free installations and for stratified ventilation, sensors for wall-mounted thermostats shall be installed

a) between 1 400 and 1 500 mm above the floor,
b) on interior *partitions* or walls, or on exterior walls with a maximum *overall thermal transmittance* of 0.286 W/(m²·K),
c) away from direct exposure to sunlight and heat-producing sources, and
d) away from drafts and dead pockets of air.

(See Appendix A.)

5.2.8.4. Heat Pump Controls

1) Heat pumps equipped with supplementary heaters shall incorporate controls to prevent supplementary heater operation when the heating load can be met by the heat pump alone, except during defrost cycles. (See Appendix A.)

5.2.8.5. Space Temperature Control

1) Except as provided in Sentence (2), the supply of heating and cooling energy to a zone shall be controlled by individual thermostatic controls responding to temperature within the zone.

2) An independent perimeter heating and cooling system designed to offset only *building envelope* heat losses or gains, or both, is permitted to be used, provided

a) it includes at least one thermostatic control for each *building* exposure having exterior walls facing only one orientation for an uninterrupted distance of 15 m or more (see Appendix A), and
b) its heating and cooling energy supply is controlled by thermostat(s) located within the zone(s) it serves.

3) Where separate thermostatic controls are provided to control heating and cooling to a space, means shall be provided to prevent these controls from simultaneously calling for heating and cooling. (See Appendix A.)

4) Thermostats installed to control electric resistance heater units shall conform to CAN/CSA-C828, "Thermostats Used with Individual Room Electric Space Heating Devices."

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5) Vestibules between *conditioned spaces* and the outdoors shall have a temperature-control device that limits the maximum heating temperature in the vestibule to 15°C.

5.2.8.6. Ice- and Snow-Melting Heater Controls

1) Ice- and snow-melting heaters shall be provided with automatic controls or readily accessible manual controls that allow them to be shut down when not required.

5.2.8.7. Control of Temperature of Air Leaving the Supply Air Handler

1) Except as provided in Sentences (2) and (3), a *supply air handler* shall be designed and equipped with controls to achieve the design supply air temperature without

a) heating previously cooled air,
b) cooling previously heated air, or
c) heating outdoor air, separately from the return air or mixed with it, in excess of the minimum required for ventilation.

2) Reheating supply air for humidity control is permitted where specified humidity levels are required. (See Appendix A.)

3) Reheating supply air is permitted where such reheating will not cause an increase in energy consumption.

5.2.8.8. Control of Space Temperature by Reheating or Recooling

1) Except as provided in Sentence (4), HVAC systems that control the temperature of a space by reheating previously cooled air shall be equipped with controls that automatically adjust the temperature of the cool air supply to the highest temperature that will satisfy the *temperature-control zone* requiring the coolest air.

2) Except as provided in Sentence (4), HVAC systems that control the temperature of a space by recooling previously heated air shall be equipped with controls that automatically adjust the temperature of the warm air supply to the lowest temperature that will satisfy the *temperature-control zone* requiring the warmest air.

3) Except as provided in Sentence (4), HVAC systems that control the temperature of a space by mixing heated supply air and cooled supply air shall be equipped with controls that

a) automatically adjust the temperature of the warm supply air to the lowest temperature that will satisfy the *temperature-control zone* requiring the warmest air, and
b) automatically adjust the temperature of the cool supply air to the highest temperature that will satisfy the *temperature-control zone* requiring the coolest air.

4) HVAC systems that are designed to reduce the air supplied to each *temperature-control zone* to no more than 2 L/s per m^2 of *floor surface area* of the *temperature-control zone* before reheating, recooling or mixing of supply air takes place need not comply with Sentences (1) to (3).

5.2.9. Humidification

5.2.9.1. Humidification Controls

1) If an HVAC system is equipped with a means for adding or removing moisture to maintain specific humidity levels in a space, an automatic humidity control device shall be provided.

5.2.10. Heat Recovery

5.2.10.1. Heat-Recovery Systems

1) Except as provided in Sentence (3), when the sensible heat content of an exhaust air system as calculated in accordance with Sentence (4) exceeds 150 kW, the system

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shall be equipped with a heat-recovery apparatus capable of recovering sensible heat with a minimum 50% efficiency. (See Appendix A.)

2) Heat recovered in accordance with Sentence (1) shall be used in *building* systems.

3) Specialized exhaust systems, such as those used to exhaust smoke, grease-laden vapours, or toxic, flammable, paint, or corrosive fumes or dust, need not comply with Sentence (1).

4) The sensible heat, in kW, referred to in Sentence (1), which is the sensible heat content of the total quantity of exhaust, shall be calculated as follows:

$$\text{Sensible Heat} = 0.00123 \cdot Q \cdot (T_e - T_o)$$

where

Q = rated capacity of exhaust system at normal exhaust air temperature, in L/s,
T_e = temperature of exhaust air before heat recovery, in °C, and
T_o = outdoor 2.5% January design temperature, in °C (see Appendix A).

5) At airflow rates not less than the system design capacity, the sensible-heat-recovery efficiency of a heat-recovery apparatus referred to in Sentence (1) shall be determined in conformance with

a) the test method described in ANSI/AHRI 1060, "Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation," or
b) another acceptable test method.

5.2.10.2. Heat Recovery from Dehumidification in Swimming Pools

1) Except for pools with a water surface area of less than 10 m² and except as provided in Sentence (2), systems that exhaust air from swimming pools within *conditioned spaces* shall be capable of recovering at least 40% of the sensible heat from exhaust air at design conditions, as calculated in accordance with Sentence 5.2.10.1.(4). (See Appendix A.)

2) Indoor swimming pools need not comply with Sentence (1), provided a stationary mechanical or desiccant dehumidification system is installed that provides at least 80% of the dehumidification that would result from compliance with Sentence (1).

5.2.10.3. Heat Recovery from Ice-making Machines in Ice Arenas and Curling Rinks

1) Where an ice arena or a curling rink has a heating requirement, the refrigeration system shall incorporate a means of recovering the heat rejected by the system to satisfy some or all of the *building*'s space-heating or *service water* heating requirements. (See Appendix A.)

5.2.10.4. Heat Recovery in Dwelling Units

1) Except for climate zones 4, 5 and 6, where a self-contained mechanical ventilation system serves a single *dwelling unit*, the principal exhaust component of the ventilation system shall be equipped with heat-recovery capability. (See Appendix A.)

2) Heat-recovery ventilators used to meet the requirements of Sentence (1) shall have a sensible-heat-recovery efficiency, when tested in conformance with the low-temperature thermal and ventilation test methods described in CAN/CSA-C439, "Rating the Performance of Heat/Energy-Recovery Ventilators," of

a) at least 65% at an outside air test temperature of 0°C, and
b) not less than that required by Table 5.2.10.4. for the 2.5% January design temperature for the *building*'s location, as listed in Appendix C of Division B of the NBC.

(See Appendix A.)

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Table 5.2.10.4.
Performance of Heat-recovery Ventilators
Forming Part of Sentence 5.2.10.4.(2)

2.5% January Design Temperature at *Building* Location	Outside Air Test Temperature at Station 1,(1) °C	Sensible-Heat-Recovery Efficiency, %
≥ –10	0	65
< –10 and > –30	–25	55
≤ –30	–40	45

Notes to Table 5.2.10.4.:
(1) "Station 1" is a term that is defined in CAN/CSA-C439 and means the location where temperature is measured.

3) The tests described in Sentence (2) shall be performed at the rated airflow for continuous operation of the equipment, which meets the principal exhaust component of the ventilation system referred to in Sentence (1).

4) Except as stated in Sentence (5), where a heat-recovery system other than a heat-recovery ventilator is used to meet the requirements of Sentence (1), that system shall have a heat-recovery performance equivalent to that required in Sentence (2) for heat-recovery ventilators.

5) Where heat-recovery systems are required in multi-unit residential *buildings*, the minimum sensible-heat-recovery efficiency shall be 50%. (See Appendix A.)

5.2.11. Shut-off and Setback Controls

5.2.11.1. Off-hours Controls

1) Except as provided in Sentence (3), systems serving *dwelling units* or other areas that are not intended to operate continuously and whose zone-heating or -cooling capacity requirement is 5 kW or more shall be equipped with automatic controls capable of setting back or shutting down the systems during periods of non-use of the zones served. (See Appendix A.)

2) Controls required by Sentence (1) shall be capable of
a) shutting down fan systems and/or heating and cooling equipment and auxiliaries, where appropriate, when conditioning is not required by the space,
b) setting back the space-heating temperature setpoint,
c) setting up the space-cooling temperature setpoint if the cooling system is required to operate during periods when the space is not in use,
d) reducing or shutting off outdoor air intake during heating or cooling system operation when the space is not in use (see Appendix A), and
e) in the case of heat pumps, temporarily suppressing electrical back-up or adaptive anticipation of the recovery point in order to prevent the unit from resorting to supplementary heat at the time of recovery (see Appendix A and A-5.2.8.4.(1) in Appendix A).

3) Zones with a total heating or cooling capacity requirement of less than 5 kW may be controlled by readily accessible manual controls.

4) Controls required by Sentence (1) shall be designed so that lowering a heating thermostat setpoint will not cause energy for cooling to be expended to reach the lowered setting and raising a cooling thermostat setpoint will not cause energy for heating to be expended to reach the raised setting.

5.2.11.2. Airflow Control Areas

1) Except as provided in Sentences (2) and (8), each air distribution system serving multiple *temperature-control zones* having a combined *floor surface area* of *conditioned space* of more than 2 500 m² shall be divided into *airflow control areas* so

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that the supply and exhaust of air to individual *airflow control areas* can be reduced or stopped independently of other *airflow control areas* served by the system.

2) Where it is impractical to control air distribution as described in Sentence (1), individual air distribution systems shall serve *airflow control areas* no greater than 2 500 m².

3) Each *airflow control area* required by Sentences (1) and (2) shall include only *temperature-control zones* intended to be operated simultaneously. (See Appendix A.)

4) Each *airflow control area* required by Sentences (1) and (2) shall not span more than one *storey*.

5) Each *airflow control area* required by Sentence (1) shall be equipped with controls meeting the requirements of Article 5.2.11.1.

6) The air distribution system shall be designed such that a reduction in air delivery of up to 50% of design flow results in at least a proportional reduction in fan power.

7) Controls and devices such as direct digital control and variable-air-volume systems shall be provided to allow stable operation of all fan systems and associated *primary systems* for any length of time while they are serving a single *airflow control area*.

8) *Temperature-control zones* in which outdoor air and exhaust requirements prevent the reduction or stopping of the air supply need not be incorporated into *airflow control areas*.

5.2.11.3. Seasonal Shutdown

1) HVAC pumping systems that are used on a seasonal basis shall be equipped with

a) automatic controls, or
b) readily accessible and clearly labeled manual controls that allow them to be shut down when not required.

5.2.11.4. Multiple Boilers

1) HVAC systems with multiple *boilers* shall incorporate a means for preventing heat loss through the *boilers* when they are not operating, such as a device that prevents the flow of heat-carrying fluid through the *boilers* or dampers installed in the flues.

2) Except as provided in Sentence (3), where the heating load exceeds 176 kW, the *boiler* plant shall consist of

a) more than one *boiler*,
b) a two-stage single *boiler*, or
c) a multi-stage *boiler*.

3) Where the heating load exceeds 352 kW, the *boiler* plant shall be fully modulating.

5.2.11.5. Loop Temperature Reset for Chilled- and Hot-Water Systems

1) Except as provided in Sentences (2) and (3), chilled- or hot-water systems with a design capacity greater than 88 kW supplying chilled or heated water to comfort-conditioning systems shall be equipped with automatic controls that reset the supply water loop temperatures

a) in relation to the outdoor temperature using an indoor/outdoor controller, or
b) in relation to representative *building* heating and cooling loads using the return water temperature in the system.

2) Chilled- and hot-water systems described in Sentence (1) need not be equipped with loop temperature reset controls where such controls would cause the improper operation of heating, cooling, humidifying, or dehumidifying equipment or systems.

3) Chilled- and hot-water systems described in Sentence (1) that are designed with variable-flow pumping complying with Sentence 5.2.6.2.(1) need not be equipped with loop temperature reset controls.

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5.2.12. Equipment Efficiency

5.2.12.1. Unitary and Packaged HVAC Equipment

1) Unitary and packaged HVAC equipment and components shall comply with the performance requirements in Table 5.2.12.1. (See Appendix A.) (See also Article 6.2.2.4.)

Table 5.2.12.1.
Unitary and Packaged HVAC Equipment Performance Requirements
Forming Part of Sentences 5.2.12.1.(1), 6.2.2.4.(2), 6.2.2.5.(1) and 8.4.4.19.(6)

Air-cooled Unitary Air Conditioners and Heat Pumps — Electrically Operated				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Split system	≤ 19 (65 000)	CAN/CSA-C656	—	SEER = 15
Single-package system	≤ 19 (65 000)	CAN/CSA-C656		SEER = 14
All phases	> 19 (65 000) and < 73 (250 000)	CAN/CSA-C746		EER = 9.7
Air conditioners, all phases, split and single-package	73 (250 000) – 222.7 (760 000)	CAN/CSA-C746	≥ 19 kW and < 40 kW, electric resistance heating section	COP = 3.28 ICOP = 3.34
			≥ 19 kW and < 40 kW, other heating section	COP = 3.22 ICOP = 3.28
			≥ 40 kW and < 70 kW, electric resistance heating section	COP = 3.22 ICOP = 3.28
			≥ 40 kW and < 70 kW, other heating section	COP = 3.16 ICOP = 3.22
			≥ 70 kW and < 223 kW, electric resistance heating section	COP = 2.93 ICOP = 2.96
			≥ 70 kW and < 223 kW, other heating section	COP = 2.87 ICOP = 2.90
			≥ 223 kW, electric resistance heating section	COP = 2.84 ICOP = 2.87
	> 222.7 (760 000)		≥ 223 kW, other heating section	COP = 2.78 ICOP = 2.81
Heat pumps	73 (250 000) – 222.7 (760 000)	CAN/CSA-C746	≥ 19 kW and < 40 kW, electric resistance heating section, split and single	COP = 3.22 ICOP = 3.28
			≥ 19 kW and < 40 kW, other heating section, split and single	COP = 3.16 ICOP = 3.22
			≥ 40 kW and < 70 kW, electric resistance heating section, split and single	COP = 3.10 ICOP = 3.13
			≥ 40 kW and < 70 kW, other heating section, split and single	COP = 3.04 ICOP = 3.08
			≥ 70 kW, electric resistance heating section, split and single	COP = 2.78 ICOP = 2.81
			≥ 70 kW, other heating section, split and single	COP = 2.72 ICOP = 2.75
			≥ 19 kW and < 70 kW in cooling mode at 8.3°C db / 6.1°C wb	COP = 3.3
			≥ 19 kW and < 70 kW in cooling mode at –8.3°C db / –9.4°C wb	COP = 2.25
			≥ 70 kW in cooling mode at 8.3°C db / 6.1°C wb	COP = 3.2
			≥ 70 kW in cooling mode at –8.3°C db / –9.4°C wb	COP = 2.05

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Table 5.2.12.1. (Continued)

Single-Package Vertical Air Conditioners (SPVAC) and Heat Pumps (SPVHP)				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
SPVAC and SPVHP in cooling mode	—	ANSI/AHRI 390	< 19 kW	EER = 10
		CAN/CSA-C746	≥ 19 kW and < 40 kW	EER = 9.5
		CAN/CSA-C746	≥ 40 kW and < 70 kW	EER = 8.6
SPVHP in heating mode	—	ANSI/AHRI 390	< 19 kW	COP = 3.1
		CAN/CSA-C746	≥ 19 kW and < 40 kW	COP = 3.0
		CAN/CSA-C746	≥ 40 kW and < 70 kW	COP = 2.9
Evaporatively Cooled and Water Evaporatively Cooled Unitary Air Conditioners and Heat Pumps — Electrically Operated				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Evaporatively cooled	≤ 19 (65 000)	ANSI/AHRI 210/240 or CTI 201	< 19 kW	COP = 3.54
Evaporatively cooled and water evaporatively cooled, split and single-package	> 19 (65 000) and < 73 (250 000)	CAN/CSA-C746	≥ 19 kW and < 40 kW, electric resistance heating section	COP = 3.37
			≥ 19 kW and < 40 kW, other heating section	COP = 3.31
			≥ 40 kW and < 70 kW, electric resistance heating section	COP = 3.22
			≥ 40 kW and < 70 kW, other heating section	COP = 3.16
Water evaporatively cooled air conditioners, split and single-package	≥ 73 (250 000)	ANSI/AHRI 340/360 or CTI 201	≥ 70 kW, electric resistance heating section	COP = 3.22 IPLV = 3.02
			≥ 70 kW, other heating section	COP = 3.16 IPLV = 2.96
Condensing Units				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Air-cooled and water evaporatively cooled	> 19 (65 000) and < 73 (250 000)	CAN/CSA-C746	—	See standard
Air-cooled	≥ 73 (250 000)	AHRI 365	≥ 40 kW	COP = 2.96 IPLV = 3.28
Water evaporatively cooled		CTI 201		COP = 3.84 IPLV = 3.84

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Table 5.2.12.1. (Continued)

Water-Cooled Unitary Air Conditioners and Heat Pumps — Electrically Operated				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Ground-source and water-source heat pumps	< 35 (119 500)	CAN/CSA-C13256-1	—	See standard
Internal water-loop heat pumps	< 40 (136 500)	CAN/CSA-C13256-2		
Water-cooled air conditioners	< 19 (65 000)	ANSI/AHRI 210/240 or CTI 201	< 19 kW	COP = 3.54 ICOP = 3.60
	19 (65 000) – 39.5 (135 000)	ANSI/AHRI 340/360 or CTI 201	≥ 19 kW and < 40 kW, electric resistance heating (or none)	COP = 3.37 ICOP = 3.43
			≥ 19 kW and < 40 kW, all other	COP = 3.31 ICOP = 3.37
			≥ 40 kW and < 70 kW, electric resistance heating (or none)	COP = 3.22 ICOP = 3.28
			≥ 40 kW and < 70 kW, all other	COP = 3.16 ICOP = 3.22
			≥ 70 kW, electric resistance heating (or none)	COP = 3.22 IPLV = 3.02 ICOP = 3.25
			≥ 70 kW, all other	COP = 3.16 IPLV = 2.96 ICOP = 3.19
Direct-Expansion Ground-Source Heat Pumps — Electrically Operated				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Direct-expansion ground-source heat pumps	≤ 21 (71 700)	CSA C748	—	See standard

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Table 5.2.12.1. (Continued)

Packaged Terminal Air Conditioners (PTAC) and Heat Pumps (PTHP)				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
PTAC and PTHP, air-cooled, electrically operated	All capacities	ARI 310/380/CAN/CSA-C744	—	COP = 3.66 – (0.213 x Cap_c/1000)
PTAC			Application rating	COP = 3.19 – (0.213 x Cap_c/1000)
PTHP in cooling mode			Standard rating	COP = 3.6 – (0.213 x Cap_c/1000)
			Application rating	COP = 3.16 – (0.213 x Cap_c/1000)
PTHP in heating mode			Standard rating	COP = 3.2 – (0.026 x Cap_c/1000)
			Application rating	COP = 2.9 – (0.026 x Cap_c/1000)
Room Air Conditioners and Room Air Conditioner Heat Pumps				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Room air conditioners with reverse cycle	< 10.55 (36 000)	ANSI/AHAM RAC-1	—	
with louvered sides				EER = 8.5
without louvered sides				EER = 8.0
Room air conditioners without reverse cycle		CAN/CSA-C368.1		See standard
Room air conditioners with louvered sides	< 1.8 (6 150)	CAN/CSA-C368.1	< 1.8 kW	COP = 2.84
	≥ 1.8 (6 150) and < 2.3 (7 800)		≥ 1.8 kW and < 2.3 kW	COP = 2.84
	≥ 2.3 (7 800) and < 4.1 (14 000)		≥ 2.3 kW and < 4.1 kW	COP = 2.87
	≥ 4.1 (14 000) and < 5.9 (20 150)		≥ 4.1 kW and < 5.9 kW	COP = 2.84
	≥ 5.9 (20 150)		≥ 5.9 kW	COP = 2.49
Room air conditioners without louvered sides	< 2.3 (7 800)		< 2.3 kW	COP = 2.64
	≥ 2.3 (7 800) and < 5.9 (20 150)		≥ 2.3 kW and < 5.9 kW	COP = 2.49
	≥ 5.9 (20 150)		≥ 5.9 kW	COP = 2.49
Room air conditioner heat pumps with louvered sides	< 5.9 (20 150)		< 5.9 kW	COP = 2.65
	≥ 5.9 (20 150)		≥ 5.9 kW	COP = 2.49
Room air conditioner heat pumps without louvered sides	< 4.1 (14 000)		< 4.1 kW	COP = 2.49
	≥ 4.1 (14 000)		≥ 4.1 kW	COP = 2.34
Room air conditioner, casement only	All capacities		All capacities	COP = 2.55
Room air conditioner, casement slider	All capacities		All capacities	COP = 2.78

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Table 5.2.12.1. (Continued)

Computer Room Air Conditioners				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Air conditioners, air-cooled	< 19 (65 000)	ANSI/ASHRAE 127	—	SCOP = 2.20 / 2.09
	≥ 19 (65 000) and < 70 (240 000)			SCOP = 2.10 / 1.99
	≥ 70 (240 000)			SCOP = 1.90 / 1.79
Air conditioners, water-cooled	< 19 (65 000)			SCOP = 2.60 / 2.49
	≥ 19 (65 000) and < 70 (240 000)			SCOP = 2.50 / 2.39
	≥ 70 (240 000)			SCOP = 2.40 / 2.29
Air conditioners, water-cooled with fluid economizer	< 19 (65 000)			SCOP = 2.55 / 2.44
	≥ 19 (65 000) and < 70 (240 000)			SCOP = 2.45 / 2.34
	≥ 70 (240 000)			SCOP = 2.35 / 2.24
Air conditioners, glycol-cooled	< 19 (65 000)		rated at 40% propylene glycol	SCOP = 2.50 / 2.39
	≥ 19 (65 000) and < 70 (240 000)			SCOP = 2.15 / 2.04
	≥ 70 (240 000)			SCOP = 2.10 / 1.99
Air conditioners, glycol-cooled with fluid economizer	< 19 (65 000)			SCOP = 2.45 / 2.34
	≥ 19 (65 000) and < 70 (240 000)			SCOP = 2.10 / 1.99
	≥ 70 (240 000)			SCOP = 2.05 / 1.94
Chilled water air handler	< 19 (65 000)		—	SCOP = 8.00 / 6.06
	≥ 19 (65 000) and < 70 (240 000)			SCOP = 9.00 / 7.06
	≥ 70 (240 000)			SCOP = 11.00 / 9.06
Packaged Water Chillers				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions[1]	Minimum Performance[2]
Vapour compression, air- or water-cooled, electrically operated	< 5 600 (19 000 000)	CAN/CSA-C743	—	See standard
Absorption, single- or double-effect, indirect- or direct-fired				

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Table 5.2.12.1. (Continued)

Boilers				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions(1)	Minimum Performance(2)
Electric *boilers*	—	—	—	(3)
Gas-fired *boilers*(4)	< 88 (300 000)	ANSI Z21.13/CSA 4.9	—	AFUE = 85%
	≥ 88 (300 000) and < 733 (2 500 000)	ANSI Z21.13/CSA 4.9 or ASME PTC 4	—	$E_c \geq 82.5\%$ $E_t \geq 83.0\%$
	≥ 733 (2 500 000)		—	$E_c \geq 83.3\%$
Oil-fired *boilers*	< 88 (300 000)	CSA B212 or ASME PTC 4	—	AFUE ≥ 84.7%
	≥ 88 (300 000) and < 733 (2 500 000)			$E_t \geq 83.4\%$
	≥ 733 (2 500 000)			$E_c \geq 85.8\%$
Oil-fired *boilers*, residual (No. 5 or No. 6 oil) and other	< 88 (300 000)	CSA B212	—	AFUE ≥ 84.7%
	≥ 88 (300 000) and < 733 (2 500 000)	ASME PTC 4		$E_t \geq 83.4\%$
	≥ 733 (2 500 000)			$E_c \geq 85.8\%$
Warm-Air Furnaces, Combination Warm-Air Furnace/Air-conditioning Units, Duct Furnaces and Unit Heaters				
Component or Equipment	Cooling or Heating Capacity, kW (Btu/h)	Standard	Rating Conditions(1)	Minimum Performance(2)
Gas-fired warm-air *furnaces*(4)(5)	≤ 117.23 (400 000)	ANSI Z21.47/CSA 2.3	—	AFUE ≥ 92.4%
	> 117.23 (400 000)		Maximum rated capacity, steady-state	$E_t \geq 81\%$
			Minimum rated capacity, steady-state	$E_t \geq 81\%$
Gas-fired duct *furnaces*(4)(5)	≤ 117.23 (400 000)	ANSI Z83.8/CSA 2.6	—	$E_t \geq 81\%$
Gas-fired *unit heaters*(4)				$E_t \geq 82\%$
Oil-fired warm-air *furnaces*(5)	≤ 66 (225 000)	CSA B212		$E_t \geq 84.5\%$
	> 66 (225 000)	CAN/CSA-B140.4		$E_t \geq 81.3\%$
Oil-fired duct *furnaces*(5) and *unit heaters*	—			$E_t \geq 81\%$

Notes to Table 5.2.12.1.:

(1) The abbreviations that appear in this column have the following meanings:

db = dry bulb outdoor air temperature
wb = wet bulb outdoor air temperature

(2) The symbols and abbreviations that appear in this column have the following meanings:

AFUE = annual fuel utilization efficiency, in %
Cap_c = rated cooling capacity, in W(Btu/h)
COP = *coefficient of performance*, in W/W
E_c = *combustion efficiency*, in %
EER = *energy efficiency ratio*, in (Btu/h)/W
E_t = *thermal efficiency*, in %
ICOP = integrated *coefficient of performance*, in W/W
IPLV = *integrated part-load value* (no units)
SCOP = sensible *coefficient of performance*, in downflow units/upflow units (first value is downflow; second value is upflow). The SCOP is a ratio that is calculated by dividing the net sensible cooling capacity, in W, by the total power input, in W (excluding re-heaters and humidifiers).
SEER = *seasonal energy efficiency ratio*, in (Btu/h)/W (no metric equivalent)

(3) No standards address the performance efficiency of electric *boilers*; however, their efficiency typically approaches 100%.

(4) Includes propane.

(5) Excludes packaged rooftop units.

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5.2.12.2. Field-Assembled Equipment and Components

1) Where components from more than one manufacturer are used as parts of a heating, ventilating or air-conditioning system, the system shall be designed in accordance with good engineering practice and based on component efficiency data provided by the component manufacturers so as to provide the overall efficiency required by Article 5.2.12.1.

5.2.12.3. Service Water Heating Equipment Used for Space Heating

1) *Service water* heating equipment used solely to provide space heating or used to provide a combination of space and *service water* heating shall comply with the applicable standard listed in Table 6.2.2.1. or, where such equipment is not covered in this Table, with the Energy Efficiency Act and its Regulations.

Section 5.3. Trade-off Path

(See A-1.1.2.1. in Appendix A.)

5.3.1. General

5.3.1.1. Application

1) Except as provided in Article 5.3.1.2., this Section applies only to *buildings*

a) whose *occupancy* is known,

b) for which sufficient information is known from the specifications for the HVAC components listed in Table 5.3.2.3. whose γ_i value is 1 in Table 5.3.2.2., and

c) whose HVAC system meets the following criteria:

   i) it is one of the types listed in Table 5.3.1.1.,

   ii) the heating system's energy type is natural gas, propane, fuel oil or electricity,

   iii) the cooling system's energy type is electricity, and

   iv) the heat pump's energy type is electricity.

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Table 5.3.1.1.
Types of HVAC Systems
Forming Part of Sentence 5.3.1.1.(1)

Type ID	HVAC System Description(1)
HVAC-1	Built-up variable-volume
HVAC-2	Constant-volume reheat
HVAC-3	Packaged single duct – single zone
HVAC-4	Built-up single duct – single zone
HVAC-5	Packaged variable-volume
HVAC-6	Packaged constant-volume with reheat
HVAC-7	Built-up ceiling bypass VAV
HVAC-8	Packaged ceiling bypass VAV
HVAC-9	Powered induction unit
HVAC-10	Built-up multi-zone system
HVAC-11	Packaged multi-zone system
HVAC-12	Constant-volume dual-duct system
HVAC-13	Variable-volume dual-duct system
HVAC-14	Two-pipe fan coil with optional make-up air unit
HVAC-15	Four-pipe fan coil with optional make-up air unit
HVAC-16	Three-pipe fan coil with optional make-up air unit
HVAC-17	Water-loop heat pump with optional make-up air unit
HVAC-18	Ground-source heat pump with optional make-up air unit
HVAC-19	Induction unit – two-pipe
HVAC-20	Induction unit – four-pipe
HVAC-21	Induction unit – three-pipe
HVAC-22	Packaged terminal AC – split
HVAC-23	Radiant (in-floor, ceiling) with optional make-up air unit
HVAC-24	Active chilled beams with optional make-up air unit
HVAC-25	*Unit heater*
HVAC-26	Unit ventilator
HVAC-27	Radiation with optional make-up air unit

Notes to Table 5.3.1.1.:
(1) Systems shall not use a gas-fired *unit heater* < 117.23 kW.

5.3.1.2. Application Limitation

1) This Section does not apply to back-up HVAC systems, which shall comply with Sentence 5.1.1.3.(2).

5.3.1.3. Compliance

1) HVAC systems with an HVAC trade-off index, $HVAC_{TOI}$, greater than or equal to 0, as calculated in accordance with Subsection 5.3.2., shall be deemed to comply with this Section.

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5.3.1.4. Definition

1) For the purposes of this Section, "total degree-days" (TDD) shall mean the sum of heating degree-days (HDD) below 18°C and cooling degree-days (CDD) above 13°C.

5.3.2. Compliance Calculation

5.3.2.1. HVAC Trade-off Index

1) The HVAC trade-off index, $HVAC_{TOI}$, for a specific HVAC system shall be calculated using the following equation:

$$\mathrm{HVAC_{TOI}} = \sum_{i=1}^{32} \left(\alpha_i \cdot \mathrm{ToV}_i + \beta_i \cdot \mathrm{ToV}_i^2\right) \cdot \gamma_i - \sum_{i=1}^{32} \left(\alpha_i \cdot \mathrm{BaV}_i + \beta_i \cdot \mathrm{BaV}_i^2\right) \cdot \gamma_i$$

where

i = counter for number of components included in proposed *building*'s HVAC system,

α_i = first order weighting factor linking the component efficiency variations of component i to the system efficiency variations, determined as per Article 5.3.2.5.,

β_i = second order weighting factor linking the component efficiency variations of component i to the system efficiency variations, determined as per Article 5.3.2.5.,

ToV_i = trade-off value of component i for the proposed *building*, determined as per Article 5.3.2.3.,

BaV_i = base value for component i for the reference *building*, determined as per Article 5.3.2.4., and

γ_i = factor to determine components to be included, determined as per Article 5.3.2.2. for the given HVAC system.

5.3.2.2. Determination of Components to Be Included, γi

1) The value of the component factor, γ_i, to be used in the equation in Sentence 5.3.2.1.(1) shall be taken from Table 5.3.2.2.

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Table 5.3.2.2.
Component Factors, γ_i, for Trade-off Calculations
Forming Part of Sentences 5.3.1.1.(1) and 5.3.2.2.(1)

Trade-off Value[1]	HVAC System ID[2]																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
	γ_i Factor[3]																										
ToV_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_5	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1
ToV_6	1	1	0	0	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ToV_7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_{10}	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_{11}	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	0	0	1
ToV_{12}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ToV_{13}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{14}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1
ToV_{15}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1
ToV_{16}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{17}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{18}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	0	0	1	1	1	0	1	1	0	0	1
ToV_{19}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1
ToV_{20}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1
ToV_{21}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1
ToV_{22}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1
ToV_{23}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{24}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{25}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{26}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{27}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{28}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{29}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{30}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{31}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
ToV_{32}	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1

Notes to Table 5.3.2.2.:

(1) See Table 5.3.2.3. for a description of these values.

(2) See Table 5.3.1.1. for a description of each system.

(3) Only components with $\gamma_i = 1$ are to be included for a given HVAC system.

5.3.2.3. Determination of Trade-off Value of Components, ToV_i

1) The trade-off value of component i, ToV_i, to be used in the equation in Sentence 5.3.2.1.(1), shall be determined in accordance with Table 5.3.2.3.

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Table 5.3.2.3.
Component Trade-off Values, ToV_i, for the Proposed Building
Forming Part of Sentences 5.3.1.1.(1) and 5.3.2.3.(1)

Trade-off Value	Description	ToV Unit	Source
ToV_1	Supply fan mechanical efficiency	%	Specifications
ToV_2	Supply motor efficiency	%	Specifications
ToV_3	Return fan mechanical efficiency	%	Specifications
ToV_4	Return fan motor efficiency	%	Specifications
ToV_5	Supply temperature control	ratio	Table 5.3.2.7.
ToV_6	Airflow control efficiency	ratio	Table 5.3.2.7.
ToV_7	Supply fan total static pressure	in. w.g.	Specifications
ToV_8	*Supply duct* insulation	R-value	Specifications
ToV_9	Return fan total static pressure	in. w.g.	Specifications
ToV_{10}	Heating coil design temperature drop	°F	Specifications
ToV_{11}	Baseboard heater design temperature drop	°F	Specifications
ToV_{12}	*Boiler*/*furnace*/heat pump heating efficiency	%	Specifications(1)
ToV_{13}	Chillers/direct expansion system/heat pump cooling efficiency	COP	Specifications
ToV_{14}	Rejection fan input power ratio	W/Btu/h	Specifications
ToV_{15}	Cooling by direct use of outdoor air (air economizer)	ratio	Table 5.3.2.7.
ToV_{16}	Outdoor airflow control	ratio	Table 5.3.2.7.
ToV_{17}	Exhaust air heat-recovery efficiency	%	Specifications
ToV_{18}	Cooling by indirect use of outdoor air (water economizer)	%	Specifications
ToV_{19}	Piping insulation – hot water	R-value	Specifications
ToV_{20}	Piping insulation – chilled water	R-value	Specifications
ToV_{21}	Piping pressure losses – hot water	ft. w.g.	Specifications
ToV_{22}	Piping pressure losses – chilled water	ft. w.g.	Specifications
ToV_{23}	Pump mechanical efficiency – hot water	%	Specifications
ToV_{24}	Pump mechanical efficiency – chilled water	%	Specifications
ToV_{25}	Pump motor efficiency – hot water	%	Specifications
ToV_{26}	Pump motor efficiency – chilled water	%	Specifications
ToV_{27}	Hot water pump control	ratio	Table 5.3.2.7.
ToV_{28}	Chilled water pump control	ratio	Table 5.3.2.7.
ToV_{29}	Hot water loop temperature control	ratio	Table 5.3.2.7.
ToV_{30}	Chilled water loop temperature control	ratio	Table 5.3.2.7.
ToV_{31}	Hot water flow control	ratio	Table 5.3.2.7.
ToV_{32}	Chilled water flow control	ratio	Table 5.3.2.7.

Notes to Table 5.3.2.3.:
(1) ToV_{12} shall not be a gas-fired *unit heater* < 117.23 kW.

5.3.2.4. Determination of Base Value of Components, BaV_i

1) The base value of component i for the reference *building*, BaV_i, to be used in the equation in Sentence 5.3.2.1.(1), shall be taken from Table 5.3.2.4. for the applicable HVAC system for the proposed *building*.

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Table 5.3.2.4.
Base Values, BaV_i
Forming Part of Sentence 5.3.2.4.(1)

BaV_i	HVAC System ID[1]																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
BaV_1	60.00%	60.00%	44.00%	54.55%	60.00%	49.09%	60.00%	49.09%	60.00%	60.00%	49.09%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	65.00%	65.00%	65.00%	43.64%	60.00%	65.00%	54.55%	54.55%	60.00%
BaV_2	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%	91.67%
BaV_3	38%	37.50%	31%	31.25%	37.50%	25%	37.50%	25%	30%	37.50%	25%	37.50%	37.50%	37.50%	37.50%	37.50%	37.50%	37.50%	37.50%	37.50%	37.50%	31.25%	37.50%	37.50%	31.25%	31.25%	37.50%
BaV_4	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
BaV_5	0.5	0.2	0.943	0.943	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.943	0.5	0.5	0.943	0.943	0.5
BaV_6	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557	0.557
BaV_7	4	4	1.3	2	4	3	4	3	6	4	3	4	4	2	2	2	2	2	6	6	6	1.3	2	6	2	2	2
BaV_8	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.2932	3.29	3.29	3.29	3.29	3.29	3.2932	3.2932	3.2932	3.2932	3.29	3.2932	3.2932	3.2932	3.29
BaV_9	1	1	0	0.6	1	0.6	1	0.6	1.5	1	0.6	1	1	0.6	0.6	0.6	0.6	0.6	1.5	1.5	1.5	0	0.6	1.5	0.6	0.6	0.6
BaV_{10}	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
BaV_{11}	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
BaV_{12}[2]	See Table 5.2.12.1. for performance efficiency of *boiler*/*furnace*/heat pump of base system.																										
BaV_{13}	See Table 5.2.12.1. for performance efficiency of chiller/direct expansion/heat pump of base system.																										
BaV_{14}	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
BaV_{15}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BaV_{16}	0	0.8	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BaV_{17}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BaV_{18}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	420.17	420.17	0	0	0	0	0	0	0	0	0
BaV_{19}	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
BaV_{20}	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
BaV_{21}	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
BaV_{22}	40	40	40	40	40	40	40	40	40	40	40	40	40	60	40	40	40	60	60	40	40	40	40	40	40	40	40
BaV_{23}	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
BaV_{24}	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
BaV_{25}	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
BaV_{26}	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
BaV_{27}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BaV_{28}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BaV_{29}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BaV_{30}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BaV_{31}	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5
BaV_{32}	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Notes to Table 5.3.2.4.:

(1) See Table 5.3.1.1. for a description of each system.

(2) BaV_{12} shall not be a gas-fired *unit heater* < 117.23 kW.

5.3.2.5. Determination of Weighting Factor Linking the Component Efficiency Variation to the System Efficiency Variation, α_i and β_i

1) The first order weighting factor linking the component efficiency variations of component i to the system efficiency variations, α_i, shall be calculated using the following equation:

$$\alpha_i = \alpha 1_i + \alpha 2_i \cdot XDD_i + \alpha 3_i \cdot XDD_i^2$$

where

$\alpha 1_i$ = constant coefficient value for weighting factor for the HVAC system of the proposed *building*, α_i, determined as per Article 5.3.2.8.,
$\alpha 2_i$ = first order coefficient value for weighting factor for the HVAC system of the proposed *building*, α_i, determined as per Article 5.3.2.8.,
$\alpha 3_i$ = second order coefficient value for weighting factor for the HVAC system of the proposed *building*, α_i, determined as per Article 5.3.2.8., and
XDD_i = climatic parameter relevant to component i for the HVAC system of the proposed *building*, determined as per Article 5.3.2.6.

2) The second order weighting factor linking the component efficiency variations of component i to the system efficiency variations, β_i, shall be calculated using the following equation:

$$\beta_i = \beta 1_i + \beta 2_i \cdot XDD_i + \beta 3_i \cdot XDD_i^2$$

where

$\beta 1_i$ = constant coefficient value for weighting factor for the HVAC system of the proposed *building*, β_i, determined as per Article 5.3.2.8.,
$\beta 2_i$ = first order coefficient value for weighting factor for the HVAC system of the proposed *building*, β_i, determined as per Article 5.3.2.8.,
$\beta 3_i$ = second order coefficient value for weighting factor for the HVAC system of the proposed *building*, β_i, determined as per Article 5.3.2.8., and
XDD_i = climatic parameter relevant to component i for the HVAC system of the proposed *building*, determined as per Article 5.3.2.6.

5.3.2.6. Determination of Climatic Parameter Relevant to the Component, XDD_i

1) The climatic parameters relevant to component i, XDD_i, to be used in the equation in Article 5.3.2.5., shall be those specified in Tables 5.3.2.8.A. to 5.3.2.8.AA.

5.3.2.7. Determination of Trade-off Value of Component, ToV_i

1) As indicated in Table 5.3.2.3., the values for ToV_5, ToV_6, ToV_{15}, ToV_{16}, and ToV_{27} to ToV_{32}, to be used in the equation in Sentence 5.3.2.1.(1), shall be taken from Table 5.3.2.7. for the applicable control type and HVAC system.

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Table 5.3.2.7.
ToV_i Based on Control Type and HVAC System
Forming Part of Sentence 5.3.2.7.(1)

ToV_i	HVAC System ID[1]																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ToV_5																											
Supply OA Reset	0.9344	0.3490	0.9180	0.9180	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9344	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300
Warmest	1.0000	0.4253	0.7303	0.7303	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Constant > 15°C	0.8623	0.3228	0.9181	0.9181	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8623	0.8600	0.8600	0.8600	0.8600	0.8600	0.8600	0.8600	0.8600	0.8600	0.8600	0.8600
Constant ≤ 15°C	0.5000	0.2000	0.9400	0.9400	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.9400	0.5000	0.5000	0.9400	0.9400	0.5000
ToV_6																											
Forward curve with vanes	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557
VSD	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604	0.0604
Airfoil with inlet vanes	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366
Riding fan curve	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207	0.0207
ToV_{15}																											
Dual DBT	0.8000	0.8000	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8000	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
Enthalpy	0.8000	0.8000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.8000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000
Dual Enthalpy	0.8005	0.8000	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.8000	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
Fixed	0.7612	0.8007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dry Bulb	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
ToV_{16}																											
Fraction of hourly	0.8435	0.8000	0.0000	0.0000	0.8500	0.8500	0.8500	0.8500	0.8500	0.8000	0.8500	0.8500	0.8500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DCV Return	0.9091	0.8511	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.9000	0.8493	0.9000	0.9000	0.9000	0.1172	0.1172	0.1172	0.1200	0.1200	0.1200	0.1200	0.1200	0.9000	0.9000	0.1172	0.9000	0.9000	0.9000
DCV Supply	0.9059	0.8510	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800	0.8800	0.8493	0.8800	0.8800	0.8800	0.1088	0.1088	0.1088	0.1100	0.1100	0.1100	0.1100	0.1100	0.8800	0.8800	0.1088	0.8800	0.8800	0.8800
DCV, frac hourly, Return	0.9299	0.8511	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.9300	0.8493	0.9300	0.9300	0.9300	0.1172	0.1172	0.1172	0.1200	0.1200	0.1200	0.1200	0.1200	0.9300	0.9300	0.1172	0.9300	0.9300	0.9300
Fixed	0.0000	0.8000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ToV_{27}																											
Demand-only	0.8555	0.7971	0.8913	0.8992	0.8478	0.7971	0.8252	0.8478	0.8478	0.7818	0.7785	0.7816	0.8011	0.9857	0.9588	0.9588	0.9600	0.9600	0.8000	1.0200	1.0200	0.8913	1.0719	1.0964	1.2183	1.2164	1.0719
Standby	0.7954	0.7849	0.7831	0.7816	0.7864	0.7834	0.7915	0.7864	0.7864	0.7818	0.7785	0.7816	0.7836	0.7715	0.7709	0.7709	0.7700	0.7700	0.6216	0.7700	0.7700	0.7831	0.7851	0.7665	0.7875	0.7875	0.7851
Snap zone	0.8066	0.7869	0.8517	0.8567	0.8021	0.7857	0.7991	0.8021	0.8021	0.8498	0.8510	0.8485	0.8043	0.9060	0.8939	0.8939	0.8900	0.8900	0.7743	0.8800	0.8800	0.8517	1.0089	0.8988	1.3411	1.3190	1.0089
Scheduled	0.7975	0.7854	0.7856	0.7844	0.7904	0.7841	0.7927	0.7904	0.7904	0.7861	0.7835	0.7859	0.7860	0.7750	0.7765	0.7765	0.7800	0.7800	0.6216	0.7800	0.7800	0.7856	0.7868	0.7710	0.7896	0.7896	0.7868
Snap outdoor	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
ToV_{28}																											
Demand-only	0.8021	0.8165	0.7453	0.7594	0.8011	0.8011	0.0037	0.8011	0.8011	0.8120	0.8011	0.8096	0.8357	0.8000	0.7686	0.7686	0.8100	0.8100	0.8000	0.8000	0.8000	0.7453	0.8505	0.7901	0.7594	0.7594	0.8505
Standby	0.7924	0.8148	0.6875	0.7236	0.7627	0.7627	0.0000	0.7627	0.7627	0.8109	0.7627	0.8084	0.8253	0.7912	0.7631	0.7631	0.8000	0.8000	0.6216	0.8000	0.8000	0.6875	0.7715	0.7893	0.7236	0.7236	0.7715
Snap zone	0.8051	0.8231	0.7102	0.7355	0.7799	0.7799	0.0085	0.7799	0.7799	0.8109	0.7799	0.8084	0.8271	0.8087	0.7651	0.7651	0.8100	0.8100	0.7588	0.8000	0.8000	0.7102	0.7736	0.7907	0.7355	0.7355	0.7736
Scheduled	0.8026	0.8203	0.7549	0.7913	0.7731	0.7731	0.0051	0.7731	0.7731	0.8158	0.7731	0.8135	0.8341	0.8000	0.7506	0.7506	0.8100	0.8100	0.6216	0.7900	0.7900	0.7549	0.7534	0.7862	0.7913	0.7913	0.7534
Snap outdoor	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000

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Table 5.3.2.7. (Continued)

ToV_i	HVAC System ID[1]																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ToV_{29}																											
Fixed	0.7914	0.7990	0.7831	0.7821	0.7945	0.7945	0.7945	0.7945	0.7945	0.7995	0.7945	0.7945	0.7913	0.7908	0.7666	0.7666	0.7700	0.7700	0.7792	0.7900	0.7900	0.7831	0.7666	0.7911	0.6200	0.6188	0.7666
Scheduled	0.7974	0.7996	0.7958	0.7954	0.7982	0.7982	0.7982	0.7982	0.7982	0.7999	0.7982	0.7982	0.7985	0.7978	0.7686	0.7686	0.7700	0.7700	0.7912	0.8000	0.8000	0.7958	0.7938	0.7973	0.7433	0.7372	0.7938
Load reset	0.8675	0.8154	0.9077	0.9177	0.8544	0.8544	0.8544	0.8544	0.8544	0.8008	0.8544	0.8544	0.8311	1.0477	1.0298	1.0298	1.0300	1.0300	0.8453	1.0500	1.0500	0.9077	1.0405	1.1301	1.4026	1.3865	1.0405
OA Reset, min 140°F	0.7996	0.7999	0.7994	0.7994	0.7998	0.7998	0.7998	0.7998	0.7998	0.8000	0.7998	0.7998	0.8001	0.7993	0.7900	0.7900	0.7900	0.7900	0.7975	0.8000	0.8000	0.7994	0.7995	0.7993	0.7924	0.7905	0.7995
OA Reset, min >140°F	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
ToV_{30}																											
Fixed	0.7774	0.7940	0.7680	0.7606	0.8035	0.8035	0.7829	0.7952	0.7693	0.7966	0.8035	0.8035	0.7757	0.8000	0.7734	0.7734	0.8000	0.8000	0.8000	0.7800	0.7800	0.7680	0.7842	0.7834	0.7606	0.7606	0.7842
Scheduled	0.7884	0.7967	0.7796	0.7740	0.8000	0.8000	0.7910	0.7979	0.7834	0.7981	0.8000	0.8000	0.7876	0.8040	0.7868	0.7868	0.8400	0.8000	0.8020	0.7900	0.7900	0.7796	0.7929	0.7911	0.7740	0.7740	0.7929
Load reset	0.8333	0.8080	0.7942	0.8014	0.8035	0.8035	0.8266	0.8558	0.8360	0.8041	0.8035	0.8035	0.8324	0.8223	0.8405	0.8405	0.8000	0.8000	0.8006	0.8000	0.8000	0.7942	0.8218	0.8006	0.8014	0.8014	0.8218
OA Reset, 44°F to 58°F	0.8170	0.8043	0.8136	0.8168	0.8035	0.8035	0.8125	0.7995	0.8223	0.8024	0.8035	0.8035	0.8182	0.8169	0.8173	0.8173	0.8400	0.8000	0.8028	0.8100	0.8100	0.8136	0.8075	0.8136	0.8168	0.8168	0.8075
OA Reset, 44°F to 54°F	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
ToV_{31}																											
VSD, valve reset	0.8032	0.8006	0.8158	0.5121	0.3500	0.3500	0.3500	0.3500	0.4995	0.7999	0.4994	0.4998	0.5021	0.4973	0.4973	0.4973	0.5000	0.5000	0.4875	0.5000	0.5000	0.8158	0.4976	0.4969	0.3646	0.6681	0.4976
Two speed, .67	0.8039	0.8009	0.8167	0.5128	0.4500	0.4500	0.4500	0.4500	0.4997	0.8000	0.4997	0.5000	0.5027	0.4987	0.4987	0.4987	0.5000	0.5000	0.4908	0.5000	0.5000	0.8167	0.4988	0.4984	0.3735	0.6752	0.4988
VSD, fixed	0.8032	0.8006	0.8158	0.5121	0.5000	0.5000	0.5000	0.5000	0.4995	0.7999	0.4994	0.4998	0.5021	0.4973	0.4973	0.4973	0.5000	0.5000	0.4875	0.5000	0.5000	0.8158	0.4976	0.4969	0.3646	0.6681	0.4976
Two speed, .5	0.8038	0.8009	0.8165	0.5127	0.4800	0.4800	0.4800	0.4800	0.4997	0.8000	0.4997	0.5000	0.5027	0.4983	0.4983	0.4983	0.5000	0.5000	0.4868	0.5000	0.5000	0.8165	0.4986	0.4980	0.3678	0.6713	0.4986
Constant	0.5000	0.8000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.8000	0.5000	0.5000	0.8000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.8000	0.5000	0.5000	0.5000	0.5000	0.5000
ToV_{32}																											
VSD, valve reset	0.8068	0.8017	0.8623	0.5604	0.9000	0.9000	0.9000	0.9000	0.9000	0.8009	0.9000	0.5008	0.5075	0.4966	0.5067	0.5067	0.5200	0.5200	0.9000	0.9000	0.9000	0.8623	0.5101	0.5036	0.5604	0.8604	0.5101
Two speed, .67, valve reset	0.8053	0.8013	0.8593	0.5577	0.8000	0.8000	0.8000	0.8000	0.8000	0.8006	0.8000	0.5006	0.5055	0.4992	0.5052	0.5052	0.5000	0.5000	0.8000	0.8000	0.8000	0.8593	0.5092	0.5018	0.5577	0.8577	0.5092
VSD, fixed	0.8022	0.8005	0.8544	0.5533	0.7000	0.7000	0.7000	0.7000	0.7000	0.8003	0.7000	0.5003	0.5025	0.4968	0.5025	0.5025	0.4900	0.4900	0.7000	0.7000	0.7000	0.8544	0.5076	0.5014	0.5533	0.8533	0.5076
Two speed, .5, fixed	0.8000	0.8000	0.8500	0.5490	0.6000	0.6000	0.6000	0.6000	0.6000	0.8000	0.6000	0.5000	0.5000	0.4985	0.5000	0.5000	0.5000	0.5000	0.6000	0.6000	0.6000	0.8500	0.5061	0.5000	0.5490	0.8490	0.5061
Constant	0.5000	0.8000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.8000	0.5000	0.5000	0.8000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.8000	0.5000	0.5000	0.5000	0.8000	0.5000

Notes to Table 5.3.2.7.:

(1) See Table 5.3.1.1. for a description of each system.

5.3.2.8. Coefficient Values: $\alpha 1_i$, $\alpha 2_i$, $\alpha 3_i$, $\beta 1_i$, $\beta 2_i$ and $\beta 3_i$

1) The coefficient values of $\alpha 1_i$, $\alpha 2_i$, $\alpha 3_i$, $\beta 1_i$, $\beta 2_i$ and $\beta 3_i$ to be used for weighting α_i and β_i in Article 5.3.2.5. shall be selected from Tables 5.3.2.8.A. to 5.3.2.8.AA. for the given HVAC type and component.

Table 5.3.2.8.A.
Coefficient Values for System Type HVAC-1 (Built-up Variable-Volume)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	9.901E-01	-1.418E-04	5.710E-09	-5.191E-01	7.037E-05	-2.626E-09
ToV_2	HDD	6.994E-01	-1.013E-04	4.055E-09	-2.670E-01	3.687E-05	-1.362E-09
ToV_3	HDD	6.087E-01	-5.513E-05	7.352E-10	-5.244E-01	4.324E-05	-2.153E-10
ToV_4	HDD	2.916E-01	-2.712E-05	3.972E-10	-1.264E-01	1.095E-05	-8.620E-11
ToV_5	HDD	-2.175E-01	1.610E-04	-1.976E-08	1.081	-3.448E-04	2.887E-08
ToV_6	TDD	1.034E-01	3.422E-05	-3.997E-09	8.110E-01	-2.076E-04	1.353E-08
ToV_7	HDD	-6.404E-02	1.180E-05	-6.096E-10	1.976E-03	-4.923E-07	3.046E-11
ToV_8	HDD	2.472E-03	-8.682E-07	4.094E-11	-6.740E-04	1.777E-07	-9.988E-12
ToV_9	HDD	-7.726E-02	9.584E-06	-3.300E-10	4.849E-03	-1.126E-06	6.597E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	1.351	4.943E-06	-7.093E-10	-3.484E-01	-1.701E-06	2.704E-09
ToV_{13}	HDD	7.436E-02	3.208E-06	-1.108E-09	-4.464E-03	-2.334E-07	7.026E-11
ToV_{14}	TDD	1.121E-01	-1.661E-04	1.652E-08	-4.322E-01	1.884E-04	-1.581E-08
ToV_{15}	CDD	9.952E+01	-4.686E-01	4.601E-04	-6.365E+01	3.051E-01	-3.031E-04
ToV_{16}	TDD	-1.162	2.174E-05	6.845E-09	1.299	-1.210E-06	-7.954E-09
ToV_{17}	TDD	2.405E-01	-1.217E-04	1.233E-08	-2.879E-01	1.346E-04	-1.207E-08
ToV_{18}	CDD	-1.193E-02	8.378E-05	-1.197E-07	1.624E-02	-2.165E-05	2.748E-08
ToV_{19}	TDD	8.839E-02	-2.099E-05	1.345E-09	-6.071E-03	1.452E-06	-9.134E-11
ToV_{20}	CDD	2.707E-05	5.515E-06	-7.092E-09	7.653E-06	-2.892E-07	3.201E-10
ToV_{21}	HDD	-3.231E-05	-1.068E-07	1.683E-10	3.001E-08	-9.039E-12	8.778E-16
ToV_{22}	CDD	4.463E-05	-1.355E-06	1.643E-09	-1.699E-08	-7.296E-10	1.243E-12
ToV_{23}	TDD	6.387E-03	5.602E-05	-8.427E-08	-2.844E-03	-3.653E-05	5.469E-08
ToV_{24}	CDD	-1.101E-02	3.037E-04	-3.664E-07	6.831E-03	-1.741E-04	2.094E-07
ToV_{25}	HDD	2.783E-02	7.041E-06	-5.352E-10	-1.049E-02	-2.671E-06	1.989E-10
ToV_{26}	CDD	-3.722E-03	1.520E-04	-1.593E-07	1.207E-03	-5.516E-05	5.264E-08
ToV_{27}	HDD	-1.315E+02	4.822E-02	-3.904E-06	7.979E+01	-2.898E-02	2.342E-06
ToV_{28}	CDD	1.053E+02	7.298E-01	-2.461E-03	-6.601E+01	-4.535E-01	1.538E-03
ToV_{29}	HDD	4.091E+01	-1.309E-02	9.272E-07	-2.317E+01	7.633E-03	-5.442E-07
ToV_{30}	CDD	-5.601	1.325E-02	1.281E-05	3.552	-4.414E-03	-1.343E-05
ToV_{31}	TDD	2.165E+03	-6.784E-01	4.722E-05	-1.347E+03	4.222E-01	-2.939E-05
ToV_{32}	CDD	-2.499	3.264E-02	-5.483E-05	1.481	-1.638E-02	2.938E-05

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Table 5.3.2.8.B.
Coefficient Values for System Type HVAC-2 (Constant-Volume Reheat)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	1.056E-01	6.472E-05	-4.633E-09	-5.498E-02	-3.464E-05	2.427E-09
ToV_2	HDD	8.163E-02	4.215E-05	-3.026E-09	-3.239E-02	-1.562E-05	1.097E-09
ToV_3	HDD	-4.940E-02	1.079E-04	-7.375E-09	4.175E-02	-9.438E-05	6.424E-09
ToV_4	HDD	-2.366E-02	5.118E-05	-3.498E-09	9.902E-03	-2.229E-05	1.516E-09
ToV_5	HDD	-7.300	2.709E-03	-1.905E-07	1.341E+01	-4.390E-03	3.102E-07
ToV_6	HDD	1.297E-02	6.363E-06	-4.656E-10	-1.669E-02	-8.252E-06	6.049E-10
ToV_7	TDD	-5.647E-03	-3.978E-06	3.110E-10	1.397E-04	1.221E-07	-1.194E-11
ToV_8	HDD	-1.242E-03	-7.991E-07	4.946E-11	4.397E-05	9.910E-08	-6.314E-12
ToV_9	TDD	8.107E-03	-1.272E-05	8.605E-10	-4.623E-04	7.435E-07	-6.313E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	1.530E-01	1.399E-04	-7.067E-09	-1.293E-02	-4.298E-05	3.359E-09
ToV_{13}	CDD	1.222E-04	8.323E-05	-8.026E-08	-1.560E-05	-5.208E-06	5.047E-09
ToV_{14}	CDD	1.106E-02	-4.160E-04	3.781E-07	-5.515E-02	3.455E-04	-5.038E-07
ToV_{15}	CDD	4.047E-02	-1.114E-04	1.153E-07	-2.852E-02	1.121E-04	-1.284E-07
ToV_{16}	HDD	2.196E-01	2.635E-04	-1.315E-08	-8.540E-02	-8.557E-05	4.056E-09
ToV_{17}	TDD	1.251E-01	-5.073E-05	4.130E-09	-1.219E-01	5.341E-05	-4.531E-09
ToV_{18}	CDD	-6.578E-03	1.874E-05	-2.457E-08	1.045E-02	-1.299E-05	1.584E-08
ToV_{19}	HDD	2.258E-03	-3.063E-07	3.070E-11	-3.251E-04	9.954E-08	-8.482E-12
ToV_{20}	CDD	-1.069E-04	2.890E-06	-3.909E-09	8.046E-06	-1.693E-07	2.212E-10
ToV_{21}	HDD	-2.956E-04	1.616E-06	-1.364E-10	7.919E-04	-1.188E-06	1.083E-10
ToV_{22}	CDD	-1.692E-05	-1.817E-07	1.999E-10	2.462E-07	-1.141E-09	1.196E-12
ToV_{23}	HDD	3.178E-03	3.566E-06	-2.302E-10	-7.954E-04	-1.505E-06	1.028E-10
ToV_{24}	CDD	-4.563E-03	7.544E-05	-8.301E-08	3.542E-03	-4.686E-05	5.218E-08
ToV_{25}	HDD	3.178E-03	3.566E-06	-2.302E-10	-7.954E-04	-1.505E-06	1.028E-10
ToV_{26}	CDD	1.332E-03	1.549E-05	-7.931E-09	-8.998E-04	-1.828E-06	-3.276E-09
ToV_{27}	HDD	1.558E+03	-5.753E-01	4.737E-05	-9.846E+02	3.638E-01	-2.996E-05
ToV_{28}	CDD	3.413E+02	-1.981	2.604E-03	-2.090E+02	1.216	-1.598E-03
ToV_{29}	HDD	-1.908E+02	7.177E-02	-5.991E-06	1.189E+02	-4.445E-02	3.708E-06
ToV_{30}	CDD	-4.347E+01	2.082E-01	-1.998E-04	2.733E+01	-1.273E-01	1.212E-04
ToV_{31}	HDD	4.882E+03	-1.521	9.956E-05	-3.048E+03	9.499E-01	-6.217E-05
ToV_{32}	CDD	-8.128E+01	2.300E-01	3.748E-06	5.081E+01	-1.408E-01	-5.348E-06

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Table 5.3.2.8.C.
Coefficient Values for System Type HVAC-3 (Packaged Single Duct – Single Zone)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	5.393	-1.342E-03	8.829E-08	-3.757	9.121E-04	-5.917E-08
ToV_2	HDD	2.530	-6.215E-04	4.057E-08	-8.585E-01	2.017E-04	-1.284E-08
ToV_3	HDD	5.390	-1.322E-03	8.694E-08	-5.396	1.299E-03	-8.468E-08
ToV_4	HDD	2.142	-5.267E-04	3.471E-08	-8.890E-01	2.146E-04	-1.401E-08
ToV_5	CDD	0	0	0	0	0	0
ToV_6	TDD	0	0	0	0	0	0
ToV_7	HDD	-9.246E-01	2.561E-04	-1.777E-08	1.100E-01	-3.387E-05	2.461E-09
ToV_8	HDD	6.180E-02	-1.679E-05	1.151E-09	-6.275E-03	1.711E-06	-1.178E-10
ToV_9	TDD	6.605E-01	-1.570E-04	9.931E-09	-1.082	2.738E-04	-1.830E-08
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	-4.789E-06	-3.059E-09	4.432E-13	1.422E-07	9.079E-11	-1.315E-14
ToV_{12}	HDD	1.954	-1.041E-04	5.689E-09	-8.361E-01	1.106E-04	-4.905E-09
ToV_{13}	CDD	-2.348E-02	9.997E-04	-1.231E-06	2.670E-03	-1.098E-04	1.361E-07
ToV_{14}	CDD	-6.346E-01	-5.991E-03	5.907E-06	4.213E+01	-4.154E-01	5.656E-04
ToV_{15}	CDD	-8.130E-02	2.415E-03	-3.900E-06	5.123E-02	-1.420E-03	2.286E-06
ToV_{16}	TDD	-1.539E-01	6.627E-05	-5.186E-09	-8.397E-02	4.508E-05	-2.136E-09
ToV_{17}	TDD	-6.493E-01	1.811E-04	-9.384E-09	6.962E-01	-2.116E-04	1.280E-08
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	2.867E-01	-7.803E-05	5.391E-09	-1.567E-02	4.106E-06	-2.758E-10
ToV_{20}	HDD	0	0	0	0	0	0
ToV_{21}	HDD	-1.003E-05	-2.244E-08	1.995E-12	-3.126E-07	1.437E-10	-1.287E-14
ToV_{22}	HDD	0	0	0	0	0	0
ToV_{23}	HDD	2.430E-02	-4.205E-06	4.692E-10	-1.560E-02	3.698E-06	-4.091E-10
ToV_{24}	HDD	0	0	0	0	0	0
ToV_{25}	HDD	1.110E-01	-1.142E-05	3.796E-10	-5.110E-02	7.041E-06	-3.243E-10
ToV_{26}	HDD	0	0	0	0	0	0
ToV_{27}	HDD	-1.055E+02	3.558E-02	-2.600E-06	6.674E+01	-2.214E-02	1.609E-06
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	4.114E+01	-1.423E-02	1.095E-06	-1.952E+01	7.151E-03	-5.615E-07
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	-1.850	-9.193E-04	9.050E-08	1.860	5.581E-04	-5.842E-08
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.D.
Coefficient Values for System Type HVAC-4 (Built-up Single Duct – Single Zone)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	3.621	-8.684E-04	5.674E-08	-2.018	4.703E-04	-3.031E-08
ToV_2	HDD	2.255	-5.362E-04	3.480E-08	-8.091E-01	1.850E-04	-1.175E-08
ToV_3	HDD	4.044	-9.642E-04	6.369E-08	-4.103	9.638E-04	-6.329E-08
ToV_4	HDD	1.636	-3.931E-04	2.602E-08	-6.951E-01	1.648E-04	-1.085E-08
ToV_5	HDD	0	0	0	0	0	0
ToV_6	TDD	0	0	0	0	0	0
ToV_7	HDD	-5.100E-01	1.383E-04	-9.527E-09	4.024E-02	-1.226E-05	8.814E-10
ToV_8	HDD	2.552E-02	-6.987E-06	4.778E-10	-2.500E-03	6.767E-07	-4.583E-11
ToV_9	HDD	-8.794E-01	2.285E-04	-1.559E-08	1.697E-01	-5.054E-05	3.605E-09
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	9.488E-06	-4.235E-09	3.682E-13	-2.816E-07	1.257E-10	-1.093E-14
ToV_{12}	HDD	1.247	2.885E-05	-2.910E-10	-5.425E-01	2.878E-05	3.746E-10
ToV_{13}	CDD	-1.746E-02	4.978E-04	-5.986E-07	1.162E-03	-3.098E-05	3.761E-08
ToV_{14}	CDD	4.533E-03	-9.111E-04	6.524E-07	2.126E-01	-1.466E-03	2.261E-06
ToV_{15}	CDD	-1.262E-02	6.199E-04	-1.107E-06	9.641E-03	-3.749E-04	6.613E-07
ToV_{16}	TDD	-2.081E-01	7.970E-05	-6.027E-09	1.001E-02	4.903E-06	1.164E-09
ToV_{17}	HDD	8.737E-03	-3.330E-06	2.563E-09	6.686E-03	-5.967E-06	-1.361E-09
ToV_{18}	CDD	-4.141E-03	2.010E-04	-3.120E-07	2.951E-03	-1.331E-04	2.071E-07
ToV_{19}	HDD	2.316E-01	-6.295E-05	4.399E-09	-1.336E-02	3.553E-06	-2.452E-10
ToV_{20}	CDD	-2.000E-03	4.048E-05	-5.655E-08	1.734E-04	-2.617E-06	3.424E-09
ToV_{21}	HDD	-1.059E-04	1.831E-08	-1.219E-12	5.712E-07	-1.902E-10	1.453E-14
ToV_{22}	CDD	3.926E-04	-1.237E-05	1.656E-08	1.255E-07	2.215E-08	-2.757E-11
ToV_{23}	HDD	3.196E-02	-5.790E-06	4.032E-10	-2.281E-02	4.988E-06	-3.632E-10
ToV_{24}	CDD	-4.602E-01	6.888E-03	-1.015E-05	3.684E-01	-5.083E-03	7.492E-06
ToV_{25}	HDD	7.374E-03	1.510E-05	-1.322E-09	2.935E-03	-7.490E-06	6.309E-10
ToV_{26}	CDD	-2.444E-02	7.238E-04	-9.663E-07	8.460E-03	-2.647E-04	3.529E-07
ToV_{27}	HDD	-6.871E+01	2.301E-02	-1.645E-06	4.311E+01	-1.418E-02	1.009E-06
ToV_{28}	CDD	-2.588	2.648E-02	-3.939E-05	1.618	-1.216E-02	1.829E-05
ToV_{29}	HDD	3.432E+01	-1.152E-02	8.760E-07	-1.720E+01	6.014E-03	-4.642E-07
ToV_{30}	CDD	9.650E-01	1.850E-02	-4.427E-05	-7.779E-01	-6.278E-03	2.037E-05
ToV_{31}	HDD	7.889E+02	-2.675E-01	1.987E-05	-7.687E+02	2.610E-01	-1.939E-05
ToV_{32}	CDD	-1.204	1.956E-02	-3.214E-05	8.722E-01	-1.096E-02	2.046E-05

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Table 5.3.2.8.E.
Coefficient Values for System Type HVAC-5 (Packaged Variable-Volume)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	1.064	-1.657E-04	7.699E-09	-5.519E-01	8.166E-05	-3.597E-09
ToV_2	HDD	7.067E-01	-1.036E-04	4.424E-09	-2.550E-01	3.324E-05	-1.187E-09
ToV_3	HDD	5.712E-01	-6.057E-05	1.585E-09	-4.974E-01	5.053E-05	-1.178E-09
ToV_4	HDD	2.756E-01	-3.038E-05	8.552E-10	-1.200E-01	1.274E-05	-3.227E-10
ToV_5	HDD	-2.352	7.462E-04	-6.323E-08	2.558	-7.491E-04	5.900E-08
ToV_6	HDD	1.433E-01	2.396E-05	-3.383E-09	8.452E-01	-2.341E-04	1.633E-08
ToV_7	HDD	-7.266E-02	1.421E-05	-7.880E-10	2.508E-03	-6.348E-07	4.032E-11
ToV_8	TDD	-2.882E-03	1.153E-06	-1.126E-10	9.167E-06	-7.538E-08	9.345E-12
ToV_9	HDD	-7.160E-02	9.407E-06	-3.599E-10	4.055E-03	-8.213E-07	4.250E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	1.322	-2.484E-05	2.856E-09	-3.311E-01	-7.786E-06	2.815E-09
ToV_{13}	CDD	-2.869E-03	4.625E-04	-4.802E-07	2.160E-04	-4.259E-05	4.487E-08
ToV_{14}	CDD	-1.629E-03	-2.096E-02	2.680E-05	-2.687	8.055E-02	-1.050E-04
ToV_{15}	CDD	4.487E-02	1.014E-03	-1.730E-06	-2.987E-02	-5.425E-04	9.406E-07
ToV_{16}	CDD	3.303E-01	-8.166E-05	-5.557E-07	-2.422E-01	-6.608E-04	1.619E-06
ToV_{17}	HDD	-7.943E-02	-3.581E-05	6.477E-09	2.499E-02	5.879E-05	-7.305E-09
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	8.405E-02	-2.198E-05	1.519E-09	-6.172E-03	1.672E-06	-1.155E-10
ToV_{20}	CDD	0	0	0	0	0	0
ToV_{21}	HDD	-3.893E-04	1.898E-07	-2.340E-11	3.247E-06	-1.690E-09	2.130E-13
ToV_{22}	CDD	0	0	0	0	0	0
ToV_{23}	HDD	3.690E-02	-7.840E-06	1.896E-10	-2.688E-02	5.840E-06	-1.274E-10
ToV_{24}	CDD	0	0	0	0	0	0
ToV_{25}	HDD	3.075E-03	1.394E-05	-1.072E-09	2.350E-03	-6.494E-06	5.026E-10
ToV_{26}	CDD	0	0	0	0	0	0
ToV_{27}	HDD	-1.198E+02	3.574E-02	-2.711E-06	7.320E+01	-2.159E-02	1.632E-06
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	8.243E+01	-2.329E-02	1.571E-06	-4.837E+01	1.386E-02	-9.382E-07
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	1.139	-2.766E-04	2.016E-08	-1.397	3.412E-04	-2.486E-08
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.F.
Coefficient Values for System Type HVAC-6 (Packaged Constant-Volume with Reheat)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	1.483E-01	6.315E-05	-4.016E-09	-1.082E-01	-3.629E-05	2.138E-09
ToV_2	HDD	8.323E-02	3.714E-05	-2.385E-09	-3.585E-02	-1.275E-05	7.567E-10
ToV_3	HDD	-8.690E-02	1.757E-04	-1.310E-08	1.276E-01	-2.842E-04	2.106E-08
ToV_4	HDD	-2.111E-02	4.507E-05	-3.375E-09	7.907E-03	-1.937E-05	1.441E-09
ToV_5	HDD	-6.007	1.794E-03	-1.433E-07	4.309	-1.209E-03	9.720E-08
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-3.253E-03	-6.307E-06	4.677E-10	-1.913E-04	3.695E-07	-3.223E-11
ToV_8	TDD	9.692E-04	-2.514E-06	1.842E-10	-8.911E-05	2.560E-07	-1.918E-11
ToV_9	TDD	1.045E-02	-1.475E-05	1.079E-09	8.945E-05	6.322E-07	-5.178E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	8.838E-02	1.608E-04	-8.074E-09	5.116E-02	-6.887E-05	4.970E-09
ToV_{13}	CDD	3.902E-02	-2.666E-05	1.100E-07	-3.679E-03	2.764E-06	-1.026E-08
ToV_{14}	CDD	-3.404E-01	-2.601E-03	2.375E-06	-3.802E-01	7.796E-03	-7.608E-06
ToV_{15}	TDD	2.597E-01	-6.100E-05	4.368E-09	-1.439E-01	3.653E-05	-2.766E-09
ToV_{16}	CDD	5.560E-02	-2.811E-04	3.050E-07	-6.755E-02	3.414E-04	-3.702E-07
ToV_{17}	HDD	1.069E-01	-5.523E-05	4.722E-09	-1.314E-01	6.690E-05	-5.717E-09
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	8.883E-05	4.331E-07	-2.476E-11	-1.442E-04	4.481E-08	-4.675E-12
ToV_{20}	HDD	0	0	0	0	0	0
ToV_{21}	HDD	1.110E-05	-9.909E-09	7.418E-13	-1.645E-07	6.839E-11	-5.570E-15
ToV_{22}	HDD	0	0	0	0	0	0
ToV_{23}	HDD	1.871E-03	7.392E-07	-3.759E-11	-1.005E-03	-3.903E-07	1.823E-11
ToV_{24}	HDD	0	0	0	0	0	0
ToV_{25}	HDD	3.057E-03	4.545E-06	-3.391E-10	-2.082E-04	-2.114E-06	1.672E-10
ToV_{26}	HDD	0	0	0	0	0	0
ToV_{27}	HDD	1.385E+03	-5.045E-01	4.093E-05	-8.758E+02	3.193E-01	-2.591E-05
ToV_{28}	HDD	0	0	0	0	0	0
ToV_{29}	HDD	-1.938E+01	5.662E-03	-4.365E-07	1.198E+01	-3.435E-03	2.637E-07
ToV_{30}	HDD	0	0	0	0	0	0
ToV_{31}	HDD	2.213E-01	-3.834E-05	2.595E-09	-2.703E-01	4.745E-05	-3.205E-09
ToV_{32}	HDD	0	0	0	0	0	0

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Table 5.3.2.8.G.
Coefficient Values for System Type HVAC-7 (Built-up Ceiling Bypass VAV)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	8.222E-01	2.970E-05	-5.090E-09	-3.731E-01	-2.864E-05	3.222E-09
ToV_2	TDD	5.342E-01	3.149E-05	-4.232E-09	-1.722E-01	-1.711E-05	1.756E-09
ToV_3	TDD	6.343E-01	3.856E-05	-5.443E-09	-5.555E-01	-2.894E-05	4.257E-09
ToV_4	HDD	3.124E-01	1.396E-05	-2.300E-09	-1.306E-01	-7.279E-06	1.052E-09
ToV_5	HDD	-2.547	9.705E-04	-8.080E-08	2.121	-7.253E-04	5.847E-08
ToV_6	TDD	1.149E-01	1.091E-07	-5.699E-10	-1.570E-01	3.999E-06	3.915E-10
ToV_7	HDD	-9.819E-02	8.394E-06	-1.297E-10	5.537E-03	-8.423E-07	3.090E-11
ToV_8	HDD	-1.766E-02	5.419E-06	-3.685E-10	1.744E-03	-5.708E-07	4.000E-11
ToV_9	TDD	-1.047E-01	-4.125E-07	5.928E-10	1.465E-02	-1.711E-06	3.232E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	3.743E-01	1.806E-04	-8.762E-09	-1.223E-01	-6.145E-05	5.028E-09
ToV_{13}	CDD	-3.661E-03	2.696E-04	-2.928E-07	1.855E-04	-1.653E-05	1.806E-08
ToV_{14}	CDD	6.104E-02	-1.381E-03	1.432E-06	3.051E-01	-2.621E-03	3.185E-06
ToV_{15}	CDD	6.455E-02	-1.863E-04	1.893E-07	-5.147E-02	2.516E-04	-3.084E-07
ToV_{16}	TDD	-1.041E-01	-1.321E-04	6.305E-09	8.402E-02	1.923E-04	-1.058E-08
ToV_{17}	TDD	2.600E-01	-1.343E-04	1.202E-08	-2.330E-01	1.346E-04	-1.239E-08
ToV_{18}	CDD	-1.227E-02	3.578E-05	-4.900E-08	1.490E-02	4.668E-07	-1.280E-11
ToV_{19}	HDD	3.567E-02	-7.431E-06	4.886E-10	-2.462E-03	5.283E-07	-3.486E-11
ToV_{20}	CDD	2.557E-04	2.142E-06	-3.296E-09	-1.958E-05	-5.894E-08	8.578E-11
ToV_{21}	HDD	-2.092E-05	-3.993E-10	-1.253E-13	5.906E-08	-1.798E-11	1.415E-15
ToV_{22}	CDD	1.202E-05	-8.257E-07	9.051E-10	1.080E-07	-1.304E-09	2.330E-12
ToV_{23}	HDD	-1.972E-03	2.784E-06	-1.626E-10	2.540E-03	-2.032E-06	1.273E-10
ToV_{24}	CDD	-9.148E-03	2.180E-04	-2.458E-07	6.389E-03	-1.291E-04	1.437E-07
ToV_{25}	HDD	2.066E-02	1.270E-07	1.773E-10	-9.436E-03	6.197E-07	-1.237E-10
ToV_{26}	CDD	-3.632E-03	1.084E-04	-1.162E-07	1.642E-03	-4.079E-05	4.186E-08
ToV_{27}	HDD	-2.881E+02	1.070E-01	-8.829E-06	1.783E+02	-6.597E-02	5.442E-06
ToV_{28}	CDD	-3.866E-01	6.283E-03	-7.335E-06	4.654E-01	-7.732E-03	9.003E-06
ToV_{29}	HDD	3.007E+01	-5.373E-03	2.208E-07	-1.745E+01	3.160E-03	-1.280E-07
ToV_{30}	CDD	-1.454E+01	9.178E-02	-1.156E-04	9.240	-5.436E-02	6.821E-05
ToV_{31}	HDD	5.852E-01	-1.274E-04	9.384E-09	-7.166E-01	1.568E-04	-1.152E-08
ToV_{32}	CDD	4.854E-03	-1.145E-04	1.399E-07	-3.860E-03	1.366E-04	-1.623E-07

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Table 5.3.2.8.H.
Coefficient Values for System Type HVAC-8 (Packaged Ceiling Bypass VAV)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	7.978E-01	4.992E-05	-7.594E-09	-4.467E-01	-5.052E-05	5.976E-09
ToV_2	HDD	4.700E-01	2.262E-05	-3.824E-09	-1.594E-01	-1.330E-05	1.682E-09
ToV_3	HDD	6.557E-01	6.146E-05	-7.406E-09	-8.491E-01	-8.100E-05	9.510E-09
ToV_4	HDD	2.031E-01	2.343E-05	-2.677E-09	-8.446E-02	-1.153E-05	1.246E-09
ToV_5	CDD	-7.431E-01	2.331E-03	-1.372E-06	4.944E-01	-6.858E-04	-3.577E-07
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-9.519E-02	6.127E-06	3.865E-11	7.321E-03	-1.288E-06	6.466E-11
ToV_8	TDD	-4.218E-03	1.375E-06	-1.189E-10	3.227E-04	-1.358E-07	1.231E-11
ToV_9	TDD	-8.558E-02	-4.754E-06	8.003E-10	1.698E-02	-2.317E-06	9.504E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	4.274E-01	1.459E-04	-6.633E-09	-9.917E-02	-5.978E-05	4.950E-09
ToV_{13}	CDD	3.961E-03	2.519E-04	-2.235E-07	-4.352E-04	-2.316E-05	2.089E-08
ToV_{14}	CDD	-2.163E-01	-1.052E-02	1.220E-05	-2.095	3.757E-02	-4.358E-05
ToV_{15}	CDD	5.483E-02	3.584E-04	-6.336E-07	-3.501E-02	-1.730E-04	3.204E-07
ToV_{16}	TDD	6.005E-01	-1.710E-04	1.394E-08	-6.842E-01	1.974E-04	-1.564E-08
ToV_{17}	TDD	1.336E-01	-8.557E-05	8.814E-09	-1.167E-01	8.284E-05	-8.130E-09
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	TDD	1.217E-02	-1.745E-06	1.151E-10	-6.141E-04	1.548E-07	-1.329E-11
ToV_{20}	CDD	0	0	0	0	0	0
ToV_{21}	HDD	-7.156E-06	-2.450E-07	3.359E-10	-1.533E-07	1.410E-09	-1.833E-12
ToV_{22}	CDD	0	0	0	0	0	0
ToV_{23}	HDD	6.338E-03	1.851E-06	-1.597E-10	-1.323E-03	-1.817E-06	1.499E-10
ToV_{24}	CDD	0	0	0	0	0	0
ToV_{25}	HDD	3.873E-02	9.323E-07	-2.054E-10	-1.135E-02	-1.519E-06	1.798E-10
ToV_{26}	CDD	0	0	0	0	0	0
ToV_{27}	HDD	-1.488E+02	5.114E-02	-4.042E-06	9.216E+01	-3.144E-02	2.478E-06
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	-6.889E+01	2.207E-02	-1.651E-06	4.353E+01	-1.373E-02	1.022E-06
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	1.133	-2.846E-04	2.046E-08	-1.386	3.495E-04	-2.513E-08
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.I.
Coefficient Values for System Type HVAC-9 (Powered Induction Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	4.878E-01	8.605E-05	-9.450E-09	-2.268E-01	-5.398E-05	5.460E-09
ToV_2	HDD	3.157E-01	8.448E-05	-8.668E-09	-9.729E-02	-4.517E-05	4.261E-09
ToV_3	HDD	2.322E-01	1.308E-04	-1.146E-08	-2.417E-01	-1.511E-04	1.313E-08
ToV_4	HDD	8.689E-02	4.960E-05	-4.335E-09	-3.601E-02	-2.282E-05	1.975E-09
ToV_5	CDD	-3.064E-01	-4.662E-03	1.180E-05	1.933E-01	5.848E-03	-1.182E-05
ToV_6	HDD	-2.953E-01	1.095E-04	-6.389E-09	8.592E-01	-3.929E-05	-1.292E-09
ToV_7	TDD	-2.936E-02	-7.923E-07	2.590E-10	1.041E-03	-1.360E-07	4.068E-12
ToV_8	TDD	2.129E-02	-1.533E-06	2.355E-12	-2.373E-03	2.522E-07	-8.702E-12
ToV_9	TDD	-1.978E-02	-5.433E-06	5.152E-10	2.190E-03	-4.865E-07	2.863E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	4.990E-01	2.277E-04	-1.264E-08	-1.348E-01	-6.953E-05	6.593E-09
ToV_{13}	CDD	-1.750E-03	3.500E-04	-3.827E-07	5.604E-05	-2.131E-05	2.346E-08
ToV_{14}	CDD	3.063E-02	-1.257E-03	1.096E-06	3.085E-01	-2.488E-03	3.154E-06
ToV_{15}	CDD	9.516E-02	2.924E-04	-5.892E-07	-6.393E-02	-8.288E-05	2.237E-07
ToV_{16}	TDD	-8.388E-01	7.779E-05	-2.999E-09	1.033	-1.105E-04	5.565E-09
ToV_{17}	HDD	1.144E-01	-5.719E-05	5.239E-09	-1.182E-01	5.818E-05	-5.016E-09
ToV_{18}	CDD	-2.240E-02	9.584E-05	-1.352E-07	3.381E-02	-3.851E-05	4.871E-08
ToV_{19}	HDD	1.368E-02	-8.411E-07	4.565E-11	-7.932E-04	4.714E-08	-2.600E-12
ToV_{20}	CDD	-1.070E-04	4.842E-06	-7.190E-09	1.271E-05	-3.051E-07	4.540E-10
ToV_{21}	HDD	-1.387E-05	1.072E-09	-9.280E-14	4.975E-09	-1.772E-12	1.492E-16
ToV_{22}	CDD	3.615E-06	-1.459E-06	1.757E-09	3.828E-07	-2.245E-09	2.668E-12
ToV_{23}	HDD	5.171E-03	-6.529E-07	5.251E-11	-3.163E-03	4.715E-07	-3.762E-11
ToV_{24}	CDD	-1.006E-02	3.686E-04	-4.597E-07	5.788E-03	-2.090E-04	2.642E-07
ToV_{25}	HDD	2.437E-02	-6.063E-06	5.751E-10	-1.177E-02	3.482E-06	-3.292E-10
ToV_{26}	CDD	-1.357E-02	2.666E-04	-3.351E-07	7.350E-03	-1.162E-04	1.484E-07
ToV_{27}	HDD	-6.079E+01	2.953E-02	-2.465E-06	3.761E+01	-1.808E-02	1.506E-06
ToV_{28}	CDD	-2.370E+01	2.715E-01	-3.718E-04	1.532E+01	-1.729E-01	2.363E-04
ToV_{29}	HDD	5.019E+01	-8.801E-03	5.117E-07	-2.997E+01	5.283E-03	-3.074E-07
ToV_{30}	CDD	-6.583	3.866E-02	-4.167E-05	4.332	-2.124E-02	2.177E-05
ToV_{31}	HDD	-1.453E+02	7.719E-02	-8.464E-06	1.469E+02	-7.735E-02	8.471E-06
ToV_{32}	CDD	-3.344E-03	-1.105E-04	1.367E-07	4.399E-03	1.567E-04	-1.893E-07

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Table 5.3.2.8.J.
Coefficient Values for System Type HVAC-10 (Built-up Multi-zone System)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	1.870E-02	5.182E-05	-3.479E-09	-9.328E-03	-2.816E-05	1.878E-09
ToV_2	HDD	1.318E-02	3.655E-05	-2.508E-09	-4.070E-03	-1.470E-05	1.018E-09
ToV_3	HDD	-6.491E-02	7.977E-05	-4.725E-09	5.448E-02	-6.943E-05	4.108E-09
ToV_4	HDD	-3.089E-02	3.776E-05	-2.239E-09	1.293E-02	-1.638E-05	9.713E-10
ToV_5	HDD	-2.159E-01	2.962E-04	-3.925E-08	1.697E-01	-1.789E-04	2.531E-08
ToV_6	HDD	3.339E-03	4.953E-06	-3.376E-10	-4.294E-03	-6.408E-06	4.370E-10
ToV_7	TDD	-5.965E-04	-2.807E-06	1.910E-10	9.063E-06	6.843E-08	-5.665E-12
ToV_8	HDD	-1.621E-03	-1.171E-06	5.395E-11	1.723E-04	1.176E-07	-5.632E-12
ToV_9	TDD	1.152E-02	-9.837E-06	5.540E-10	-1.678E-03	9.237E-07	-6.323E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	9.603E-02	1.097E-04	-4.968E-09	8.751E-04	-3.020E-05	2.188E-09
ToV_{13}	CDD	3.195E-03	2.676E-05	-1.564E-08	-2.055E-04	-1.690E-06	1.003E-09
ToV_{14}	CDD	-2.229E-03	-1.674E-04	1.094E-07	-3.062E-02	-9.381E-05	2.644E-07
ToV_{15}	CDD	5.117E+02	-3.185	4.205E-03	-3.223E+02	2.011	-2.655E-03
ToV_{16}	CDD	6.453E+01	-1.167E-01	-1.494E-04	-3.819E+01	6.865E-02	9.339E-05
ToV_{17}	TDD	2.674E-02	-1.078E-05	8.729E-10	-2.693E-02	1.174E-05	-9.903E-10
ToV_{18}	CDD	-4.530E-03	1.820E-05	-2.474E-08	7.022E-03	-1.703E-05	2.299E-08
ToV_{19}	HDD	2.922E-04	2.348E-07	-8.663E-12	-2.737E-05	-1.120E-08	2.688E-13
ToV_{20}	CDD	3.675E-05	1.232E-06	-1.501E-09	-1.312E-06	-7.084E-08	8.680E-11
ToV_{21}	HDD	1.267E-06	-1.866E-09	1.107E-13	-4.991E-09	1.807E-12	-1.391E-16
ToV_{22}	CDD	-1.758E-05	-3.812E-08	-1.095E-11	1.247E-07	-7.219E-10	1.020E-12
ToV_{23}	HDD	6.259E-04	4.808E-07	-2.600E-11	-3.545E-04	-2.623E-07	1.381E-11
ToV_{24}	CDD	-1.244E-03	4.225E-05	-4.898E-08	1.440E-03	-2.956E-05	3.664E-08
ToV_{25}	HDD	3.620E-04	2.451E-06	-1.692E-10	1.288E-04	-1.050E-06	7.637E-11
ToV_{26}	CDD	4.739E-04	9.260E-06	-1.756E-09	-9.103E-05	-3.023E-06	-6.868E-10
ToV_{27}	HDD	-1.317E+02	4.993E-02	-4.193E-06	8.120E+01	-3.054E-02	2.565E-06
ToV_{28}	CDD	3.249E+02	-2.072	2.792E-03	-1.991E+02	1.274	-1.716E-03
ToV_{29}	HDD	4.628E+02	-8.723E-02	-4.083E-07	-2.892E+02	5.471E-02	2.399E-07
ToV_{30}	CDD	-1.235E+02	6.502E-01	-7.212E-04	7.764E+01	-4.055E-01	4.499E-04
ToV_{31}	HDD	-3.214E+03	1.232	-1.053E-04	2.009E+03	-7.698E-01	6.585E-05
ToV_{32}	CDD	1.718E+02	-2.283	4.335E-03	-1.071E+02	1.427	-2.709E-03

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Table 5.3.2.8.K.
Coefficient Values for System Type HVAC-11 (Packaged Multi-zone System)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, TOV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	-8.081E-02	1.145E-04	-7.763E-09	5.649E-02	-7.703E-05	5.235E-09
ToV_2	HDD	-2.260E-02	5.837E-05	-3.930E-09	3.936E-03	-2.140E-05	1.428E-09
ToV_3	HDD	-6.772E-02	1.062E-04	-6.975E-09	8.699E-02	-1.403E-04	9.218E-09
ToV_4	HDD	-1.372E-02	3.116E-05	-2.015E-09	3.906E-03	-1.303E-05	8.341E-10
ToV_5	HDD	-2.050	9.159E-04	-7.327E-08	1.445	-6.064E-04	4.908E-08
ToV_6	HDD	-9.075E-03	1.035E-05	-7.250E-10	1.137E-02	-1.324E-05	9.254E-10
ToV_7	HDD	3.741E-03	-6.231E-06	4.283E-10	-4.174E-05	1.408E-07	-1.054E-11
ToV_8	HDD	-9.923E-03	3.041E-06	-2.285E-10	1.124E-03	-3.599E-07	2.582E-11
ToV_9	HDD	6.722E-03	-1.054E-05	6.836E-10	-4.034E-04	4.882E-07	-2.968E-11
ToV_{10}	HDD	-5.513E-05	6.862E-09	-8.386E-13	7.571E-07	-7.997E-11	1.052E-14
ToV_{11}	HDD	-1.253E-04	9.428E-09	-1.516E-12	1.860E-06	-1.042E-10	2.044E-14
ToV_{12}	HDD	6.545E-02	1.255E-04	-5.746E-09	4.573E-02	-4.827E-05	3.325E-09
ToV_{13}	CDD	2.818E-02	-4.650E-05	1.111E-07	-2.650E-03	4.457E-06	-1.034E-08
ToV_{14}	CDD	-2.215E-01	-1.402E-03	1.061E-06	-1.837E-01	4.989E-03	-4.405E-06
ToV_{15}	CDD	6.390E-02	2.737E-05	-9.961E-08	-3.673E-02	-1.394E-05	5.481E-08
ToV_{16}	TDD	1.096E-01	-3.687E-05	2.565E-09	-1.282E-01	4.615E-05	-3.359E-09
ToV_{17}	TDD	9.140E-02	-3.609E-05	2.856E-09	-9.525E-02	4.049E-05	-3.338E-09
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	2.292E-05	3.717E-07	-2.021E-11	-1.128E-05	-1.907E-08	9.329E-13
ToV_{20}	CDD	0	0	0	0	0	0
ToV_{21}	HDD	-8.814E-06	-1.915E-09	5.364E-14	-5.732E-10	4.717E-13	-3.732E-17
ToV_{22}	CDD	0	0	0	0	0	0
ToV_{23}	HDD	2.486E-03	6.674E-07	-2.287E-11	-1.318E-03	-3.960E-07	1.478E-11
ToV_{24}	CDD	0	0	0	0	0	0
ToV_{25}	HDD	8.224E-03	2.288E-06	-7.793E-11	-2.870E-03	-9.395E-07	3.513E-11
ToV_{26}	CDD	0	0	0	0	0	0
ToV_{27}	HDD	-1.256E+02	4.782E-02	-4.032E-06	7.741E+01	-2.923E-02	2.465E-06
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	-7.948E-01	1.424E-03	-1.204E-07	4.811E-01	-8.578E-04	7.254E-08
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	-2.655E+02	5.794E-02	-1.082E-06	2.665E+02	-5.796E-02	1.086E-06
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.L.
Coefficient Values for System Type HVAC-12 (Constant-Volume Dual-Duct System)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	2.809E-02	4.947E-05	-3.240E-09	-1.353E-02	-2.722E-05	1.771E-09
ToV_2	HDD	1.976E-02	3.494E-05	-2.365E-09	-6.625E-03	-1.408E-05	9.670E-10
ToV_3	HDD	-5.901E-02	7.798E-05	-4.536E-09	4.938E-02	-6.781E-05	3.933E-09
ToV_4	HDD	-2.538E-02	3.588E-05	-2.039E-09	9.987E-03	-1.536E-05	8.635E-10
ToV_5	HDD	-1.737	7.545E-04	-6.075E-08	1.225	-5.003E-04	4.080E-08
ToV_6	HDD	3.985E-03	4.840E-06	-3.239E-10	-5.190E-03	-6.227E-06	4.146E-10
ToV_7	TDD	-2.620E-03	-2.145E-06	1.408E-10	1.699E-04	7.837E-09	-1.105E-12
ToV_8	HDD	-2.750E-03	-6.356E-07	9.823E-12	3.614E-04	2.171E-08	1.734E-12
ToV_9	TDD	1.097E-02	-9.728E-06	5.477E-10	-1.819E-03	9.951E-07	-7.320E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	1.045E-01	1.076E-04	-4.763E-09	1.017E-03	-3.055E-05	2.212E-09
ToV_{13}	CDD	3.592E-03	2.438E-05	-1.195E-08	-2.345E-04	-1.512E-06	7.277E-10
ToV_{14}	CDD	6.876E-05	-1.946E-04	1.508E-07	-1.134E-01	6.869E-04	-1.018E-06
ToV_{15}	TDD	1.113E-01	-2.570E-05	1.968E-09	-6.012E-02	1.442E-05	-1.150E-09
ToV_{16}	HDD	9.318E-02	-1.681E-04	9.694E-09	-1.135E-01	2.049E-04	-1.181E-08
ToV_{17}	HDD	5.238E-02	-2.047E-05	1.761E-09	-5.879E-02	2.303E-05	-1.988E-09
ToV_{18}	CDD	-4.517E-03	1.786E-05	-2.349E-08	7.266E-03	-1.787E-05	2.295E-08
ToV_{19}	TDD	3.147E-04	1.872E-07	-3.771E-12	-3.055E-05	-8.975E-09	4.496E-14
ToV_{20}	CDD	2.795E-04	-3.483E-07	7.617E-10	-2.697E-05	9.402E-08	-1.490E-10
ToV_{21}	HDD	-8.547E-07	-2.035E-09	1.246E-13	-1.430E-09	5.587E-13	-4.333E-17
ToV_{22}	CDD	-1.092E-05	-7.944E-08	5.173E-11	3.597E-08	-1.692E-10	1.540E-13
ToV_{23}	HDD	2.576E-04	6.269E-07	-3.803E-11	-1.164E-04	-3.580E-07	2.177E-11
ToV_{24}	CDD	1.052E-03	1.995E-05	-9.561E-09	-5.530E-04	-1.066E-05	3.427E-09
ToV_{25}	HDD	4.445E-03	7.875E-07	-1.631E-11	-2.372E-03	-3.689E-08	-1.591E-11
ToV_{26}	CDD	1.807E-03	8.597E-06	-6.999E-09	-8.637E-04	-2.452E-06	2.072E-09
ToV_{27}	HDD	-1.354E+02	5.131E-02	-4.308E-06	8.357E+01	-3.143E-02	2.638E-06
ToV_{28}	CDD	4.180E+02	-2.603	3.439E-03	-2.569E+02	1.604	-2.119E-03
ToV_{29}	HDD	9.714E-01	4.820E-04	-3.176E-08	-5.882E-01	-2.884E-04	1.898E-08
ToV_{30}	CDD	7.948E-01	-5.590E-04	5.846E-07	-1.013E-01	6.233E-05	-5.891E-08
ToV_{31}	HDD	2.372E+02	8.285E-02	-2.238E-05	-2.368E+02	-8.268E-02	2.237E-05
ToV_{32}	CDD	-3.193E+02	1.818	-2.205E-03	3.194E+02	-1.814	2.201E-03

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Table 5.3.2.8.M.
Coefficient Values for System Type HVAC-13 (Variable-Volume Dual-Duct System)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	1.150	-1.349E-04	5.613E-09	-6.091E-01	7.052E-05	-2.971E-09
ToV_2	HDD	7.295E-01	-6.905E-05	2.049E-09	-2.563E-01	1.806E-05	-1.901E-10
ToV_3	HDD	7.210E-01	2.285E-05	-5.507E-09	-6.124E-01	-2.668E-05	5.266E-09
ToV_4	HDD	3.238E-01	1.837E-05	-3.238E-09	-1.340E-01	-1.082E-05	1.618E-09
ToV_5	HDD	6.457	-1.021E-03	3.553E-08	-3.729	5.412E-04	-1.414E-08
ToV_6	HDD	9.410E-01	-1.270E-04	6.012E-09	-5.640E-01	7.085E-05	-3.167E-09
ToV_7	HDD	-7.759E-02	1.115E-05	-5.072E-10	2.628E-03	-4.826E-07	2.365E-11
ToV_8	TDD	-1.420E-01	3.157E-05	-2.106E-09	1.369E-02	-3.307E-06	2.317E-10
ToV_9	HDD	-9.937E-02	7.158E-07	4.788E-10	8.736E-03	-9.093E-07	1.869E-11
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	1.370	-9.102E-06	2.372E-09	-3.275E-01	-2.601E-05	4.136E-09
ToV_{13}	CDD	1.696E-03	2.908E-04	-2.540E-07	-1.657E-04	-1.771E-05	1.563E-08
ToV_{14}	CDD	-8.460E-03	-1.128E-03	6.762E-07	-3.587E-01	4.060E-03	-6.259E-06
ToV_{15}	CDD	-2.359E-01	2.510E-06	-5.074E-07	1.358E-01	-1.206E-05	3.096E-07
ToV_{16}	HDD	-1.524	2.954E-04	-2.237E-08	1.820	-3.447E-04	2.654E-08
ToV_{17}	TDD	4.973E-01	-1.581E-04	1.295E-08	-4.525E-01	1.485E-04	-1.244E-08
ToV_{18}	CDD	-1.330E-02	9.797E-05	-1.492E-07	2.668E-02	-1.073E-04	1.667E-07
ToV_{19}	HDD	4.429E-02	-7.023E-06	3.575E-10	-2.539E-03	3.757E-07	-1.791E-11
ToV_{20}	CDD	2.306E-03	-1.877E-05	3.012E-08	-1.342E-04	1.227E-06	-2.012E-09
ToV_{21}	HDD	-6.732E-06	-6.157E-09	2.842E-13	-2.760E-07	6.822E-11	-4.115E-15
ToV_{22}	CDD	4.098E-05	-1.385E-06	1.331E-09	-1.849E-07	1.014E-10	1.444E-12
ToV_{23}	HDD	3.949E-02	-1.009E-05	8.050E-10	-2.918E-02	8.085E-06	-6.398E-10
ToV_{24}	CDD	1.303E-02	1.150E-04	-5.115E-08	-1.121E-02	-2.567E-05	-2.806E-08
ToV_{25}	HDD	8.580E-02	-1.641E-05	1.291E-09	-3.808E-02	8.084E-06	-6.307E-10
ToV_{26}	CDD	-1.880E-03	1.394E-04	-1.139E-07	2.914E-04	-4.640E-05	2.981E-08
ToV_{27}	HDD	5.603E+01	5.081E-02	-1.066E-05	-3.583E+01	-3.154E-02	6.675E-06
ToV_{28}	CDD	1.945E+02	-1.393	2.039E-03	-1.179E+02	8.490E-01	-1.244E-03
ToV_{29}	HDD	1.803E+01	-8.304E-03	8.669E-07	-9.045	4.715E-03	-5.133E-07
ToV_{30}	CDD	-8.741	3.161E-02	-1.009E-05	5.679	-1.736E-02	3.308E-06
ToV_{31}	HDD	-5.924E+01	9.370E-02	-1.422E-05	6.069E+01	-9.349E-02	1.417E-05
ToV_{32}	CDD	-2.043E+01	6.136E-02	-2.551E-06	2.020E+01	-5.591E-02	-2.242E-06

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Table 5.3.2.8.N.
Coefficient Values for System Type HVAC-14 (Two-Pipe Fan Coil with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	6.073	-1.501E-03	9.844E-08	-2.904	6.869E-04	-4.398E-08
ToV_2	HDD	4.094	-9.937E-04	6.450E-08	-1.374	3.126E-04	-1.954E-08
ToV_3	HDD	9.735E-01	-2.641E-04	1.832E-08	-8.611E-01	2.325E-04	-1.598E-08
ToV_4	HDD	4.915E-01	-1.382E-04	9.683E-09	-2.164E-01	6.042E-05	-4.153E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	HDD	-1.235	3.546E-04	-2.507E-08	1.266E-01	-3.991E-05	2.941E-09
ToV_8	CDD	7.521E-03	7.897E-06	-4.349E-08	1.340E-04	-5.264E-06	9.738E-09
ToV_9	TDD	-1.286E-01	2.920E-05	-1.785E-09	-4.728E-02	1.754E-05	-1.441E-09
ToV_{10}	HDD	2.737E-03	-3.171E-07	1.047E-11	-4.746E-05	6.008E-09	-2.252E-13
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	1.668	6.940E-05	-7.238E-09	-8.055E-01	6.883E-05	-1.107E-09
ToV_{13}	CDD	-1.620E-02	7.191E-04	-9.036E-07	1.032E-03	-4.463E-05	5.637E-08
ToV_{14}	CDD	-2.573E-02	-7.202E-04	6.714E-10	2.072	-1.609E-02	2.370E-05
ToV_{15}	CDD	-4.588E-03	5.339E-04	-8.672E-07	5.023E-03	-3.266E-04	5.278E-07
ToV_{16}	TDD	-1.217E+01	4.346E-03	-3.183E-07	2.573E+01	-8.449E-03	7.303E-07
ToV_{17}	TDD	-2.307E-01	5.626E-05	-4.963E-09	-1.259E-01	1.415E-04	-1.087E-08
ToV_{18}	CDD	-1.187E-03	5.354E-05	-7.073E-08	7.859E-04	-3.544E-05	4.681E-08
ToV_{19}	HDD	0	0	0	0	0	0
ToV_{20}	TDD	8.153E-02	-2.155E-05	1.463E-09	-4.378E-03	1.219E-06	-8.655E-11
ToV_{21}	HDD	-3.336E-04	7.557E-08	-5.092E-12	1.485E-07	-7.081E-11	6.978E-15
ToV_{22}	TDD	5.491E-05	-6.557E-08	9.855E-12	1.667E-06	-2.311E-10	-1.694E-14
ToV_{23}	HDD	9.250E-02	-1.888E-05	1.144E-09	-5.067E-02	1.018E-05	-6.021E-10
ToV_{24}	TDD	1.911E-01	-4.131E-05	2.091E-09	-1.769E-01	4.331E-05	-2.546E-09
ToV_{25}	HDD	2.990E-01	-7.189E-05	4.963E-09	-1.221E-01	3.014E-05	-2.106E-09
ToV_{26}	TDD	3.165E-01	-7.263E-05	4.790E-09	-1.221E-01	3.014E-05	-2.106E-09
ToV_{27}	HDD	0	0	0	0	0	0
ToV_{28}	HDD	-5.876E+02	2.078E-01	-1.707E-05	3.729E+02	-1.315E-01	1.079E-05
ToV_{29}	HDD	0	0	0	0	0	0
ToV_{30}	HDD	3.152E+02	-1.115E-01	8.772E-06	-1.919E+02	6.822E-02	-5.375E-06
ToV_{31}	HDD	0	0	0	0	0	0
ToV_{32}	HDD	-2.857E+03	1.053	-8.650E-05	2.876E+03	-1.060	8.703E-05

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Table 5.3.2.8.O.
Coefficient Values for System Type HVAC-15 (Four-Pipe Fan Coil with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	2.074	-4.534E-04	2.768E-08	-1.173	2.554E-04	-1.554E-08
ToV_2	HDD	1.062	-1.269E-04	1.933E-09	-3.312E-01	2.471E-06	3.643E-09
ToV_3	HDD	3.527E-01	-9.250E-05	6.381E-09	-3.250E-01	8.189E-05	-5.438E-09
ToV_4	HDD	1.823E-01	-4.657E-05	3.095E-09	-8.234E-02	1.905E-05	-1.142E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-1.579E-01	3.406E-05	-2.080E-09	-3.380E-03	4.886E-07	1.164E-12
ToV_8	CDD	1.759E-02	-1.002E-04	1.238E-07	-1.328E-03	7.676E-06	-1.080E-08
ToV_9	TDD	-3.662E-02	8.171E-06	-5.454E-10	-2.113E-02	8.120E-06	-6.549E-10
ToV_{10}	HDD	9.073E-04	-9.233E-08	5.477E-12	-1.202E-05	1.001E-09	-5.598E-14
ToV_{11}	HDD	5.464E-04	-7.905E-08	4.948E-12	-7.667E-06	1.003E-09	-5.960E-14
ToV_{12}	HDD	1.126	6.831E-05	-5.219E-09	-4.343E-01	2.082E-05	6.650E-10
ToV_{13}	CDD	-4.235E-03	3.061E-04	-3.480E-07	2.635E-04	-1.912E-05	2.187E-08
ToV_{14}	CDD	1.901E-02	-1.099E-03	1.079E-06	-6.409E-01	2.574E-03	-2.956E-06
ToV_{15}	CDD	-7.610E-03	2.752E-04	-4.789E-07	5.236E-03	-1.645E-04	2.842E-07
ToV_{16}	TDD	-8.058	3.001E-03	-2.190E-07	3.023E+01	-1.167E-02	9.682E-07
ToV_{17}	HDD	-5.228E-02	1.668E-05	-1.969E-09	-9.866E-02	7.655E-05	-5.376E-09
ToV_{18}	CDD	1.356E-02	4.980E-04	-7.950E-07	-1.164E-02	-2.318E-04	3.821E-07
ToV_{19}	HDD	1.449E-02	9.114E-07	-1.738E-10	2.242E-03	-5.849E-07	3.882E-11
ToV_{20}	CDD	2.311E-03	-1.543E-05	2.387E-08	-1.850E-04	1.391E-06	-2.154E-09
ToV_{21}	HDD	-2.727E-04	6.593E-08	-4.648E-12	1.026E-06	-3.141E-10	2.263E-14
ToV_{22}	CDD	3.691E-05	-1.502E-06	2.031E-09	-9.582E-08	3.256E-10	-3.339E-13
ToV_{23}	HDD	5.759E-02	-1.503E-05	1.203E-09	-3.357E-02	9.362E-06	-7.734E-10
ToV_{24}	CDD	-6.448E-03	3.547E-04	-5.053E-07	3.848E-03	-2.110E-04	3.053E-07
ToV_{25}	HDD	1.419E-01	-1.923E-05	1.115E-09	-4.868E-02	5.684E-06	-3.047E-10
ToV_{26}	CDD	1.335E-02	3.334E-05	-3.139E-08	-8.041E-03	9.821E-06	-2.012E-08
ToV_{27}	HDD	-6.304E+01	2.142E-02	-1.560E-06	3.931E+01	-1.311E-02	9.505E-07
ToV_{28}	CDD	5.747	-6.462E-02	1.196E-04	-3.442	4.434E-02	-8.073E-05
ToV_{29}	HDD	-3.873E+01	1.350E-02	-1.004E-06	2.438E+01	-8.230E-03	6.070E-07
ToV_{30}	CDD	1.976	-1.306E-02	2.907E-05	-1.196	1.270E-02	-2.498E-05
ToV_{31}	HDD	2.283E+03	-2.359	1.916E-04	-2.291E+03	2.369	-1.925E-04
ToV_{32}	CDD	6.765	-1.130E-02	-1.092E-05	-6.879	1.875E-02	7.273E-07

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Table 5.3.2.8.P.
Coefficient Values for System Type HVAC-16 (Three-Pipe Fan Coil with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	2.074	-4.534E-04	2.768E-08	-1.173	2.554E-04	-1.554E-08
ToV_2	HDD	1.062	-1.269E-04	1.933E-09	-3.312E-01	2.471E-06	3.643E-09
ToV_3	HDD	3.527E-01	-9.250E-05	6.381E-09	-3.250E-01	8.189E-05	-5.438E-09
ToV_4	HDD	1.823E-01	-4.657E-05	3.095E-09	-8.234E-02	1.905E-05	-1.142E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-1.579E-01	3.406E-05	-2.080E-09	-3.380E-03	4.886E-07	1.164E-12
ToV_8	CDD	1.759E-02	-1.002E-04	1.238E-07	-1.328E-03	7.676E-06	-1.080E-08
ToV_9	TDD	-3.662E-02	8.171E-06	-5.454E-10	-2.113E-02	8.120E-06	-6.549E-10
ToV_{10}	HDD	9.073E-04	-9.233E-08	5.477E-12	-1.202E-05	1.001E-09	-5.598E-14
ToV_{11}	HDD	5.464E-04	-7.905E-08	4.948E-12	-7.667E-06	1.003E-09	-5.960E-14
ToV_{12}	HDD	1.126	6.831E-05	-5.219E-09	-4.343E-01	2.082E-05	6.650E-10
ToV_{13}	CDD	-4.235E-03	3.061E-04	-3.480E-07	2.635E-04	-1.912E-05	2.187E-08
ToV_{14}	CDD	1.901E-02	-1.099E-03	1.079E-06	-6.409E-01	2.574E-03	-2.956E-06
ToV_{15}	CDD	-7.610E-03	2.752E-04	-4.789E-07	5.236E-03	-1.645E-04	2.842E-07
ToV_{16}	TDD	-8.058	3.001E-03	-2.190E-07	3.023E+01	-1.167E-02	9.682E-07
ToV_{17}	HDD	-5.228E-02	1.668E-05	-1.969E-09	-9.866E-02	7.655E-05	-5.376E-09
ToV_{18}	CDD	1.356E-02	4.980E-04	-7.950E-07	-1.164E-02	-2.318E-04	3.821E-07
ToV_{19}	HDD	1.449E-02	9.114E-07	-1.738E-10	2.242E-03	-5.849E-07	3.882E-11
ToV_{20}	CDD	2.311E-03	-1.543E-05	2.387E-08	-1.850E-04	1.391E-06	-2.154E-09
ToV_{21}	HDD	-2.727E-04	6.593E-08	-4.648E-12	1.026E-06	-3.141E-10	2.263E-14
ToV_{22}	CDD	3.691E-05	-1.502E-06	2.031E-09	-9.582E-08	3.256E-10	-3.339E-13
ToV_{23}	HDD	5.759E-02	-1.503E-05	1.203E-09	-3.357E-02	9.362E-06	-7.734E-10
ToV_{24}	CDD	-6.448E-03	3.547E-04	-5.053E-07	3.848E-03	-2.110E-04	3.053E-07
ToV_{25}	HDD	1.419E-01	-1.923E-05	1.115E-09	-4.868E-02	5.684E-06	-3.047E-10
ToV_{26}	CDD	1.335E-02	3.334E-05	-3.139E-08	-8.041E-03	9.821E-06	-2.012E-08
ToV_{27}	HDD	-6.304E+01	2.142E-02	-1.560E-06	3.931E+01	-1.311E-02	9.505E-07
ToV_{28}	CDD	5.747	-6.462E-02	1.196E-04	-3.442	4.434E-02	-8.073E-05
ToV_{29}	HDD	-3.873E+01	1.350E-02	-1.004E-06	2.438E+01	-8.230E-03	6.070E-07
ToV_{30}	CDD	1.976	-1.306E-02	2.907E-05	-1.196	1.270E-02	-2.498E-05
ToV_{31}	HDD	2.283E+03	-2.359	1.916E-04	-2.291E+03	2.369	-1.925E-04
ToV_{32}	CDD	6.765	-1.130E-02	-1.092E-05	-6.879	1.875E-02	7.273E-07

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Table 5.3.2.8.Q.
Coefficient Values for System Type HVAC-17 (Water-Loop Heat Pump with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	4.582	-9.278E-04	5.569E-08	-2.095	3.860E-04	-2.204E-08
ToV_2	HDD	2.996	-5.866E-04	3.440E-08	-9.112E-01	1.503E-04	-7.830E-09
ToV_3	HDD	5.673E-01	-1.337E-04	9.006E-09	-4.776E-01	1.108E-04	-7.390E-09
ToV_4	HDD	2.438E-01	-5.440E-05	3.439E-09	-9.278E-02	1.866E-05	-1.037E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	HDD	-9.799E-01	2.456E-04	-1.599E-08	9.777E-02	-2.710E-05	1.808E-09
ToV_8	CDD	-4.412E-02	2.223E-04	-2.534E-07	6.222E-03	-3.143E-05	3.584E-08
ToV_9	TDD	-9.851E-02	1.939E-05	-1.069E-09	-1.371E-02	6.507E-06	-6.446E-10
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	-1.916	9.107E-04	-5.554E-08	7.004E-01	-3.476E-04	2.368E-08
ToV_{13}	CDD	7.516E-03	2.307E-03	-3.108E-06	-2.808E-03	-1.898E-04	2.550E-07
ToV_{14}	CDD	3.386E-02	-2.184E-03	2.331E-06	-2.496E-01	-2.724E-04	1.942E-06
ToV_{15}	CDD	5.029E-04	-8.618E-06	1.620E-08	-7.102E-04	1.204E-05	-2.301E-08
ToV_{16}	TDD	-9.268	4.044E-03	-3.046E-07	1.793E+01	-1.087E-02	1.022E-06
ToV_{17}	CDD	-1.456E-01	3.583E-05	-4.222E-09	-2.057E-01	1.575E-04	-1.060E-08
ToV_{18}	CDD	2.921E-02	-1.029E-05	1.080E-09	-1.209E-05	-8.127E-07	2.725E-11
ToV_{19}	HDD	0	0	0	0	0	0
ToV_{20}	TDD	4.629E-03	-8.833E-07	4.960E-11	-2.498E-04	5.181E-08	-3.186E-12
ToV_{21}	TDD	0	0	0	0	0	0
ToV_{22}	TDD	-1.984E-02	4.455E-06	-2.684E-10	1.678E-04	-4.036E-08	2.589E-12
ToV_{23}	HDD	0	0	0	0	0	0
ToV_{24}	HDD	1.326	-2.811E-04	1.674E-08	-6.351E-01	1.244E-04	-6.990E-09
ToV_{25}	HDD	0	0	0	0	0	0
ToV_{26}	HDD	8.224E-01	-1.137E-04	5.677E-09	-2.721E-01	3.303E-05	-1.546E-09
ToV_{27}	HDD	0	0	0	0	0	0
ToV_{28}	HDD	4.858E-01	-1.167E-04	7.432E-09	2.486	-5.883E-04	3.706E-08
ToV_{29}	HDD	0	0	0	0	0	0
ToV_{30}	HDD	-2.556E+02	7.417E-02	-4.229E-06	1.584E+02	-4.584E-02	2.620E-06
ToV_{31}	HDD	0	0	0	0	0	0
ToV_{32}	HDD	-2.554E+02	8.450E-02	-6.029E-06	2.576E+02	-8.483E-02	6.045E-06

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Table 5.3.2.8.R.
Coefficient Values for System Type HVAC-18 (Ground-Source Heat Pump with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	1.172	-2.596E-04	1.781E-08	-6.738E-01	1.520E-04	-1.049E-08
ToV_2	HDD	9.950E-01	-2.418E-04	1.714E-08	-4.575E-01	1.169E-04	-8.450E-09
ToV_3	HDD	9.282E-01	-1.926E-04	1.241E-08	-8.421E-01	1.747E-04	-1.115E-08
ToV_4	HDD	3.636E-01	-6.409E-05	3.690E-09	-1.610E-01	2.736E-05	-1.502E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	HDD	-1.016E-01	2.348E-05	-1.782E-09	3.032E-03	-1.124E-06	1.232E-10
ToV_8	CDD	-2.158E-02	1.246E-04	-6.988E-08	2.776E-03	-1.622E-05	8.277E-09
ToV_9	TDD	-2.068E-01	4.830E-05	-3.427E-09	4.883E-02	-1.734E-05	1.496E-09
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	2.445E-01	7.338E-05	-2.673E-09	-2.741E-02	-3.683E-06	2.596E-10
ToV_{13}	CDD	2.315E-02	1.169E-03	-1.549E-06	-1.996E-03	-9.458E-05	1.245E-07
ToV_{14}	CDD	0	0	0	0	0	0
ToV_{15}	CDD	0	0	0	0	0	0
ToV_{16}	TDD	-8.332	5.611E-03	-3.203E-07	2.279E+01	-2.220E-02	1.401E-06
ToV_{17}	HDD	-6.611E-02	-4.488E-06	-2.718E-09	8.121E-02	1.035E-04	-4.718E-09
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	0	0	0	0	0	0
ToV_{20}	TDD	7.034E-03	-1.314E-06	1.019E-10	-2.123E-04	9.483E-09	-8.756E-13
ToV_{21}	TDD	0	0	0	0	0	0
ToV_{22}	HDD	-3.769E-02	6.271E-06	-4.263E-10	1.412E-04	-2.642E-08	1.742E-12
ToV_{23}	HDD	0	0	0	0	0	0
ToV_{24}	HDD	4.202	-5.307E-04	3.898E-08	-1.807	1.936E-04	-1.499E-08
ToV_{25}	HDD	0	0	0	0	0	0
ToV_{26}	HDD	3.079	-4.361E-04	3.215E-08	-9.669E-01	1.335E-04	-1.020E-08
ToV_{27}	HDD	0	0	0	0	0	0
ToV_{28}	HDD	-1.525	3.870E-04	-2.668E-08	-8.230	2.107E-03	-1.461E-07
ToV_{29}	HDD	0	0	0	0	0	0
ToV_{30}	HDD	3.243E+03	-1.546	1.590E-04	-2.023E+03	9.648E-01	-9.924E-05
ToV_{31}	HDD	0	0	0	0	0	0
ToV_{32}	HDD	-7.632E+02	1.856E-01	-1.235E-05	7.784E+02	-1.885E-01	1.255E-05

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Table 5.3.2.8.S.
Coefficient Values for System Type HVAC-19 (Induction Unit – Two-Pipe)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	2.235	-3.719E-04	1.766E-08	-1.072	1.566E-04	-6.312E-09
ToV_2	HDD	1.688	-2.845E-04	1.388E-08	-6.175E-01	9.089E-05	-3.836E-09
ToV_3	TDD	1.770	-2.034E-04	6.895E-09	-1.590	2.148E-04	-9.799E-09
ToV_4	TDD	8.778E-01	-1.090E-04	4.152E-09	-4.056E-01	6.107E-05	-3.095E-09
ToV_5	HDD	1.587E+01	-4.604E-03	3.069E-07	-1.038E+01	3.019E-03	-2.009E-07
ToV_6	HDD	0	0	0	0	0	0
ToV_7	HDD	-1.478E-01	3.435E-05	-2.095E-09	4.672E-03	-1.420E-06	1.015E-10
ToV_8	CDD	-1.189E-02	2.084E-04	-2.958E-07	1.229E-03	-2.179E-05	3.085E-08
ToV_9	TDD	-1.677E-01	2.405E-05	-1.016E-09	1.157E-02	-2.783E-06	1.702E-10
ToV_{10}	HDD	1.709E-03	-1.997E-07	8.529E-12	-2.557E-05	2.942E-09	-1.261E-13
ToV_{11}	HDD	4.842E-04	-1.177E-08	-1.846E-12	-7.526E-06	1.248E-10	3.406E-14
ToV_{12}	HDD	1.621	8.423E-06	-1.630E-09	-4.841E-01	1.242E-05	1.853E-09
ToV_{13}	CDD	-3.248E-03	1.435E-04	-4.404E-08	2.493E-04	-9.644E-06	3.658E-09
ToV_{14}	CDD	1.329E-02	-4.318E-04	-3.246E-07	-1.256E-01	-9.393E-04	1.856E-06
ToV_{15}	CDD	1.401E-01	-3.038E-03	4.729E-06	-7.993E-02	1.734E-03	-2.699E-06
ToV_{16}	HDD	-1.664	1.117E-03	-1.399E-08	6.880	-4.768E-03	4.812E-08
ToV_{17}	TDD	-8.727E-02	-1.265E-07	6.306E-09	-2.348E-03	1.239E-05	-2.734E-09
ToV_{18}	CDD	-2.660E-04	5.774E-06	-4.296E-09	1.760E-04	-3.822E-06	2.843E-09
ToV_{19}	HDD	4.914E-02	-1.140E-05	7.593E-10	-2.337E-03	5.034E-07	-3.197E-11
ToV_{20}	CDD	4.379E-03	6.356E-05	-9.493E-08	-3.138E-04	-2.438E-06	3.297E-09
ToV_{21}	HDD	-9.459E-05	-1.282E-09	5.714E-13	-1.474E-08	3.202E-10	-9.220E-13
ToV_{22}	CDD	-2.467E-04	1.943E-06	-3.049E-09	3.048E-06	4.482E-09	-1.169E-11
ToV_{23}	HDD	6.894E-02	-1.310E-05	8.396E-10	-4.840E-02	1.103E-05	-7.691E-10
ToV_{24}	CDD	1.976E-01	-2.554E-03	4.005E-06	-1.717E-01	1.917E-03	-2.957E-06
ToV_{25}	HDD	8.037E-02	8.616E-06	-1.374E-09	-2.009E-02	-6.964E-06	8.254E-10
ToV_{26}	CDD	-1.409E-03	5.388E-04	-7.183E-07	7.464E-03	-2.491E-04	3.357E-07
ToV_{27}	HDD	-2.764E+01	8.230E-03	-4.637E-07	2.050E+01	-5.882E-03	3.302E-07
ToV_{28}	CDD	1.748E+01	-1.207E-01	1.788E-04	-1.186E+01	8.661E-02	-1.280E-04
ToV_{29}	HDD	-2.563E+01	9.394E-03	-7.330E-07	1.900E+01	-6.621E-03	5.087E-07
ToV_{30}	CDD	-5.080E+02	1.831	-9.579E-04	3.168E+02	-1.139	5.957E-04
ToV_{31}	HDD	-3.243E+02	1.143E-01	-8.882E-06	3.351E+02	-1.177E-01	9.131E-06
ToV_{32}	CDD	-3.565E-02	-1.915E-03	3.183E-06	2.050E-02	1.245E-03	-2.045E-06

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Table 5.3.2.8.T.
Coefficient Values for System Type HVAC-20 (Induction Unit – Four-Pipe)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	4.095E-01	6.140E-05	-8.922E-09	-1.652E-01	-5.042E-05	5.982E-09
ToV_2	HDD	2.494E-01	6.358E-05	-8.104E-09	-5.361E-02	-4.232E-05	4.513E-09
ToV_3	TDD	1.538E-01	1.282E-04	-1.172E-08	-1.857E-01	-1.006E-04	9.607E-09
ToV_4	TDD	7.403E-02	6.032E-05	-5.536E-09	-4.425E-02	-2.363E-05	2.267E-09
ToV_5	HDD	5.607	-1.190E-03	5.869E-08	-3.419	7.397E-04	-3.613E-08
ToV_6	HDD	0	0	0	0	0	0
ToV_7	HDD	-3.733E-02	5.425E-06	-2.140E-10	1.385E-03	-3.543E-07	2.229E-11
ToV_8	HDD	4.194E-02	-2.728E-06	-1.053E-10	-3.988E-03	1.661E-07	1.904E-11
ToV_9	TDD	-1.700E-02	-7.554E-06	7.610E-10	1.794E-03	-3.685E-07	1.735E-11
ToV_{10}	HDD	3.173E-04	4.203E-08	-2.701E-12	-4.173E-06	-6.138E-10	3.973E-14
ToV_{11}	HDD	3.197E-04	-3.018E-08	2.171E-12	-4.828E-06	5.034E-10	-3.706E-14
ToV_{12}	HDD	5.264E-01	2.282E-04	-1.421E-08	-1.583E-01	-5.018E-05	5.059E-09
ToV_{13}	CDD	2.172E-04	2.218E-04	-2.300E-07	-3.344E-05	-1.376E-05	1.433E-08
ToV_{14}	CDD	-1.100E-02	-7.443E-04	4.797E-07	-2.606E-02	-6.473E-04	7.638E-07
ToV_{15}	CDD	-1.241E-02	-1.619E-03	2.263E-06	5.504E-03	9.373E-04	-1.312E-06
ToV_{16}	HDD	-3.983E-01	4.258E-04	6.137E-09	1.824	-1.905E-03	-2.558E-08
ToV_{17}	TDD	8.659E-02	-4.955E-05	6.631E-09	-5.760E-02	3.095E-05	-3.693E-09
ToV_{18}	CDD	-1.253E-02	-3.304E-05	6.623E-08	1.615E-02	9.996E-05	-1.692E-07
ToV_{19}	HDD	2.403E-02	-4.825E-06	3.572E-10	-2.897E-03	8.946E-07	-6.991E-11
ToV_{20}	CDD	-1.048E-04	2.533E-06	-3.321E-09	1.052E-05	-1.402E-07	1.707E-10
ToV_{21}	HDD	-3.308E-05	-2.057E-09	1.507E-13	-7.169E-09	1.155E-11	-8.063E-16
ToV_{22}	CDD	2.143E-05	-9.001E-07	1.030E-09	-1.021E-07	7.375E-10	-6.946E-13
ToV_{23}	HDD	9.332E-03	1.052E-05	-1.456E-08	-5.483E-03	-2.778E-07	2.922E-11
ToV_{24}	CDD	2.526E-03	1.253E-04	-1.255E-07	-2.674E-03	-5.728E-05	4.967E-08
ToV_{25}	HDD	2.314E-02	6.259E-06	-5.800E-10	-6.276E-03	-3.348E-06	3.149E-10
ToV_{26}	CDD	-1.343E-02	1.766E-04	-2.094E-07	7.467E-03	-8.139E-05	9.681E-08
ToV_{27}	HDD	-4.337	2.086E-03	-1.821E-07	2.970	-1.138E-03	9.751E-08
ToV_{28}	CDD	6.128E+02	-8.931	1.734E-02	-3.842E+02	5.610	-1.089E-02
ToV_{29}	HDD	-1.035E+01	4.751E-03	-4.421E-07	6.420	-2.649E-03	2.433E-07
ToV_{30}	CDD	-4.301E+01	3.311E-01	-4.985E-04	2.701E+01	-2.036E-01	3.068E-04
ToV_{31}	HDD	3.760E+03	-1.356	1.088E-04	-3.775E+03	1.362	-1.092E-04
ToV_{32}	CDD	1.260E-03	-8.149E-05	8.297E-08	-4.513E-04	9.251E-05	-1.018E-07

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Table 5.3.2.8.U.
Coefficient Values for System Type HVAC-21 (Induction Unit – Three-Pipe)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	4.095E-01	6.140E-05	-8.922E-09	-1.652E-01	-5.042E-05	5.982E-09
ToV_2	HDD	2.494E-01	6.358E-05	-8.104E-09	-5.361E-02	-4.232E-05	4.513E-09
ToV_3	TDD	1.538E-01	1.282E-04	-1.172E-08	-1.857E-01	-1.006E-04	9.607E-09
ToV_4	TDD	7.403E-02	6.032E-05	-5.536E-09	-4.425E-02	-2.363E-05	2.267E-09
ToV_5	HDD	5.607	-1.190E-03	5.869E-08	-3.419	7.397E-04	-3.613E-08
ToV_6	HDD	0	0	0	0	0	0
ToV_7	HDD	-3.733E-02	5.425E-06	-2.140E-10	1.385E-03	-3.543E-07	2.229E-11
ToV_8	HDD	4.194E-02	-2.728E-06	-1.053E-10	-3.988E-03	1.661E-07	1.904E-11
ToV_9	TDD	-1.700E-02	-7.554E-06	7.610E-10	1.794E-03	-3.685E-07	1.735E-11
ToV_{10}	HDD	3.173E-04	4.203E-08	-2.701E-12	-4.173E-06	-6.138E-10	3.973E-14
ToV_{11}	HDD	3.197E-04	-3.018E-08	2.171E-12	-4.828E-06	5.034E-10	-3.706E-14
ToV_{12}	HDD	5.264E-01	2.282E-04	-1.421E-08	-1.583E-01	-5.018E-05	5.059E-09
ToV_{13}	CDD	2.172E-04	2.218E-04	-2.300E-07	-3.344E-05	-1.376E-05	1.433E-08
ToV_{14}	CDD	-1.100E-02	-7.443E-04	4.797E-07	-2.606E-02	-6.473E-04	7.638E-07
ToV_{15}	CDD	-1.241E-02	-1.619E-03	2.263E-06	5.504E-03	9.373E-04	-1.312E-06
ToV_{16}	HDD	-3.983E-01	4.258E-04	6.137E-09	1.824	-1.905E-03	-2.558E-08
ToV_{17}	TDD	8.659E-02	-4.955E-05	6.631E-09	-5.760E-02	3.095E-05	-3.693E-09
ToV_{18}	CDD	-1.253E-02	-3.304E-05	6.623E-08	1.615E-02	9.996E-05	-1.692E-07
ToV_{19}	HDD	2.403E-02	-4.825E-06	3.572E-10	-2.897E-03	8.946E-07	-6.991E-11
ToV_{20}	CDD	-1.048E-04	2.533E-06	-3.321E-09	1.052E-05	-1.402E-07	1.707E-10
ToV_{21}	HDD	-3.308E-05	-2.057E-09	1.507E-13	-7.169E-09	1.155E-11	-8.063E-16
ToV_{22}	CDD	2.143E-05	-9.001E-07	1.030E-09	-1.021E-07	7.375E-10	-6.946E-13
ToV_{23}	HDD	9.332E-03	1.052E-05	-1.456E-08	-5.483E-03	-2.778E-07	2.922E-11
ToV_{24}	CDD	2.526E-03	1.253E-04	-1.255E-07	-2.674E-03	-5.728E-05	4.967E-08
ToV_{25}	HDD	2.314E-02	6.259E-06	-5.800E-10	-6.276E-03	-3.348E-06	3.149E-10
ToV_{26}	CDD	-1.343E-02	1.766E-04	-2.094E-07	7.467E-03	-8.139E-05	9.681E-08
ToV_{27}	HDD	-4.337	2.086E-03	-1.821E-07	2.970	-1.138E-03	9.751E-08
ToV_{28}	CDD	6.128E+02	-8.931	1.734E-02	-3.842E+02	5.610	-1.089E-02
ToV_{29}	HDD	-1.035E+01	4.751E-03	-4.421E-07	6.420	-2.649E-03	2.433E-07
ToV_{30}	CDD	-4.301E+01	3.311E-01	-4.985E-04	2.701E+01	-2.036E-01	3.068E-04
ToV_{31}	HDD	3.760E+03	-1.356	1.088E-04	-3.775E+03	1.362	-1.092E-04
ToV_{32}	CDD	1.260E-03	-8.149E-05	8.297E-08	-4.513E-04	9.251E-05	-1.018E-07

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Table 5.3.2.8.V.
Coefficient Values for System Type HVAC-22 (Packaged Terminal AC – Split)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	9.141E-01	1.967E-04	-2.046E-08	-6.265E-01	-1.543E-04	1.531E-08
ToV_2	HDD	4.106E-01	1.072E-04	-1.082E-08	-1.325E-01	-4.551E-05	4.317E-09
ToV_3	HDD	9.997E-01	1.993E-04	-2.129E-08	-9.853E-01	-2.191E-04	2.256E-08
ToV_4	HDD	3.922E-01	8.111E-05	-8.650E-09	-1.591E-01	-3.760E-05	3.851E-09
ToV_5	CDD	0	0	0	0	0	0
ToV_6	TDD	0	0	0	0	0	0
ToV_7	HDD	-1.701E-01	-1.450E-05	2.347E-09	2.225E-02	-8.095E-07	-1.281E-10
ToV_8	HDD	9.111E-03	2.817E-06	-2.710E-10	-9.343E-04	-2.914E-07	2.801E-11
ToV_9	TDD	1.130E-01	2.518E-05	-2.703E-09	-2.090E-01	-3.299E-05	3.854E-09
ToV_{10}	HDD	0	0	0	0	0	0
ToV_{11}	HDD	-4.499E-06	-9.547E-09	7.550E-13	1.654E-07	3.184E-10	-2.619E-14
ToV_{12}	HDD	-1.044E-01	3.724E-04	-1.575E-08	4.838E-02	-1.473E-04	9.450E-09
ToV_{13}	CDD	1.711E-01	6.202E-04	-6.974E-07	-1.975E-02	-4.929E-05	5.393E-08
ToV_{14}	CDD	1.520E-01	-3.538E-02	4.494E-05	-1.224E+01	2.064E-01	-2.708E-04
ToV_{15}	CDD	0	0	0	0	0	0
ToV_{16}	TDD	2.225	-6.345E-04	3.425E-08	-1.408	4.659E-04	-2.783E-08
ToV_{17}	HDD	0	0	0	0	0	0
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	7.333E-02	-5.725E-06	3.435E-10	-5.205E-03	5.793E-07	-3.970E-11
ToV_{20}	HDD	0	0	0	0	0	0
ToV_{21}	HDD	-1.003E-05	-2.244E-08	1.995E-12	-3.126E-07	1.437E-10	-1.287E-14
ToV_{22}	HDD	0	0	0	0	0	0
ToV_{23}	HDD	2.430E-02	-4.205E-06	4.692E-10	-1.560E-02	3.698E-06	-4.091E-10
ToV_{24}	HDD	0	0	0	0	0	0
ToV_{25}	HDD	6.490E-02	7.023E-08	1.484E-11	-2.383E-02	-3.340E-08	-2.068E-11
ToV_{26}	HDD	0	0	0	0	0	0
ToV_{27}	HDD	-1.137E+02	3.765E-02	-2.700E-06	7.012E+01	-2.281E-02	1.627E-06
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	-3.427E+01	8.525E-03	-5.422E-07	2.294E+01	-5.518E-03	3.477E-07
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	-4.162	2.046E-05	-3.905E-09	3.244	-2.974E-05	3.858E-09
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.W.
Coefficient Values for System Type HVAC-23 (Radiant (In-floor, Ceiling) with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	1.217	-2.560E-04	1.526E-08	-6.299E-01	1.286E-04	-7.521E-09
ToV_2	HDD	8.508E-01	-1.796E-04	1.073E-08	-3.174E-01	6.504E-05	-3.817E-09
ToV_3	HDD	1.043	-2.206E-04	1.324E-08	-8.986E-01	1.875E-04	-1.116E-08
ToV_4	HDD	4.952E-01	-1.052E-04	6.320E-09	-2.122E-01	4.449E-05	-2.650E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-1.750E-01	3.955E-05	-2.404E-09	1.252E-02	-3.605E-06	2.537E-10
ToV_8	CDD	3.905E-02	-3.387E-05	9.739E-08	-3.849E-03	3.358E-06	-9.557E-09
ToV_9	TDD	-2.410E-01	5.141E-05	-3.014E-09	3.800E-02	-1.088E-05	7.603E-10
ToV_{10}	HDD	4.783E-04	3.962E-08	-5.924E-12	-7.084E-06	-5.313E-10	8.309E-14
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	2.794E-01	2.813E-04	-1.977E-08	-4.062E-01	5.544E-05	-2.109E-09
ToV_{13}	CDD	-6.223E-03	1.458E-04	-1.929E-07	4.106E-04	-9.328E-06	1.232E-08
ToV_{14}	CDD	5.563E-02	-5.493E-04	7.112E-07	-1.866	1.219E-02	-1.579E-05
ToV_{15}	CDD	0	0	0	0	0	0
ToV_{16}	TDD	-1.341	7.014E-04	-5.257E-08	4.146	-2.470E-03	1.915E-07
ToV_{17}	HDD	-3.747E-01	5.022E-05	-2.263E-09	2.818E-01	-4.773E-06	-1.201E-09
ToV_{18}	CDD	-3.913E-03	1.322E-04	-2.101E-07	2.808E-03	-8.513E-05	1.364E-07
ToV_{19}	HDD	9.710E-02	-1.691E-05	8.772E-10	-3.572E-03	3.772E-07	-8.364E-12
ToV_{20}	CDD	-6.421E-04	3.355E-05	-4.226E-08	3.261E-05	-1.971E-06	2.475E-09
ToV_{21}	HDD	-4.356E-05	-5.207E-10	1.892E-13	7.781E-08	-3.138E-11	2.734E-15
ToV_{22}	CDD	8.993E-05	-2.475E-06	3.551E-09	2.054E-07	4.464E-10	-1.982E-12
ToV_{23}	HDD	4.713E-03	3.254E-06	-3.095E-10	-1.398E-03	-2.216E-06	2.042E-10
ToV_{24}	CDD	-2.214E-02	4.412E-04	-6.165E-07	1.187E-02	-2.216E-04	3.080E-07
ToV_{25}	HDD	1.025E-01	-1.618E-05	1.011E-09	-5.382E-02	1.093E-05	-7.503E-10
ToV_{26}	CDD	-2.331E-02	3.494E-04	-4.558E-07	1.101E-02	-1.489E-04	1.895E-07
ToV_{27}	HDD	-3.416E+01	1.224E-02	-9.389E-07	2.149E+01	-7.402E-03	5.605E-07
ToV_{28}	CDD	2.803	-1.542E-02	2.488E-05	-1.884	1.465E-02	-2.247E-05
ToV_{29}	HDD	1.665	-9.328E-05	-6.208E-09	2.136	-7.403E-04	5.650E-08
ToV_{30}	CDD	-1.478	3.624E-02	-7.039E-05	7.358E-01	-1.658E-02	3.490E-05
ToV_{31}	HDD	-3.039E+02	8.111E-02	-3.808E-06	3.060E+02	-8.135E-02	3.812E-06
ToV_{32}	CDD	4.711	-3.213E-02	5.215E-05	-5.008	4.067E-02	-6.393E-05

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Table 5.3.2.8.X.
Coefficient Values for System Type HVAC-24 (Active Chilled Beams with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	3.276E-01	-4.201E-06	-2.388E-09	-1.656E-01	-1.451E-06	1.575E-09
ToV_2	HDD	2.997E-01	-7.079E-06	-2.176E-09	-1.291E-01	2.169E-07	1.285E-09
ToV_3	HDD	2.754E-01	1.990E-05	-3.468E-09	-2.735E-01	-5.956E-06	2.197E-09
ToV_4	HDD	1.580E-01	-2.234E-06	-6.858E-10	-7.213E-02	1.847E-06	2.346E-10
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-1.400E-02	1.108E-06	4.662E-12	2.511E-04	-4.937E-08	3.289E-12
ToV_8	TDD	-4.105E-03	4.128E-06	-3.623E-10	2.653E-04	-3.888E-07	4.124E-11
ToV_9	HDD	-2.650E-02	1.134E-06	2.331E-11	1.735E-03	-4.893E-07	4.206E-11
ToV_{10}	HDD	5.726E-04	-1.408E-09	-7.508E-14	-7.822E-06	3.091E-11	-1.039E-16
ToV_{11}	HDD	4.987E-04	-7.287E-08	5.027E-12	-7.506E-06	1.134E-09	-7.871E-14
ToV_{12}	HDD	8.784E-01	1.602E-04	-1.021E-08	-2.379E-01	-1.825E-05	3.028E-09
ToV_{13}	CDD	-1.751E-03	2.509E-04	-2.709E-07	1.320E-04	-1.582E-05	1.720E-08
ToV_{14}	CDD	-2.420E-02	-7.855E-04	5.762E-07	6.983E-01	-4.724E-03	5.601E-06
ToV_{15}	CDD	1.004E-02	-1.463E-03	2.187E-06	-6.060E-03	8.385E-04	-1.253E-06
ToV_{16}	HDD	3.201	-3.991E-05	3.380E-08	-1.608E+01	1.704E-03	-2.790E-07
ToV_{17}	TDD	1.827E-01	-6.112E-05	3.494E-09	-1.591E-01	8.394E-05	-4.626E-09
ToV_{18}	CDD	-1.110E-02	-3.656E-05	7.065E-08	1.351E-02	1.088E-04	-1.809E-07
ToV_{19}	HDD	3.317E-02	-7.340E-06	5.469E-10	-3.729E-03	1.207E-06	-9.603E-11
ToV_{20}	CDD	1.216E-05	1.200E-06	-1.120E-09	5.953E-06	-8.911E-08	8.623E-11
ToV_{21}	HDD	-3.389E-05	-7.069E-09	6.411E-13	-1.957E-07	9.377E-11	-7.561E-15
ToV_{22}	CDD	-1.294E-05	-7.538E-07	8.847E-10	2.041E-07	-1.045E-09	1.161E-12
ToV_{23}	HDD	1.067E-02	1.291E-05	-1.820E-08	-4.870E-03	-6.790E-07	5.472E-11
ToV_{24}	CDD	-9.030E-03	2.096E-04	-2.464E-07	7.466E-03	-1.273E-04	1.495E-07
ToV_{25}	HDD	7.766E-02	-9.411E-06	6.939E-10	-3.336E-02	4.936E-06	-3.735E-10
ToV_{26}	CDD	2.039E-03	1.055E-04	-1.311E-07	-1.563E-03	-3.809E-05	4.814E-08
ToV_{27}	HDD	-3.042	1.573E-03	-1.368E-07	2.445	-9.104E-04	7.562E-08
ToV_{28}	CDD	-4.220E+01	1.665E-01	-1.079E-04	2.755E+01	-1.063E-01	6.916E-05
ToV_{29}	HDD	-1.038E+01	4.568E-03	-4.095E-07	6.453	-2.534E-03	2.224E-07
ToV_{30}	CDD	-4.257E+01	3.295E-01	-4.976E-04	2.675E+01	-2.026E-01	3.061E-04
ToV_{31}	HDD	3.020E+03	-1.068	8.364E-05	-3.034E+03	1.074	-8.408E-05
ToV_{32}	CDD	1.909E+02	-1.048	1.236E-03	-1.902E+02	1.050	-1.238E-03

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Table 5.3.2.8.Y.
Coefficient Values for System Type HVAC-25 (Unit Heater)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha 1_i$	$\alpha 2_i$	$\alpha 3_i$	$\beta 1_i$	$\beta 2_i$	$\beta 3_i$
ToV_1	HDD	-9.258E-03	3.040E-06	-2.298E-10	7.138E-03	-2.344E-06	1.772E-10
ToV_2	HDD	-1.382E-02	4.539E-06	-3.432E-10	7.459E-03	-2.449E-06	1.852E-10
ToV_3	HDD	0	0	0	0	0	0
ToV_4	HDD	0	0	0	0	0	0
ToV_5	HDD	0	0	0	0	0	0
ToV_6	TDD	0	0	0	0	0	0
ToV_7	HDD	-9.434E-04	3.098E-07	-2.342E-11	6.374E-04	-2.093E-07	1.582E-11
ToV_8	HDD	0	0	0	0	0	0
ToV_9	HDD	0	0	0	0	0	0
ToV_{10}	HDD	1.696E-05	-2.683E-09	1.142E-13	-2.314E-07	3.414E-11	-1.250E-15
ToV_{11}	HDD	7.709E-04	-1.507E-07	8.659E-12	-1.945E-06	3.330E-10	-1.679E-14
ToV_{12}	HDD	9.548E-01	7.608E-05	-5.030E-09	-3.474E-01	6.300E-05	-3.473E-09
ToV_{13}	CDD	0	0	0	0	0	0
ToV_{14}	CDD	0	0	0	0	0	0
ToV_{15}	CDD	0	0	0	0	0	0
ToV_{16}	HDD	0	0	0	0	0	0
ToV_{17}	HDD	0	0	0	0	0	0
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	4.826E-02	1.022E-05	-1.459E-09	1.804E-02	-6.710E-06	5.204E-10
ToV_{20}	CDD	0	0	0	0	0	0
ToV_{21}	HDD	-8.774E-04	1.779E-07	-1.049E-11	2.471E-07	-7.542E-11	5.237E-15
ToV_{22}	CDD	0	0	0	0	0	0
ToV_{23}	HDD	2.522E-01	-4.878E-05	2.778E-09	-1.383E-01	2.643E-05	-1.490E-09
ToV_{24}	CDD	0	0	0	0	0	0
ToV_{25}	HDD	7.705E-01	-1.393E-04	7.484E-09	-2.527E-01	4.123E-05	-1.996E-09
ToV_{26}	CDD	0	0	0	0	0	0
ToV_{27}	HDD	5.568	-1.404E-03	8.972E-08	1.902	-6.822E-04	5.431E-08
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	-6.836	2.818E-03	-2.251E-07	7.232	-2.488E-03	1.882E-07
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	-1.474E+01	5.348E-03	-3.977E-07	2.083E+01	-6.941E-03	5.028E-07
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.Z.
Coefficient Values for System Type HVAC-26 (Unit Ventilator)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	1.836E-02	-3.115E-06	1.388E-10	-9.958E-03	1.492E-06	-5.265E-11
ToV_2	HDD	3.239E-02	-1.005E-05	7.028E-10	-1.643E-02	5.399E-06	-3.827E-10
ToV_3	HDD	0	0	0	0	0	0
ToV_4	HDD	0	0	0	0	0	0
ToV_5	HDD	0	0	0	0	0	0
ToV_6	TDD	0	0	0	0	0	0
ToV_7	HDD	-3.278E-03	1.034E-06	-7.366E-11	4.597E-04	-1.931E-07	1.501E-11
ToV_8	HDD	0	0	0	0	0	0
ToV_9	HDD	0	0	0	0	0	0
ToV_{10}	HDD	-1.215E-05	7.457E-09	-6.740E-13	3.046E-07	-1.504E-10	1.309E-14
ToV_{11}	HDD	7.704E-04	-1.530E-07	8.917E-12	-2.335E-06	4.670E-10	-2.711E-14
ToV_{12}	HDD	9.737E-01	7.237E-05	-4.866E-09	-3.502E-01	6.246E-05	-3.371E-09
ToV_{13}	CDD	0	0	0	0	0	0
ToV_{14}	CDD	0	0	0	0	0	0
ToV_{15}	CDD	0	0	0	0	0	0
ToV_{16}	HDD	9.598E-03	-3.007E-06	2.541E-10	-6.380E-03	2.455E-06	-2.209E-10
ToV_{17}	HDD	0	0	0	0	0	0
ToV_{18}	CDD	0	0	0	0	0	0
ToV_{19}	HDD	4.763E-02	1.084E-05	-1.507E-09	1.813E-02	-6.749E-06	5.230E-10
ToV_{20}	CDD	0	0	0	0	0	0
ToV_{21}	HDD	-8.445E-04	1.703E-07	-1.005E-11	1.914E-07	-6.760E-11	5.158E-15
ToV_{22}	CDD	0	0	0	0	0	0
ToV_{23}	HDD	2.478E-01	-4.834E-05	2.784E-09	-1.360E-01	2.631E-05	-1.505E-09
ToV_{24}	CDD	0	0	0	0	0	0
ToV_{25}	HDD	8.829E-01	-1.824E-04	1.123E-08	-3.222E-01	6.738E-05	-4.248E-09
ToV_{26}	CDD	0	0	0	0	0	0
ToV_{27}	HDD	9.471	-2.760E-03	1.937E-07	-5.896E-02	-5.988E-07	2.087E-09
ToV_{28}	CDD	0	0	0	0	0	0
ToV_{29}	HDD	-7.049	2.896E-03	-2.315E-07	7.289	-2.509E-03	1.899E-07
ToV_{30}	CDD	0	0	0	0	0	0
ToV_{31}	HDD	-3.102E+01	1.078E-02	-7.921E-07	2.328E+01	-7.763E-03	5.628E-07
ToV_{32}	CDD	0	0	0	0	0	0

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Table 5.3.2.8.AA.
Coefficient Values for System Type HVAC-27 (Radiation with Optional Make-up Air Unit)
Forming Part of Sentences 5.3.2.6.(1) and 5.3.2.8.(1)

Trade-off Values for Component i, ToV_i	Climatic Parameter for Component i, XDD_i	Coefficient Values					
		$\alpha1_i$	$\alpha2_i$	$\alpha3_i$	$\beta1_i$	$\beta2_i$	$\beta3_i$
ToV_1	HDD	1.217	-2.560E-04	1.526E-08	-6.299E-01	1.286E-04	-7.521E-09
ToV_2	HDD	8.508E-01	-1.796E-04	1.073E-08	-3.174E-01	6.504E-05	-3.817E-09
ToV_3	HDD	1.043	-2.206E-04	1.324E-08	-8.986E-01	1.875E-04	-1.116E-08
ToV_4	HDD	4.952E-01	-1.052E-04	6.320E-09	-2.122E-01	4.449E-05	-2.650E-09
ToV_5	HDD	0	0	0	0	0	0
ToV_6	HDD	0	0	0	0	0	0
ToV_7	TDD	-1.750E-01	3.955E-05	-2.404E-09	1.252E-02	-3.605E-06	2.537E-10
ToV_8	CDD	3.905E-02	-3.387E-05	9.739E-08	-3.849E-03	3.358E-06	-9.557E-09
ToV_9	TDD	-2.410E-01	5.141E-05	-3.014E-09	3.800E-02	-1.088E-05	7.603E-10
ToV_{10}	HDD	4.783E-04	3.962E-08	-5.924E-12	-7.084E-06	-5.313E-10	8.309E-14
ToV_{11}	HDD	0	0	0	0	0	0
ToV_{12}	HDD	2.794E-01	2.813E-04	-1.977E-08	-4.062E-01	5.544E-05	-2.109E-09
ToV_{13}	CDD	-6.223E-03	1.458E-04	-1.929E-07	4.106E-04	-9.328E-06	1.232E-08
ToV_{14}	CDD	5.563E-02	-5.493E-04	7.112E-07	-1.866	1.219E-02	-1.579E-05
ToV_{15}	CDD	0	0	0	0	0	0
ToV_{16}	TDD	-1.341	7.014E-04	-5.257E-08	4.146	-2.470E-03	1.915E-07
ToV_{17}	HDD	-3.747E-01	5.022E-05	-2.263E-09	2.818E-01	-4.773E-06	-1.201E-09
ToV_{18}	CDD	-3.913E-03	1.322E-04	-2.101E-07	2.808E-03	-8.513E-05	1.364E-07
ToV_{19}	HDD	9.710E-02	-1.691E-05	8.772E-10	-3.572E-03	3.772E-07	-8.364E-12
ToV_{20}	CDD	-6.421E-04	3.355E-05	-4.226E-08	3.261E-05	-1.971E-06	2.475E-09
ToV_{21}	HDD	-4.356E-05	-5.207E-10	1.892E-13	7.781E-08	-3.138E-11	2.734E-15
ToV_{22}	CDD	8.993E-05	-2.475E-06	3.551E-09	2.054E-07	4.464E-10	-1.982E-12
ToV_{23}	HDD	4.713E-03	3.254E-06	-3.095E-10	-1.398E-03	-2.216E-06	2.042E-10
ToV_{24}	CDD	-2.214E-02	4.412E-04	-6.165E-07	1.187E-02	-2.216E-04	3.080E-07
ToV_{25}	HDD	1.025E-01	-1.618E-05	1.011E-09	-5.382E-02	1.093E-05	-7.503E-10
ToV_{26}	CDD	-2.331E-02	3.494E-04	-4.558E-07	1.101E-02	-1.489E-04	1.895E-07
ToV_{27}	HDD	-3.416E+01	1.224E-02	-9.389E-07	2.149E+01	-7.402E-03	5.605E-07
ToV_{28}	CDD	2.803	-1.542E-02	2.488E-05	-1.884	1.465E-02	-2.247E-05
ToV_{29}	HDD	1.665	-9.328E-05	-6.208E-09	2.136	-7.403E-04	5.650E-08
ToV_{30}	CDD	-1.478	3.624E-02	-7.039E-05	7.358E-01	-1.658E-02	3.490E-05
ToV_{31}	HDD	-3.039E+02	8.111E-02	-3.808E-06	3.060E+02	-8.135E-02	3.812E-06
ToV_{32}	CDD	4.711	-3.213E-02	5.215E-05	-5.008	4.067E-02	-6.393E-05

Section 5.4. Performance Path

(See A-1.1.2.1. in Appendix A.)

5.4.1. General

5.4.1.1. Scope

1) Subject to the limitations stated in Article 5.4.1.2., where the heating, ventilating and air-conditioning system does not comply with the requirements of Section 5.2. or 5.3., it shall comply with Part 8.

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5.4.1.2. Limitations

1) Notwithstanding use of the performance path, all HVAC appliances and equipment shall comply with the applicable appliance or equipment energy efficiency act or, in the absence of such an act or where the appliance or equipment is not covered by such an act, with the applicable performance standard.

2) This Section does not apply to back-up HVAC systems, which shall comply with Sentence 5.1.1.3.(2).

Section 5.5. Objective and Functional Statements

5.5.1. Objective and Functional Statements

5.5.1.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in this Part shall be the objective and functional statements listed in Table 5.5.1.1. (See A-1.1.3.1.(1) in Appendix A.)

Table 5.5.1.1.
Objectives and Functional Statements Attributed to the Acceptable Solutions in Part 5
Forming Part of Sentence 5.5.1.1.(1)

Functional Statements and Objectives[1]	
5.2.2.2. Provision for Balancing	
(1)	[F95,F99-OE1.1]
5.2.2.3. Duct Sealing	
(1)	[F91,F99-OE1.1]
(2)	[F91,F99-OE1.1]
(5)	[F91,F99-OE1.1]
5.2.2.4. Leakage Testing of Ducts	
(1)	[F91,F99-OE1.1]
(2)	[F91,F99-OE1.1]
5.2.2.5. Duct and Plenum Insulation	
(1)	[F92,F93-OE1.1]
(4)	[F93-OE1.1]
(6)	[F92,F93-OE1.1]
5.2.2.6. Protection of Duct Insulation	
(1)	[F92,F93,F95-OE1.1]
(2)	[F92,F93,F95-OE1.1]
5.2.2.8. Cooling by Direct Use of Outdoor Air (Air Economizer System)	
(1)	[F95-OE1.1]
(3)	[F95-OE1.1]
(4)	[F95-OE1.1]
(5)	[F95-OE1.1]
5.2.2.9. Cooling by Indirect Use of Outdoor Air (Water Economizer System)	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]

Table 5.5.1.1. (Continued)

Functional Statements and Objectives[1]	
5.2.3.1. Application	
(2)	[F95,F97-OE1.1]
5.2.3.2. Constant-Volume Fan Systems	
(1)	[F95,F97-OE1.1]
5.2.3.3. Variable-Air-Volume Fan Systems	
(1)	[F95,F97-OE1.1]
(2)	[F95,F97-OE1.1]
(3)	[F95,F97-OE1.1]
5.2.4.1. Required Dampers	
(1)	[F91,F95-OE1.1]
5.2.4.2. Type and Location of Dampers	
(1)	[F90,F91,F95-OE1.1]
(2)	[F90,F91,F95-OE1.1]
(3)	[F92,F95-OE1.1]
5.2.5.2. Provision for Balancing	
(1)	[F95,F99-OE1.1]
5.2.5.3. Piping Insulation	
(1)	[F92,F93-OE1.1]
(3)	[F92-OE1.1]
(5)	[F92,F93-OE1.1]
(7)	[F92,F93-OE1.1]
(8)	[F92,F93-OE1.1]
5.2.5.4. Protection of Piping Insulation	
(1)	[F92,F93,F95-OE1.1]
(2)	[F92,F93,F95-OE1.1]
5.2.6.2. Variable-Flow Pumping Systems	
(1)	[F95,F97-OE1.1]

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Table 5.5.1.1. (Continued)

Functional Statements and Objectives[1]	
5.2.7.1. Manufacturer's Designation	
(1)	[F95,F99-OE1.1]
5.2.8.1. Temperature Controls	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]
5.2.8.2. Temperature Control within Dwelling Units	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]
5.2.8.3. Installation of Thermostats	
(1)	[F95-OE1.1]
5.2.8.4. Heat Pump Controls	
(1)	[F95,F97,F99-OE1.1]
5.2.8.5. Space Temperature Control	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]
(3)	[F95-OE1.1]
(4)	[F95-OE1.1]
(5)	[F95-OE1.1]
5.2.8.6. Ice- and Snow-Melting Heater Controls	
(1)	[F95-OE1.1]
5.2.8.7. Control of Temperature of Air Leaving the Supply Air Handler	
(1)	[F95-OE1.1]
5.2.8.8. Control of Space Temperature by Reheating or Recooling	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]
(3)	[F95-OE1.1]
5.2.9.1. Humidification Controls	
(1)	[F95-OE1.1]
5.2.10.1. Heat-Recovery Systems	
(1)	[F95,F100-OE1.1]
(2)	[F95,F100-OE1.1]
(5)	[F95,F100-OE1.1]
5.2.10.2. Heat Recovery from Dehumidification in Swimming Pools	
(1)	[F95,F100-OE1.1]
5.2.10.3. Heat Recovery from Ice-making Machines in Ice Arenas and Curling Rinks	
(1)	[F95,F96,F100-OE1.1]
5.2.10.4. Heat Recovery in Dwelling Units	
(1)	[F95,F100-OE1.1]
(2)	[F95,F100-OE1.1]
(3)	[F95,F100-OE1.1]
(4)	[F95,F100-OE1.1]
(5)	[F95,F100-OE1.1]

Table 5.5.1.1. (Continued)

Functional Statements and Objectives[1]	
5.2.11.1. Off-hours Controls	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]
(4)	[F95-OE1.1]
5.2.11.2. Airflow Control Areas	
(1)	[F95,F97-OE1.1]
(2)	[F95,F97-OE1.1]
(3)	[F95,F97-OE1.1]
(4)	[F95,F97-OE1.1]
(5)	[F95,F97-OE1.1]
(6)	[F95,F97-OE1.1]
(7)	[F95,F97,F99-OE1.1]
5.2.11.3. Seasonal Shutdown	
(1)	[F97-OE1.1]
5.2.11.4. Multiple Boilers	
(1)	[F93-OE1.1]
(2)	[F95-OE1.1]
(3)	[F95-OE1.1]
5.2.11.5. Loop Temperature Reset for Chilled- and Hot-Water Systems	
(1)	[F95,F98-OE1.1]
5.2.12.1. Unitary and Packaged HVAC Equipment	
(1)	[F95,F98,F99-OE1.1]
5.2.12.2. Field-Assembled Equipment and Components	
(1)	[F99-OE1.1]
5.2.12.3. Service Water Heating Equipment Used for Space Heating	
(1)	[F98-OE1.1]
5.3.1.1. Application	
(1)	[F95,F99-OE1.1]
5.3.1.3. Compliance	
(1)	[F95,F99-OE1.1]
5.3.2.1. HVAC Trade-off Index	
(1)	[F95,F99-OE1.1]
5.3.2.2. Determination of Components to Be Included, γi	
(1)	[F95,F99-OE1.1]
5.3.2.3. Determination of Trade-off Value of Components, ToV_i	
(1)	[F95,F99-OE1.1]
5.3.2.4. Determination of Base Value of Components, BaV_i	
(1)	[F95,F99-OE1.1]
5.3.2.5. Determination of Weighting Factor Linking the Component Efficiency Variation to the System Efficiency Variation, α_i and β_i	
(1)	[F95,F99-OE1.1]
(2)	[F95,F99-OE1.1]

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Table 5.5.1.1. (Continued)

Functional Statements and Objectives[1]	
5.3.2.6. Determination of Climatic Parameter Relevant to the Component, XDD_i	
(1)	[F95,F99-OE1.1]
5.3.2.7. Determination of Trade-off Value of Component, ToV_i	
(1)	[F95,F99-OE1.1]
5.3.2.8. Coefficient Values: $\alpha1_i$, $\alpha2_i$, $\alpha3_i$, $\beta1_i$, $\beta2_i$ and $\beta3_i$	
(1)	[F95,F99-OE1.1]
5.4.1.2. Limitations	
(1)	[F98,F99-OE1.1]

Notes to Table 5.5.1.1.:

(1) See Parts 2 and 3 of Division A.

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Part 6
Service Water Heating Systems

Section 6.1. General

6.1.1. General

6.1.1.1. Scope

1) This Part is concerned with the systems used to heat *service water*.

6.1.1.2. Application

1) This Part applies to *service water* heating systems.

6.1.1.3. Compliance

1) Except as provided in Sentence (2), compliance with this Part shall be achieved by following

a) the prescriptive path described in Section 6.2.,
b) the trade-off path described in Section 6.3., or
c) the performance path described in Section 6.4. (see A-3.1.1.3.(1)(c) in Appendix A).

(See Appendix A.)

2) Back-up systems shall comply with the prescriptive requirements stated in Section 6.2.

6.1.1.4. Definitions

1) Words that appear in italics are defined in Article 1.4.1.2. of Division A.

Section 6.2. Prescriptive Path

6.2.1. System Design

6.2.1.1. Regulations

1) *Service water* heating systems shall be designed in accordance with the relevant provincial, territorial or municipal *building* regulations or, in the absence of such regulations, or where *service water* heating systems are not covered by such regulations, with the National Plumbing Code of Canada 2010.

6.2.2. Water Heating Equipment and Storage Vessels

6.2.2.1. Equipment Efficiency

1) Storage-type and non-storage-type *service water* heaters and pool heaters shall comply with the performance requirements stated in Table 6.2.2.1. (See Appendix A.)

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Table 6.2.2.1.
Service Water Heating Equipment Performance Standards
Forming Part of Sentences 5.2.12.3.(1), 6.2.2.1.(1), 6.2.2.4.(2), 6.2.2.5.(1), 6.3.2.5.(1) and 6.3.2.6.(1)

Storage-Type and Non-Storage-Type (Instantaneous) Service Water Heaters							
Component	Input	Capacity, L	V_t, L (US gal.)	Input/V_t, W/L (Btu/h/US gal.)	Standard	Rating Conditions	Performance Requirement(1)
Electric	≤ 12 kW	50 – 270	—	—	CAN/CSA-C191	See standard	SL ≤ 35 + 0.20V (top inlet) SL ≤ 40 + 0.20V (bottom inlet)
	—	> 270 and ≤ 454					SL ≤ (0.472V) – 38.5 (top inlet) SL ≤ (0.472V) – 33.5 (bottom inlet)
	> 12 kW	> 454			ANSI Z21.10.3/CSA 4.3(2)	Δt = 44.4°C (80°F)	E_t ≥ 98% EF ≥ 0.98
Heat pump water heaters	≤ 24 A and ≤ 250 V	—	—	—	CAN/CSA-C745	—	EF ≥ 2.1
Gas-fired	< 22 kW	—	—	—	CAN/CSA-P.3	—	EF ≥ 0.67 – 0.0005V
	> 117 kW		—	< 310 (4000)	ANSI Z21.10.3/CSA 4.3	Δt = 50°C (90°F)	E_t ≥ 80%
			< 37.8 (10)	≥ 310 (4000)			E_t ≥ 80%(3)
			≥ 37.8 (10)			Δt = 50°C (90°F)	E_t ≥ 77%(3)
Oil-fired, instantaneous	≤ 61.5 kW(4)	—	—	—	DOE 10 CFR, Part 430, Subpart B, Appendix E	—	EF ≥ 0.59 – 0.0019 V
	Others	—	—	< 310 (4000)	ANSI Z21.10.3/CSA 4.3	Δt = 50°C (90°F)	E_t ≥ 78%(3) SL ≤ 1.3 + 95/V_t(2)
			< 37.8 (10)	≥ 310 (4000)		—	E_t ≥ 80%(3)
			≥ 37.8 (10)			Δt = 50°C (90°F)	E_t ≥ 77% SL ≤ 2.3 + 67/V_t(2)
Oil-fired, storage-type	≤ 30.5 kW	≤ 190	—	—	CAN/CSA-B211	—	EF ≥ 0.55
		> 190			DOE 10 CFR, Part 430, Subpart B, Appendix E		
	> 30.5 kW	> 190	—	< 310 (4000)	ANSI Z21.10.3/CSA 4.3	Δt = 50°C (90°F)	EF ≥ 0.55
			< 37.8 (10)	≥ 310 (4000)		—	EF ≥ 0.55
			≥ 37.8 (10)			Δt = 50°C (90°F)	EF ≥ 0.55 SL ≤ 2.3 + 67/V_t(2)
Pool Heaters							
Component	Input	Capacity, L	V_t, L (US gal.)	Input/V_t, W/L (Btu/h/US gal.)	Standard	Rating Conditions	Performance Requirement(1)
Gas-fired(2)	< 117.2 kW	—	—	—	ANSI Z21.56/CSA 4.7	—	E_t ≥ 78%
Oil-fired	—						E_t ≥ 78%(3)

Notes to Table 6.2.2.1.:

(1) The symbols and abbreviations used in this column have the following meanings:

V_t = tank storage volume, in L, as measured according to the referenced standard
SL = *standby losses,* in %/h or in W, depending on standard
E_t = *thermal efficiency* with 38.9°C (70°F) water temperature difference
EF = *energy factor*, in %/h
V = storage volume, in L, as specified by the manufacturer

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Table 6.2.2.1. (Continued)

(2) When testing an electric *storage-type service water heater* for *standby losses* using the test procedure described in Section 2.9. of the referenced standard, the electrical supply voltage shall be maintained within ±1% of the centre of the voltage range specified on the water heater nameplate. Also, when needed for calculations, the *thermal efficiency* (E_t) shall be 98%.

(3) Includes propane.

(4) Consistent with the US National Appliance Energy Conservation Act of 1987.

6.2.2.2. Equipment Insulation

1) Except for tanks covered by Article 6.2.2.1., hot *service water* storage tanks shall be covered with insulation having a maximum U-value of 0.45 W/(m²·K).

2) Tank insulation referred to in Sentence (1) that is installed in areas where it may be subject to mechanical damage shall be protected.

6.2.2.3. Solar Thermal Service Water Heating Equipment

1) *Service water* heating equipment using solar thermal technology shall be designed and installed in accordance with

a) the manufacturer's procedures, or
b) CAN/CSA-F379 SERIES, "Packaged Solar Domestic Hot Water Systems (Liquid-to-Liquid Heat Transfer)."

6.2.2.4. Combination Service Water Heating and Space-Heating Equipment

1) Combination *service water* heating and space-heating equipment is only permitted to be used where input to the combination equipment is

a) less than 22 kW, or
b) less than twice the design *service water* heating load.

2) Where combination equipment referred to in Sentence (1) is used, its performance shall meet the greater of the minimum energy efficiency ratings for *service water* heating equipment and space-heating equipment required in the applicable standards listed in Table 5.2.12.1. or 6.2.2.1. or, where such equipment is not covered in these Tables, with the Energy Efficiency Act and its Regulations.

6.2.2.5. Space-Heating Equipment Used for Indirect Service Water Heating

1) Space-heating equipment used solely to provide indirect *service water* heating or used to provide a combination of space heating and indirect *service water* heating shall meet the greater of the minimum energy efficiency ratings for *service water* heating equipment and space-heating equipment required in the applicable standards listed in Table 5.2.12.1. or 6.2.2.1. or, where such equipment is not covered in these Tables, with the Energy Efficiency Act and its Regulations.

6.2.3. Piping

6.2.3.1. Insulation

1) All piping conveying hot *service water* in circulating systems, non-circulating systems without *heat traps* and non-circulating systems with electric heating elements along the pipes to maintain temperature shall be insulated in accordance with Table 6.2.3.1. and Sentences (2) to (4). (See Appendix A.)

2) Where piping insulation has a thermal conductivity, as determined in accordance with Sentence (4), that is greater than the range given in Table 6.2.3.1., the thickness given in the Table shall be increased by the ratio u2/u1, where u1 is the value at the higher end of the conductivity range for the operating temperature and u2 is the measured thermal conductivity of the insulation at the mean rating temperature.

3) Where piping insulation has a thermal conductivity, as determined in accordance with Sentence (4), that is lower than the range given in Table 6.2.3.1., the thickness given in the Table may be decreased by the ratio u2/u1, where u1 is the value

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at the lower end of the conductivity range for the operating temperature and u2 is the measured thermal conductivity of the insulation at the mean rating temperature.

4) The thermal conductivity of piping insulation at the mean rating temperature shall be determined in conformance with ASTM C 335/C 335M, "Steady-State Heat Transfer Properties of Pipe Insulation."

5) On non-circulating systems with *heat traps*, the inlet and outlet piping between the storage or heating vessel and the *heat traps* as well as the first 2.4 m of outlet piping downstream of the *heat trap*, shall be insulated in accordance with Table 6.2.3.1. and Sentences 5.2.5.3.(5) to (7).

Table 6.2.3.1.
Minimum Thickness of Piping Insulation for Service Water Heating Systems
Forming Part of Sentences 6.2.3.1.(1), (2), (3) and (5)

Location of Piping	Thermal Conductivity of Insulation		Nominal Pipe Diameter, in. (mm)	Minimum Thickness of Piping Insulation,(1) mm
	Conductivity Range, W/m·°C	Mean Rating Temperature, °C		
Conditioned space	0.035-0.040	38	Runouts(1) ≤ 2 (51)	25.4
			≤ 1 (25.4)	
			1¼ to 2 (32 to 51)	
			2½ to 4 (64 to 102)	38.1
			≥ 5 (127)	
Unconditioned space or outside	0.046-0.049	38	Runouts(1) ≤ 2 (51)	38.1
			≤ 1 (25.4)	63.5
			1¼ to 2 (32 to 51)	
			2½ to 4 (64 to 102)	76.2
			≥ 5 (127)	88.9

Notes to Table 6.2.3.1.:
(1) Applies to recirculating sections of *service water* heating systems and to the first 2.4 m from storage tanks for non-recirculating systems.

6.2.4. Controls

6.2.4.1. Temperature Controls

1) *Service water* heating systems with storage tanks shall be equipped with automatic temperature controls capable of adjustment between the lowest and the highest acceptable temperature settings for the intended use. (See Appendix A.)

6.2.4.2. Shutdown

1) Except for systems whose storage capacity is less than 100 L, each *service water* heating system shall be equipped with a readily accessible and clearly labeled shut-off device that allows the system, including any heating elements installed along the pipes to maintain temperature, to be shut-off. (See Appendix A.)

6.2.4.3. Maintaining Temperature of Hot Service Water

1) Heating elements installed along *service water* heating system pipes to maintain the water temperature shall incorporate automatic controls that maintain the temperature of the hot water within the range required for the intended use.

6.2.5. Systems with More Than One End Use Design Temperature

6.2.5.1. Remote or Booster Heaters

1) Where less than 50% of the total design flow of a *service water* heating system has a design discharge temperature higher than 60°C, separate remote heaters or

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booster heaters shall be installed for those portions of the system with a design temperature higher than 60°C. (See Appendix A.)

6.2.6. Hot Service Water

6.2.6.1. Showers

1) Individual shower heads used for reasons other than safety shall have an integral means of limiting the maximum water discharge to 9.5 L/min when tested in accordance with

a) ASME A112.18.1/CAN/CSA-B125.1, "Plumbing Supply Fittings," and
b) CAN/CSA-B125.3, "Plumbing Fittings."

(See Appendix A.)

2) Where multiple shower heads are served by one temperature control, each shower head shall be equipped with a device capable of automatically shutting off the flow of water when the shower is not in use. (See Appendix A.)

6.2.6.2. Lavatories

1) Lavatory faucets shall have an integral means of limiting the maximum hot water discharge to 8.3 L/min when tested in accordance with

a) ASME A112.18.1/CAN/CSA-B125.1, "Plumbing Supply Fittings," and
b) CAN/CSA-B125.3, "Plumbing Fittings."

2) Each lavatory in a public access washroom in a *building* of *assembly occupancy* shall be equipped with a device capable of automatically shutting off the flow of water when the lavatory is not in use. (See Appendix A.)

6.2.7. Swimming Pools

6.2.7.1. Controls

1) Pool heaters shall be equipped with a readily accessible and clearly labelled device that allows

a) the heater to be shut off without adjusting the thermostat setting, and
b) where applicable, the heater to be restarted without manually relighting the pilot light.

2) Except for pool pumps required by public health standards to operate on a 24-h basis, swimming pool pumps and swimming pool heaters shall be equipped with time switches or other controls that can be set to automatically turn off the pumps and heaters when their operation is not required.

6.2.7.2. Pool and Hot Tub Covers

1) Heated outdoor swimming pools and tubs shall be equipped with covers capable of covering at least 90% of the water surface.

2) Where pools or tubs are heated to a temperature above 32°C, the covers described in Sentence (1) shall have a nominal thermal transmittance of no more than 0.48 $W/m^{2}\cdot°C$.

Section 6.3. Trade-off Path

(See A-1.1.2.1. in Appendix A.)

6.3.1. General

6.3.1.1. Application

1) Except as provided in Article 6.3.1.2., this Section applies only to *buildings*

a) whose *occupancy* is known,

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b) for which sufficient information is known from the specifications for the *service water* heating (SWH) components listed in Article 6.3.2.2., and
c) whose SWH system meets the following criteria:
   i) it is one of the types listed in Table 6.3.1.1.,
   ii) its heating energy type is natural gas, propane, fuel oil or electricity, and
   iii) its heat pump energy type is electricity.

Table 6.3.1.1.
Types of SWH System
Forming Part of Sentence 6.3.1.1.(1)

SWH System Type ID	SWH System Type Description
SWH-1	Tank
SWH-2	Tankless (Instantaneous)
SWH-3	Space-heating *boiler*

6.3.1.2. Application Limitation

1) This Section does not apply to back-up SWH systems, which shall comply with Sentence 6.1.1.3.(2).

6.3.1.3. Compliance

1) A SWH system shall be deemed to comply with Section 6.3. if its SWH trade-off index, SWH-TOI, as calculated in accordance with Subsection 6.3.2., is greater than or equal to 0.

6.3.2. Calculation of Service Water Heating Trade-off Index

6.3.2.1. SWH Trade-off Index

1) The *service water* heating trade-off index, SWH-TOI, for an SWH-1 tank system shall be calculated using the following equation:

$$\mathrm{SWH-TOI} = 2.813 \cdot \left\{ \begin{array}{l} \dfrac{2.813 \cdot \mathrm{PDR}}{\mathrm{ToV}_1} \cdot \left\{1 - 0.6514 \cdot \mathrm{ToV}_6 \cdot \mathrm{e}^{-0.312 \cdot \mathrm{ToV}_6}\right\} \\ \qquad +0.06153 \cdot \left(\dfrac{\mathrm{A}_{\mathrm{norm}}}{\mathrm{ToV}_2} + \dfrac{26.180}{\mathrm{ToV}_3}\right) + \dfrac{0.00677}{\mathrm{ToV}_4 \cdot \mathrm{ToV}_5} \end{array} \right\}^{-1} - 2.813 \cdot \left\{ \frac{2.813}{\eta_{\mathrm{ref}}} + 0.06153 \cdot \left(\frac{\mathrm{A}_{\mathrm{norm}}}{12.4} + 6.807\right) + 0.0141 \right\}^{-1}$$

where
PDR = peak daily flow ratio, determined as per Article 6.3.2.2.,
ToV_1 = *service water* heating equipment efficiency, determined as per Article 6.3.2.5.,
ToV_2 = tank insulation value, determined as per Article 6.3.2.5.,
ToV_3 = piping insulation value, determined as per Article 6.3.2.5.,
ToV_4 = pump motor efficiency, determined as per Article 6.3.2.5.,
ToV_5 = pump efficiency, determined as per Article 6.3.2.5.,
ToV_6 = heat recovery ratio, determined as per Article 6.3.2.5.,
$\mathrm{A}_{\mathrm{norm}}$ = normalized tank area, determined as per Article 6.3.2.3., and
η_{ref} = reference heat generator efficiency, determined as per Article 6.3.2.6.

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2) The SWH-TOI for an SWH-2 tankless system shall be calculated using the following equation:

$$\text{SWH} - \text{TOI} = 2.813 \cdot \left\{ \begin{array}{l} \dfrac{2.813 \cdot \text{PDR}}{\text{ToV}_1} \cdot \left\{1 - 0.6514 \cdot \text{ToV}_6 \cdot \text{e}^{-0.312 \cdot \text{ToV}_6}\right\} \\ \qquad + \dfrac{1.611}{\text{ToV}_3} + \dfrac{0.00677}{\text{ToV}_4 \cdot \text{ToV}_5} \end{array} \right\}^{-1} - 2.813 \cdot \left\{ \frac{2.813}{\eta_{\text{ref}}} + 0.4329 \right\}^{-1}$$

where
- PDR = peak daily flow ratio, determined as per Article 6.3.2.2.,
- ToV_1 = *service water* heating equipment efficiency, determined as per Article 6.3.2.5.,
- ToV_3 = piping insulation value, determined as per Article 6.3.2.5.,
- ToV_4 = pump motor efficiency, determined as per Article 6.3.2.5.,
- ToV_5 = pump efficiency, determined as per Article 6.3.2.5.,
- ToV_6 = heat recovery ratio, determined as per Article 6.3.2.5., and
- η_{ref} = reference heat generator efficiency, determined as per Article 6.3.2.6.

3) The SWH-TOI for an SWH-3 space-heating *boiler* system shall be calculated using the following equation:

$$\text{SWH} - \text{TOI} = 2.813 \cdot \left\{ \begin{array}{l} \dfrac{2.813 \cdot \text{PDR}}{\eta_{\text{ref}}} \cdot \left\{1 - 0.6514 \cdot \text{ToV}_6 \cdot \text{e}^{-0.312 \cdot \text{ToV}_6}\right\} \\ \qquad + 0.06153 \cdot \left(\dfrac{\text{A}_{\text{norm}}}{\text{ToV}_2} + \dfrac{26.180}{\text{ToV}_3} \right) + \dfrac{0.00677}{\text{ToV}_4 \cdot \text{ToV}_5} \end{array} \right\}^{-1} - 2.813 \cdot \left\{ \frac{2.813}{\eta_{\text{ref}}} + 0.06153 \cdot \left(\frac{\text{A}_{\text{norm}}}{12.4} + 6.807 \right) + 0.0141 \right\}^{-1}$$

where
- PDR = peak daily flow ratio, determined as per Article 6.3.2.2.,
- ToV_2 = tank insulation value, determined as per Article 6.3.2.5.,
- ToV_3 = piping insulation value, determined as per Article 6.3.2.5.,
- ToV_4 = pump motor efficiency, determined as per Article 6.3.2.5.,
- ToV_5 = pump efficiency, determined as per Article 6.3.2.5.,
- ToV_6 = heat recovery ratio, determined as per Article 6.3.2.5.,
- A_{norm} = normalized tank area, determined as per Article 6.3.2.3., and
- η_{ref} = reference heat generator efficiency, determined as per Article 6.3.2.6.

6.3.2.2. Determination of Peak Daily Flow Ratio

1) The peak daily flow ratio, PDR, shall be calculated using the following equation:

$$\text{PDR} = \frac{\text{ToV}_7 \cdot \text{ToV}_9 + \text{ToV}_8 \cdot \text{ToV}_{10} + \text{AFOU} \cdot (1 - \text{ToV}_9 - \text{ToV}_{10})}{2.2 \cdot \text{ToV}_9 + 2.5 \cdot \text{ToV}_{10} + \text{AFOU} \cdot (1 - \text{ToV}_9 - \text{ToV}_{10})}$$

where
- ToV_7 = average flow of all faucets, determined as per Article 6.3.2.5.,
- ToV_8 = average flow of all showers, determined as per Article 6.3.2.5.,
- ToV_9 = faucet flow ratio, determined as per Article 6.3.2.5.,
- ToV_{10} = shower flow ratio, determined as per Article 6.3.2.5., and
- AFOU = average flow of other uses, in USGPM as per specification.

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6.3.2.3. Determination of Normalized Tank Area

1) The normalized tank area, A_{norm}, shall be calculated using the following equation:

$$A_{norm} = 5.5\pi \left(D_{norm}\right)^2$$

where

D_{norm} = normalized tank diameter, determined as per Article 6.3.2.4.

6.3.2.4. Determination of Normalized Tank Diameter

1) The normalized tank diameter, D_{norm}, shall be calculated using the following equation

$$D_{norm} = 0.32409 \left(STS\right)^{1/3}$$

where

STS = storage tank size, in US gal., as per specification.

6.3.2.5. Determination of Trade-off Values of Components, ToV_i

1) The trade-off value of the SWH component in the proposed *building*, ToV_i, shall be determined in accordance with Table 6.3.2.5.

Table 6.3.2.5.
Component Trade-off Values, ToV_i
Forming Part of Sentence 6.3.2.5.(1)

Trade-off Value	Description	ToV_i Unit	Source
ToV_1	*Service water* heating equipment efficiency	%(1)	Specifications
ToV_2	Tank insulation value	R-value	Specifications
ToV_3	Piping insulation value	R-value	Specifications
ToV_4	Pump motor efficiency	%	Specifications
ToV_5	Pump efficiency	%	Specifications
ToV_6	Heat recovery ratio	kW/kW	The installed recovery capacity divided by the total installed capacity of the SWH system, in kW/kW, from the specifications(2)
ToV_7	Average flow of all faucets	USGPM(3)	Specifications
ToV_8	Average flow of all showers	USGPM(3)	Specifications
ToV_9	Faucet flow ratio	fraction	Specifications(4)
ToV_{10}	Shower flow ratio	fraction	Specifications(4)

Notes to Table 6.3.2.5.:

(1) Efficiency is measured according to applicable test method listed in Table 6.2.2.1.

(2) If ToV_6 is limited to grey-water waste heat recovery then installed capacity = $Q \cdot (T_{in} - T_{out}) \cdot 4.182$ where

Q = flow rate, in L/s,

T_{in} = inlet temperature (warm) of the waste heat fluid, in °C, and

T_{out} = outlet temperature (cold) of the waste heat fluid, in °C.

(3) The conversion rate from litre per second to USGPM is 15.85.

(4) Fixture count including gender-based requirements.

6.3.2.6. Determination of Reference Heat Generator Efficiency, η_{ref}

1) The reference heat generator efficiency, η_{ref}, shall be the minimum required performance efficiency stated in Table 6.2.2.1. for the specified type of equipment.

Section 6.4. Performance Path

(See A-1.1.2.1. in Appendix A.)

6.4.1. General

6.4.1.1. Scope

1) Subject to the limitations stated in Article 6.4.1.2., where the *service water* heating system does not comply with the requirements of Section 6.2. or 6.3., it shall comply with Part 8.

6.4.1.2. Limitations

1) Notwithstanding use of the performance path, all *service water* heating appliances and equipment shall comply with the applicable appliance or equipment energy efficiency act or, in the absence of such an act or where the appliance or equipment is not covered by such an act, with the applicable performance standard.

2) This Section does not apply to back-up SWH systems, which shall comply with Sentence 6.1.1.3.(2).

Section 6.5. Objective and Functional Statements

6.5.1. Objective and Functional Statements

6.5.1.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in this Part shall be the objective and functional statements listed in Table 6.5.1.1. (See A-1.1.3.1.(1) in Appendix A.)

Table 6.5.1.1.
Objectives and Functional Statements Attributed to the Acceptable Solutions in Part 6
Forming Part of Sentence 6.5.1.1.(1)

Functional Statements and Objectives[1]	
6.2.1.1. Regulations	
(1)	[F96,F98-OE1.1]
6.2.2.1. Equipment Efficiency	
(1)	[F96,F98-OE1.1]
6.2.2.2. Equipment Insulation	
(1)	[F93,F96-OE1.1]
(2)	[F93,F96-OE1.1]
6.2.2.3. Solar Thermal Service Water Heating Equipment	
(1)	[F96,F98,F99-OE1.1]
6.2.2.4. Combination Service Water Heating and Space-Heating Equipment	
(1)	[F95,F96,F98,F99-OE1.1]
(2)	[F95,F96,F98,F99-OE1.1]
6.2.2.5. Space-Heating Equipment Used for Indirect Service Water Heating	
(1)	[F95,F96,F98,F99-OE1.1]

Table 6.5.1.1. (Continued)

Functional Statements and Objectives[1]	
6.2.3.1. Insulation	
(1)	[F92,F93-OE1.1]
(2)	[F92,F93-OE1.1]
(4)	[F92,F93-OE1.1]
(5)	[F92,F93-OE1.1]
6.2.4.1. Temperature Controls	
(1)	[F96-OE1.1]
6.2.4.2. Shutdown	
(1)	[F96-OE1.1]
6.2.4.3. Maintaining Temperature of Hot Service Water	
(1)	[F96-OE1.1]
6.2.5.1. Remote or Booster Heaters	
(1)	[F96-OE1.1]
6.2.6.1. Showers	
(1)	[F96-OE1.1]
(2)	[F96-OE1.1]
6.2.6.2. Lavatories	
(1)	[F96-OE1.1]

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Table 6.5.1.1. (Continued)

Functional Statements and Objectives[1]	
(2)	[F96-OE1.1]
6.2.7.1. Controls	
(1)	[F95,F96,F99-OE1.1]
(2)	[F95,F96,F99-OE1.1]
6.2.7.2. Pool and Hot Tub Covers	
(1)	[F95-OE1.1]
(2)	[F95-OE1.1]
6.3.1.1. Application	
(1)	[F96,F99-OE1.1]
6.3.1.3. Compliance	
(1)	[F96,F99-OE1.1]
6.3.2.1. SWH Trade-off Index	
(1)	[F96,F99-OE1.1]
(2)	[F96,F99-OE1.1]
(3)	[F96,F99-OE1.1]
6.3.2.2. Determination of Peak Daily Flow Ratio	
(1)	[F96,F99-OE1.1]
6.3.2.3. Determination of Normalized Tank Area	
(1)	[F96,F99-OE1.1]
6.3.2.4. Determination of Normalized Tank Diameter	
(1)	[F96,F99-OE1.1]
6.3.2.5. Determination of Trade-off Values of Components, ToV_i	
(1)	[F96,F99-OE1.1]
6.3.2.6. Determination of Reference Heat Generator Efficiency, η_{ref}	
(1)	[F96,F99-OE1.1]
6.4.1.2. Limitations	
(1)	[F98,F99-OE1.1]

Notes to Table 6.5.1.1.:

(1) See Parts 2 and 3 of Division A.

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Part 7
Electrical Power Systems and Motors

Section 7.1. General

7.1.1. General

7.1.1.1. Scope

1) This Part is concerned with electrical power systems and motors for the application listed in Article 7.1.1.2.

7.1.1.2. Application

1) This Part applies to the electrical power systems and motors that are connected to the *building*'s electrical service. (See Appendix A.)

7.1.1.3. Compliance

1) Compliance with this Part shall be achieved by following
a) the prescriptive path described in Section 7.2., or
b) the performance path described in Section 7.4. (see A-3.1.1.3.(1)(c) in Appendix A).
(See Appendix A.)

7.1.1.4. Definitions

1) Words that appear in italics are defined in Article 1.4.1.2. of Division A.

Section 7.2. Prescriptive Path

7.2.1. Electrical Distribution System

7.2.1.1. Monitoring

(See Appendix A.)

1) Electrical distribution systems whose load-carrying capacity is greater than 250 kVA shall be designed to facilitate the installation of a means to monitor the electrical energy consumption of
a) HVAC systems,
b) *interior lighting*, and
c) *exterior lighting*.

2) The electrical distribution systems of *buildings* with tenants or *dwelling units* shall have a means to separately monitor the electrical energy consumption of the total *building* and of each individual tenant or *dwelling unit*, excluding shared systems.

7.2.2. Voltage Drop

7.2.2.1. Feeders

1) Feeder conductors shall be sized for a maximum voltage drop of 2% at design load.

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7.2.2.2. Branch Circuits

1) Branch circuit conductors shall be sized for a maximum voltage drop of 3% at design load.

7.2.3. Transformers

7.2.3.1. Transformer Selection

1) Transformers shall conform to
a) CAN/CSA-C802.1, "Minimum Efficiency Values for Liquid-Filled Distribution Transformers,"
b) CAN/CSA-C802.2, "Minimum Efficiency Values for Dry-Type Transformers,"or
c) CAN/CSA-C802.3, "Maximum Losses for Power Transformers."

7.2.4. Electrical Motors

7.2.4.1. Efficiency

1) Except for elevator motors and motors that are components of rated equipment, permanently wired polyphase motors serving the *building* shall have a nominal full-load motor efficiency not less than the minimum specified in Tables 3 and 5 of CSA C390, "Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors."

Section 7.3. Trade-off Path (Reserved)

Section 7.4. Performance Path

(See A-1.1.2.1. in Appendix A.)

7.4.1. General

7.4.1.1. Scope

1) Where electrical power systems and motors do not comply with the requirements of Section 7.2., they shall comply with Part 8.

Section 7.5. Objective and Functional Statements

7.5.1. Objective and Functional Statements

7.5.1.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in this Part shall be the objective and functional statements listed in Table 7.5.1.1. (See A-1.1.3.1.(1) in Appendix A.)

Table 7.5.1.1.
Objectives and Functional Statements Attributed to the Acceptable Solutions in Part 7
Forming Part of Sentence 7.5.1.1.(1)

Functional Statements and Objectives[1]	
7.2.2.1. Feeders	
(1)	[F99-OE1.1]

Table 7.5.1.1. (Continued)

Functional Statements and Objectives[1]	
7.2.2.2. Branch Circuits	
(1)	[F99-OE1.1]
7.2.3.1. Transformer Selection	
(1)	[F97,F98-OE1.1]

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Table 7.5.1.1. (Continued)

Functional Statements and Objectives[1]	
7.2.4.1. Efficiency	
(1)	[F97,F98,F99-OE1.1]

Notes to Table 7.5.1.1.:

(1) See Parts 2 and 3 of Division A.

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Part 8
Building Energy Performance Compliance Path

Section 8.1. General

8.1.1. General

8.1.1.1. Scope

1) Compliance with this Code is permitted to be achieved by applying the provisions of this Part in lieu of

a) the prescriptive requirements in Sections 3.2., 4.2., 5.2., 6.2. and 7.2., or
b) the trade-off provisions in Sections 3.3., 4.3., 5.3. and 6.3.

(See A-1.1.2.1. in Appendix A.)

8.1.1.2. Application

1) Except as provided in Sentence (2), this Part applies only to *buildings*

a) whose *occupancy* is known, and
b) for which sufficient information is known about their components, materials and assemblies that are covered by the scope of this Code.

2) Where insufficient information is known about the *building*'s components, materials and assemblies, the applicable prescriptive requirements in Sections 3.2., 4.2., 5.2., 6.2. and 7.2. shall apply.

3) If, during construction, conditions are found to be altered from those used in the original performance assessment, the *building* shall be reassessed for compliance with this Part.

4) Except as provided in Sentence (5), the procedures stated in this Part shall be applied to a single *building* at a time.

5) Where the structure is divided into multiple *buildings*, the whole structure is permitted to be treated as one *building*.

8.1.1.3. Definitions

1) Words that appear in italics are defined in Article 1.4.1.2. of Division A.

Section 8.2. Reserved

Section 8.3. Reserved

Section 8.4. Performance Path

8.4.1. Compliance

8.4.1.1. General

1) In establishing the *building energy target*, *building* components must be accounted for in accordance with the prescriptive requirements of Sections 3.2., 4.2., 5.2., 6.2. and 7.2. for the climate zone under consideration.

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2) Where the construction techniques or *building* components used are more energy-efficient than those prescribed by the prescriptive requirements, the performance compliance calculations are permitted to take this increased performance level into account in the determination of the *annual energy consumption*, provided it can be quantified and is not dependent on occupant interaction.

3) The following *building* components are permitted to be excluded from the performance compliance calculations, provided they comply with the prescriptive requirements of Parts 4 and 5, as applicable:

a) lighting of unconditioned spaces,
b) *exterior lighting*, and
c) ventilation of unconditioned spaces.

8.4.1.2. Determination of Compliance

1) Subject to the limitations stated in Article 8.4.1.3., compliance with this Part shall be determined based on Sentences (2) to (5).

2) The *annual energy consumption* of the proposed *building*, as determined in accordance with this Part, shall not exceed the *building energy target* of the reference *building*.

3) The number of hours during which the heating loads for each *thermal block* are not met shall not exceed 100 hours in a simulated year for both the proposed and reference *buildings*.

4) The number of hours during which the cooling loads for each *thermal block* of the proposed *building* are not met shall not differ by more than ±10% from the number of hours in a simulated year that the cooling loads of the reference *building* are not met.

5) Where the requirements of Sentences (3) and (4) are not met, the capacities of the *primary* and *secondary systems* of the proposed or reference *building* shall be incrementally increased until those loads are met.

8.4.1.3. Limitations

1) Compliance with this Part shall be subject to the limitations stated in Sections 3.4., 4.4., 5.4., 6.4. and 7.4.

8.4.1.4. Treatment of Additions

(See Appendix A.)

1) For the purpose of performance compliance calculations, the assessment of *additions* shall be based on

a) the *addition* being considered by itself, or
b) the *addition* being considered together with the existing *building*, in which case both the *building energy target* and the *annual energy consumption* shall be determined using the thermal characteristics of existing components of the *building envelope*.

2) Where the *addition* is being considered by itself, existing *primary* and *secondary systems* that are extended to serve the *addition* shall be modeled for the proposed *building*

a) as if they met the prescriptive requirements of the Code, or
b) using the characteristics of the existing equipment as determined in accordance with the standards referenced in Articles 5.2.12.1. and 6.2.2.1. (see Appendix A).

3) When the *addition* is being considered together with the existing *building*, the characteristics of existing components shall be their actual characteristics determined in accordance with Sections 3.2., 4.2., 5.2., 6.2. and 7.2.

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8.4.2. Compliance Calculations

8.4.2.1. General

1) Compliance with this Part shall be assessed through modelling that conforms to specifications detailed in this Part.

8.4.2.2. Calculation Methods

1) Except as provided in Sentences (2) and (6), the energy model calculations shall account for the *annual energy consumption* of

a) space-heating equipment,
b) space-cooling equipment,
c) fans,
d) *interior* and *exterior lighting* devices,
e) *service water* heating equipment,
f) pumps,
g) auxiliary HVAC equipment (see Appendix A),
h) receptacle loads and miscellaneous equipment as per Article 8.4.2.7.,
i) appliances, and
j) elevators and escalators.

2) For the purpose of compliance calculations, *building* components that meet the prescriptive requirements of this Code are permitted to be excluded from the energy model, provided their energy consumption or output produces no cross effects with other *building* components covered by this Code that result in an increase in the overall energy consumption of the proposed *building*.

3) The energy model calculations shall be performed for a one-year period (8 760 hours) using time intervals no greater than one hour.

4) Operating schedules and climatic data input in the energy model shall use a time interval no greater than one hour.

5) If a computer program is used to carry out the compliance calculations, the calculation methods employed in the energy model shall conform to

a) ANSI/ASHRAE 140, "Evaluation of Building Energy Analysis Computer Programs," or
b) an equivalent test method.

6) Redundant or back-up equipment is permitted to be excluded from the energy model, provided it is equipped with controls that operate the equipment only when the primary equipment is down.

8.4.2.3. Climatic Data

(See Appendix A.)

1) The energy model calculations shall be performed using values of climatic data, including temperature, humidity and insolation, that are derived from measured climatic data and shown to be good representations of climate at the *building* site compared to the average of at least 10 years of measured data collected at the weather station nearest to the *building* site.

2) For urban regions with several climatic data sets and for locations where weather data are not available, the energy model calculations shall be performed using available weather data that best represents the climate at the *building* site.

8.4.2.4. Thermal Mass

1) The energy model calculations shall account for the effect of thermal mass.

8.4.2.5. Space Temperature

1) The energy model calculations shall include a dynamic calculation of space temperatures.

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8.4.2.6. Heat Transfer Between Thermal Blocks

1) Where the temperature difference between two adjacent *thermal blocks* is greater than 10°C, the energy model calculations shall account for heat transfer between those *thermal blocks*.

2) Where the adjacent *thermal blocks* referred to in Sentence (1) are not fully separated by solid *partitions* or solid *building* elements, the energy model calculations shall use a heat transfer coefficient of 0.35 W/(m²·K).

8.4.2.7. Internal and Service Water Heating Loads

1) The energy model calculations shall account for the loads due to
a) number of occupants,
b) receptacle equipment,
c) *service water* heating systems, and
d) miscellaneous equipment, as applicable.
(See Appendix A.)

2) The energy model shall calculate the sensible and latent loads due to internal loads, lighting, and appliances. (See A-8.4.3.2.(1) and A-8.4.3.3.(1) in Appendix A.)

3) The internal loads shall be adjusted for each time interval referred to in Sentence 8.4.2.2.(4) based on the applicable operating schedule in A-8.4.3.2.(1) in Appendix A.

4) The calculation of sensible loads due to lighting shall account for
a) the effect of the proportion of radiant and convective heat, and
b) the percentage of heat gain from lighting going directly to return air.

5) Miscellaneous equipment located within a *conditioned space* that affects the energy consumption of one or more of the *building* systems described in Sentence 8.4.2.2.(1) shall be included in the energy model and its energy consumption shall be calculated.

8.4.2.8. Building Envelope

1) The energy model calculations shall account for heat transfer through walls, roofs and floors for each *thermal block*, while accounting for the dynamic response due to the thermal characteristics of the particular assembly.

2) Calculations of heat transfer through walls and roofs shall account for the effect of solar radiation absorbed on their exterior surfaces, which depends on the orientation and absorptance of each surface.

3) The energy model calculations shall account for heat transfer through *fenestration*, including *skylights*, while accounting for both indoor-outdoor temperature difference and transmission of solar radiation through the glazing.

4) Calculations of cooling and heating loads due to the transmission of solar radiation through *fenestration* shall account for
a) the orientation of the *fenestration*,
b) the solar optical properties of the glazing, and
c) dynamic response due to the effect of the thermal characteristics of each *thermal block*.

5) The insulated surface areas of above-ground roof assemblies shall
a) be calculated along the plane of the insulation using dimensions measured to the interior surfaces of intersecting exterior walls, and
b) exclude openings for *skylights* and chimneys as measured to the surfaces of structural framing surrounding such openings.

6) The insulated surface areas of exterior above-ground wall assemblies shall
a) be calculated using dimensions measured to the exterior surfaces of intersecting exterior walls and to the exterior ground level, exclusive of the perimeter areas where floor or roof slabs interrupt the wall construction (see A-3.1.1.7.(8) in Appendix A),

b) include perimeter areas of intersecting interior walls, and
c) exclude openings for doors and *fenestration*, as measured to the surfaces of structural framing surrounding such openings.

7) The insulated surface areas of above-ground exterior floor assemblies shall be calculated using dimensions measured to the exterior surface of perimeter walls.

8) The insulated surface areas of roof assemblies in contact with the ground shall be calculated along the plane of the insulation using dimensions measured to the exterior surfaces of intersecting exterior walls.

9) The insulated surface areas of wall assemblies in contact with the ground shall be calculated using dimensions measured
a) horizontally to the exterior surfaces of perimeter wall assemblies in contact with the ground, and
b) vertically from the exterior ground level to the underside of intersecting floors in contact with the ground.

10) The insulated surface areas of floor assemblies in contact with the ground shall be calculated using dimensions measured to the exterior surfaces of perimeter walls.

8.4.2.9. Air Leakage

1) The energy model calculations shall account for air leakage through the *building envelope*.

8.4.2.10. HVAC Systems Calculations

1) For the purpose of compliance calculations, the reference *building*'s HVAC systems determined in accordance with Article 8.4.4.8. shall be modeled without substituting their components with thermodynamically similar components or using approximated calculations.

2) The energy model calculations shall account for the effect of terminal devices, *primary systems* and *secondary systems* having limited capacities on space temperature and energy use.

3) Where applicable, the energy modelling of *secondary systems* shall account for
a) temperature rise of supply air due to heat from supply fan,
b) temperature rise of return air due to heat from return fan,
c) temperature rise of return air due to heat gain from lights,
d) fan power as a function of supply airflow in variable-air-volume systems,
e) temperature and humidity rise or drop of supply or return air due to heat (sensible and latent energy) transferred from a heat-recovery device, and
f) temperature rise of the outside air due to preheaters.

4) The energy model calculations shall determine how many hours the *primary system*, *secondary system* and terminal device loads are not met.

5) The energy model calculations shall account for the efficiency and capacity of the HVAC equipment as a function of part load and parameters such as, but not limited to, the temperatures of entering fluids and climatic conditions.

8.4.3. Annual Energy Consumption of Proposed Building

8.4.3.1. General

1) The *annual energy consumption* of the proposed *building* shall be calculated as described in this Subsection.

2) Except as stated otherwise in this Subsection, the energy model shall be consistent with the proposed *building*'s specifications including proper accounting of
a) *fenestration*, doors and *opaque building assembly* types and areas,
b) lighting systems and controls,
c) HVAC system types, capacities and controls,
d) *service water* heating system types, capacities and controls, and
e) electrical systems.

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3) The energy model calculations shall include all the energy use addressed in Sections 3.2., 4.2., 5.2., 6.2. and 7.2.

4) Each conditioned *thermal block* in the proposed *building* shall be modeled as being

a) heated, if only heating systems are provided,
b) cooled, if only cooling systems are provided, and
c) heated and cooled, if complete heating and cooling systems or only rough-ins are provided.

5) For the purpose of compliance calculations, where a *building* system or part of a *building* system has not been fully specified, it shall be assumed that it complies with the prescriptive requirements.

6) Where a *building envelope* assembly covers less than 5% of the total area of that assembly type, it is permitted to be excluded from the energy model, provided its area is included in an adjacent assembly having a similar U-value and the same orientation.

7) The energy model calculations shall not include manually operated *fenestration* shading devices, such as blinds or shades.

8) The energy model calculations shall include permanent *fenestration* shading devices, such as fins, overhangs, and light shelves.

8.4.3.2. Operating Schedules

1) The operating schedules relating to the presence of occupants and of loads due to the operation of lighting, receptacle equipment, and heating, cooling and *service water* heating systems shall be representative of the proposed *building*'s type or space functions. (See Appendix A.)

8.4.3.3. Internal and Service Water Heating Loads

1) Internal and *service water* heating loads used in the energy compliance calculations shall be representative of the proposed *building*'s type or space functions. (See Appendix A.)

8.4.3.4. Building Envelope Components

1) Where the solar absorptance of a *building envelope* component is not known, the energy model shall use a constant value of 0.7.

2) Where the energy model does not include a detailed calculation of *fenestration* shading, the actual solar heat gain coefficient of the *fenestration* shall be multiplied by an adjustment factor of 0.8. (See Appendix A.)

3) Air leakage shall be set to a constant value of 0.25 L/s·m² of total gross above-ground wall and roof areas. (See Appendix A.)

8.4.3.5. Interior Lighting

1) *Dwelling units* shall be modeled with an installed lighting power density of 5 W/m².

2) Where *occupant sensors* are provided, the *installed interior lighting power* shall be corrected with the appropriate adjustment factor from Section 4.3.

3) Where a detailed daylight calculation is not provided in the energy model, it shall be carried out in accordance with Section 4.3.

8.4.3.6. Purchased Energy

(See Appendix A.)

1) Where the proposed *building* uses purchased energy, Sentences (2) to (6) shall apply.

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2) Where purchased energy is used for heating, it shall be modeled as an electric *boiler* that

a) is sized for the peak heating load of the heating system, and
b) has a constant efficiency of 100%, independent of load.

3) Where purchased energy is used for cooling, it shall be modeled as an electric air-cooled chiller that

a) is sized for the peak cooling load on the primary cooling system, and
b) has a constant COP of 1.0, independent of load.

4) Where purchased energy is used for *service water* heating, it shall be modeled as an electric *service water* heater that

a) is sized for the peak heating capacity of the purchased energy,
b) has a constant efficiency of 100%, independent of load, and
c) where the purchased energy is used to heat *service water* in a heater with a storage tank, has the same storage capacity.

5) The operating schedule, priority of use and other operational characteristics of the purchased energy shall be included in the energy model.

6) Secondary use of purchased energy is permitted to be modeled in the compliance calculations for the proposed *building*. (See Appendix A.)

8.4.3.7. Outdoor Air

1) For the purpose of compliance calculations, the peak outdoor air ventilation rates shall be set to the minimum rates required by the applicable ventilation standard, based on the proposed *building*'s specifications. (See Appendix A.)

8.4.3.8. Space Temperature Control

1) Where the proposed *building*'s specifications do not specify the throttling ranges of the heating and cooling equipment, the energy model shall use a range of ±1°C.

8.4.3.9. Part-Load Performance Curves

1) Part-load performance curves for the proposed *building*'s systems shall be consistent with the equipment detailed in the *building* specifications.

2) Where part-load performance curves referred to in Sentence (1) are not available, the performance curves provided in Article 8.4.4.22. shall be used.

8.4.3.10. Ice-Making Machines for Curling Rinks and Ice Arenas

(See Appendix A.)

1) Where the proposed *building* is a curling rink or ice arena that recovers heat rejected by an ice-making machine, the machine shall be modeled as a water-cooled, double-bundle water chiller that rejects heat

a) to the appropriate hydronic systems, where these systems have a load, or
b) to the atmosphere using a cooling tower in accordance with Article 8.4.4.12.

8.4.4. Building Energy Target of the Reference Building

8.4.4.1. General

1) The *building energy target* of the reference *building* shall be calculated based on the parameters described in this Subsection.

2) The components and systems of the reference *building* shall meet the prescriptive requirements of Sections 3.2., 4.2., 5.2., 6.2. and 7.2.

3) The energy model calculations shall include all the energy uses addressed in Sections 3.2., 4.2., 5.2., 6.2. and 7.2.

4) Except as noted otherwise in this Subsection, the following characteristics of the reference *building* shall be modeled as being identical to those of the proposed *building*:

a) total floor area of *conditioned spaces*,
b) use of *building* spaces,

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c) number, type and conditioning of *thermal blocks*,
d) shape and exterior dimensions, and
e) orientation.

5) The presence or absence of heating and/or cooling systems in each conditioned *thermal block* of the reference *building* shall be modeled as being identical to those in the proposed *building*.

6) Climatic data used in the compliance calculations for the proposed *building* shall be applied.

7) The simulation shall account for the effect of part-load operation on equipment performance.

8.4.4.2. Operating Schedules

1) The reference *building*'s operating schedules shall be modeled as being identical to those determined for the proposed *building* in Sentence 8.4.3.2.(1).

8.4.4.3. Internal and Service Water Heating Loads

1) The reference *building*'s internal and *service water* heating loads shall be modeled as being identical to those determined for the proposed *building* in Sentence 8.4.3.3.(1).

2) A semi-heated *building* is permitted to have its set-point temperature set at 18°C, provided the capacity of the installed heating equipment in the proposed *building* is no more than the proposed *building*'s peak heating load plus 5%. (See A-3.3.4.1.(3) and 8.4.4.3.(2) in Appendix A.)

8.4.4.4. Building Envelope Components

1) Except as provided in Sentence (2), the solar absorptance of each *opaque building assembly* shall be modeled as being identical to that determined for the proposed *building* in Sentence 8.4.3.4.(1).

2) The solar absorptance of roof assemblies shall be
a) if the actual solar absorptance for the proposed *building* is not used, set to the same value used in the proposed *building*, or
b) if the actual solar absorptance for the proposed *building* is used, set to 0.7.

3) If the total vertical *fenestration* and door area to gross wall area ratio (FDWR) of the proposed *building* differs from the maximum permitted by Article 3.2.1.4., the FDWR of the reference *building* shall be adjusted proportionally along each orientation until it complies with that Article.

4) Permanent *fenestration* shading devices and projections shall not be modeled in the reference *building*.

5) If the proposed *building* is modeled with exterior shading provided by a nearby structure or *building*, the reference *building* shall also be modeled as such.

6) Air leakage rates shall be modeled as being identical to those determined for the proposed *building* in Sentence 8.4.3.4.(3).

7) Heat transfer through interior *partitions* shall be modeled as being identical to that of the proposed *building*.

8.4.4.5. Thermal Mass

1) The thermal characteristics of the reference *building*'s *building envelope* assembly shall be modeled as being identical to those of lightweight construction. (See Appendix A.)

2) The thermal characteristics of the reference *building*'s space shall be modeled as being identical to those of the proposed *building*. (See Appendix A.)

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8.4.4.6. Lighting

1) Except as provided in Sentences (2) and (3), the *installed interior lighting power* of the reference *building* shall be set at the *interior lighting power allowance* determined in Article 4.2.1.5. or 4.2.1.6., as applicable.

2) *Dwelling units* shall be modeled with an installed lighting power density of 5 W/m^2.

3) Where *occupant sensors* are required by Subsection 4.2.2., the *installed interior lighting power* shall be multiplied by an adjustment factor of 0.9.

4) The proportions of radiant and convective heat and the percentage of heat gain from lighting going directly to return air shall be modeled as being identical to those determined for the proposed *building* in Article 8.4.2.7.

8.4.4.7. Purchased Energy

1) Where a primary heating system of the proposed *building* uses purchased energy, the reference *building*'s corresponding system shall be modeled in accordance with the requirements of Article 8.4.4.10. adjusted as follows:

a) the energy type of each *boiler* shall be electricity,
b) each *boiler* shall have 100% efficiency, independent of load, and
c) the total capacity of the *boilers*, relative to the reference *building*'s total heating capacity, shall correspond to the ratio of the proposed *building*'s purchased energy capacity divided by its total heating capacity.

2) Where a primary cooling system of the proposed *building* uses purchased energy, the reference *building*'s corresponding system shall be modeled in accordance with the requirements of Article 8.4.4.11. adjusted as follows:

a) the energy type of each chiller shall be electricity,
b) each chiller shall have a COP of 1.0, independent of load, and
c) the total capacity of the chillers, relative to the reference *building*'s total cooling capacity, shall correspond to the ratio of the proposed *building*'s purchased energy capacity divided by its total cooling capacity.

3) Where a primary *service water* heating system of the proposed *building* uses purchased energy, the reference *building*'s corresponding system shall be modeled in accordance with the requirements of Article 8.4.4.14. adjusted as follows:

a) the energy type of each *service water* heater shall be electricity,
b) each *service water* heater shall have 100% efficiency, independent of load, and
c) the total capacity of the *service water* heaters, relative to the reference *building*'s total *service water* heating capacity, shall correspond to the ratio of the proposed *building*'s purchased energy capacity divided by its total heating capacity.

4) The operating schedule, priority of use and other operational characteristics of the proposed *building*'s use of purchased energy shall apply to the equipment representing the purchased energy in Sentences (1) to (3).

8.4.4.8. HVAC System Selection

1) Except as provided in Sentences (3) and (4), the type of HVAC system assigned to each *thermal block* of the reference *building* shall be determined based on each *thermal block*'s *building* or space type using Table 8.4.4.8.A. with the corresponding descriptions in Table 8.4.4.8.B.

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Table 8.4.4.8.A.
HVAC System Selection for the Reference Building
Forming Part of Sentences 8.4.4.8.(1), 8.4.4.11.(1) and (7), 8.4.4.14.(1) and 8.4.4.19.(6)

Building or Space Type of the Proposed *Building*	Size of *Building* or Space[1][2]	Type of HVAC System Required[3]
Assembly Area: exhibit space, conference/meeting/multi-purpose room, performing arts/motion picture *theatre*, courtroom, classroom/lecture/training room, place of worship, fellowship hall, sports centre, arena and swimming pool seating area, waiting room	Maximum 4 *storeys*	System - 3
	More than 4 *storeys*	System - 6
Automotive Area: *repair garage* or parking garage, fire engine room, indoor truck dock, indoor bus or train platform	All sizes	System - 4
Data Processing Area: control room, data centre	All sizes	Where the proposed *building* or space has a cooling capacity exceeding 20 kW, the reference *building* or space shall use System - 2; otherwise, the reference *building* or space shall use System - 1.
General Area: office, banking, health care clinic, library, retail/mall concourse, gymnasium, athletic play area, swimming pool, exercise centre, dressing room, lighting control room, atrium	Maximum 2 *storeys*	System - 3
	More than 2 *storeys*	System - 6
Historical Collections Area: archival library, museum and gallery archives	All sizes	System - 2
Hospital Area: operating theatre, emergency room, patient/recovery room, clean room, hospital laboratories, forensics laboratory	All sizes	System - 3
Indoor Arena: ice rinks, curling rinks	All sizes	System - 7
Industrial Area: industrial manufacturing and workshop without dust exhausting hood	All sizes	System - 3 Where the reference *building* or space is a single zone, it can be divided into multiple units as long as it matches the proposed *building* or space's units.
Residential/Accommodation Area: multi-unit residential, hotel/motel guest room	All sizes	Where the proposed *building* or space is heated only, the reference *building* or space shall use System - 1.
		Where the proposed *building* or space is heated as well as being cooled with an air-cooled unitary, packaged terminal or room air-conditioner (or heat pumps), or fan coils, the reference *building* or space's HVAC system shall be modeled as being identical to that of the proposed *building* or space; otherwise, the reference *building* or space shall use through-the-wall systems.
Sleeping Area: dormitory, detention cell, sleeping quarters	All sizes	System - 3
Supermarket/Food Service Area:		
grocery store, bar lounge/leisure, cafeteria, fast food, family dining, food preparation without kitchen hood or vented appliance[4]	All sizes	System - 3
food preparation with kitchen hood or vented appliance[4]	All sizes	System - 4
Warehouse Area: fine, medium and bulky material storage, self-storage, material handling/sorting/baggage areas	All sizes of non-refrigerated space	System - 4
	All sizes of refrigerated space	System - 5

Notes to Table 8.4.4.8.A.:

(1) Spaces generally located in the same vicinity shall be grouped together for the purpose of selecting the reference *building*'s type of HVAC system.

(2) Small individual spaces in the proposed *building* that are located among larger spaces of another space type shall be considered ancillary to that larger space: for example, a conference room serving office spaces would be grouped with the office spaces as one space type. The HVAC system serving that space in the reference *building* shall be the same as the one for the larger space type.

(3) See Table 8.4.4.8.B. for descriptions of HVAC Systems 1 - 7.

(4) Vented appliances include, for example, steam dishwashers.

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Table 8.4.4.8.B.
Descriptions of HVAC Systems 1 - 7
Forming Part of Sentences 8.4.4.8.(1) and 8.4.4.19.(3) and (4)

System Number	Type of HVAC System	Fan Control	Type of Cooling System	Type of Heating System(1)
System - 1	Unitary air-conditioner with baseboard heating(2)	Constant-volume	Air-cooled direct-expansion with remote condenser	Hot water with fuel-fired water *boiler* or electric resistance baseboard
System - 2	Four-pipe fan-coil(2)	Constant-volume	Water-cooled water chiller	Fuel-fired or electric resistance water *boiler*
System - 3	Single-zone packaged rooftop unit with baseboard heating	Constant-volume	Air-cooled direct-expansion	Fuel-fired or electric resistance *furnace* for rooftop, hot water with fuel-fired *boiler*, or electric resistance for baseboards
System - 4	Single-zone make-up air unit with baseboard heating	Constant-volume	Air-cooled direct-expansion	Make-up air unit: electric or indirect fuel-fired *furnace*
				Baseboards: electric resistance or hydronic with fuel-fired *boiler*
System - 5	Two-pipe fan-coil(2)	Constant-volume	Water-cooled water chiller	None
System - 6	Multi-zone built-up system with baseboard heating	Variable-volume	Water-cooled water chiller	Baseboards: electric resistance or hydronic with fuel-fired *boiler*
System - 7	Four-pipe fan-coil(2)	Constant-volume	Water-cooled water chiller	Hydronic with electric resistance or fuel-fired *boiler*

Notes to Table 8.4.4.8.B.:

(1) Where present, humidification systems shall use the same energy source as the heating system.

(2) Except for HVAC systems serving *dwelling units*, outside air requirements for the *thermal blocks* served by those systems shall be met by a single ventilation system able to meet all the required outside and exhaust air rates. For HVAC systems serving *dwelling units*, outside air requirements shall be met by a ventilation system identical to that of the proposed *building*.

2) If the *building* or space type of a *thermal block* of the proposed *building* is not listed in Table 8.4.4.8.A., the type that most closely corresponds to that *thermal block* shall be used for the reference *building*.

3) Where the area of a *building* or space type in the proposed *building* accounts for 10% or less of the total area of *conditioned spaces*, it is permitted to be excluded from the energy model, provided its area is added to an adjacent *building* or space type having similar space loads as those listed in Sentence 8.4.2.2.(1) and similar operating schedules as those determined in Sentence 8.4.3.2.(1).

4) For each *thermal block* of the proposed *building* having an HVAC system that includes a heat pump, the corresponding *thermal blocks* of the reference *building* shall be modeled with a type of HVAC system determined in accordance with Article 8.4.4.14.

8.4.4.9. Equipment Oversizing

1) The heating equipment of the reference *building* shall be modeled as being oversized by the lesser of

a) the percentage of oversizing applied to the proposed *building*, or
b) 30%.

2) The cooling equipment of the reference *building* shall be modeled as being oversized by the lesser of

a) the percentage of oversizing applied to the proposed *building*, or
b) 10%.

8.4.4.10. Heating System

1) Except as provided in Sentence (2), the heating system serving each *thermal block* of the reference *building* shall be determined in accordance with Table 8.4.4.8.A. and this Article.

2) Where the proposed *building* uses purchased energy, Article 8.4.4.7. shall apply to the reference *building*.

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3) Where Tables 8.4.4.8.A. and 8.4.4.8.B. indicate that a heating system is required in the *secondary system* as well as in a terminal device, the heating capacity of each type of equipment shall be set as follows:

a) the heating capacity of the terminal device shall meet the *thermal block*'s heating load due to the transfer of energy through the *building envelope* only,
b) the combined heating capacities of the heating systems in the terminal device and *secondary system* shall meet the peak heating load of the *thermal blocks* served by those systems, and
c) the applicable oversize factor shall apply to each type of equipment.

4) Except as provided in Sentence (5), the energy type of the reference *building*'s heating system shall be modeled as being identical to the energy type of the proposed *building*'s heating system.

5) Where more than one energy type is used by the proposed *building*'s heating system,

a) the heating capacities of the reference *building*'s heating equipment shall match the ratio of the proposed *building*'s heating equipment capacity allocation, and
b) the operating schedule, priority of use and other operational characteristics of the proposed *building*'s use of energy types shall apply.

6) Where a hydronic system is modeled in the reference *building*, the heating plant shall be modeled as follows:

a) the heating capacity of the heating plant shall be the sum of the heating capacities of the systems served by the plant, multiplied by the applicable oversize factor,
b) where the heating capacity is not greater than 176 kW, the heating plant shall be modeled with one single-stage *boiler*,
c) where the heating capacity is greater than 176 kW and not greater than 352 kW, the heating plant shall be modeled to operate as required by the reference *building*'s load with
   i) two *boilers* of equal capacity, or
   ii) a two-staged *boiler* that operates in stages with a 1:2 ratio,
d) where the heating capacity exceeds 352 kW, the heating plant shall be modeled with a *boiler* that is fully modulating down to 25% of its capacity,
e) the pumping system shall be modeled as a *primary system* with constant speed operation,
f) the peak pumping flow rate shall be set considering
   i) the installed heating plant's capacity,
   ii) use of pure water, and
   iii) a 16°C temperature drop,
g) the pump's operating schedule shall be modeled as being identical to that of the proposed *building*, and
h) the hot water supply temperature shall be reset to
   i) 82°C for an outside air temperature of –16°C, and
   ii) 60°C for an outside air temperature of 0°C.

7) Where the reference *building* contains a *furnace*, it shall be modeled as follows:

a) the heating capacity of the *furnace* shall be the sum of the heating loads of the *thermal blocks* served by the *furnace*, multiplied by the applicable oversize factor,
b) where the heating capacity is not greater than 66 kW, the *furnace* shall be modeled with two stages of equal capacity, and
c) where the heating capacity is greater than 66 kW, the *furnace* shall be modeled with a number of stages equal to its capacity divided by 66 kW and rounded up to the nearest integer.

8) Heating equipment performance characteristics as a function of part-load shall be modeled in accordance with the part-load performance curves found in Table 8.4.4.22.A.

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8.4.4.11. Cooling Systems

1) Except as provided in Sentence (2), the cooling system serving each *thermal block* of the reference *building* shall be determined in accordance with Table 8.4.4.8.A. and this Article.

2) Where the proposed *building* uses purchased energy, Article 8.4.4.7. shall apply to the reference *building*.

3) Except as provided in Sentence (4), the energy type of the reference *building*'s cooling system shall be modeled as being identical to that of the proposed *building*'s cooling system.

4) Where more than one energy type is used by the proposed *building*'s cooling system,

a) the cooling capacities of the reference *building*'s cooling equipment shall match the ratio of the proposed *building*'s cooling equipment capacity allocation, and
b) the operating schedule, priority of use and other operational characteristics of the proposed *building*'s use of energy types shall apply.

5) Cooling equipment performance characteristics as a function of part-load shall be modeled in accordance with the part-load performance curves found in Tables 8.4.4.22.C. to 8.4.4.22.F.

6) Where a hydronic system is installed, the cooling plant shall be modeled as follows:

a) the cooling capacity of the cooling plant shall be the sum of the cooling capacities of the systems served by the plant, multiplied by the applicable oversize factor,
b) where the cooling capacity is not greater than 2 100 kW, the cooling plant shall be modeled with one water chiller,
c) where the cooling capacity is greater than 2 100 kW, the cooling plant shall be modeled with two water chillers, each having half the capacity of the cooling plant's capacity,
d) the water chiller's pumping system shall be modeled as a *primary system* with constant speed operation,
e) the water chiller's pumping flow rate shall be set considering
    i) the cooling plant's capacity,
    ii) use of pure water, and
    iii) a 6°C temperature rise,
f) the types of water chillers shall be modeled as being identical to those of the proposed *building*,
g) the chilled water supply temperature shall be set at 7°C, and
h) each water chiller shall be fully modulating down to 25% of its capacity.

7) Where Table 8.4.4.8.A. indicates that a cooling system is required in the *secondary system* as well as in a terminal device, the cooling capacity of each type of equipment shall be set as follows:

a) the cooling capacity of the terminal device shall meet the *thermal block*'s cooling load due to the transfer of energy through the *building envelope* and internal loads only,
b) the combined cooling capacities of the cooling systems in the terminal device and *secondary system* shall meet the peak cooling load of the *thermal blocks* served by the system, and
c) the applicable oversize factor shall apply on each type of equipment.

8) Where a direct-expansion system is modeled in the reference *building*, that system shall be modeled as follows:

a) the cooling capacity of the system shall be the sum of the cooling loads of the *thermal blocks* served by the system, multiplied by the applicable oversize factor,

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b) where the cooling capacity of the system is not greater than 66 kW, the system shall be modeled with two stages of equal capacity, and
c) where the cooling capacity is greater than 66 kW, the system shall be modeled with a number of stages equal to its capacity divided by 66 kW and rounded up to the nearest integer.

9) For water-cooled systems, heat rejection to the atmosphere shall be modeled in accordance with Article 8.4.4.12.

8.4.4.12. Cooling Tower Systems

1) Where applicable, water-cooled systems shall be paired to a direct-contact cooling tower that has
a) a capacity equal to the nominal heat rejection rate of the equipment,
b) inlet and outlet water temperatures of 35°C and 29°C, respectively, and
c) an inlet outside air wet bulb temperature of 24°C.

2) A cooling tower with a capacity not greater than 1 750 kW shall be modeled with one cell.

3) A cooling tower with a capacity greater than 1 750 kW shall be modeled with a number of cells equal to its capacity divided by 1 750 and rounded up to the nearest integer.

4) The pumping system shall be modeled as constant speed operation.

5) The pumping flow rate shall be set considering
a) the cooling tower's capacity,
b) use of pure water, and
c) a 6°C temperature drop.

6) The fan of each cooling tower cell shall be modeled
a) as constant speed operation,
b) with a fan power equal to 0.015 multiplied by the cell's capacity in kW, and
c) with cycling control to maintain an outlet water temperature of 29°C.

8.4.4.13. Cooling with Outside Air

1) Where Article 5.2.2.6. applies to a proposed *building*'s HVAC system, the HVAC systems of the corresponding *thermal blocks* in the reference *building* shall be modeled in accordance with that Article and Table 8.4.4.13.

Table 8.4.4.13.
Applicable Requirements for Cooling with Outside Air According to Type of HVAC System
Forming Part of Sentence 8.4.4.13.(1)

Type of System	Applicable Article for Cooling with Outside Air
HVAC systems – 1, 3, 4 and 6(1)	5.2.2.8.
HVAC systems – 2, 5 and 7(1)	5.2.2.9.
All types of heat pump systems(2)	5.2.2.8.

Notes to Table 8.4.4.13.:
(1) See Table 8.4.4.8.B.
(2) See Table 8.4.4.14.

8.4.4.14. Heat Pumps

(See Appendix A.)

1) Except as provided in Sentence (2), where the proposed *building*'s HVAC system includes a water loop heat pump that supplies conditioned air to a *thermal block* or conditioned water to a hydronic loop, the reference *building*'s HVAC system for that *thermal block* shall be selected using Table 8.4.4.8.A. (See Appendix A.)

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2) Where the proposed *building*'s HVAC system includes an air-source, water-source or ground-source heat pump that supplies conditioned air to a *thermal block* or conditioned water to a hydronic loop,

a) the reference *building*'s HVAC system for that *thermal block* or for the *thermal blocks* supplied by the hydronic loop shall be an air-source heat pump described in Table 8.4.4.14.,
b) the heat pump's cooling capacity shall be set based on the peak cooling load, without oversizing,
c) the heat pump's heating capacity at an outdoor air temperature of 8.3°C shall be identical to its cooling capacity and reduced to 50% at –8.3°C,
d) the heat pump shall not operate in heating mode when the outdoor air temperature is below –10°C,
e) the heat pump's part-load performance shall be modeled in accordance with Table 8.4.4.22.E.,
f) the terminal heating's capacity or the heat pump's auxiliary heating capacity shall be set based on the peak heating load of the *thermal block* and the requirements of Subsections 8.4.1., 8.4.2. and 8.4.4.,
g) except as provided in Clause (h), the energy type of the heat pump's terminal heating or auxiliary heating shall be
    i) for an air-source heat pump, the energy type used for terminal or auxiliary heating of the *thermal blocks* of the proposed *building* served by that heat pump and having the largest annual energy use, provided the heat pump exceeds 33% of the total annual energy use for space heating for these *thermal blocks*, or
    ii) for a water-source or ground-source heat pump, the energy type used for terminal or auxiliary heating of the *thermal blocks* of the proposed *building* served by all the heat pumps connected to the same water loop and having the largest annual energy use, provided the heat pump exceeds 33% of the total annual energy use for space heating for these *thermal blocks*, and
h) where the heat pump is not an air-, water- or ground-source pump, the energy type of the heat pump's terminal heating or auxiliary heating shall be electricity.

Table 8.4.4.14.
Heat Pump System Description
Forming Part of Sentences 8.4.4.14.(2) and 8.4.4.19.(6)

System Number(1)	Type of System	Fan Control	Type of Terminal or Auxiliary Heating
System - 7	See Table 8.4.4.8.B.		
Systems - 1 to 6	Packaged unitary rooftop heat pump	Constant volume	Rooftop unit: fuel-fired or electric resistance *furnace*
			Baseboards: electric resistance or hydronic with fuel-fired *boiler*

Notes to Table 8.4.4.14.:
(1) System number is based on building or space type determined in accordance with Table 8.4.4.8.A.

8.4.4.15. Hydronic Pumps

1) Except as provided in Sentences (2) and (3), each hydronic pump of the reference *building* shall have a total static head and efficiency identical to that of the corresponding pump of the proposed *building*.

2) Where the proposed *building* uses more than one pump in a given hydronic system, the peak shaft power demand of the reference *building*'s pump shall be modeled as being identical to the combined peak shaft power demand of the proposed *building*'s pumps. (See Appendix A.)

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3) Where the total static head or efficiency of the proposed *building*'s hydronic pump is not known, the characteristics of the reference *building*'s hydronic pump shall be based on the peak power demand, in W/(L/s), of the proposed *building*'s pump.

4) Pump power, P, versus flow rate, V, shall be calculated using one of the following equations:

$$\text{If } V_{partload}/V_{rated} < d, \text{ then } P_{partload} = P_{rated} \cdot e$$

$$\text{If } V_{partload}/V_{rated} \geq d, \text{ then } P_{partload} = P_{rated} \cdot \left(a + b \cdot (V_{partload}/V_{rated}) + c \cdot (V_{partload}/V_{rated})^2\right)$$

where

$V_{partload}$ = flow rate at part-load conditions, in L/s,
V_{rated} = flow rate at rated conditions, in L/s,
$P_{partload}$ = power draw at part-load conditions, in kW,
P_{rated} = power draw at rated conditions, in kW, and
a, b, c, d, e = coefficients defined in Table 8.4.4.15.

Table 8.4.4.15.
Coefficients Used in Calculating Pump Power versus Flow Rate
Forming Part of Sentence 8.4.4.15.(4)

Coefficients	Type of Pump	
	Pump Riding its Curve	Pump with Variable Speed Drive
a	0.227143	0.00153028
b	1.178929	0.00520806
c	–0.41071	1.0086242
d	0.47	0.20
e	0.68	0.04

5) Variable-flow pumps shall be modeled as a pump riding its curve.

6) Where the *secondary system* defined in Tables 8.4.4.8.A. and 8.4.4.14. represents equipment meeting the requirements of Article 5.2.12.1. and whose minimum performance includes pump energy (in part or in whole), the performance of the heating and cooling equipment of the *secondary system* shall be adjusted so that the maximum power demand of the system, including pump power demand, meets the requirements of Article 5.2.12.1.

8.4.4.16. Outdoor Air

1) Except as provided in Sentence (2), the outdoor air ventilation rates for the reference *building* shall be modeled as being identical to those determined for the proposed *building* in Sentence 8.4.3.7.(1).

2) Except for heated parking garages, demand control ventilation strategies shall not be modeled in the reference *building*.

8.4.4.17. Space Temperature Control

1) If an in-floor, in-ceiling or in-wall radiant heating and/or cooling system is used in the proposed *building*, each conditioned *thermal block* in the reference *building* shall be modeled using heating and/or cooling temperature schedules, as applicable, that are 2°C warmer and 2°C cooler respectively than those used for the proposed *building* in Sentence 8.4.3.2.(1).

2) The throttling range of the heating and cooling equipment shall be modeled as being identical to that determined for the proposed *building* in Sentence 8.4.3.8.(1).

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8.4.4.18. Fans

1) Where the HVAC system of a *thermal block* of the proposed *building* includes a fan that exhausts air directly to the outside and complies with Sentences 5.2.3.1.(2) and 5.2.10.1.(3), its flow rate, power demand, operating schedule and part-load performance shall be modeled identically in the reference *building*. (See Appendix A.)

2) Fan power, P, versus flow rate, F, shall be calculated using one of the following equations:

$$\text{If } P < D, \text{ then } F = E$$
$$\text{If } P \geq D, \text{ then } F = A + B \cdot P + C \cdot P^2$$

where
A, B, C, D, E = coefficients defined in Table 8.4.4.18. (see Appendix A).

Table 8.4.4.18.
Coefficients Used in Calculating Fan Power versus Flow Rate
Forming Part of Sentence 8.4.4.18.(2)

Type of Fan	Coefficients				
	A	B	C	D	E
airfoil or backward inclined riding fan curve	0.227143	1.178929	–0.41071	0.47	0.68
airfoil or backward inclined with inlet vanes	0.584345	–0.57917	0.970238	0.35	0.50
forward curved with inlet vanes	0.339619	–0.84814	1.495671	0.25	0.22
variable speed drive	0.00153028	0.00520806	1.0086242	0.20	0.04

3) Except as provided in Sentences (4) and (5), individual fans shall be modeled as airfoil or backward inclined riding fan curve.

4) Where variable-air-volume fans are used, individual fans having a fan power greater than 7.5 kW and less than 25 kW shall be modeled as airfoil or backward inclined with inlet vanes.

5) Where variable-air-volume fans are used, individual fans having a fan power greater than or equal to 25 kW shall be modeled as forward curved with inlet vanes.

8.4.4.19. Supply Air Systems

1) The supply airflow rate provided by *secondary systems* shall be modeled as being equal to the sum of the airflow rates supplied to each of the *thermal blocks* calculated in accordance with Sentence (2).

2) The supply airflow rate to a *thermal block* shall be modeled as being the greater of
a) the airflow rate for heating, based on the peak heating load and a temperature difference of 21°C,
b) the airflow rate for cooling, based on the peak cooling load and a temperature difference of 11°C, or
c) the outdoor air ventilation rate supplied to the *thermal block* in the proposed *building*.

3) Except as provided in Sentence (6), HVAC systems - 1 to 5 and 7 of Table 8.4.4.8.B. shall be modeled with
a) a supply air temperature that is reset according to the *thermal block*'s load,
b) a supply fan that has a static pressure of 640 Pa and a combined fan-motor efficiency of 40%, and
c) no return fan.

4) Except as provided in Sentence (6), HVAC system - 6 of Table 8.4.4.8.B. shall be modeled with
a) a supply air temperature that is constant at 13°C,

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b) a supply fan that has a static pressure of 1 000 Pa and a combined fan-motor efficiency of 55%,
c) a return fan that has a static pressure of 250 Pa and a combined fan-motor efficiency of 30%, and
d) for each *thermal block*, a minimum supply airflow rate of
   i) 2 L/s per m² when the schedule indicates the *thermal block* is occupied, or
   ii) 0 L/s per m² otherwise.

5) Where the proposed *building*'s *secondary system* does not meet the requirements of Clause 5.2.3.1.(1)(b), the reference *building*'s *secondary system* shall be modeled as having an identical fan power demand.

6) Where a *secondary system* defined in Tables 8.4.4.8.A. and 8.4.4.14. comprises equipment whose fan energy is included in the minimum performance level required by Table 5.2.12.1., the capacity and performance of its heating and cooling equipment shall be adjusted so the maximum power demand of the *secondary system*, including fan power demand, meets the requirements of Article 5.2.12.1.

8.4.4.20. Heat-Recovery System

1) Where Subsection 5.2.10. applies to a proposed *building*'s HVAC system, the reference *building*'s HVAC systems for the corresponding *thermal blocks* shall use a heat-recovery system that complies with Subsection 5.2.10. and Sentences (2) and (3).

2) Heat recovered from an HVAC system's exhaust air shall be used to preheat the outside air supplied by that system.

3) Where the proposed *building* has ice-making loads along with simultaneous heating and/or *service water* heating loads, the reference *building*'s ice-making machine shall be modeled with the following characteristics and components:
a) a water-cooled, double-bundle water chiller having 100% heat-recovery capacity,
b) operation and performance characteristics, such as efficiency, capacity, part-load performance and pumping flow rates, that are identical to those of the proposed *building*'s machine,
c) peak load and demand schedules that are identical to those of the proposed *building*, and
d) the capability to reject heat to
   i) the hydronic systems for heating and *service water* heating, where these systems have a load, or
   ii) the atmosphere using a cooling tower defined in accordance with Articles 8.4.4.11. and 8.4.4.12. (see A-8.4.3.10. in Appendix A).

8.4.4.21. Service Water Heating Systems

1) Except as provided in Sentences (2) to (4), the reference *building*'s *service water* heating system shall be modeled as being identical to that of the proposed *building* as regards the following characteristics:
a) storage capacity,
b) power input, and
c) energy type.

2) Where the energy type of the proposed *building*'s *service water* heating system is an air-, water- or ground-source heat pump, the energy type of the reference *building*'s *service water* heating system shall be an air-source heat pump.

3) Where the energy type of the proposed *building*'s *service water* heating system is an immersion coil supplied by a *boiler*, the energy type of the reference *building*'s *service water* heating system shall be the same as that of the *boiler*.

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4) Where more than one energy type is used by the proposed *building*'s *service water* heating system,

a) the heating capacities of the reference *building*'s *service water* heating equipment shall match the ratio of the proposed *building*'s *service water* heating equipment capacity allocation, and
b) the operating schedule, priority of use and other operational characteristics of the proposed *building*'s use of energy types shall apply.

5) *Service water* heating equipment performance characteristics as a function of part-load shall be modeled in accordance with the part-load performance curves found in Table 8.4.4.22.G.

6) The *service water* heating system's supply temperature shall be modeled as being identical to that of the proposed *building*. (See Appendix A.)

7) Where a storage tank is to be modeled, the *service water* heating system's storage temperature shall be modeled as being identical to that of the proposed *building*. (See Appendix A.)

8) Where the proposed *building*'s *service water* heating system comprises multiple water heaters, the reference *building*'s *service water* heating system shall be modeled with the same number of water heaters.

9) Where the proposed *building*'s *service water* heating system is a recirculation system, the circulation pumps shall be modeled as

a) constant speed operation, and
b) having a flow rate that is identical to that of the proposed *building*'s circulation pumps.

8.4.4.22. Part-Load Performance Curves

1) Part-load performance curves for the reference *building*'s systems shall be calculated in accordance with Tables 8.4.4.22.A. to 8.4.4.22.G., as applicable.

Table 8.4.4.22.A.
Heating Equipment Part-Load Performance Characteristics
Forming Part of Sentences 8.4.4.10.(8) and 8.4.4.22.(1)

Boiler Part-Load Performance Curve(s)	The fuel consumption at part-load conditions, derived by applying an adjustment factor to the fuel consumption at design conditions, shall be calculated using the following equation. Condensing and non-condensing *boiler* curves fit the quadratic equation of FHeatPLC defined therein. For modulating *boilers*, values for $Q_{partload}/Q_{design}$ and corresponding values for FHeatPLC shall be those listed in the last row of this Table.

$$\mathrm{Fuel_{partload}} = \mathrm{Fuel_{design}} \cdot \mathrm{FHeatPLC} \quad (1)$$

where
$Fuel_{partload}$ = fuel consumption at part-load conditions, in Btu/h,
$Fuel_{design}$ = fuel consumption at design conditions, in Btu/h, and
FHeatPLC = fuel heating part-load efficiency curve determined using Equation (2) or values from the last row of this Table, as applicable.

$$\mathrm{FHeatPLC} = \left(\mathrm{a} + \mathrm{b} \cdot \frac{\mathrm{Q_{partload}}}{\mathrm{Q_{design}}} + \mathrm{c} \cdot \left(\frac{\mathrm{Q_{partload}}}{\mathrm{Q_{design}}}\right)^2\right) \quad (2)$$

where
$Q_{partload}$ = *boiler* capacity at part-load conditions, in Btu/h, or values from the last row of this Table, as applicable,
Q_{design} = *boiler* capacity at design conditions, in Btu/h, or values from the last row of this Table, as applicable, and
a, b, c = applicable values as follows:

Variable	Condensing *Boiler*	Non-condensing *Boiler*
a	0.00533	0.082597
b	0.904	0.996764
c	0.09066	–0.079361

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Table 8.4.4.22.A. (Continued)

<table>
<tr><td>*Furnace* Part-Load Performance Curve(s)</td><td>The fuel consumption at part-load conditions, derived by applying an adjustment factor to the fuel consumption at rated conditions, shall be calculated using the following equation. Condensing and atmospheric *furnace* curves fit the quadratic equation of FHeatPLC defined therein. For modulating *furnaces*, values for $Q_{partload}/Q_{rated}$ and corresponding values for FHeatPLC shall be those listed in the last row of this Table.

$$\mathrm{Fuel_{partload}} = \mathrm{Fuel_{rated}} \cdot \mathrm{FHeatPLC} \quad (3)$$
where
$Fuel_{partload}$ = fuel consumption at part-load conditions, in Btu/h,
$Fuel_{rated}$ = fuel consumption at rated conditions, in Btu/h, and
FHeatPLC = fuel heating part-load efficiency curve determined using Equation (4) or values from the last row of this Table, as applicable.

$$\mathrm{FHeatPLC} = \left(\mathrm{a} + \mathrm{b} \cdot \frac{\mathrm{Q_{partload}}}{\mathrm{Q_{rated}}} + \mathrm{c} \cdot \left(\frac{\mathrm{Q_{partload}}}{\mathrm{Q_{rated}}}\right)^2\right) \quad (4)$$
where
$Q_{partload}$ = *furnace* capacity at part-load conditions, in Btu/h, or values from the last row of this Table, as applicable,
Q_{rated} = *furnace* capacity at rated conditions, in Btu/h, or values from the last row of this Table, as applicable, and
a, b, c = applicable values as follows:

<table>
<tr><th>Variable</th><th>Condensing *Furnace*</th><th>Atmospheric *Furnace*</th></tr>
<tr><td>a</td><td>0.00533</td><td>0.0186100</td></tr>
<tr><td>b</td><td>0.904</td><td>1.0942090</td></tr>
<tr><td>c</td><td>0.09066</td><td>–0.1128190</td></tr>
</table></td></tr>
<tr><td>Modulating *Boilers* and *Furnaces*</td><td>
<table>
<tr><th>$Q_{partload}$, Q_{rated} and Q_{design} (Part-Load Ratio)</th><th>FHeatPLC</th></tr>
<tr><td>0.1</td><td>0.118</td></tr>
<tr><td>0.2</td><td>0.209</td></tr>
<tr><td>0.3</td><td>0.308</td></tr>
<tr><td>0.4</td><td>0.407</td></tr>
<tr><td>0.5</td><td>0.506</td></tr>
<tr><td>0.6</td><td>0.605</td></tr>
<tr><td>0.7</td><td>0.704</td></tr>
<tr><td>0.8</td><td>0.802</td></tr>
<tr><td>0.9</td><td>0.901</td></tr>
<tr><td>1</td><td>1</td></tr>
</table></td></tr>
</table>

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Table 8.4.4.22.B.
Direct-Expansion Cooling Equipment Part-Load Performance Characteristics
Forming Part of Sentence 8.4.4.22.(1)

Electric Direct-Expansion (DX) Coil Cooling Capacity Adjustment Curve(s)	This curve or group of curves represents the available total cooling capacity of a DX coil as a function of cooling coil and condenser conditions. $$Q_{available} = CAP_FT_{EDX} \cdot Q_{rated} \quad (1)$$ where $Q_{available}$ = available cooling capacity at present evaporator and condenser conditions, in MBH, CAP_FT_{EDX} = cooling capacity adjustment determined using Equation (2), and Q_{rated} = rated capacity at ARI conditions, in MBH. $$CAP_FT_{EDX} = a + b \cdot t_{wb} + c \cdot t_{wb}^2 + d \cdot t_{odb} + e \cdot t_{odb}^2 + f \cdot t_{wb} \cdot t_{odb} \quad (2)$$ where t_{wb} = entering coil wet-bulb temperature, in °F, t_{odb} = outside-air dry-bulb temperature, in °F (If an air-cooled unit uses an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.), a = 0.8740302, b = –0.0011416, c = 0.0001711, d = –0.0029570, e = 0.0000102, and f = –0.0000592.
Electric Direct-Expansion (DX) Coil Cooling Efficiency Adjustment Curve(s)	This curve or group of curves varies the cooling efficiency of a DX coil as a function of evaporator and condenser conditions and part-load ratio. $$P_{operating} = P_{rated} \cdot EIR_FPLR \cdot EIR_FT \cdot CAP_FT_{EDX} \quad (3)$$ where $P_{operating}$ = power draw at specified operating conditions, in kW, P_{rated} = rated power draw at ARI conditions, in kW, EIR_FPLR = electric input ratio adjustment to rated efficiency due to changes in coil load determined using Equation (4), EIR_FT = electric input ratio adjustment to rated efficiency due to environmental variables determined using Equation (6), and CAP_FT_{EDX} = cooling capacity adjustment determined using Equation (2). $$EIR_FPLR = a + b \cdot PLR + c \cdot PLR^2 + d \cdot PLR^3 \quad (4)$$ where PLR = part-load ratio based on available capacity (not rated capacity) determined using Equation (5), a = 0.2012301, b = –0.0312175, c = 1.9504979, and d = –1.1205105. $$PLR = \frac{Q_{operating}}{Q_{available}} \quad (5)$$ where $Q_{operating}$ = present load, in Btu/h, and $Q_{available}$ = available capacity at present evaporator and condenser conditions, in Btu/h, determined using Equation (1).

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Table 8.4.4.22.B. (Continued)

	$$EIR_FT = a + b \cdot t_{wb} + c \cdot t_{wb}^{2} + d \cdot t_{odb} + e \cdot t_{odb}^{2} + f \cdot t_{wb} \cdot t_{odb} \quad (6)$$ where t_{wb} = entering coil wet-bulb temperature, in °F, t_{odb} = outside-air dry-bulb temperature, in °F (If an air-cooled unit uses an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.), a = –1.0639310, b = 0.0306584, c = –0.0001269, d = 0.0154213, e = 0.0000497, and f = –0.0002096.

Table 8.4.4.22.C.
Electric Chiller Cooling Equipment Part-Load Performance Characteristics
Forming Part of Sentences 8.4.4.11.(5) and 8.4.4.22.(1)

<table>
<tr><td>Electric Chiller Cooling Capacity Adjustment Curve(s)</td><td colspan="8">This curve or group of curves represents the available total cooling capacity of an electric chiller as a function of evaporator and condenser conditions.
$$Q_{available} = CAP_FT_{EC} \cdot Q_{rated} \quad (1)$$
where
$Q_{available}$ = available cooling capacity at present evaporator and condenser conditions, in MBH,
CAP_FT_{EC} = cooling capacity adjustment determined using Equation (2), and
Q_{rated} = rated capacity at ARI conditions, in MBH.
$$CAP_FT_{EC} = a + b \cdot t_{chws} + c \cdot t_{chws}^{2} + d \cdot t_{cws} + e \cdot t_{cws}^{2} + f \cdot t_{chws} \cdot t_{cws} \quad (2)$$
where
t_{chws} = chilled water supply temperature, in °F,
t_{cws} = condenser water supply temperature, in °F, and
a-f = applicable coefficient values as follows:</td></tr>
<tr><td></td><td colspan="8">Capacity Coefficients for Calculation of CAP_FT_{EC}</td></tr>
<tr><td colspan="2">Type of Chiller</td><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>f</td></tr>
<tr><td rowspan="4">Air-Cooled</td><td>Scroll</td><td>0.40070684</td><td>0.01861548</td><td>0.00007199</td><td>0.00177296</td><td>–0.00002014</td><td>–0.00008273</td></tr>
<tr><td>Reciprocating</td><td>0.57617295</td><td>0.02063133</td><td>0.00007769</td><td>–0.00351183</td><td>0.00000312</td><td>–0.00007865</td></tr>
<tr><td>Screw</td><td>–0.09464899</td><td>0.03834070</td><td>–0.00009205</td><td>0.00378007</td><td>–0.00001375</td><td>–0.00015464</td></tr>
<tr><td>Centrifugal</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td rowspan="4">Water-Cooled</td><td>Scroll</td><td>0.36131454</td><td>0.01855477</td><td>0.00003011</td><td>0.00093592</td><td>–0.00001518</td><td>–0.00005481</td></tr>
<tr><td>Reciprocating</td><td>0.58531422</td><td>0.01539593</td><td>0.00007296</td><td>–0.00212462</td><td>–0.00000715</td><td>–0.00004597</td></tr>
<tr><td>Screw</td><td>0.332669598</td><td>0.00729116</td><td>–0.00049938</td><td>0.01598983</td><td>–0.00028254</td><td>0.00052346</td></tr>
<tr><td>Centrifugal</td><td>–0.29861975</td><td>0.02996076</td><td>–0.00080125</td><td>0.01736268</td><td>–0.00032606</td><td>0.00063139</td></tr>
<tr><td>Electric Chiller Cooling Efficiency Adjustment Curve(s)</td><td colspan="8">This curve or group of curves varies the cooling efficiency of an electric chiller as a function of evaporator and condenser conditions and part-load ratio.
$$P_{operating} = P_{rated} \cdot EIR_FPLR \cdot EIR_FT \cdot CAP_FT_{EC} \quad (3)$$
where
$P_{operating}$ = power draw at specified operating conditions, in kW,
P_{rated} = rated power draw at ARI conditions, in kW,
EIR_FPLR = electric input ratio adjustment to rated efficiency due to changes in load determined using Equation (4),
EIR_FT = electric input ratio adjustment to rated efficiency due to environmental variables determined using Equation (6), and
CAP_FT_{EC} = value determined using Equation (2).</td></tr>
</table>

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Table 8.4.4.22.C. (Continued)

$$\mathrm{EIR_FPLR} = \mathrm{a} + \mathrm{b} \cdot \mathrm{PLR} + \mathrm{c} \cdot \mathrm{PLR}^2 \quad (4)$$

where

PLR = part-load ratio based on available capacity (not rated capacity) determined using Equation (5), and

a-c = applicable coefficient values as follows:

Efficiency Coefficients for Calculation of EIR_FPLR				
Type of Chiller		a	b	c
Air-cooled	Scroll	0.06369119	0.58488832	0.35280274
	Reciprocating	0.1143742	0.5459334	0.34229861
	Screw	0.03648722	0.73474298	0.21994748
	Centrifugal	n/a	n/a	n/a
Water-cooled	Scroll	0.04411957	0.64036703	0.31955532
	Reciprocating	0.08144133	0.41927141	0.49939604
	Screw	0.33018833	0.23554291	0.46070828
	Centrifugal	0.17149273	0.58820208	0.23737257

$$\mathrm{PLR} = \frac{\mathrm{Q_{operating}}}{\mathrm{Q_{available}}} \quad (5)$$

where

$Q_{operating}$ = present load on chiller, in Btu/h, and

$Q_{available}$ = chiller available capacity at present evaporator and condenser conditions, in Btu/h, determined using Equation (1).

$$\mathrm{EIR_FT} = \mathrm{a} + \mathrm{b} \cdot \mathrm{t_{chws}} + \mathrm{c} \cdot \mathrm{t_{chws}}^2 + \mathrm{d} \cdot \mathrm{t_{cws}} + \mathrm{e} \cdot \mathrm{t_{cws}}^2 + \mathrm{f} \cdot \mathrm{t_{chws}} \cdot \mathrm{t_{cws}} \quad (6)$$

where

t_{chws} = chilled water supply temperature, in °F,

t_{cws} = condenser water supply temperature, in °F, and

a-f = applicable coefficient values as follows:

Efficiency Coefficients for Calculation of EIR_FT							
Type of Chiller		a	b	c	d	e	f
Air-Cooled	Scroll	0.99006553	–0.00584144	0.00016454	–0.00661136	0.00016808	–0.00022501
	Reciprocating	0.66534403	–0.01383821	0.00014736	0.00712808	0.00004571	–0.00010326
	Screw	0.013545636	0.02292946	–0.00016107	–0.00235396	0.00012991	–0.00018585
	Centrifugal	n/a	n/a	n/a	n/a	n/a	n/a
Water-Cooled	Scroll	1.00121431	–0.01026981	0.00016703	–0.0128136	0.00014613	–0.00021959
	Reciprocating	0.46140041	–0.0882156	0.00008223	0.00926607	0.00005722	–0.00011594
	Screw	0.66625406	0.00068584	0.00028496	–0.00341677	0.00025484	–0.00048195
	Centrifugal	0.51777196	–0.00400363	0.00002026	0.00698793	0.00008290	–0.00015467

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Table 8.4.4.22.D.
Cooling Tower Equipment Part-Load Performance Characteristics
Forming Part of Sentences 8.4.4.11.(5) and 8.4.4.22.(1)

Cooling Tower Capacity Adjustment Curve(s)	This curve or group of curves represents the available total cooling capacity of a cooling tower as a function of outdoor air wet-bulb, condenser water supply and condenser water return temperatures.

$$Q_{available} = Q_{rated} \cdot FWB \cdot \left(\frac{t_R}{10}\right) \quad (1)$$

where
$Q_{available}$ = available cooling capacity at present outside air and condenser water conditions, in MBH,
Q_{rated} = rated cooling capacity at CTI test conditions, in MBH,
FWB = ratio of available capacity to rated capacity, in gpm/gpm, determined using Equation (2), and
t_R = tower range, in °F, determined using Equation (4).

$$FWB = a + b \cdot FRA + c \cdot FRA^2 + d \cdot t_{cwb} + e \cdot t_{cwb}{}^2 + f \cdot FRA \cdot t_{cwb} \quad (2)$$

where
FRA = intermediate capacity curve based on range and approach determined using Equation (3),
t_{cwb} = outside-air wet-bulb temperature, in °F,
a = 0.60531402,
b = –0.03554536,
c = 0.00804083,
d = –0.02860259,
e = 0.00024972, and
f = 0.00490857.

$$FRA = \frac{-d - f \cdot t_R + \sqrt{(d + f \cdot t_R)^2 - 4 \cdot e \cdot (a + b \cdot t_R + c \cdot t_R{}^2 - t_A)}}{2 \cdot e} \quad (3)$$

where
t_R = tower range, in °F, determined using Equation (4),
t_A = tower approach, in °F, determined using Equation (5),
a = –2.22888899,
b = 0.16679543,
c = –0.01410247,
d = 0.03222333,
e = 0.18560214, and
f = 0.24251871.

$$t_R = t_{cwr} - t_{cws} \quad (4)$$

and

$$t_A = t_{cws} - t_{owb} \quad (5)$$

where
t_{cwr} = condenser water return temperature, in °F,
t_{cws} = condenser water supply temperature, in °F, and
t_{owb} = outside-air wet-bulb temperature, in °F.

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Table 8.4.4.22.E.
Electric Air-Source Heat Pump Equipment Part-Load Performance Characteristics
Forming Part of Sentences 8.4.4.11.(5), 8.4.4.14.(2) and 8.4.4.22.(1)

Electric Air-Source Heat Pump Heating Capacity Adjustment Curve(s)	This curve or group of curves represents the available heating capacity of the heat pump as a function of evaporator and condenser conditions. $$Q_{available} = CAP_FT_{EAS} \cdot Q_{rated} \quad (1)$$ where $Q_{available}$ = available heating capacity at present evaporator and condenser conditions, in MBH, CAP_FT_{EAS} = heating capacity adjustment determined using Equation (2), and Q_{rated} = rated capacity at ARI conditions, in MBH. $$CAP_FT_{EAS} = a + b \cdot t_{odb} + c \cdot t_{odb}^{2} + d \cdot t_{odb}^{3} \quad (2)$$ where t_{odb} = outside-air dry-bulb temperature, in °F, a = 0.2536714, b = 0.0104351, c = 0.0001861, and d = –0.0000015.
Electric Air-Source Heat Pump Heating Efficiency Adjustment Curve(s)	This curve or group of curves varies the heating efficiency of the heat pump as a function of evaporator and condenser conditions and part-load ratio. $$P_{operating} = P_{rated} \cdot EIR_FPLR \cdot EIR_FT \cdot CAP_FT_{EAS} \quad (3)$$ where $P_{operating}$ = power draw at specified operating conditions, in kW, P_{rated} = rated power draw at ARI conditions, in kW, EIR_FPLR = electric input ratio adjustment to rated efficiency due to changes in heat pump load determined using Equation (4), EIR_FT = electric input ratio adjustment to rated efficiency due to environmental variables determined using Equation (6), and CAP_FT_{EAS} = heating capacity adjustment determined using Equation (2). $$EIR_FPLR = a + b \cdot PLR + c \cdot PLR^{2} + d \cdot PLR^{3} \quad (4)$$ where PLR = part-load ratio based on available capacity (not rated capacity) determined using Equation (5), a = 0.0856522, b = 0.9388137, c = –0.1834361, and d = 0.1589702. $$PLR = \frac{Q_{operating}}{Q_{available}} \quad (5)$$ where $Q_{operating}$ = present load on heat pump, in Btu/h, and $Q_{available}$ = heat pump available capacity at present evaporator and condenser conditions, in Btu/h, determined using Equation (1). $$EIR_FT = a + b \cdot t_{odb} + c \cdot t_{odb}^{2} + d \cdot t_{odb}^{3} \quad (6)$$ where t_{odb} = outside-air dry-bulb temperature, in °F, a = 2.4600298, b = –0.0622539, c = 0.0008800, and d = –0.0000046.

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Table 8.4.4.22.F.
Absorption Chiller Cooling Equipment Part-Load Performance Characteristics
Forming Part of Sentences 8.4.4.11.(5) and 8.4.4.22.(1)

Absorption Chiller Cooling Capacity Adjustment Curve(s)

This curve or group of curves represents the available total cooling capacity of the absorption chiller as a function of evaporator and condenser conditions.

$$Q_{available} = CAP_FT_{AC} \cdot Q_{rated} \quad (1)$$

where
$Q_{available}$ = available cooling capacity at present evaporator and condenser conditions, in MBH,
CAP_FT_{AC} = cooling capacity adjustment determined using Equation (2), and
Q_{rated} = rated capacity at ARI conditions, in MBH.

$$CAP_FT_{AC} = a + b \cdot t_{chws} + c \cdot t_{chws}^{\ 2} + d \cdot t_{cws} + e \cdot t_{cws}^{\ 2} + f \cdot t_{chws} \cdot t_{cws} \quad (2)$$

where
t_{chws} = chilled water supply temperature, in °F,
t_{cws} = condenser water supply temperature, in °F, and
a-f = applicable coefficients as follows:

Capacity Coefficients for Calculation of CAP_FT_{AC}						
Absorption	a	b	c	d	e	f
Single-effect	0.723412	0.079006	0.000897	–0.025285	–0.000048	0.000276
Double-effect	–0.816039	–0.038707	0.000450	0.071491	–0.000636	0.000312
Direct-fired	1.0	0	0	0	0	0

Absorption Chiller: Steam-driven, Single- and Double-effect Chiller Efficiency Curve(s)

This curve or group of curves varies the cooling efficiency of a steam-driven, single- and double-effect absorption chiller as a function of evaporator and condenser conditions and part-load ratio.

$$Fuel_{partload} = Fuel_{rated} \cdot FIR_FPLR \cdot FIR_FT \cdot CAP_FT_{AC} \quad (3)$$

where
$Fuel_{partload}$ = fuel consumption at specified operating conditions, in Btu/h,
$Fuel_{rated}$ = rated fuel consumption at ARI conditions, in Btu/h,
FIR_FPLR = fuel input ratio adjustment to rated efficiency due to changes in load determined using Equation (4),
FIR_FT = fuel input ratio adjustment to rated efficiency due to environmental variables determined using Equation (6), and
CAP_FT_{AC} = value determined using Equation (2).

$$FIR_FPLR = a + b \cdot PLR + c \cdot PLR^2 \quad (4)$$

where
PLR = part-load ratio based on available capacity (not rated capacity) determined using Equation (5), and
a-c = applicable coefficients as follows:

Efficiency Coefficients for Calculation of FIR_FPLR			
Absorption	a	b	c
Single-effect	0.098585	0.583850	0.560658
Double-effect	0.013994	1.240449	–0.914883

$$PLR = \frac{Q_{operating}}{Q_{available}} \quad (5)$$

where
$Q_{operating}$ = present load on chiller, in Btu/h, and
$Q_{available}$ = chiller available capacity at present evaporator and condenser conditions, in Btu/h, determined using Equation (1).

$$FIR_FT = a + b \cdot t_{chws} + c \cdot t_{chws}^{\ 2} + d \cdot t_{cws} + e \cdot t_{cws}^{\ 2} + f \cdot t_{chws} \cdot t_{cws} \quad (6)$$

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Table 8.4.4.22.F. (Continued)

<table>
<tr><td></td><td>
where
t_{chws} = chilled water supply temperature, in °F,
t_{cws} = condenser water supply temperature, in °F, and
a-f = applicable coefficients as follows:
<table>
<tr><th colspan="7">Efficiency Coefficients for Calculation of FIR_FT</th></tr>
<tr><th>Absorption</th><th>a</th><th>b</th><th>c</th><th>d</th><th>e</th><th>f</th></tr>
<tr><td>Single-effect</td><td>0.652273</td><td>0</td><td>0</td><td>–0.000545</td><td>0.000055</td><td>0</td></tr>
<tr><td>Double-effect</td><td>1.658750</td><td>0</td><td>0</td><td>–0.29</td><td>0.000250</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>Absorption Chiller: Direct-fired, Double-effect Chiller Efficiency Adjustment Curve(s)</td><td>
This curve or group of curves varies the cooling efficiency of a direct-fired, double-effect absorption chiller as a function of evaporator and condenser conditions and part-load ratio.

$$\mathrm{Fuel_{partload}} = \mathrm{Fuel_{rated}} \cdot \mathrm{FIR_FPLR} \cdot \mathrm{FIR_FT1} \cdot \mathrm{FIR_FT2} \cdot \mathrm{CAP_FT_{AC}} \quad (7)$$
where
$Fuel_{partload}$ = fuel consumption at specified operating conditions, in Btu/h,
$Fuel_{rated}$ = rated fuel consumption at ARI conditions, in Btu/h,
FIR_FPLR = fuel input ratio adjustment to rated efficiency due to changes in load determined using Equation (8),
FIR_FT1 = fuel input ratio adjustment to rated efficiency due to environmental variables determined using Equation (10),
FIR_FT2 = fuel input ratio adjustment to rated efficiency due to environmental variables determined using Equation (11), and
CAP_FT_{AC} = value determined using Equation (2).

$$\mathrm{FIR_FPLR} = \mathrm{a} + \mathrm{b} \cdot \mathrm{PLR} + \mathrm{c} \cdot \mathrm{PLR}^2 \quad (8)$$
where
PLR = part-load ratio based on available capacity (not rated capacity) determined using Equation (9),
a = 0.13551150,
b = 0.61798084, and
c = 0.24651277.

$$\mathrm{PLR} = \frac{\mathrm{Q_{operating}}}{\mathrm{Q_{available}}} \quad (9)$$
where
$Q_{operating}$ = present load, in Btu/h, and
$Q_{available}$ = chiller available capacity at present evaporator and condenser conditions, in Btu/h, determined using Equation (1).

$$\mathrm{FIR_FT1} = \mathrm{a} + \mathrm{b} \cdot \mathrm{t_{chws}} + \mathrm{c} \cdot \mathrm{t_{chws}}^2 \quad (10)$$

and

$$\mathrm{FIR_FT2} = \mathrm{d} + \mathrm{e} \cdot \mathrm{t_{cws}} + \mathrm{f} \cdot \mathrm{t_{cws}}^2 \quad (11)$$
where
t_{chws} = chilled water supply temperature, in °F,
t_{cws} = condenser water supply temperature, in °F,
a = 4.42871284,
b = –0.13298607,
c = 0.00125331,
d = 0.86173749,
e = –0.00708917, and
f = 0.0010251.
</td></tr>
</table>

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Table 8.4.4.22.G.
Fuel-Fired Service Water Heater Part-Load Performance Characteristics
Forming Part of Sentences 8.4.4.21.(5) and 8.4.4.22.(1)

Fuel-Fired *Service Water* Heater Part-Load Efficiency Curve(s)	The fuel consumption at part-load conditions, derived by applying an adjustment factor to the fuel consumption at full load, shall be calculated using the following equation: $$\mathrm{Fuel_{partload}} = \mathrm{Fuel_{design}} \cdot \mathrm{FHeatPLC} \quad (1)$$ where $Fuel_{partload}$ = fuel consumption at part-load conditions, in Btu/h, $Fuel_{design}$ = fuel consumption at design conditions, in Btu/h, and FHeatPLC = fuel heating part-load efficiency curve determined using Equation (2). $$\mathrm{FHeatPLC} = \left(\mathrm{a} + \mathrm{b} \cdot \frac{\mathrm{Q_{partload}}}{\mathrm{Q_{design}}} + \mathrm{c} \cdot \left(\frac{\mathrm{Q_{partload}}}{\mathrm{Q_{design}}}\right)^2\right) \quad (2)$$ where $Q_{partload}$ = *service water* heater capacity at part-load conditions, in Btu/h, Q_{design} = *service water* heater capacity at design conditions, in Btu/h, a = 0.021826, b = 0.977630, and c = 0.000543.

Section 8.5. Objective and Functional Statements

8.5.1. Objective and Functional Statements

8.5.1.1. Attributions to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1.(1)(b) of Division A, the objective and functional statements attributed to the acceptable solutions in this Part shall be the objective and functional statements listed in Table 8.5.1.1. (See A-1.1.3.1.(1) in Appendix A.)

Table 8.5.1.1.
Objectives and Functional Statements Attributed to the Acceptable Solutions in Part 8
Forming Part of Sentence 8.5.1.1.(1)

Functional Statements and Objectives[1]	
8.1.1.2. Application	
(1)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
8.4.1.1. General	
(1)	[F99-OE1.1]
(2)	[F92,F93,F94,F95,F96,F97,F98,F99,F100-OE1.1]
8.4.1.2. Determination of Compliance	
(2)	[F92,F93,F94,F95,F96,F97,F98,F99,F100-OE1.1]
(3)	[F99-OE1.1]

Table 8.5.1.1. (Continued)

Functional Statements and Objectives[1]	
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
8.4.1.4. Treatment of Additions	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
8.4.2.1. General	
(1)	[F99-OE1.1]
8.4.2.2. Calculation Methods	
(1)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]

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Table 8.5.1.1. (Continued)

Functional Statements and Objectives[1]	
8.4.2.3. Climatic Data	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
8.4.2.4. Thermal Mass	
(1)	[F99-OE1.1]
8.4.2.5. Space Temperature	
(1)	[F99-OE1.1]
8.4.2.6. Heat Transfer Between Thermal Blocks	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
8.4.2.7. Internal and Service Water Heating Loads	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
8.4.2.8. Building Envelope	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
(7)	[F99-OE1.1]
(8)	[F99-OE1.1]
(9)	[F99-OE1.1]
(10)	[F99-OE1.1]
8.4.2.9. Air Leakage	
(1)	[F99-OE1.1]
8.4.2.10. HVAC Systems Calculations	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
8.4.3.1. General	
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(7)	[F99-OE1.1]
(8)	[F99-OE1.1]

Table 8.5.1.1. (Continued)

Functional Statements and Objectives[1]	
8.4.3.2. Operating Schedules	
(1)	[F99-OE1.1]
8.4.3.3. Internal and Service Water Heating Loads	
(1)	[F99-OE1.1]
8.4.3.4. Building Envelope Components	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
8.4.3.5. Interior Lighting	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
8.4.3.6. Purchased Energy	
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
8.4.3.7. Outdoor Air	
(1)	[F99-OE1.1]
8.4.3.8. Space Temperature Control	
(1)	[F99-OE1.1]
8.4.3.9. Part-Load Performance Curves	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
8.4.3.10. Ice-Making Machines for Curling Rinks and Ice Arenas	
(1)	[F99-OE1.1]
8.4.4.1. General	
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
(7)	[F99-OE1.1]
8.4.4.2. Operating Schedules	
(1)	[F99-OE1.1]
8.4.4.3. Internal and Service Water Heating Loads	
(1)	[F99-OE1.1]
8.4.4.4. Building Envelope Components	
(1)	[F99-OE1.1]
(2)	(a) [F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]

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Table 8.5.1.1. (Continued)

Functional Statements and Objectives[1]	
(6)	[F99-OE1.1]
(7)	[F99-OE1.1]
8.4.4.5. Thermal Mass	
(2)	[F99-OE1.1]
8.4.4.6. Lighting	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
8.4.4.7. Purchased Energy	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
8.4.4.8. HVAC System Selection	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(4)	[F99-OE1.1]
8.4.4.9. Equipment Oversizing	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
8.4.4.10. Heating System	
(1)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
(7)	[F99-OE1.1]
(8)	[F99-OE1.1]
8.4.4.11. Cooling Systems	
(1)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
(7)	[F99-OE1.1]
(8)	[F99-OE1.1]
(9)	[F99,F100-OE1.1]
8.4.4.12. Cooling Tower Systems	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]

Table 8.5.1.1. (Continued)

Functional Statements and Objectives[1]	
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
8.4.4.13. Cooling with Outside Air	
(1)	[F99-OE1.1]
8.4.4.14. Heat Pumps	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
8.4.4.15. Hydronic Pumps	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
8.4.4.16. Outdoor Air	
(1)	[F99-OE1.1]
8.4.4.17. Space Temperature Control	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
8.4.4.18. Fans	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
8.4.4.19. Supply Air Systems	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]
(6)	[F99-OE1.1]
8.4.4.20. Heat-Recovery System	
(1)	[F99,F100-OE1.1]
(2)	[F99,F100-OE1.1]
(3)	(a) [F99-OE1.1]
	(b), (c) [F100-OE1.1]
8.4.4.21. Service Water Heating Systems	
(1)	[F99-OE1.1]
(2)	[F99-OE1.1]
(3)	[F99-OE1.1]
(4)	[F99-OE1.1]
(5)	[F99-OE1.1]

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Table 8.5.1.1. (Continued)

Functional Statements and Objectives[1]	
(6)	[F99-OE1.1]
(7)	[F99-OE1.1]
(8)	[F99-OE1.1]
(9)	[F99-OE1.1]
8.4.4.22. Part-Load Performance Curves	
(1)	[F99-OE1.1]

Notes to Table 8.5.1.1.:

(1) See Parts 2 and 3 of Division A.

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Appendix A
Explanatory Material

A-1.1.2.1. NECB Compliance Options. Figure A-1.1.2.1. shows the three compliance options available in Division B.

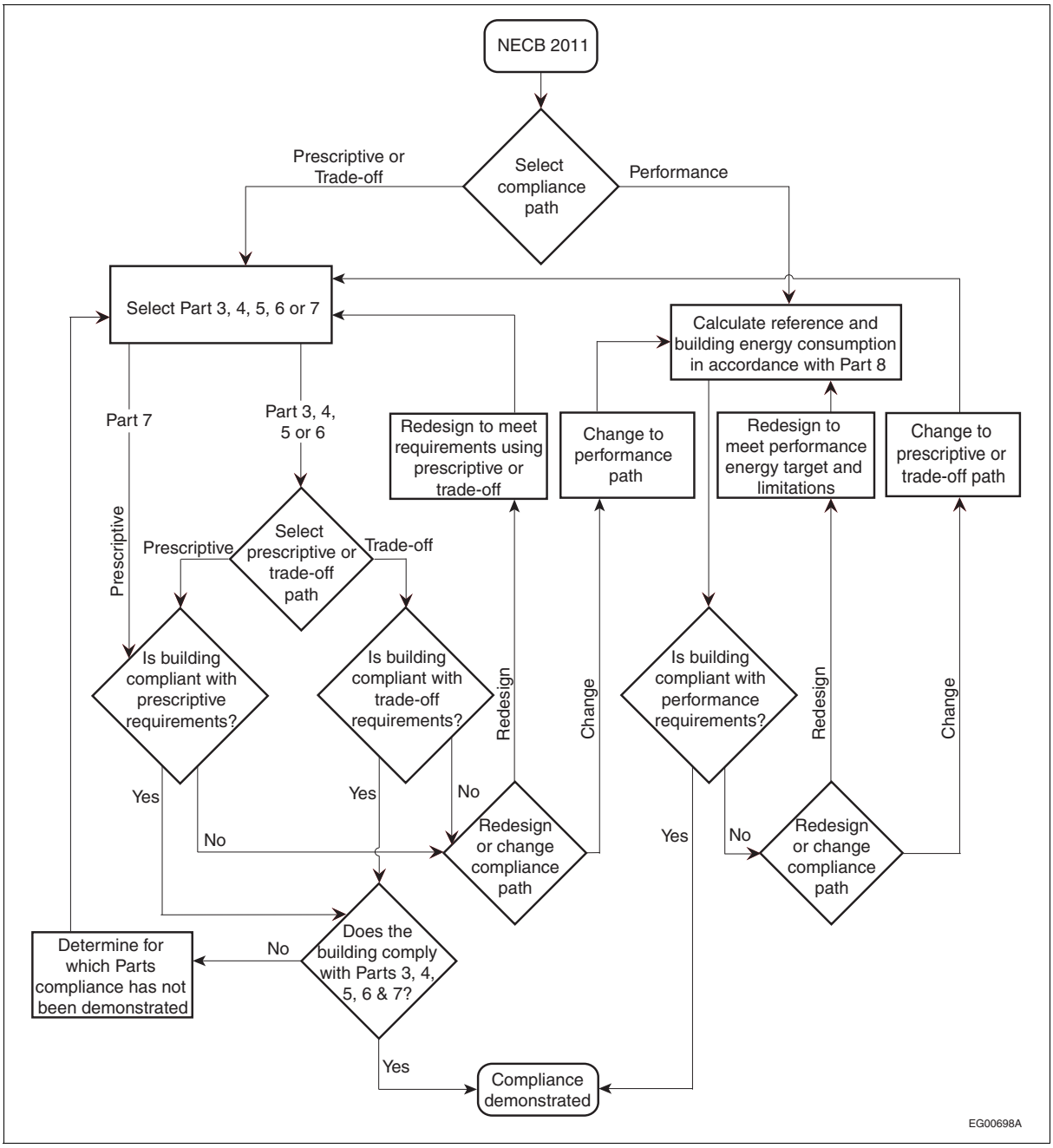

Figure A-1.1.2.1.
Decision flow chart for Code compliance

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Prescriptive Path

The first compliance option is to apply the prescriptive requirements of the Code, which generally dictate minimum thermal characteristics for envelope elements and energy efficiency measures that can be stated as specific instructions.

Trade-off Path

The second option affords some degree of flexibility in the application of the prescriptive requirements. For example, the trade-off paths for Part 3 allow Code users to vary the thermal characteristics of one or more components of the building envelope and/or vary the fenestration and door area from that permitted in Section 3.2., provided it can be demonstrated that the resultant building envelope will not transfer more energy than it would if all its components complied with that Section. The trade-off options present an easy way to make small adjustments to the characteristics of the building without having to follow the whole-building performance route.

Performance Path

The third option is a performance path: if some aspects of the prescriptive and trade-off routes are considered too limiting, the building could, for example, be designed with any thermal characteristics desired (subject to certain limitations), provided that it would not have a calculated energy consumption under standardized conditions that is greater than it would have been had the building been designed in strict conformity with the prescriptive requirements, all other aspects of the building (those that are not the object of a requirement in this Code) remaining the same in both cases. The proof of compliance when using the performance path option is achieved through two energy analyses: one on the building as if it met the prescriptive requirements, which gives the "target" performance, and the other on the actual design for which a building permit is requested.

A-1.1.3.1.(1) Objective and Functional Statements Attributed to Acceptable Solutions. The objective and functional statements attributed to each Code provision are shown in Tables at the end of each Part in Division B.

Many provisions in Division B serve as modifiers of or pointers to other provisions, or serve other clarification or explanatory purposes. In most cases, no objective and functional statements have been attributed to such provisions, which therefore do not appear in the above-mentioned tables.

For provisions that serve as modifiers of or pointers to other referenced provisions and that do not have an objective and functional statements attributed to them, the objective and functional statements that should be used are those attributed to the provisions they reference.

A-1.1.4.1.(1) Climatic Values. Climatic values for municipalities not listed in Table C-2 of Appendix C of the National Building Code may be obtained by contacting the Meteorological Service of Canada, Environment Canada, 4905 Dufferin Street, Downsview, Ontario M3H 5T4; http://climate.weatheroffice.gc.ca/Welcome_e.html.

Hourly climatic values are available from multiple sources such as Environment Canada, Natural Resources Canada, the Regional Conservation Authority and other such public agencies that record this type of information. Hourly weather data are also available from public and private agencies that format this information for use with annual energy consumption simulation software; in some cases, these data have been incorporated into the software.

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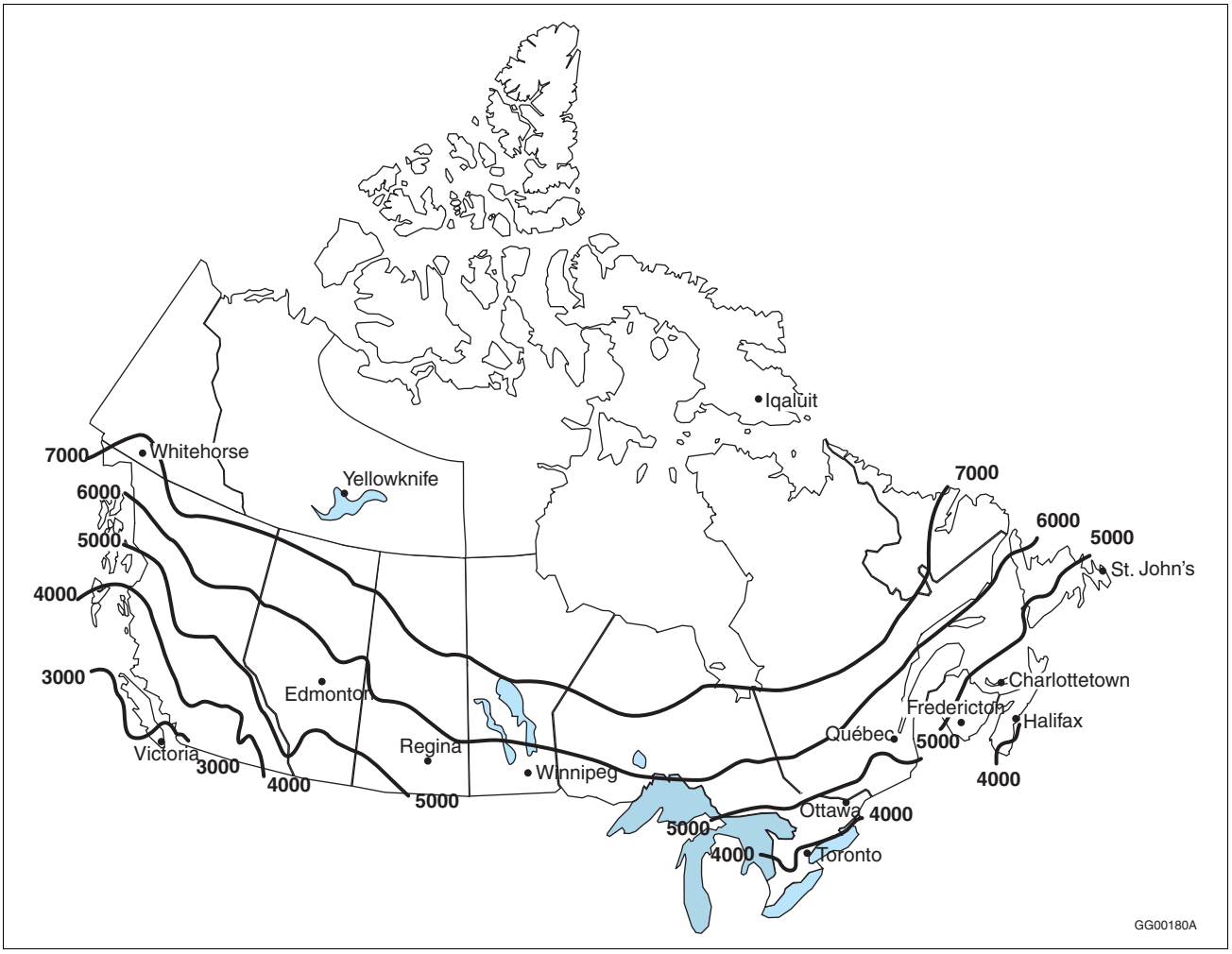

Figure A-1.1.4.1.(1)
Average annual heating degree-days (C-degrees)

A-1.3.1.2.(1) Applicable Editions. Where documents are referenced in the Appendices of this Code, they shall be the editions designated in Table A-1.3.1.2.(1).

Table A-1.3.1.2.(1)
Documents Referenced in the Appendices of the National Energy Code of Canada for Buildings 2011

Issuing Agency	Document Number(1)	Document Title(2)	Code Reference
ASHRAE	2007	ASHRAE Handbook – HVAC Applications	A-6.2.4.1.(1)
ASHRAE	2009	ASHRAE Handbook – Fundamentals	A-8.4.4.5.(1)
ASHRAE	ANSI/ASHRAE/ IESNA 90.1-2007	Energy Standard for Buildings Except Low-Rise Residential Buildings	A-Table 3.2.2.2. A-5.2.10.1.(1)
ASHRAE	90.1-2007	User's Manual	A-5.2.10.4.(5) A-6.2.3.1.(1)
ASHRAE	ANSI/ASHRAE 111-2008	Measurement, Testing, Adjusting and Balancing of Building HVAC Systems	A-5.2.5.2.(1)

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Table A-1.3.1.2.(1) (Continued)

Issuing Agency	Document Number(1)	Document Title(2)	Code Reference
CCBFC	NRCC 53301	National Building Code of Canada 2010	A-1.1.1.1.(1)(3) A-1.1.4.1.(1) A-3.2.1.1.(1)(3) A-3.2.1.2.(4) A-3.2.3.1.(3) A-5.2.2.8.(2) A-5.2.8.3.(1) A-5.2.10.1.(4) A-5.2.10.4.(1) A-5.2.10.4.(5) A-8.4.2.3. A-8.4.3.7.(1)
CCBFC	NRCC 53302	National Plumbing Code of Canada 2010	A-3.2.1.1.(1)(3) A-5.2.10.4.(1) A-8.4.4.21.(6) A-8.4.4.21.(7)
CCBFC	NRCC 53303	National Fire Code of Canada 2010	A-3.2.1.1.(1)(3)
CSA	A440.2-09/A440.3-09	Fenestration Energy Performance/User Guide to CSA A440.2-09, Fenestration Energy Performance	A-3.1.1.6.(1)
CSA	C22.1-09	Canadian Electrical Code, Part I	A-7.2.1.1.
CSA	CAN/CSA-C439-09	Rating the Performance of Heat/Energy-Recovery Ventilators	A-5.2.10.4.(2)
HRAI	SAR-G1	HRAI Digest 2005	A-5.2.1.1.(1)
HVI		Certified Home Ventilating Products Directory	A-5.2.10.4.(2)
IESNA	2000	Lighting Handbook	A-Table 4.3.2.8.
SMACNA	ANSI/SMACNA 006-2006	HVAC Duct Construction Standards – Metal and Flexible	A-5.2.2.1.(1)
SMACNA	1985	HVAC Air Duct Leakage Test Manual	A-5.2.2.1.(1)
SMACNA	2003	Fibrous Glass Duct Construction Standards	A-5.2.2.1.(1)
SMACNA	2006	HVAC Systems – Duct Design	A-5.2.2.1.(1)
TIAC	2010	Best Practices Guide	A-5.2.2.5.(6) and 5.2.5.3.(8)

Notes to Table A-1.3.1.2.(1):

(1) Some documents may have been reaffirmed or reapproved. Check with the applicable issuing agency for up-to-date information.

(2) Some titles have been abridged to omit superfluous wording.

(3) Code reference is in Division A.

A-3.1.1.2.(1)(a) Space-conditioning Systems. A cooking stove, pot heater or window air conditioner should not be considered a system in the context of Clause 3.1.1.2.(1)(a), but electric baseboard heaters, for example, in the principal rooms should.

A-3.1.1.3.(1) Compliance. The flow chart in Figure A-3.1.1.3.(1) illustrates the process for all three paths of compliance applicable to Part 3.

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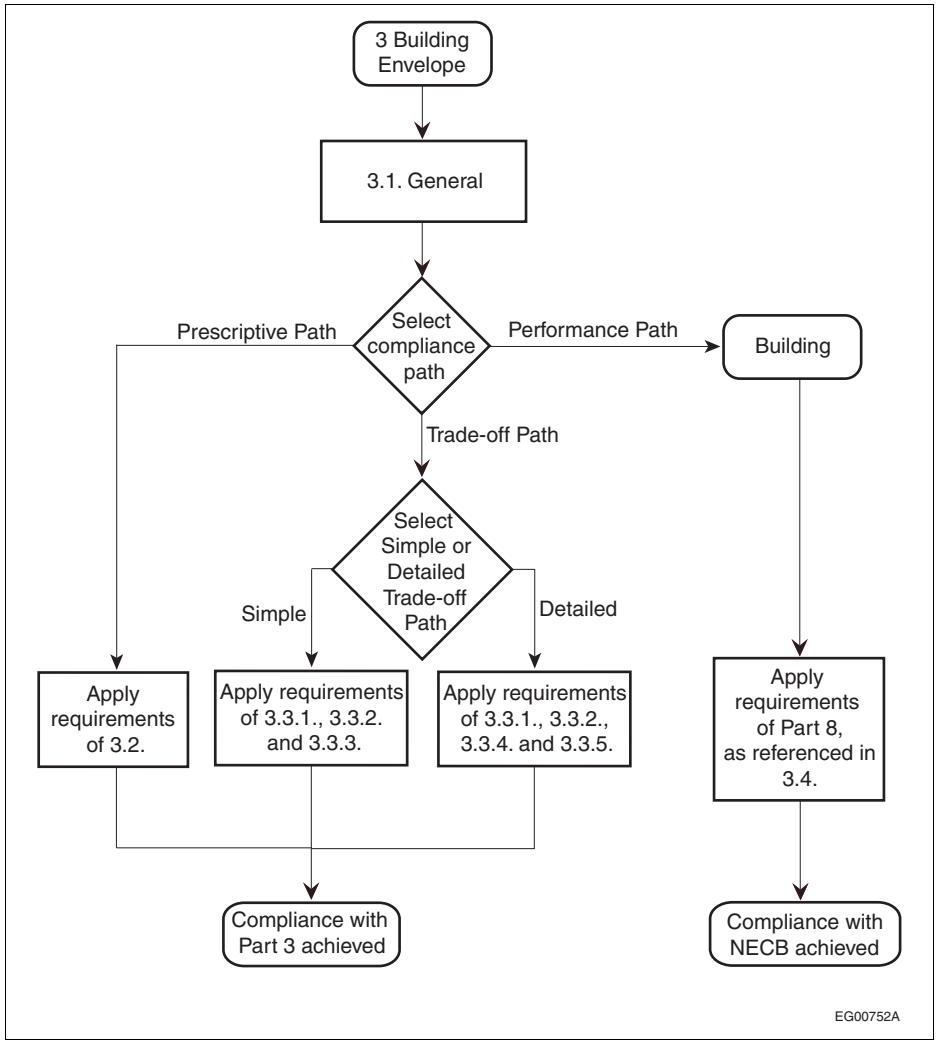

Figure A-3.1.1.3.(1)
Code compliance paths for the building envelope

A-3.1.1.3.(1)(c) Performance Path. The building energy performance compliance path is a whole-building approach; therefore if this path is chosen to achieve compliance, it must be the only path applied to all building parameters.

A-3.1.1.5. Thermal Characteristics of Building Assemblies. Thermal characteristics of building assemblies can also be determined through the use of computer simulation models.

A-3.1.1.6.(1) Fenestration and Door Areas. The method of calculation of fenestration and door areas is slightly different in Sentence 3.1.1.6.(1) from the one used in CSA A440.2/A440.3, "Fenestration Energy Performance/User Guide to CSA A440.2-09, Fenestration Energy Performance," for windows and doors. For calculating the fenestration area of a building, this Code uses the dimensions of rough openings to facilitate determination of compliance.

Figure A-3.1.1.6.(1) illustrates the requirements of Sentence 3.1.1.6.(1).

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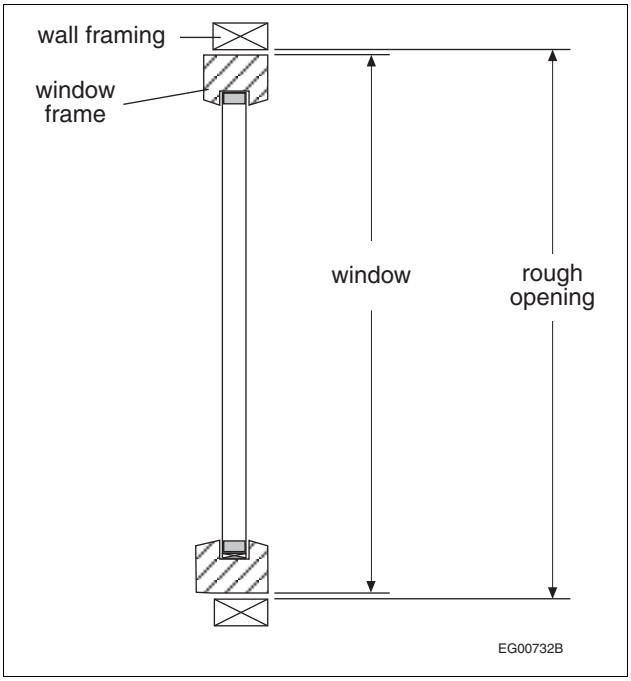

Figure A-3.1.1.6.(1)
Measuring fenestration and door areas

A-3.1.1.6.(2) Areas of Other Fenestration. Figure A-3.1.1.6.(2) illustrates how to measure the area of glass panes as described in Sentence 3.1.1.6.(2).

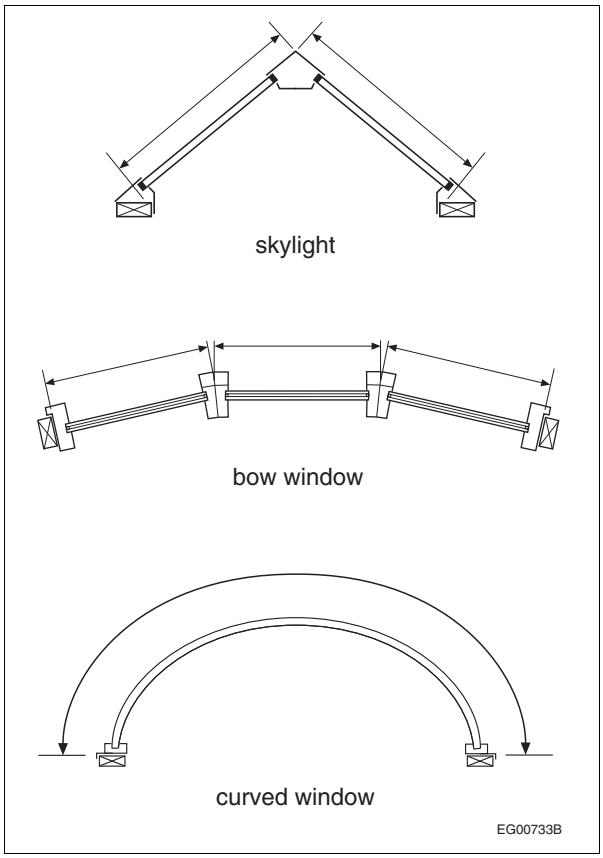

Figure A-3.1.1.6.(2)
Measuring areas of glazing that is not in the same plane

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A-3.1.1.7.(2) Continuity of Insulation at Beams and Columns. The overall thermal transmittance at spandrel beams may be increased compared to what is required for the surrounding wall without any penalty, provided that the resulting overall thermal transmittance across the building envelope at the spandrel beam is not increased to more than twice the required overall thermal transmittance for the wall (see Figure A-3.1.1.7.(2)). A similar approach may be used for columns in exterior walls.

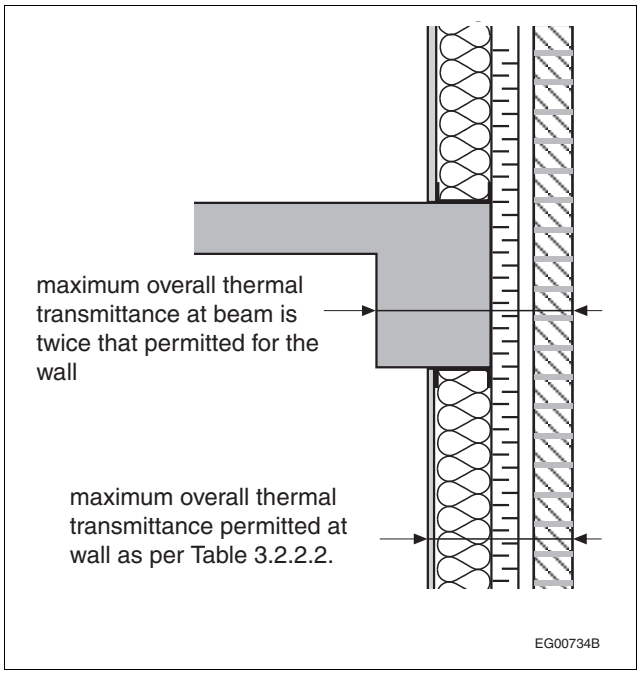

Figure A-3.1.1.7.(2)
Continuity of insulation at beams

A-3.1.1.7.(3) Penetrations through the Building Envelope. The impact of penetrations described in Sentence 3.1.1.7.(3) on the overall thermal transmittance is difficult to assess but is considered to be negligible if the insulation is installed tight to the penetration.

A-3.1.1.7.(4) Major Structural Penetrations through the Building Envelope. The impact of penetrations described in Sentence 3.1.1.7.(4) on the overall thermal transmittance is difficult to assess but is considered to be negligible if the insulation is installed tight to the penetration.

Permafrost

In permafrost areas where buildings are constructed above the ground on metal pilings with little or no insulating materials between the top of the piling, the pile cap and metal structural members joined to the pile cap, the thermal transmittance from the building structure to the pilings and ground may be appreciable and should be taken into consideration.

A-3.1.1.7.(5) Effect of an Unconditioned Space. The conservative overall thermal transmittance allowed in Sentence 3.1.1.7.(5) is intended to provide an easy credit under the prescriptive path for any unconditioned space that may be protecting a component of the building envelope.

The value given does not take into account the construction of the enclosure surrounding the unconditioned space; the construction of this enclosure being uncontrolled by this Code, too many variables, such as its size or airtightness, may negate any higher credit that could be allowed. There may be simulation tools under the performance path that can provide a better assessment of the effect of an indirectly heated space, which may be used to advantage when an unheated space is designed to provide significantly better protection than the worst-case scenario assumed here. Vented spaces, such as attic and roof spaces or crawl spaces, are considered to be part of the exterior space; therefore, Sentence 3.1.1.7.(5) does not apply when calculating the overall thermal transmittance of their building envelope components.

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A-3.1.1.7.(8) Wall Area. Figure A-3.1.1.7.(8) illustrates the extent of the surface that is considered as a wall at the intersection with a floor. This Code may have different requirements for the perimeter area of floors.

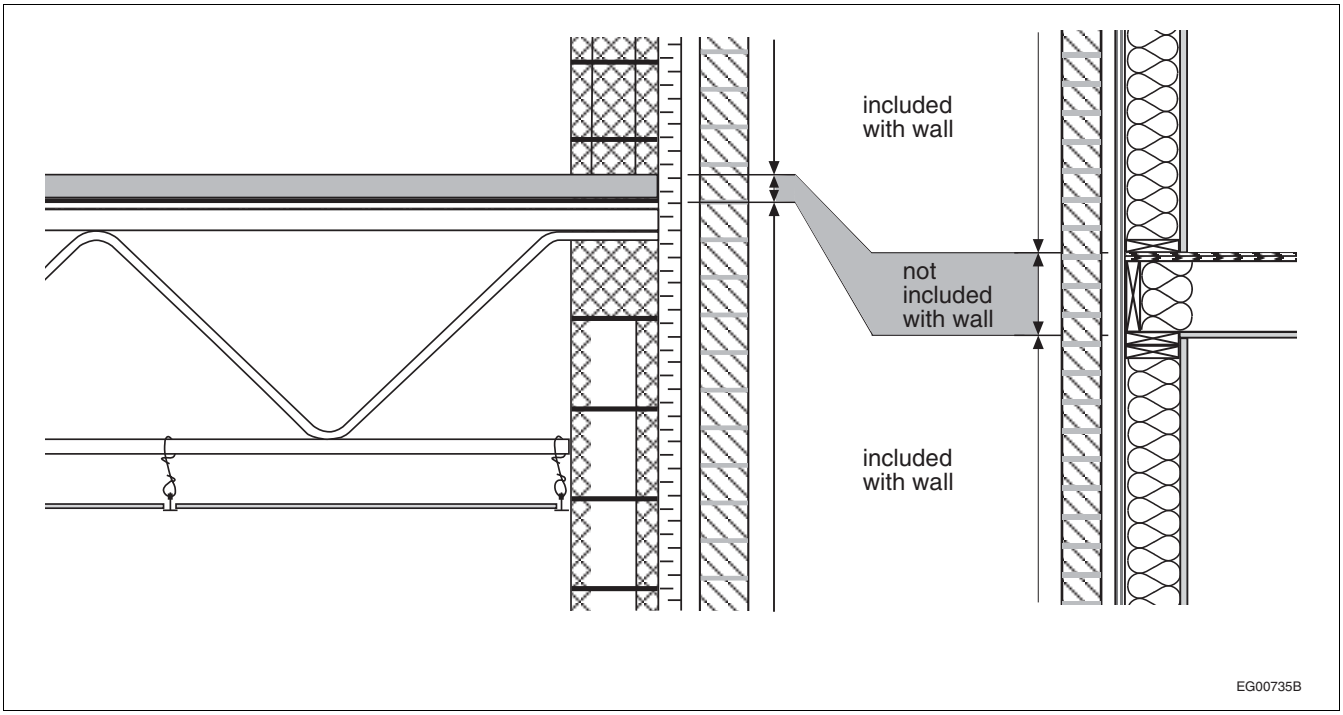

Figure A-3.1.1.7.(8)
Wall area discontinuous at floor

A-3.2.1.1.(1) Protection of Insulation Materials. Sentence 3.2.1.1.(1) is not intended to preclude the use of building envelope systems such as protected membrane roofing systems, vegetative roofing systems, EIFS in rainscreen applications, and exterior insulation on below-grade walls.

A-3.2.1.2.(1) Continuity of Insulation. Sentence 3.2.1.2.(1) is intended to apply to building components such as partitions, chimneys, fireplaces, and columns and beams that are embedded along exterior walls, but not to stud framing and ends of joists. Studs and joists in frame construction are not considered to break the continuity of the insulation because the method for calculating the overall thermal transmittance of such assemblies described in Article 3.1.1.7. takes their presence into consideration.

A-3.2.1.2.(4) Maintaining Continuity of Insulation. The continuity of the insulation is compromised when, for example, foundation walls are insulated on the outside below grade and on the inside above grade. In the case of hollow-core masonry walls, no amount of overlap can overcome the effect of convection in the cores, which renders overlapped interior/exterior insulation totally ineffective, unless the continuity of the air barrier is effectively carried across the wall by blocking the cells at the level of the insulation overlap. Such blocking of the core cells is required by Division B of the NBC in Sentence 5.3.1.3.(2) and, for small buildings, in Sentence 9.25.2.3.(3), which requires that insulation be installed so its function will not be compromised by convective airflow.

A-3.2.1.2.(6) Continuity of Insulation Where Components Meet. Sentence 3.2.1.2.(6) calls for continuity of the insulation at the intersection of two components of the building envelope, such as a wall with another wall or a roof, or a wall with a window. This means that there should be no gap in the insulation between the two components. An obvious application is insulating the space between a window or door frame and the rough framing members. However, closely spaced structural members, such as studs or top plates, do not have to be taken into account, as provided in Sentence 3.1.1.7.(1).

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A-3.2.1.3.(1) Spaces Heated to Different Temperatures. This requirement applies, for example, to walls or floors that separate spaces, one of which is heated to a normal comfort temperature and the other of which is heated to a significantly lower temperature and kept floating above that point. This would be the case of a wall between an office block and an attached warehouse that is heated just to keep it above freezing.

A-3.2.1.4.(1) Total Vertical Fenestration and Door Area to Gross Wall Area. Table A-3.2.1.4.(1) shows a sample of maximum allowable FDWR for various HDD.

Table A-3.2.1.4.(1)
Maximum Allowable FDWR for Various HDD

HDD	Max. FDWR
< 4000	0.40
4000	0.40
4250	0.38
4500	0.37
4750	0.35
5000	0.33
5250	0.32
5500	0.30
5750	0.28
6000	0.27
6250	0.25
6500	0.23
6750	0.22
7000	0.20
> 7000	0.20

A-3.2.2.2.(1) Thermal Characteristics of Components of the Building Envelope. The overall thermal transmittance of a building assembly is the area-weighted average thermal transmittance, or U-value, of the overall assembly, including insulation, sheathing, interior and exterior finish materials and air films, and taking into account thermal bridging due to framing members, in accordance with the calculation procedures of Article 3.1.1.7. The U-value for above-ground walls also applies to the perimeter areas of intersecting interior walls and to the above-ground portion of foundation walls, except as provided in Sentence 3.2.2.2.(2).

A-3.2.2.2.(3) Thermal Characteristics of Components with Embedded Radiant Heating or Cooling. Sentence 3.2.2.2.(3) applies to insulated walls and top-storey ceilings under a roof or unheated attic space that have radiant heating or cooling equipment embedded in them. The maximum overall thermal transmittance of a wall or ceiling containing radiant heating cables or heating or cooling pipes or membranes is decreased in order to counteract the increased heat loss that occurs due to the increased temperature difference between the interior and exterior surfaces. Below-ground walls incorporating radiant heating or cooling equipment are covered in Sentence 3.2.3.1.(2); slabs-on-ground incorporating radiant heating or cooling equipment are covered in Sentence 3.2.3.3.(3).

A-Table 3.2.2.2. Climate Zones. The thermal criteria and climate zones referred to in this Code are based on ANSI/ASHRAE/IESNA 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," however, the thermal criteria have been revised

- to eliminate the moist (A), dry (B) and marine (C) definitions, which have no bearing on NECB requirements, and
- to separate climate zone 7 into 7A (5000 to 5999 HDD) and 7B (6000 to 6999 HDD).

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A-3.2.2.3.(3) Application to Small Skylight Areas. Sentence 3.2.2.3.(3) corresponds to double-glazed windows in thermally broken aluminum frames.

A-3.2.2.4.(4) Application to Sliding Glass Doors and Revolving Doors. Notwithstanding the exemption in Sentence 3.2.2.4.(4) regarding the thermal requirements of the types of doors listed, the glazed areas of automatic sliding doors and revolving doors must be factored in as part of the area of fenestration, as required by Article 3.1.1.6.

A-3.2.3.1.(3) Walls in Contact with the Ground. The term "ground level" as used in Sentence 3.2.3.1.(3) has a different meaning than "grade," which is a defined term in the NBC and the NECB. The wording of Sentence 3.2.3.1.(3) requires that the bottom of the insulation follow the contours of the exterior ground level at the required depth.

A-3.2.3.2.(1) Roofs in Contact with the Ground. Sentence 3.2.3.2.(1) refers to structures that are normally below grade such as walkways or parking garages. It does not refer to structures with vegetative roofs as might be built at elevations above grade.

A-3.2.3.3. Floors in Contact with the Ground. Article 3.2.3.3. is intended to include floors of crawl spaces even when there is no actual constructed floor.

The minimum depth at which insulation is required is measured once for the entire floor from the level of grade (see Appendix Note A-3.2.3.1.(3)), i.e., even if the exterior soil level (ground) varies, the whole floor (or perimeter) either has to be insulated or doesn't; this doesn't require some parts of the floor (or perimeter) to be insulated and some parts not. Consideration should be given to insulating the entire floor at sites where the soil is highly conductive or where there is a permanently high water table. The diagrams in Figure A-3.2.3.3. illustrate the insulation requirements for various types of floors-on-ground, where these are less than 0.6 m below grade.

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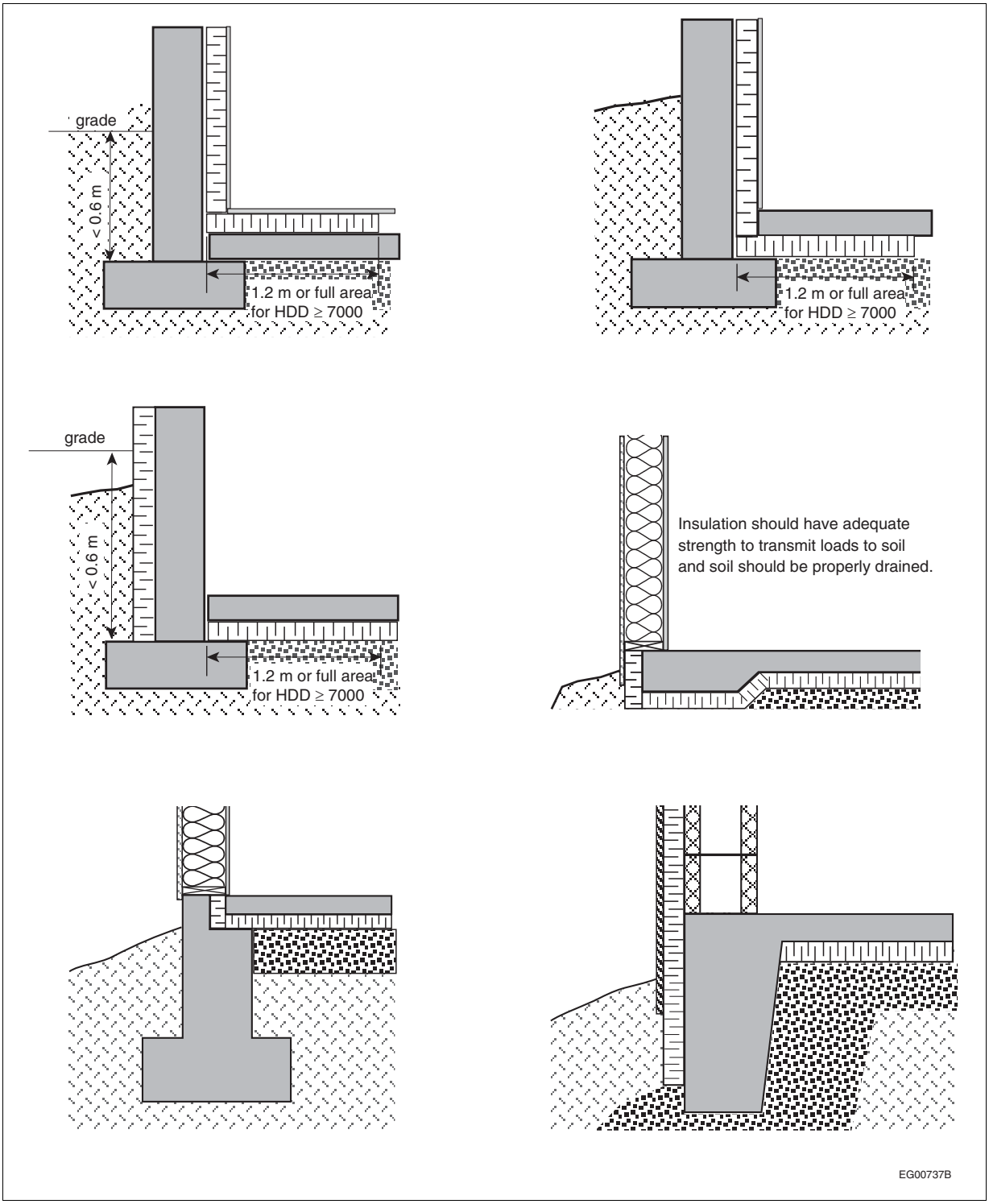

Figure A-3.2.3.3.
Insulation of floors in contact with the ground

Note to Figure A-3.2.3.3.:

(1) Grade does not necessarily coincide with the ground levels shown in the diagrams.

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A-3.3.1.1.(3) Limits to Trade-offs. There are several reasons why the listed prescriptive provisions are not subject to trade-off calculations. In some cases, the energy-conserving impact of provisions cannot be easily quantified and allowing trade-offs would be unenforceable: this is the case, for instance, for building envelope air leakage requirements (Subsection 3.2.4.). Other prescriptive provisions simply do not lend themselves to trade-offs.

A-3.3.4.1.(3) and 8.4.4.3.(2) Semi-heated Buildings. For the purposes of Subsection 3.3.4. and Part 8, a semi-heated building is considered to be a building heated to less than 18°C.

A-3.3.4.3.(1)(b) Treatment of Additions. The trade-off path cannot be used to allow the upgrading of existing components of the building envelope to compensate for components of the addition that do not satisfy the prescriptive requirements of this Code; for example, taking advantage of new windows that are replacing existing ones. Thus, even if windows in the existing building are to be upgraded at the same time as the addition is built, the new characteristics of the existing building's windows cannot be used in the trade-off calculations described in Sentences 3.3.4.2.(1) and 3.3.4.4.(1). However, the provision of Sentence 3.1.1.6.(4) that permits averaging the window-to-wall ratio over the entire building—including existing and added portions' parts—may be used to determine the window-to-wall ratio for the addition.

A-3.3.4.9.(4)(d) Thermal Mass. The building envelope assemblies should follow the layer structure of the proposed building's assemblies (type and order) but the insulation thickness should be varied to match the maximum overall thermal transmittance of Section 3.2.

A-4.1.1.2.(1) Application. Part 4 is intended to apply to all lighting components and systems in or on the building or building site that are connected to the building's electrical service.

A-4.1.1.2.(2)(c) Exemptions. In some cases, the requirements of Part 4 may adversely affect the use of spaces with special functional requirements and so exceptions to the Code requirements may be necessary. Except for particular types of process lighting, however, it is unlikely that a space or lighting system would be exempt from all the requirements of Part 4. Some necessary exceptions to particular requirements are identified in the Code. Exemption should be determined on a case-by-case basis, depending on the space's function, available technologies and cost-effectiveness.

A-4.1.1.3.(1) Compliance. The flow charts in Figures A-4.1.1.3.(1)-A and A-4.1.1.3.(1)-B illustrate the process for all three paths of compliance applicable to Part 4. The prescriptive path options for interior lighting requirements using the building area method or the space-by-space method are also shown in Figure A-4.1.1.3.(1)-A.

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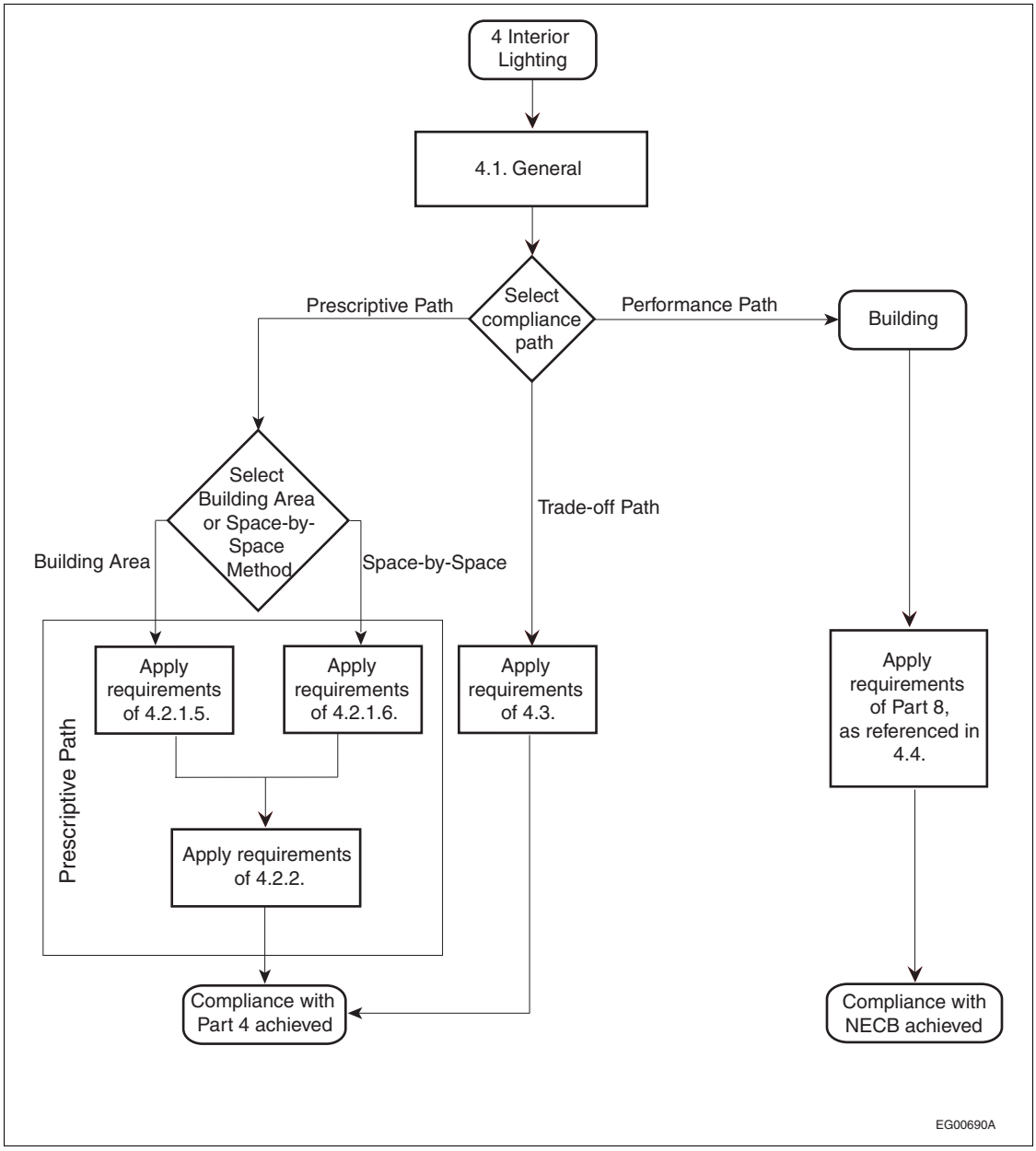

Figure A-4.1.1.3.(1)-A
Code compliance paths for interior lighting

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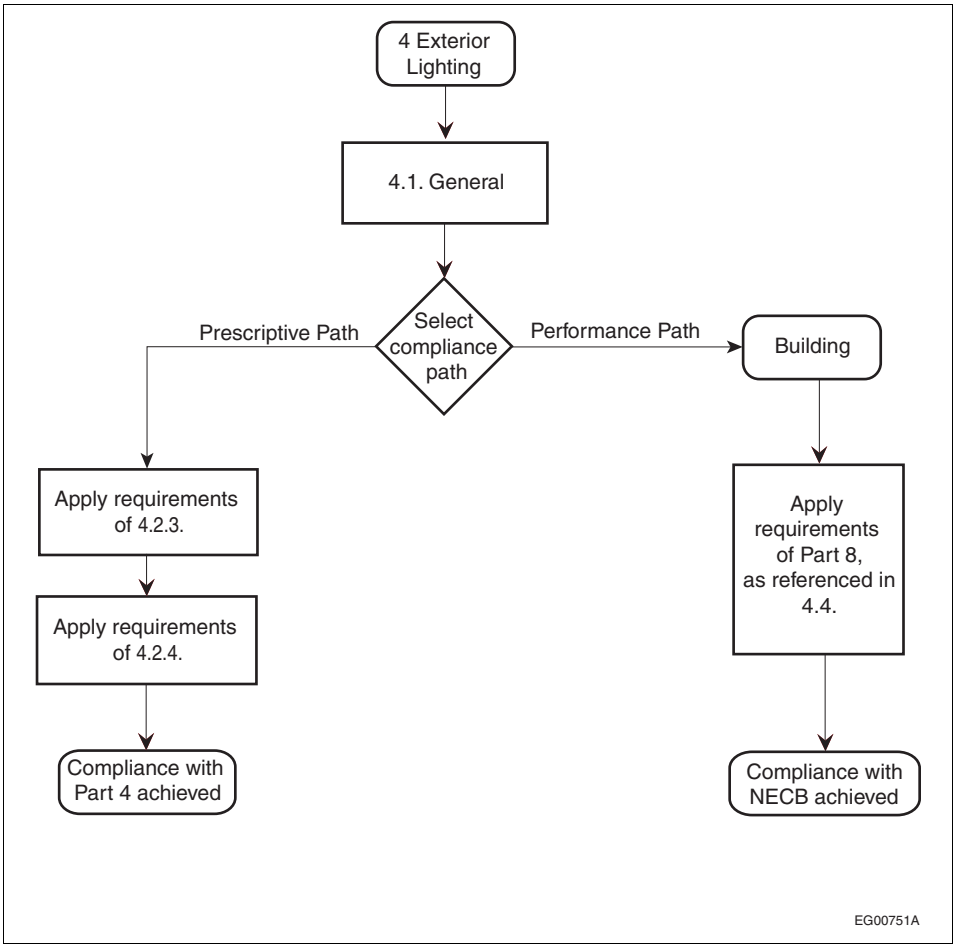

Figure A-4.1.1.3.(1)-B
Code compliance paths for exterior lighting

A-4.2.1.3. Prescriptive Compliance with Interior Lighting Power Requirements. The prescriptive criteria in Section 4.2. compare the installed interior lighting power to a permitted interior lighting power allowance.

Mixing the two methods described in Sentence 4.2.1.3.(1) within a building is not permitted.

The building area method is based on building type only and has limited flexibility. The criteria are not sensitive to specific task and room configurations that affect lighting power in any particular building, but permit faster calculations that will be appropriate for typical buildings and normal uses.

The space-by-space method provides greater flexibility but requires a more detailed calculation procedure. It may provide a more appropriate allowance for complex buildings and buildings with multiple spaces and activities.

The building area and space-by-space methods are not to be used as lighting design procedures. Once the interior lighting power allowance for the building has been determined, the designer should strive to design a lighting system that will provide an effective and pleasing illuminated environment without exceeding the interior lighting power allowance or reducing the level of control.

Note that, for flexibility in design, the trade-off path detailed in Section 4.3. or the performance path described in Section 4.4. and Part 8 may be followed in lieu of the interior lighting prescriptive requirements stated in Section 4.2.

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A-4.2.1.4.(2) Installed Interior Lighting Power. Where the interior lighting power allowance includes an allowance for a particular space, the installed interior lighting power must also include a reasonable value for connected lighting power for that space. Recognizing that moveable plug-in units are moved, plugged in, unplugged and easily replaced over time, the connected lighting power of moveable and plug-in luminaires is not intended to reflect the actual connected lighting power of these units over the life of the space. Rather, it is to indicate a power level that will support a lighting level appropriate for the initial intended use of the space. Thus, where the design calls for moveable or plug-in luminaires, the designer must select a sufficient quantity and quality of luminaires to provide the necessary lighting level. The installed interior lighting power must include the lighting load for the installation of those typical units.

The installed interior lighting power should reflect the variety and numbers of luminaires in accordance with good lighting design practice, taking into account the intended use of the space lit by the luminaires.

A-4.2.1.4.(3)(a) Auxiliary. The term "auxiliary" includes luminaire components that affect the energy consumption or efficiency of the lighting system other than the lamp such as ballasts, drivers, starters, transformers, active heat sinks, power supplies and sensors.

A-4.2.1.5. Applying the Building Area Method. In the building area method, the interior lighting power allowance is determined by multiplying the gross lighted area of the building by the lighting power density listed in Table 4.2.1.5., which is selected based on the project's building type. It may be permissible on a case-by-case basis to use one of the listed building types for a project whose building type is not listed but whose lighting needs and applicable technologies are similar to those of a listed building type. For instance, an indoor swimming pool might be allowed the lighting power density of an exercise centre (9.5 W/m^2) but not a workshop (12.9 W/m^2).

A single building often has two or more distinct building types, such as a hotel with retail space. If one type comprises more than 10% of the gross lighted area, then the space-by-space method must be used. If one distinct building type is less than 10% of the gross lighted area, either the building area method or the space-by-space method can be used. If the building area method is used, it must be for the building type representing 90% or more of the building area.

A-Table 4.2.1.6. Building Space Types. In some cases, a space can be described as both a common space type and a building-specific space type. For example, the judges' chambers in a courthouse could also be an enclosed office. As a general rule, the building-specific space type must be used whenever possible; in this case, "judges' chambers" should be used.

A-4.2.2.1. Automatic Control Devices. "Occupant sensors" refers to motion sensors, presence sensors, vacancy sensors, and other similar devices.

Products that allow for on-site calibration of their sensitivity are recommended as they allow situations of false tripping to be managed.

Using controllable circuit breakers as a means of automatic control is only permitted when they are connected to sensors.

A-4.2.2.2.(3) and 4.2.2.3.(5) Commercial Temporary Lodgings. For the purposes of Sentences 4.2.2.2.(3) and 4.2.2.3.(5), "commercial temporary lodgings" refers to hotels, motels and other similar buildings.

A-4.2.2.3.(2)(c) Location of Controls Operated by Staff. In public spaces where controls are intended to be operated by staff, consideration should be given to locating the controls at the principal staff entrance to the space rather than in a remote location. This entrance may or may not be the principal public entrance to the space.

A-4.2.2.3.(4) to (7) Additional Requirements for Lighting Controls. All types of lighting are required to meet automatic shut-off requirements; the same shut-off system can be used to extinguish all lighting in the same space. The manual control of general lighting, however, must be separate from controls for specific lighting loads such as those mentioned in Sentences 4.2.2.3.(4) to (7).

A-4.2.2.3.(5) and (6) Master Switches in Guest Rooms and Suites. For the purposes of Sentences 4.2.2.3.(5) and (6), a guest room or suite is intended to include all areas under the control of the guest, such as hallways, kitchens, sleeping spaces, etc., but not bathrooms.

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A-4.2.2.3.(7)(d) Lighting Equipment for Sale or Demonstrations in Lighting Education. The intent of Clause 4.2.2.3.(7)(d) is that it be possible to collectively extinguish the lighting equipment by means of separate control devices such as circuit breakers, switches, etc.

A-4.2.2.4. Toplighting. The total toplighted area is not a measure of fenestration area. It is the sum of the floor area that is lighted by skylights and the floor area that is lighted by rooftop monitors.

A-4.2.2.4.(1) Automatic Daylighting Controls. Calibration adjustments are generally made with a remotely mounted controller, but may also be made with handheld devices that communicate with the photocontrol sensor or other system devices, such as continuous dimming devices.

Continuous dimming is not required; the minimum requirement is stepped dimming controls with at least 2 control levels, which can be accomplished by selective lamp extinguishing or stepped dimming ballasts.

A-4.2.2.5.(1) and 4.2.2.6.(1) Double-counting Toplighted Areas. To avoid double-counting overlapping toplighted areas,

- daylighting contribution to an area can only be counted once either from sidelighting or toplighting, and
- overlapping toplighted areas can be included in one toplighted area only.

A-4.2.2.5.(2) Daylighted Area Under Skylights. Figure A-4.2.2.5.(2) illustrates how to determine the daylighted area under skylights.

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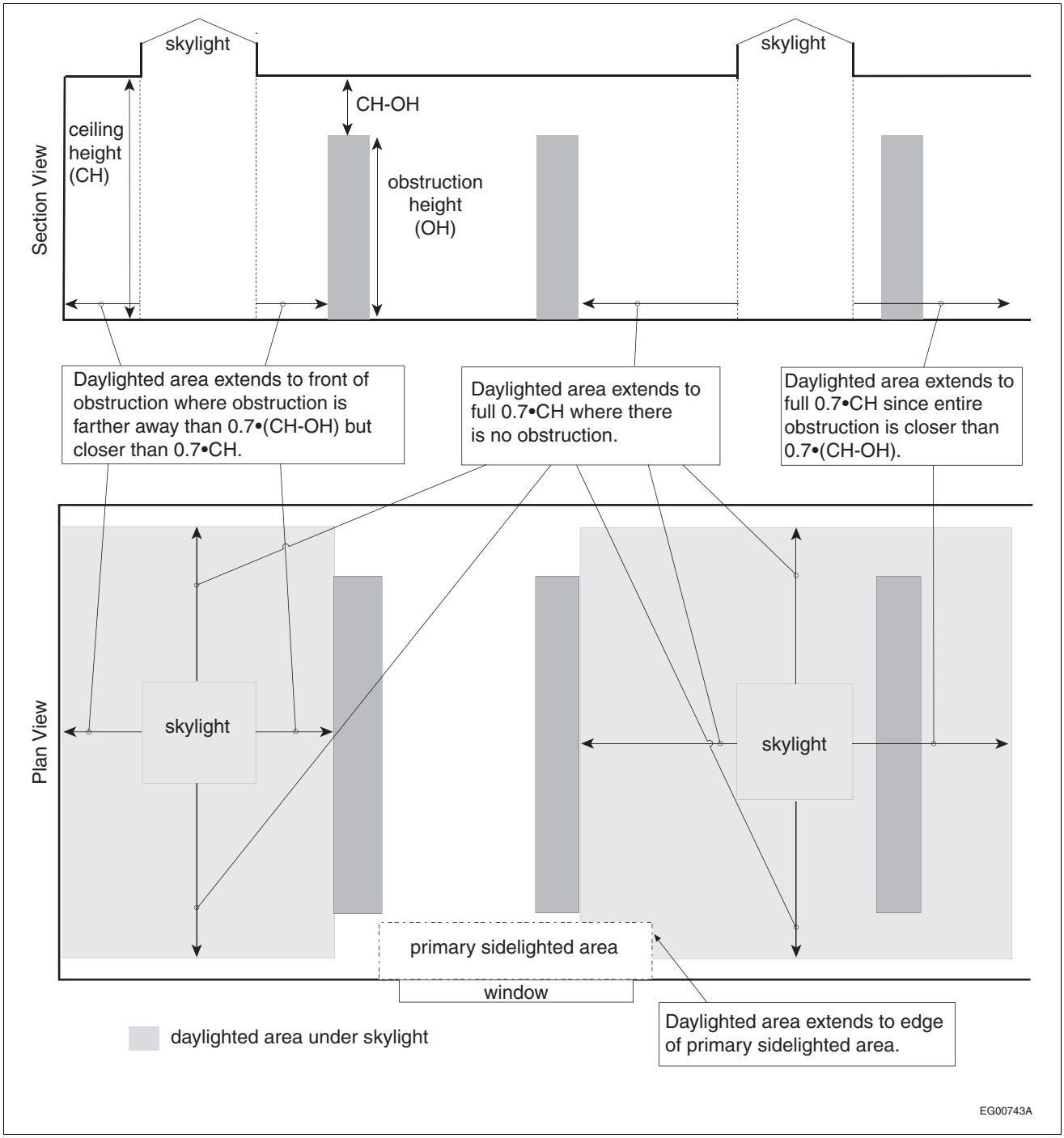

Figure A-4.2.2.5.(2)
Determining daylighted area under skylights

Note to Figure A-4.2.2.5.(2):

(1) If an obstruction is closer to the skylight than 0.7·(CH-OH), it will not substantially alter the daylight penetration and thus the daylighted area will extend the full 0.7·CH.

A-4.2.2.6. Rooftop Monitors. A rooftop monitor is fenestration with glazing more or less in the vertical plane that is part of a rooftop architectural structure.

A-4.2.2.6.(2) Daylighted Area Under Rooftop Monitors. Figure A-4.2.2.6.(2) illustrates how to determine daylighted areas under rooftop monitors.

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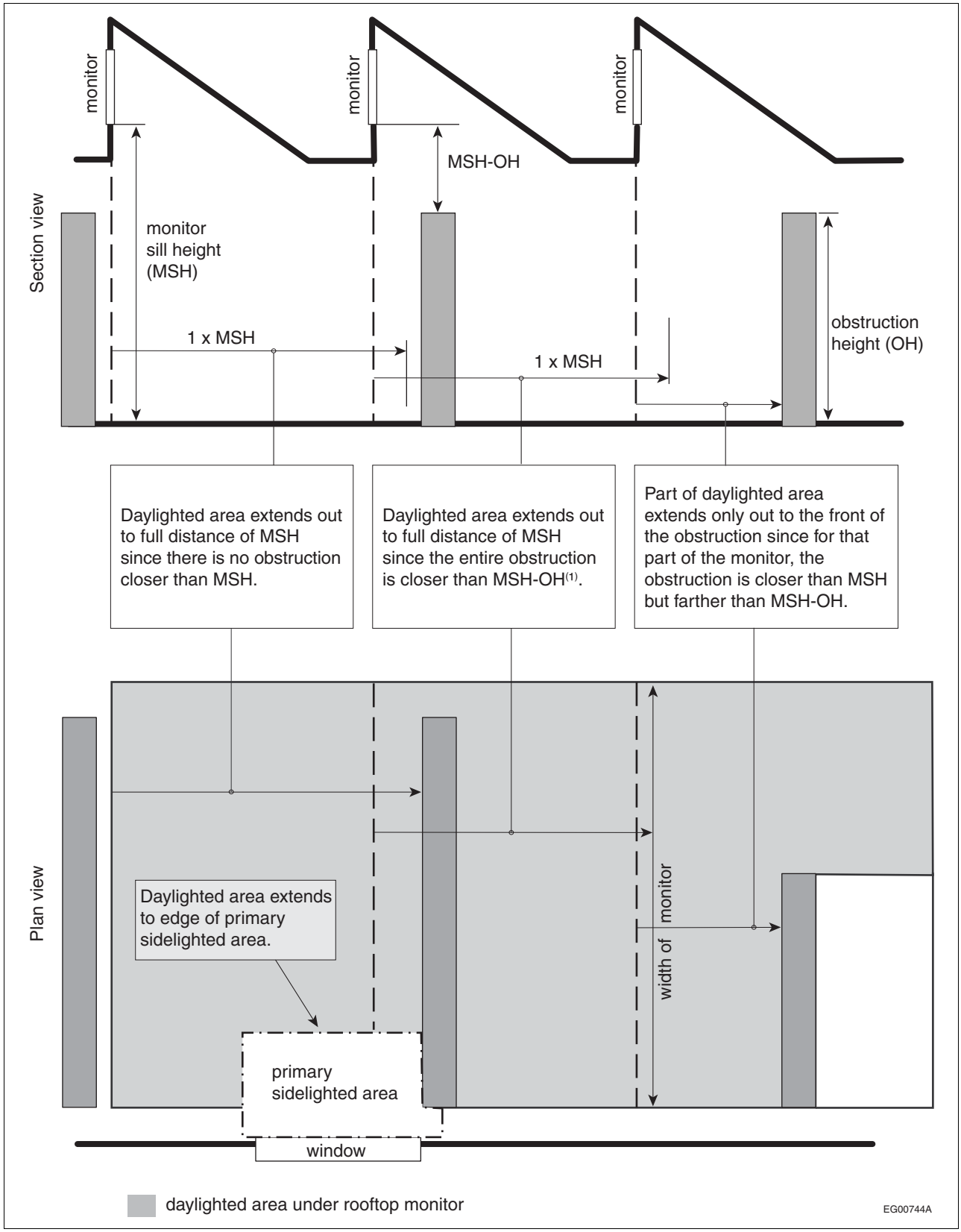

Figure A-4.2.2.6.(2)
Determining daylighted areas under rooftop monitors

Note to Figure A-4.2.2.6.(2):

(1) If an obstruction is closer to the rooftop monitor than MSH-OH, it will not substantially alter the daylight penetration and thus the daylighted area will extend the full MSH.

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A-4.2.2.7. Skylight Effective Aperture. The effective aperture of a skylight approximates the percentage of available daylight that will reach the floor or task area in a space with skylights. It is used to determine whether a daylighted space has enough daylight to justify the use of automatic daylighting controls.

A-4.2.2.8. Primary Sidelighted Area. The floor area affected by sidelighting can extend beyond the primary sidelighted area.

A-4.2.2.9. Primary Sidelighted Areas. Figure A-4.2.2.9. illustrates how to determine primary sidelighted areas.

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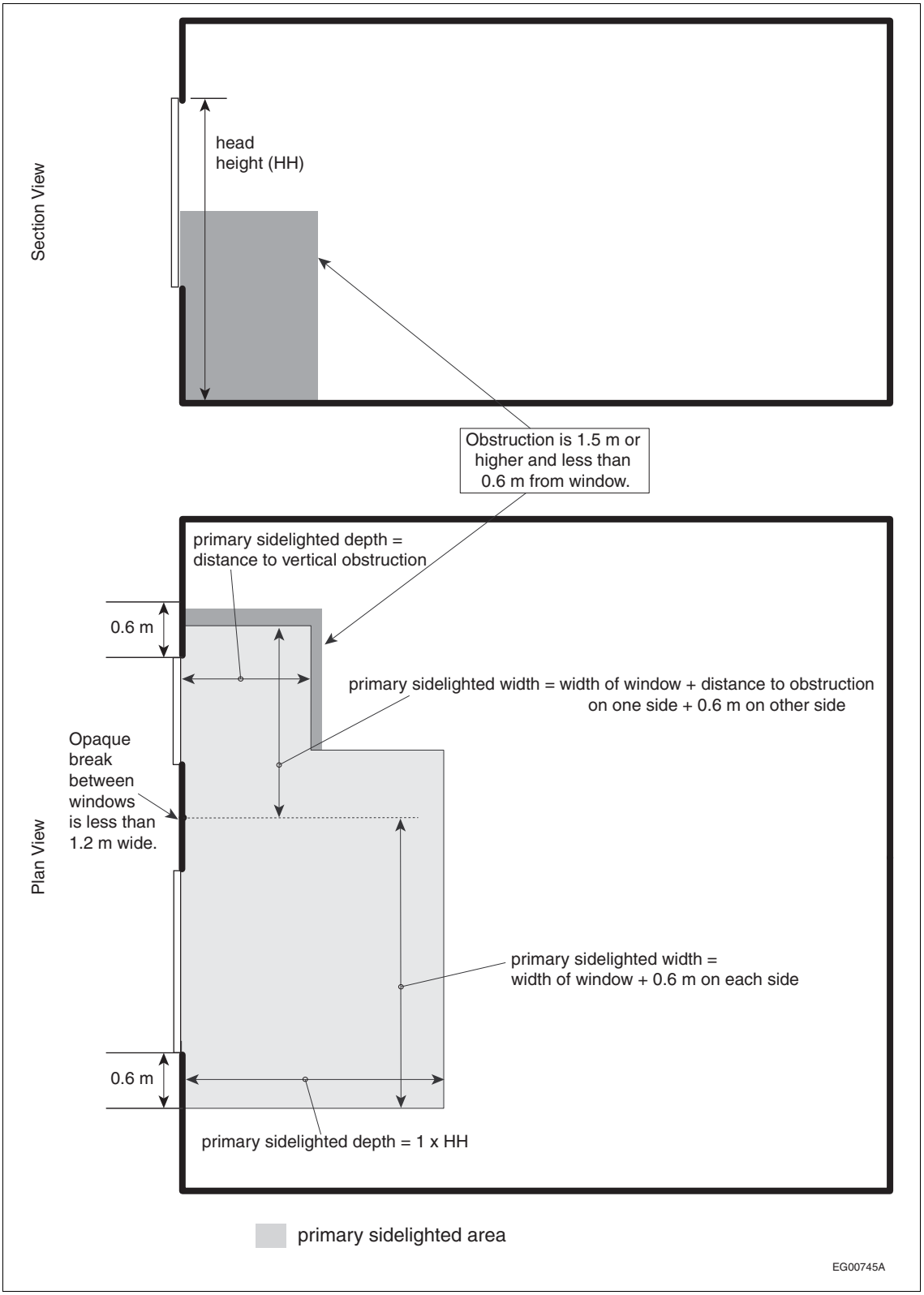

Figure A-4.2.2.9.
Determining primary sidelighted areas

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A-4.2.2.9.(1) Double-counting Primary Sidelighted Areas. To avoid double-counting overlapping primary sidelighted areas,

- daylighting contribution to an area can only be counted once either from sidelighting or toplighting, and
- overlapping areas can be included in one primary sidelighted area only.

A-4.2.2.10. Calculation of Sidelighting Effective Aperture. The effective aperture of a sidelight approximates the percentage of available daylight that will reach the floor or task area in a space with windows. It is used to determine whether a daylighted space has enough daylight to justify the use of automatic daylighting controls.

A-4.2.3.1.(3) Lighting Power Allowances for Specific Building Exterior Applications. The lighting power allowance for each specific exterior application listed in Table 4.2.3.1.C. is non-transferable: no trading of allowances with other lighting applications is permitted (in other words, "use it or lose it"). Some or all of the basic site allowance may be applied to the specific lighting applications.

A-4.2.3.1.(4) Lighting Power Allowances for General Building Exterior Applications. The lighting power allowance for each general building exterior application plus the portion of the basic site allowance that remains unused following the application of Sentence 4.2.3.1.(3) may be shared among the applications listed in Table 4.2.3.1.D.

A-4.2.4.1.(3) Exterior Lighting Controls. Using controllable circuit breakers as a means of automatic control is only permitted when they are connected to sensors.

A-4.3.2.3.(2) Daylighted Area. If the space is illuminated by sidelighting and toplighting, only the dominant daylight supply should be used in the trade-off calculations.

A-Table 4.3.2.8. Design Illuminances. Recommendations for design illuminances for various space types can be found in the IESNA Lighting Handbook. These recommended illuminance levels ensure that visual tasks can be safely performed in a given space. The design illuminance values can be modified from the recommended levels where specific visual tasks require different illuminances.

For design illuminances below 300 lx, the 300 lx values should be used. For design illuminances between the levels listed in Table 4.3.2.8., the raw daylight supply factor can be determined using linear interpolation. For design illuminances above 1 000 lx, the raw daylight supply factor cannot be extrapolated.

A-5.1.1.2.(2) Exemptions. Since any list of potentially exempted spaces or equipment would necessarily be incomplete, only a broad exemption statement can be provided in the Code. One example of a space that could be exempted from complying with certain Part 5 requirements is a building or room in which the processes or activities call for temperature or humidity conditions outside the normal range required for comfort.

A-5.1.1.3.(1) Compliance. The flow chart in Figure A-5.1.1.3.(1) illustrates the process for all three paths of compliance applicable to Part 5.

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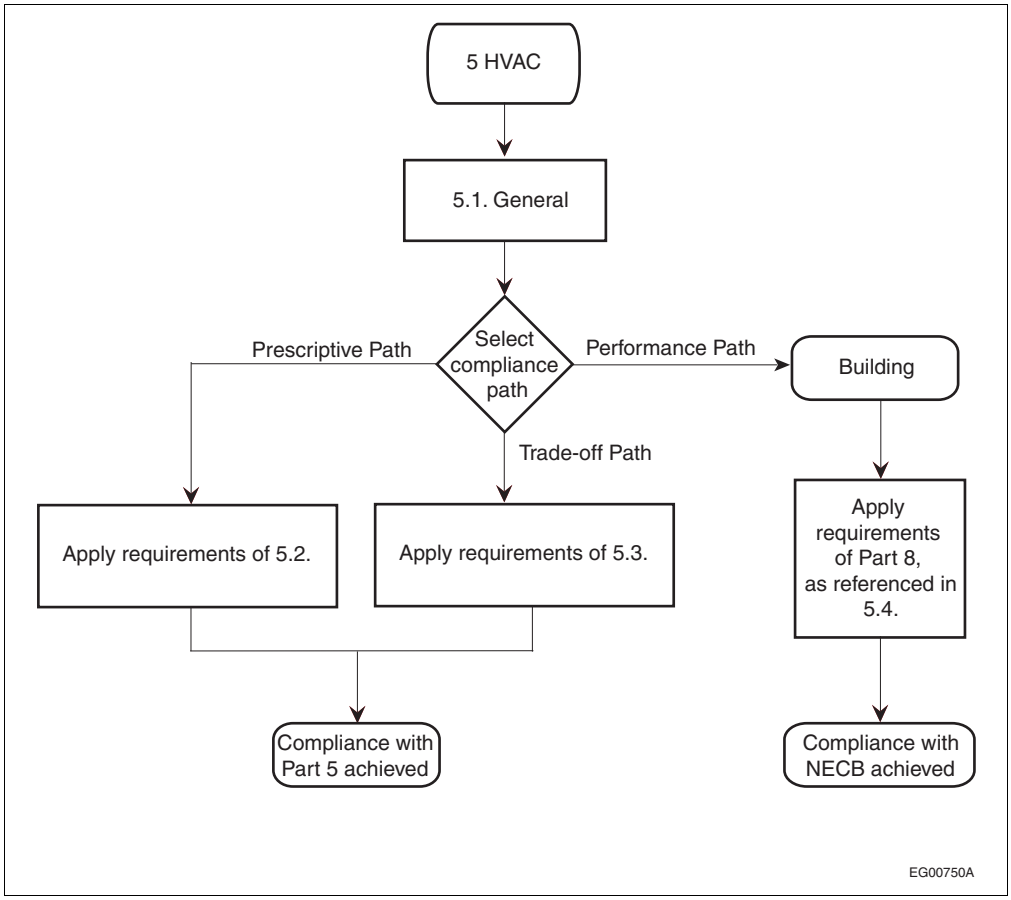

Figure A-5.1.1.3.(1)
Code compliance paths for HVAC

A-5.2.1.1.(1) Load Calculations. ASHRAE Handbooks and Standards and, for smaller buildings, the HRAI Digest, are also useful sources of information on HVAC systems.

A-5.2.2.1.(1) Design and Installation of Ducts. The following publications are a useful source of additional information on this subject:

- Publications by ASHRAE:
  - –the ASHRAE Handbooks
- Publications by SMACNA:
  - –HVAC Duct Construction Standards — Metal and Flexible
  - –Fibrous Glass Duct Construction Standards
  - –HVAC Systems — Duct Design
  - –HVAC Air Duct Leakage Test Manual

A-5.2.2.2.(1) Provision for Balancing. Balancing an air distribution system is a means of fine-tuning it so that the correct amount of air for which the heating, ventilating or air-conditioning system is designed can be delivered. Except for systems having some other means of air-volume control, such as variable air-volume systems, major supply air ducts such as main, sub-main or branch ducts intended to carry conditioned air must contain air-volume balancing dampers capable of being set for specified airflows.

A-5.2.2.3.(1) SMACNA Duct Sealing Classification. Table A-5.2.2.3.(1) provides examples of how to achieve the SMACNA air duct leakage seal classes.

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Table A-5.2.2.3.(1)
SMACNA Duct Sealing Classification

Static Pressure Class	Seal Class	Description
≤ 2	C	Sealing required at transverse joints
> 2 and < 4	B	Sealing required at all transverse joints and longitudinal seams
≥ 4	A	Sealing required at all transverse joints, longitudinal seams and duct wall penetrations

A-5.2.2.3.(4) Duct Sealing Exemption. The exemption afforded by Sentence 5.2.2.3.(4) does not apply to ducts in ceiling plenums or other service spaces that are immediately adjacent to the conditioned space served by the ducts.

The rationale behind the exemption from compliance with Sentence 5.2.2.3.(1) is that the energy penalty would be insignificant if a little supply air from a duct located in the same conditioned space to which it is supplying air leaks into the conditioned space before it gets to the diffuser. However, if there is a controlled element, such as a reheat coil, mixing box or variable-air-volume box or a damper, between the leak and the diffuser, a more significant energy loss may result; these types of elements are therefore required to comply with Sentence 5.2.2.3.(1).

A-5.2.2.4.(1) Leakage Testing of Ducts. The choice of ducts to be tested is left to the authority having jurisdiction.

A-5.2.2.5.(6) and 5.2.5.3.(8) Installation Standards. For the purposes of Sentences 5.2.2.5.(6) and 5.2.5.3.(8), "good practice" includes the TIAC Best Practices Guide.

A-5.2.2.8.(1) High-Limit Shut-off. All air economizers should be capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake no longer reduces cooling energy usage. Table A-5.2.2.8.(1) shows the high-limit shut-off settings for different types of air economizers.

Table A-5.2.2.8.(1)
High-Limit Shut-off (HLSO) Control Settings for Air Economizers

Type of HLSO Control[1]	Conditions at which Air Economizer Turns Off	
	Equation[2]	Description
Fixed dry bulb	T_{OA} > 24°C (dry climate)	Outdoor air temperature exceeds 24°C
	T_{OA} > 18°C (humid climate)	Outdoor air temperature exceeds 18°C
Differential dry bulb	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Electronic enthalpy[3]	(T_{OA},RH_{OA}) > A	Outdoor air temperature/RH exceeds the "A" setpoint curve[4]
Differential enthalpy	$h_{OA} > h_{RA}$	Outdoor air enthalpy exceeds return air enthalpy
Dew-point and dry-bulb temperatures	DP_{oa} > 18°C or T_{oa} > 24°C	Outdoor air dry bulb exceeds 24°C or outside dew point exceeds 13°C (65 gr/lb)

Notes to Table A-5.2.2.8.(1):

(1) Fixed enthalpy is a prohibited type of control for the climate zones to which the NECB applies, namely zones 4 to 8.

(2) T_{OA} = temperature outdoor air; T_{RA} = temperature return air; h_{OA} = enthalpy outdoor air; RH_{OA} = relative humidity outdoor air; h_{RA} = enthalpy return air; DP_{OA} = dew point outdoor air

(3) Electronic enthalpy controls use a combination of humidity and dry-bulb temperature in their switching algorithm.

(4) Setpoint "A" corresponds to a curve on the psychrometric chart that goes through a point at approximately 24°C and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

A-5.2.2.8.(2) Outdoor Air Intake for Acceptable Indoor Air Quality. Outdoor air requirements for acceptable indoor air quality are covered in Part 6 of Division B of the NBC.

A-5.2.2.8.(6) Controls to Allow Proper Operation of Direct Expansion Systems. Preventing frost build-up on coils is an example of how the controls referred to in Sentence 5.2.2.8.(6) enable the proper operation of the equipment.

A-5.2.3.1.(2) Fan System Design. Although the allowed maximum power demand of a fan system is based solely on the supply airflow, the calculation of actual power demand includes supply fans, return fans, relief fans, and fans for series fan-powered boxes, but not parallel-powered boxes or exhaust fans such as bathroom or laboratory exhausts.

A-5.2.3.2.(1) Constant-Volume Fan Systems. This type of system includes bypass variable-air-volume systems in which the airflow through the fan is not varied.

Both supply and return fans must be accounted for, but not exhaust fans.

The power demand of the motors refers to the power drawn by the motors and not their nameplate rating.

A-5.2.3.3.(1) Variable-Air-Volume Fan Systems. The power demand of supply, relief and return fans—but not that of exhaust fans—must be accounted for in Sentence 5.2.3.2.(1).

The power demand of fans for series-fan-powered boxes—but not that of fans in parallel-fan-powered boxes—must be accounted for in Sentence 5.2.3.2.(1).

The power demand of the motors refers to the power drawn by the motors and not their nameplate rating.

A-5.2.5.2.(1) Provision for Balancing. Balancing a hydronic system is a means of fine-tuning it so that the correct amount of fluid for which the system is designed can be delivered to each of the sectors served. Pumps and major circuit divisions must be installed with adequate access to the fluid to measure differential pressure or flow, and must be equipped with a means of adjusting the flow.

The following publications are useful sources of information on hydronic systems:
- ANSI/ASHRAE 111, "Measurement, Testing, Adjusting and Balancing of Building HVAC Systems"
- the ASHRAE Handbooks
- publications by the National Environmental Balancing Bureau

A-5.2.6.2.(1) Variable-Flow Pumping Systems. Flow may be varied by one of several methods such as variable-speed-driven pumps, staged multiple pumps or pumps riding their characteristic performance curves, etc. Sentence 5.2.6.2.(1) reduces the use of three-way valves.

A-5.2.8.3.(1) Mounting Height and Location of Thermostats.

Mounting Height of Thermostats

Article 3.8.1.5. of Division B of the NBC contains a specific requirement regarding the mounting height of thermostats located in a barrier-free path of travel; the use of thermostats with separate sensors and controls may be the best option in such spaces.

Location of Thermostats

Examples of locations to be avoided are exterior walls and locations near exterior entrances, corners and within throw of supply air diffusers. Installation should include all necessary settings and adjustments, including, in the case of electric heaters, setting of the heat anticipator to match the capacity of the heaters being controlled, as required on some thermostats for performance certification.

A-5.2.8.4.(1) Supplementary Heater. For the purposes of Sentence 5.2.8.4.(1) and Clause 5.2.11.1.(2)(e), "supplementary" heat or heater refers to the provision of heat over and above the capacity of the heat pump in order to meet peak heating load demand.

A–5.2.8.5.(2)(a) Thermostatic Controls for Perimeter Systems. Clause 5.2.8.5.(2)(a) is intended to prohibit the use of an outdoor sensor as the sole control that determines the heat supplied to a space. However, a single-zone thermostat is permitted to be used to measure the radiation for each building exposure as input to control the heat supplied to the perimeter system.

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A-5.2.8.5.(3) Heating and Cooling Controls. The requirement in Sentence 5.2.8.5.(3) can be met by means of software in a direct digital control system, or through the provision of a concealed, adjustable mechanical stop in each thermostat.

A-5.2.8.7.(2) Reheating Supply Air for Humidity Control. Sentence 5.2.8.7.(2) could apply to spaces such as computer rooms, operating rooms and museums. Theatres often require reheating since the cooling coil discharge temperature necessary to maintain reasonable humidity levels is too low for adequate comfort conditions.

A-5.2.10.1.(1) Heat-Recovery Systems. Building exhaust airstreams are an important source of recoverable heat (assuming the exhaust air is clean and safe). However, heat recovery on small amounts of airflow is not economical due to the costs involved in installing a heat-recovery apparatus, which will vary by project as will the actual savings realized for each project.

The minimum value of sensible heat in the exhaust air system at which the Code requirement for a heat-recovery apparatus is triggered is based on a reasonable amount of airflow, as could be expected in a small- to medium-size building or air handler, at winter design conditions. The minimum 150 kW sensible heat content stated in Sentence 5.2.10.1.(1) is derived from the minimum airflow recommended in ANSI/ASHRAE/IESNA 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," for heat recovery (2 360 L/s), at a winter design condition giving a difference of 55°C between exhaust air and incoming air (the temperature difference between outside air and building exhaust air can range up to approximately 55°C at winter design conditions in cold climates, but for the most part will be somewhat less).

A-5.2.10.1.(4) January Design Temperatures. The outdoor 2.5% January design temperature for many locations across Canada can be found in Appendix C of Division B of the NBC.

A-5.2.10.2.(1) Heat Recovery from Dehumidification in Swimming Pools. Sentence 5.2.10.2.(1) is not intended to require that all exhaust air from the swimming pool area pass through a heat-recovery unit, only sufficient air to recover 40% of the total sensible heat. Most heat-recovery units can recover more than 40% of the sensible heat from the exhaust air, but because it may not be cost-effective to reclaim heat from all exhaust systems, the overall recovery requirement is set at 40%.

A-5.2.10.3.(1) Heat Recovery from Ice-making Machines in Ice Arenas and Curling Rinks. Heat recovered from refrigeration equipment can also be used for ice resurfacing or heating the soil beneath the ice's surface to prevent frost heave.

A-5.2.10.4.(1) Heat Recovery in Dwelling Units. The NBC contains detailed requirements for the mechanical ventilation of dwelling units. As the NECB only addresses the objective of energy efficiency, requirements that address other objectives can be found in the NBC and NPC. Therefore, the requirements of this Code should be read in conjunction with those of the NBC. For example, the requirements of Subsection 9.32.3. of Division B of the NBC can be satisfied using a heat-recovery ventilator but can also be satisfied with other types of ventilation equipment. In cases where the NECB requires heat recovery from the exhaust component of the ventilation system, a heat-recovery ventilator is often the most likely choice.

Article 9.32.3.4. of Division B of the NBC describes the principal exhaust component of a mechanical ventilation system, which represents 50% of the total ventilation capacity required by Article 9.32.3.3. of that Code.

A-5.2.10.4.(2) Heat-Recovery Ventilators. CAN/CSA-C439, "Rating the Performance of Heat/Energy-Recovery Ventilators," describes a laboratory test that determines the energy performance of a heat-recovery ventilator. Test results for many models are listed in HVI's Certified Home Ventilating Products Directory. The results also usually appear on a label on the equipment itself or in the manufacturer's published literature.

Sentence 5.2.10.4.(2) is not intended to preclude the use of energy-recovery ventilators (ERVs).

A-5.2.10.4.(5) Heat-Recovery Ventilators in Multi-Unit Residential Buildings. Heat-recovery ventilators used in multi-unit residential buildings must not allow any cross-contamination of airflow from one dwelling unit to another as per the NBC. The minimum sensible-heat-recovery efficiency can be calculated in accordance with formula 6-J of ASHRAE 90.1, "User's Manual."

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A-5.2.11.1.(1) Off-hours Controls. For a system serving only a single dwelling unit, one way to satisfy Sentence 5.2.11.1.(1) is to use an automatic programmable thermostat that permits automatic setback of the thermostat setpoint. For larger buildings with more than one system, a central control is recommended.

A-5.2.11.1.(2)(d) Reducing or Shutting off Outdoor Air Intake. Setback and morning startup periods are examples of periods when outdoor air intake may be reduced or shut off.

A-5.2.11.1.(2)(e) Heat Pump Controls for Recovery from Setback. The requirements of Clause 5.2.11.1.(2)(e) can be achieved through several methods:

(a) installation of a separate exterior temperature sensor,
(b) setting a gradual rise of the control point,
(c) installation of controls that "learn" when to start recovery based on stored data.

A-5.2.11.2.(3) Temperature Control for Airflow Control Areas. All of the zones in a building should not have to be conditioned when only some of them are occupied. At the very least, each floor should be able to be isolated; where the floor surface area exceeds 2 500 m^2, it should be divided into areas no greater than 2 500 m^2.

A-5.2.12.1.(1) Unitary and Packaged HVAC Equipment. Units of equipment subject to federal, provincial or territorial appliance or equipment energy efficiency acts carry a label certifying that their performance meets the requirements of the standard and acts shown thereon; there is therefore no need for figures to be checked.

It should be noted that, where a building is served by multiple heating or cooling units that are activated in sequence in response to increasing heating or cooling needs, it is likely economically justified to specify higher efficiency than is mandated in this Code for the lead units, which operate for the longest periods of time.

A-6.1.1.3.(1) Compliance. The flow chart in Figure A-6.1.1.3.(1) illustrates the process for all three paths of compliance applicable to Part 6.

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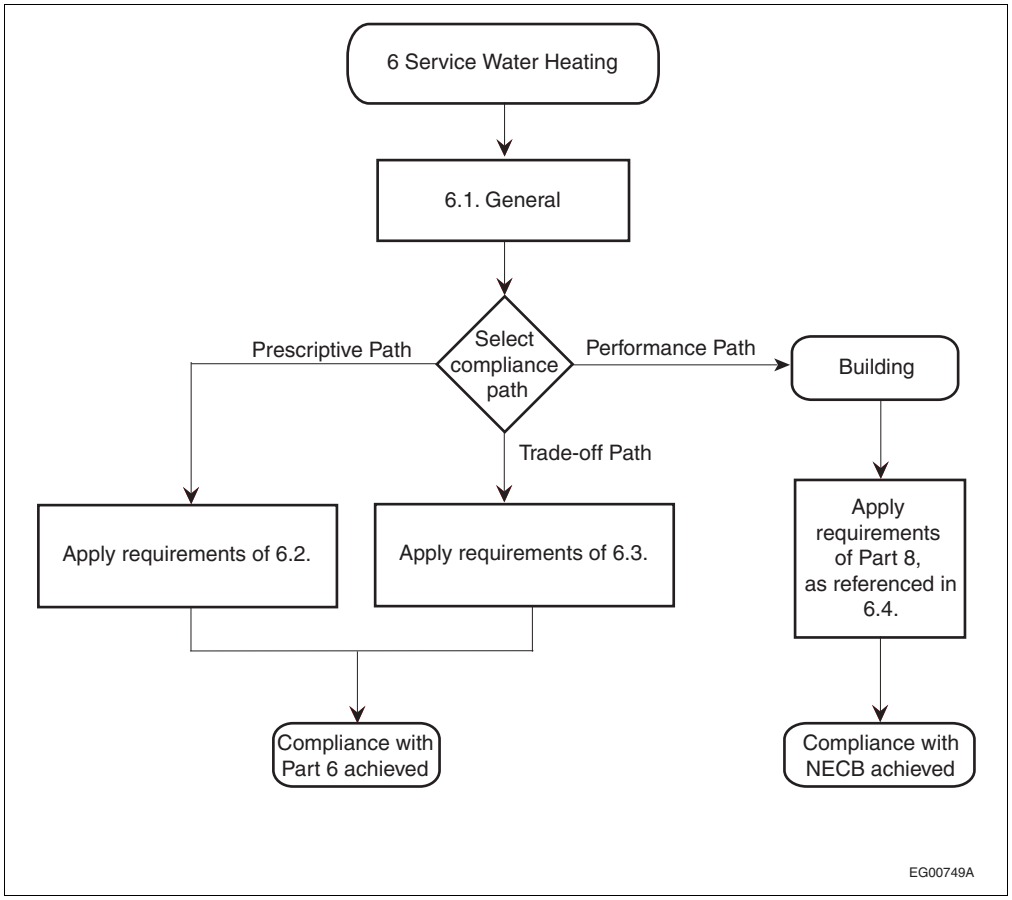

Figure A-6.1.1.3.(1)
Code compliance paths for service water heating

A-6.2.2.1.(1) Equipment Efficiency. Units of equipment subject to federal, provincial or territorial appliance or equipment energy efficiency acts carry a label certifying that their performance meets the standard shown thereon.

A-6.2.3.1.(1) Heat Traps. ASHRAE 90.1, "User's Manual," defines a heat trap as follows:

"A heat trap is a device or arrangement of piping that keeps the buoyant hot water from circulating through a piping distribution system through natural convection. By restricting the flow from the storage tank, standby heat loss is minimized.

Heat traps are required for storage heaters and storage tanks in non-circulating systems with vertical piping. Storage heaters with integral heat traps on both inlet and outlet piping satisfy this requirement. External heat traps must be insulated and should be placed as close as possible to the tank inlet and outlet fittings.

In all configurations heat traps can be a 360° loop of piping, a pre-manufactured device, or some arrangement of piping and elbows that forms an inverted "U" on the tank fittings. Tanks that have horizontal outlets need only a section of vertical pipe that turns downward after leaving the tank (an inverted "L")."

Figure A-6.2.3.1.(1) illustrates two examples of site-built heat traps. An inlet pipe that feeds directly into the cold region of the tank may also be considered to have an effect equivalent to that of a heat trap.

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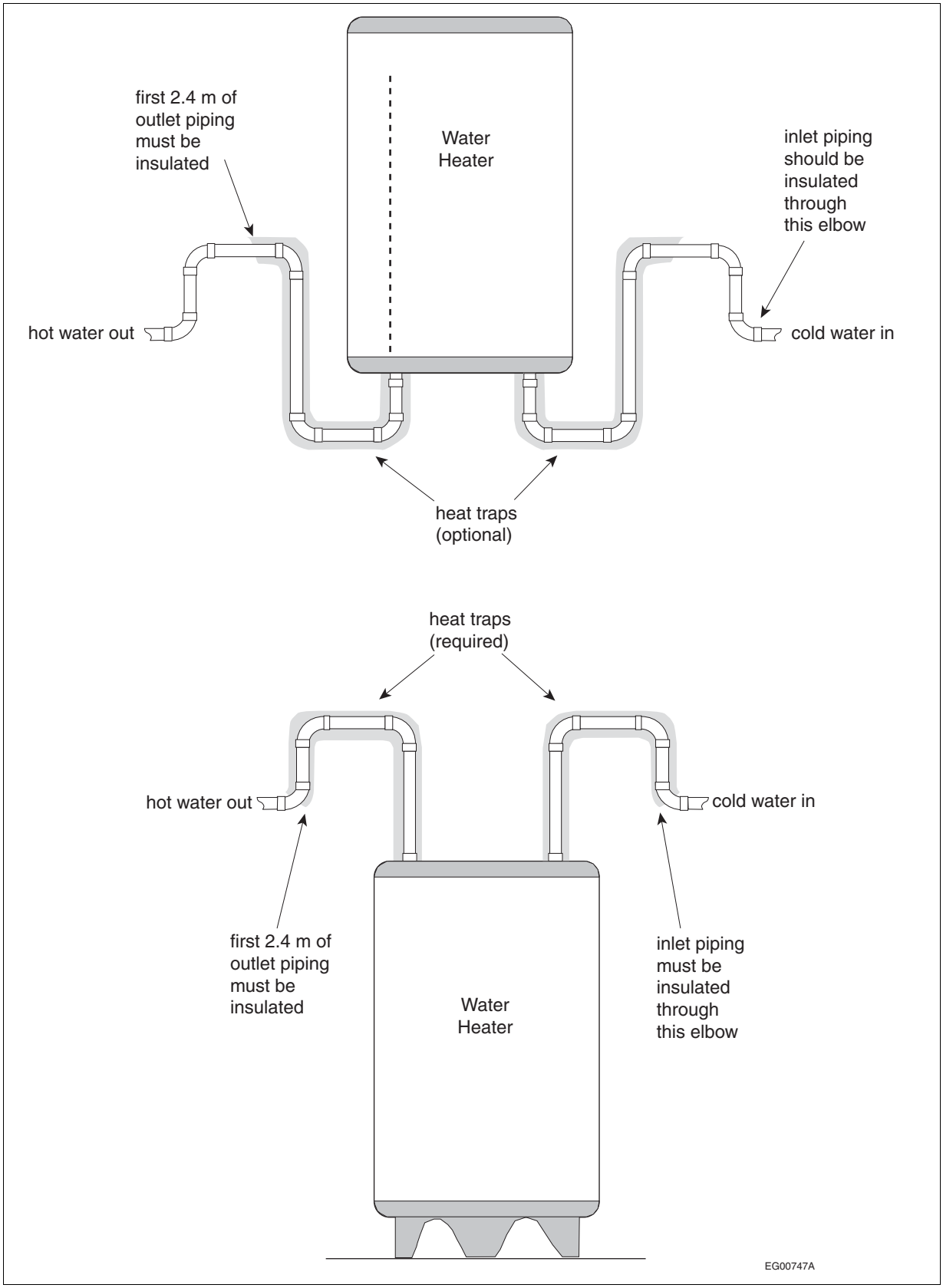

Figure A-6.2.3.1.(1)
Heat traps

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A-6.2.4.1.(1) Temperature Control. The temperatures applicable to various uses of service water can be found in the ASHRAE Handbook – HVAC Applications.

A-6.2.4.2.(1) Shutdown. Sentence 6.2.4.2.(1) is intended to apply to seasonal or long-term shutdown of the service water heating system. For electrical water heaters, a breaker approved for use as a disconnect and installed in the distribution panel can act as the required shut-off device. For gas water heaters, a down position on the temperature control, which sets the heater to standby with only the pilot light running, meets this requirement.

A-6.2.5.1.(1) Remote or Booster Heaters. Sentence 6.2.5.1.(1) applies to appliances that require very hot water for their purpose such as dishwashers, etc. The intent is that the general water supply temperature not be raised to meet the hot water requirements of such appliances.

A-6.2.6.1.(1) Flow-Restricting Shower Heads. Flow-restricting inserts should not be used to meet the requirement of Sentence 6.2.6.1.(1). A flow of 9.5 L/min is equivalent to 2.5 US gal/min.

A-6.2.6.1.(2) and 6.2.6.2.(2) Water Shut-off Devices. Examples of devices meeting the intent of Sentences 6.2.6.1.(2) and 6.2.6.2.(2) include occupant sensors and self-closing valves.

A-7.1.1.2.(1) Application. Sentence 7.1.1.2.(1) is intended to apply to all electrical power systems and motors in or on the building or building site that are connected to the building's electrical service.

A-7.1.1.3.(1) Compliance. The flow chart in Figure A-7.1.1.3.(1) illustrates the process for the compliance paths applicable to Part 7.

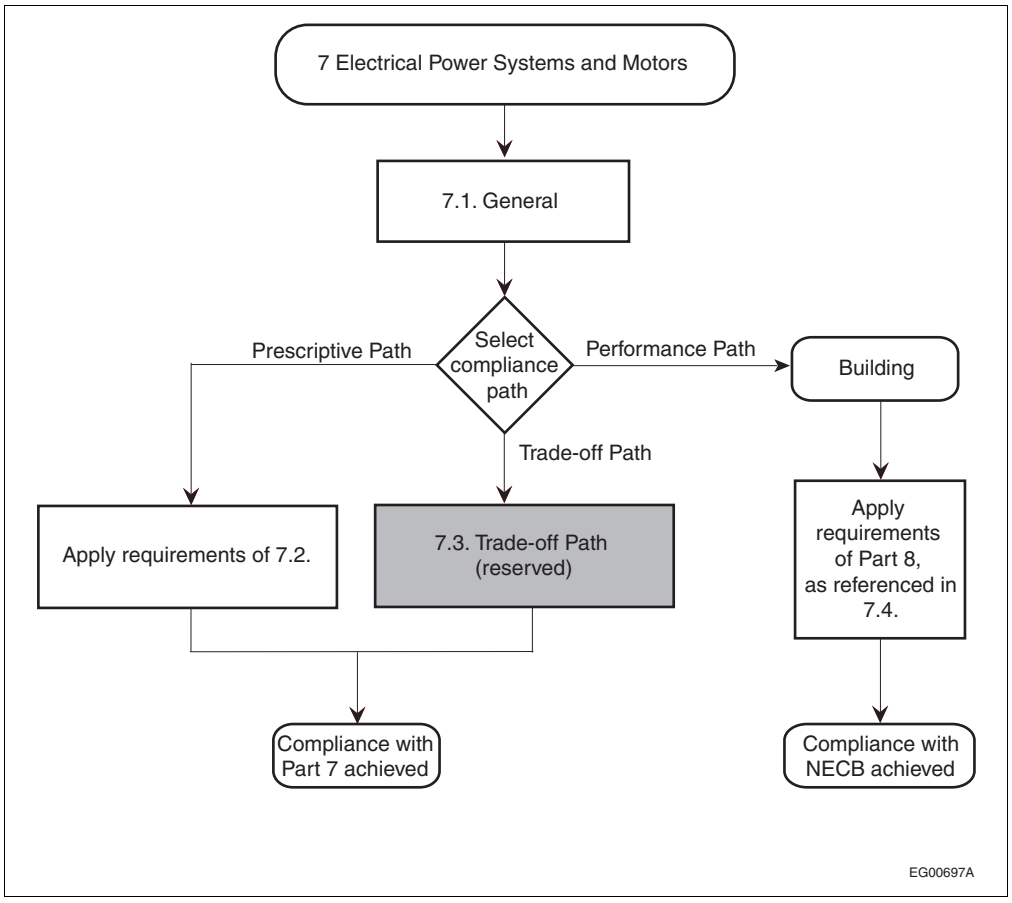

Figure A-7.1.1.3.(1)
Code compliance paths for electrical power systems and motors

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A-7.2.1.1. Means to Monitor Energy Consumption. Monitoring electrical energy consumption is considered essential to energy management. However, Article 7.2.1.1. is not intended to require the installation of electrical energy consumption monitoring equipment but rather to require the provision of the necessary access and hardware to permit the eventual installation and use of monitoring equipment, if desired. This might include, for example, the installation of a meter socket or the provision of access to the load side of the service box or main distribution panel to allow for the measurement of energy consumption using voltage and/or current transformers on a separately mounted meter or data logger. Requirements for safe access to metering locations are provided in local electrical codes and in Section 2 of the Canadian Electrical Code, published by CSA.

A-8.4.1.4. Treatment of Additions. When the addition is considered by itself, its dimensions and thermal characteristics are used without considering the existing building. The wall or floor or virtual plane separating the addition from the existing building is considered for what it is — a building component separating two conditioned spaces: heat exchange across the building component is not taken into consideration unless the design calls for a temperature differential across it or the existing building is an unconditioned space. Only the new mechanical and electrical systems that are part of the addition or serve only the addition are accounted for in the calculations; existing central plants are not accounted for.

When the addition is considered together with the existing building, energy analyses of the whole building are required, including existing parts and additions. Some existing parts of the building, such as existing central plants, may not be needed for the comparison of the proposed and reference buildings and may not have to be simulated. It may be advantageous to consider the whole building only in cases where considering the addition by itself would result in a very high fenestration-to-wall ratio. Existing portions of the building need not be upgraded to meet Code requirements; the compliance calculations are expected to use the characteristics of the existing components in the analyses of both the proposed and reference buildings.

However, as implied in Clause 8.4.1.4.(1)(b), the performance path cannot be used to allow the upgrading of existing components of the building to compensate for components of the addition that do not satisfy the prescriptive requirements of the Code: for example, existing windows cannot be replaced with new ones to compensate for a building envelope on the addition with a high thermal transmittance. Even if the windows in the existing building are to be upgraded at the same time as the addition is being constructed, the characteristics of the existing windows will be used in both analyses. Thus, energy savings in the existing parts of the building cannot be used to offset any shortcomings of the addition's components.

The degree of precision required in determining the thermal characteristics of existing components, as required in Clause 8.4.1.4.(2)(b) and Sentence 8.4.1.4.(3), is not high, since the characteristics of the existing parts of the building remain identical in both simulations. In fact, the existing parts of the building get compared to themselves.

A-8.4.1.4.(2)(b) Characteristics of Existing Equipment. Clause 8.4.1.4.(2)(b) is intended to direct Code users to apply the standards and test methods listed in Parts 5 and 6.

A-8.4.2.2.(1)(g) Auxiliary HVAC Equipment. This category of equipment generally includes cooling tower fans, humidifiers and other devices that do not directly fall under one of the other categories listed in Sentence 8.4.2.2.(1).

A-8.4.2.3. Climatic Data. The following data formats are acceptable to represent climatic data:

- TMY2 (Typical Meteorological Year 2),
- TMY3 (Typical Meteorological Year 3),
- WYEC2 (Weather Year for Energy Calculation 2),
- CWEC (Canadian Weather Year for Energy Calculations),
- IWEC (International Weather for Energy Calculations), and
- CWEEDS (Canadian Weather Energy and Engineering Datasets).

The CWEC represent average heating and cooling degree-days which impact heating and cooling loads in buildings. The CWEC follow the ASHRAE WYEC2 format and were derived from the CWEEDS of hourly weather information for Canada from the 1953-1995 period of record. The CWEC are available from Environment Canada at http://climate.weatheroffice.gc.ca/prods_servs/index_e.html.

Where climatic data for a target location are not available, climatic data for a representative alternative location should be selected based on the following considerations: same climatic zone, same geographic area or characteristics, heating degree-days (HDD) of the alternative location are within 10% of the target location's HDD, and the January 1% heating design criteria of the alternative location is within 2°C of the target location's

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same criteria (see Appendix C of Division B of the NBC). Where several alternative locations are representative of the climatic conditions at the target location, their proximity to the target location should also be a consideration.

A-8.4.2.7.(1) Internal and Service Water Heating Loads. Common internal loads include loads due to lighting, presence of occupants, equipment that is directly operated by the occupants such as personal computers, equipment that operates automatically such as computer servers, and other non-energy-consuming loads such as food to be frozen in a freezer. Internal loads usually generate sensible, latent and/or radiant heat gains.

Except for lighting, internal loads are not regulated within the scope of the NECB. However, because they add cooling and/or heating loads to the building's HVAC and service water heating systems, internal loads representative of the building type or space function should be included in the compliance calculations in order to correctly evaluate part-load performance of the HVAC and service water heating systems and, by extension, the energy consumption of the proposed and reference buildings. The internal loads must be modeled identically in the proposed and reference building energy models; only the energy consumed by the equipment and systems regulated by the NECB can be modeled differently in the proposed and reference buildings.

Appendix Note A-8.4.3.3.(1) provides default internal loads and associated hourly profiles for occupants and receptacle equipment that are representative of different building types and space functions. While any internal load values are permitted to be used, those default values should be used in the absence of better information.

The default values for receptacle equipment generally represent common electrical equipment directly operated by the occupants, as well as some automatically operated electrical equipment commonly found in the building types listed. For example, for an office building, the default value implicitly includes equipment such as office computer servers, photocopiers, printers, escalators, elevators, etc., but does not include the servers of main data centres.

Reasonable professional judgment should be applied in evaluating whether less common internal loads are correctly represented or not in the default values and profiles for receptacle equipment. These less common loads are generally associated with commercial and industrial operations and processes, such as

- manufacturing machinery in an industrial building
- medical imaging equipment in a hospital
- computer servers in a data centre of an office building
- swimming pool water heating in a recreation centre
- cooking appliances and refrigeration equipment in a commercial kitchen or restaurant

Generally, if the default values provided in Appendix Note A-8.4.3.3.(1) appear too small compared to the actual expected internal loads, some commercial and/or industrial operations and/or processes will not be correctly represented.

A-8.4.3.2.(1) Operating Schedules. Tables A-8.4.3.2.(1)A. to A-8.4.3.2.(1)I. contain default values of operating schedules of building parameters for simulation purposes. These schedules may be used with Table A-8.4.3.3.(1)B. if more accurate information is not available. If the building or space type is not listed in Table A-8.4.3.3.(1)A. or A-8.4.3.3.(1)B., the schedule that most closely corresponds to the occupancy of the proposed building or space should be used.

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Table A-8.4.3.2.(1)A.
Operating Schedule A

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0	0	0	0	0	0	0.1	0.7	0.9	0.9	0.9	0.5	0.5	0.9	0.9	0.9	0.7	0.3	0.1	0.1	0.1	0.1	0	0
Sat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting, fraction "on"																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.3	0.3	0.1	0.1	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle Equipment, fraction of load																								
Mon - Fri	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.3	0.3	0.2	0.2	0.2	0.2
Sat	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sun	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fans																								
Mon - Fri	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Cooling System, °C																								
Mon - Fri	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Heating System, °C																								
Mon - Fri	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	18	18	18
Sat	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Sun	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Service Water Heating System, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.3	0.2	0.2	0.2	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

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Table A-8.4.3.2.(1)B.
Operating Schedule B

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0.1	0	0	0	0	0	0	0	0.1	0.2	0.5	0.9	0.8	0.5	0.2	0.2	0.3	0.6	0.9	0.9	0.9	0.6	0.4	0.3
Sat	0.3	0	0	0	0	0	0	0	0.1	0.2	0.5	0.9	0.8	0.5	0.2	0.2	0.3	0.6	0.9	0.9	0.9	0.6	0.6	0.5
Sun	0.3	0	0	0	0	0	0	0	0	0.1	0.4	0.5	0.5	0.4	0.2	0.2	0.2	0.5	0.7	0.7	0.5	0.3	0.1	0.1
Lighting, fraction "on"																								
Mon - Fri	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5
Receptacle Equipment, fraction of load																								
Mon - Fri	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5
Fans																								
Mon - Fri	On	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Cooling System, °C																								
Mon - Fri	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sat	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sun	Off	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	Off	Off
Heating System, °C																								
Mon - Fri	22	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sat	22	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sun	22	18	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	18	18
Service Water Heating System, fraction of load																								
Mon - Fri	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.4	0.5	0.6	0.6	0.4	0.3	0.3	0.4	0.5	0.8	0.8	0.9	0.9	0.6
Sat	0.6	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.4	0.5	0.6	0.6	0.4	0.3	0.3	0.4	0.5	0.8	0.8	0.9	0.9	0.7
Sun	0.6	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.7	0.7	0.4	0.5	0.6	0.6	0.4	0.3	0.3	0.4	0.5	0.8	0.8	0.5	0.5	0.5

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Table A-8.4.3.2.(1)C.
Operating Schedule C

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0	0	0	0	0	0	0	0.1	0.2	0.5	0.5	0.7	0.7	0.7	0.7	0.8	0.7	0.5	0.3	0.3	0	0	0	0
Sat	0	0	0	0	0	0	0	0.1	0.2	0.5	0.6	0.8	0.9	0.9	0.9	0.8	0.7	0.5	0.2	0.2	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0.1	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.2	0	0	0	0	0	0
Lighting, fraction "on"																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.5	0.05	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.5	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle Equipment, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.5	0.05	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.5	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6	0.05	0.05	0.05	0.05	0.05	0.05
Fans																								
Mon - Fri	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off
Cooling System, °C																								
Mon - Fri	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	Off	Off	Off	Off	Off	Off
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	18	18	18	18
Sat	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	18	18	18	18
Sun	18	18	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	18	18	18	18	18	18
Service Water Heating System, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.2	0.3	0.4	0.8	0.8	0.8	0.8	0.6	0.4	0.3	0.2	0.2	0.05	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.2	0.3	0.5	0.9	0.9	0.9	0.9	0.7	0.5	0.3	0.2	0.2	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.8	0.8	0.6	0.4	0.3	0.2	0.05	0.05	0.05	0.05	0.05	0.05

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Table A-8.4.3.2.(1)D.
Operating Schedule D

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0	0	0	0	0	0	0	0.1	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.5	0.2	0.1	0.3	0.3	0.3	0.1	0	0
Sat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting, fraction "on"																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.7	0.7	0.7	0.3	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle Equipment, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.7	0.7	0.7	0.3	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fans																								
Mon - Fri	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Cooling System, °C																								
Mon - Fri	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	18	18
Sat	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Sun	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Service Water Heating System, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.3	0.5	0.5	0.5	0.3	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

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Table A-8.4.3.2.(1)E.
Operating Schedule E

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0	0	0	0	0	0	0	0.2	0.7	0.9	0.9	0.9	0.9	0.5	0.9	0.8	0.8	0.2	0	0	0	0	0	0
Sat	0	0	0	0	0	0	0	0	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting, fraction "on"																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.4	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.4	0.05	0.05	0.05	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle Equipment, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.4	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.4	0.05	0.05	0.05	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fans																								
Mon - Fri	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Cooling System, °C																								
Mon - Fri	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	Off	Off	Off	Off	Off	Off
Sat	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	Off	Off	Off	Off	Off	Off	Off	Off
Sun	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	18	18	18	18	18	18
Sat	18	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	18	18	18	18	18	18	18	18
Sun	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Service Water Heating System, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.4	0.5	0.5	0.7	0.9	0.8	0.7	0.8	0.3	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.2	0.4	0.2	0.2	0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

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Table A-8.4.3.2.(1)F.
Operating Schedule F

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.7	0.7	0.8	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.6	0.6	0.6	0.7	0.7	0.7
Sun	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.6	0.6	0.8	0.8	0.8
Lighting, fraction "on"																								
Mon - Fri	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.8	0.9	0.8	0.6	0.3
Sat	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.7	0.7	0.7	0.6	0.3
Sun	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.5	0.7	0.8	0.6	0.5	0.3
Receptacle Equipment, fraction of load																								
Mon - Fri	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.8	0.9	0.8	0.6	0.3
Sat	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6	0.7	0.7	0.7	0.6	0.3
Sun	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.5	0.7	0.8	0.6	0.5	0.3
Fans																								
Mon - Fri	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling System, °C																								
Mon - Fri	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sat	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sun	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sat	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sun	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Service Water Heating System, fraction of load																								
Mon - Fri	0.3	0.2	0.1	0.1	0.2	0.4	0.6	0.9	0.7	0.5	0.5	0.4	0.5	0.4	0.3	0.3	0.3	0.3	0.5	0.7	0.7	0.7	0.7	0.5
Sat	0.3	0.2	0.1	0.1	0.2	0.4	0.5	0.8	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.5	0.7	0.7	0.7	0.7	0.5
Sun	0.3	0.2	0.1	0.1	0.2	0.4	0.4	0.6	0.9	0.7	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.3	0.4	0.6	0.6	0.6	0.6	0.5

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Table A-8.4.3.2.(1)G.
Operating Schedule G

Day	Times of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Lighting, fraction "on"																								
Mon - Fri	0	0	0	0	0	0.2	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.9	0.9	0.9	0.8	0.6	0.3
Sat	0	0	0	0	0	0.2	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.9	0.9	0.9	0.8	0.6	0.3
Sun	0	0	0	0	0	0.2	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.9	0.9	0.9	0.8	0.6	0.3
Receptacle Equipment, fraction of load																								
Mon - Fri	0.2	0.2	0.2	0.2	0.2	0.2	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.2	0.9	0.9	0.7	0.5	0.5	0.5	0.3
Sat	0.2	0.2	0.2	0.2	0.2	0.2	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.2	0.9	0.9	0.7	0.5	0.5	0.5	0.3
Sun	0.2	0.2	0.2	0.2	0.2	0.2	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.2	0.9	0.9	0.7	0.5	0.5	0.5	0.3
Fans																								
Mon - Fri	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling System, °C																								
Mon - Fri	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sat	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sun	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sat	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sun	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Service Water Heating System, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.2	0.8	0.7	0.5	0.4	0.2	0.2	0.2	0.3	0.5	0.5	0.7	0.7	0.4	0.4	0.2	0.2	0.1	0.1
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.7	0.9	0.7	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.3	0.3	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.4	0.3	0.2	0.2	0.2	0.2	0.1

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Table A-8.4.3.2.(1)H.
Operating Schedule H

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Lighting, fraction "on"																								
Mon - Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Receptacle Equipment, fraction of load																								
Mon - Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Fans																								
Mon - Fri	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sat	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Cooling System, °C																								
Mon - Fri	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sat	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sun	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sat	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Sun	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
Service Water Heating System, fraction of load																								
Mon - Fri	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sun	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

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Table A-8.4.3.2.(1)I.
Operating Schedule I

Day	Time of Day																							
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	12
Occupants, fraction occupied																								
Mon - Fri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.4	0.8	0.8	0.8	0.6	0.4	0.1
Sat	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.4	0.6	0.8	0.6	0.4	0.2	0.4	0.8	0.8	0.6	0.4	0.1
Sun	0	0	0	0	0	0	0	0.2	0.4	0.8	0.8	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0
Lighting, fraction "on"																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.5	0.8	0.9	0.9	0.9	0.9	0.9	0.5
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.5	0.5	0.8	0.9	0.9	0.9	0.8	0.6	0.8	0.9	0.9	0.9	0.9	0.5
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.9	0.9	0.9	0.9	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle Equipment, fraction of load																								
Mon - Fri	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.8	0.8	0.8	0.8	0.8	0.8	0.1
Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.1
Sun	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.8	0.8	0.8	0.8	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fans																								
Mon - Fri	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On
Sat	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Sun	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Cooling System, °C																								
Mon - Fri	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	Off
Sat	Off	Off	Off	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	24	24	24	24	24	24	24	Off
Sun	Off	Off	Off	Off	Off	Off	24	24	24	24	24	24	24	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Heating System, °C																								
Mon - Fri	18	18	18	18	18	18	18	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	18
Sat	18	18	18	18	18	18	18	18	18	20	22	22	22	22	22	22	22	22	22	22	22	22	22	18
Sun	18	18	18	18	18	18	20	22	22	22	22	22	22	18	18	18	18	18	18	18	18	18	18	18
Service Water Heating System, fraction of load																								
Mon - Fri	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.2	0.2	0.4	0.9	0.9	0.9	0.8	0.6	0.2
Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.2	0.2	0.4	0.8	0.9	0.8	0.6	0.4	0.4	0.9	0.9	0.8	0.6	0.2
Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.2	0.4	0.4	0.2	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

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A-8.4.3.3.(1) Internal and Service Water Heating Loads. Tables A-8.4.3.3.(1)A. and A-8.4.3.3.(1)B. contain default values of internal and service water heating loads and their operating schedules for simulation purposes.

Table A-8.4.3.3.(1)A.
Default Loads and Operating Schedules by Building Type

Building Type	Occupant Density, m^2/occupant	Peak Receptacle Load, W/m^2	Service Water Heating Load, W/person	Operating Schedule from A-8.4.3.2.(1)
Automotive facility	20	5	90	E
Convention centre	8	2.5	30	C
Courthouse	15	5	60	A
Dining				
bar lounge/leisure	10	1	115	B
cafeteria/fast food	10	1	115	B
family	10	1	115	B
Dormitory	30	2.5	500	G
Exercise centre	10	1	90	B
Fire station	25	2.5	400	F
Gymnasium	10	1	90	B
Health-care clinic	20	7.5	90	A
Hospital	20	7.5	90	H
Hotel	25	2.5	500	F
Library	20	2.5	90	C
Manufacturing facility	30	10	90	A
Motel	25	2.5	500	F
Motion picture theatre	8	1	30	C
Multi-unit residential building	60	5	500	G
Museum	20	2.5	60	C
Office	25	7.5	90	A
Parking garage	1000	0	0	H
Penitentiary	30	2.5	400	H
Performing arts theatre	8	1	30	C
Police station	25	7.5	90	H
Post office	25	7.5	90	A
Religious building	5	1	15	I
Retail area	30	2.5	40	C
School/university	8	5	60	D
Sports arena	10	1	90	B
Town hall	25	7.5	90	D
Transportation	15	1	65	H
Warehouse	1500	1	300	A
Workshop	30	10	90	A

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Table A-8.4.3.3.(1)B.
Default Loads and Operating Schedules by Space Type

Common Space Types				
Space Type	Occupant Density, m^2/occupant	Peak Receptacle Load, W/m^2	Service Water Heating Load, W/person	Operating Schedule[(1)] from A-8.4.3.2.(1)
Atrium				
first 13 m in height	10	2.5	0	C
height above 13 m	10	2.5	0	C
Audience seating area – permanent				
for auditorium	5	2.5	30	C
for performing arts theatre	7.5	2.5	30	C
for motion picture theatre	5	2.5	30	C
Classroom/lecture/training	7.5	5	65	D
Conference area/meeting/multi-purpose	5	1	45	C
Corridor/transition area				
≥ 2.4 m wide	100	0	0	*
< 2.4 m wide	100	0	0	*
Dining area				
for bar lounge/leisure dining	10	1	90	B
for family dining	10	1	120	B
other	10	1	120	B
Dressing/fitting room for performing arts theatre	30	2.5	40	C
Electrical/Mechanical area	200	1	0	*
Food preparation area	20	10	120	B
Laboratory				
for classrooms	20	10	180	D
for medical/industrial/research	20	10	180	A
Lobby				
for elevator	10	1	0	C
for performing arts theatre	10	1	0	C
for motion picture theatre	10	1	0	C
other	10	1	0	C
Locker room	10	2.5	0	*
Lounge/recreation area	10	1	60	B
Office				
enclosed	20	7.5	90	A
open plan	20	7.5	90	A
Sales area	30	2.5	40	C
Stairway	200	0	0	*
Storage area	100	1	300	E
Washroom	30	1	0	*
Workshop	30	10	90	A

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Table A-8.4.3.3.(1)B. (Continued)

Building-Specific Space Types				
Space Type	Occupant Density, m^2/occupant	Peak Receptacle Load, W/m^2	Service Water Heating Load, W/person	Operating Schedule[1] from A-8.4.3.2.(1)
Automotive – repair garage	20	5	90	E
Bank – banking activity area and offices	25	5	60	A
Convention centre				
audience seating	5	2.5	30	C
exhibit space	5	2.5	30	C
Courthouse/Police station/Penitentiary				
courtroom	5	2.5	30	A
confinement cell	25	2.5	325	H
judges' chambers	20	7.5	90	A
penitentiary – audience seating	5	2.5	30	C
penitentiary – classroom	7.5	5	65	D
penitentiary – dining area	10	1	120	B
Dormitory – living quarters	25	2.5	500	G
Fire station				
engine room	25	2.5	325	H
sleeping quarters	25	2.5	500	G
Gymnasium/Fitness centre				
fitness area	5	1	90	B
gymnasium – audience seating	5	0	30	B
play area	5	1.5	90	B
Hospital				
corridor/transition area ≥ 2.4 m wide	100	0	0	*
corridor/transition area < 2.4 m wide	100	0	0	*
emergency	20	10	180	H
exam/treatment	20	10	90	C
laundry – washing	20	20	60	C
lounge/recreation	10	1	60	B
medical supply	20	1	0	H
nursery	20	10	90	H
nurses' station	20	2.5	45	H
operating room	20	10	300	H
patient room	20	10	90	H
pharmacy	20	2.5	45	C
physical therapy	20	10	45	C
radiology/imaging	20	10	90	H
recovery	20	10	180	H
Hotel/Motel				
hotel dining	10	1	115	B
hotel guest rooms	25	2.5	600	F
hotel lobby	10	2.5	30	H
highway lodging dining	10	1	115	B
highway lodging guest rooms	25	2.5	600	F

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Table A-8.4.3.3.(1)B. (Continued)

Building-Specific Space Types				
Space Type	Occupant Density, m^2/occupant	Peak Receptacle Load, W/m^2	Service Water Heating Load, W/person	Operating Schedule[1] from A-8.4.3.2.(1)
Library				
card file and cataloguing	20	2.5	90	C
reading area	20	1	90	C
stacks	20	0	90	C
Manufacturing				
corridor/transition area ≥ 2.4 m wide	100	0	0	*
corridor/transition area < 2.4 m wide	100	0	0	*
detailed manufacturing	30	10	90	A
equipment room	30	10	90	A
extra high bay (> 15 m floor-to-ceiling height)	30	10	90	A
high bay (7.5 to 15 m floor-to-ceiling height)	30	10	90	A
low bay (< 7.5 m floor-to-ceiling height)	30	10	90	A
Museum				
general exhibition	5	2.5	60	C
restoration	20	5	50	A
Parking garage – garage area	1000	0	0	H
Post office – sorting area	20	7.5	90	A
Religious buildings				
audience seating	5	1	15	I
fellowship hall	5	1	45	C
worship pulpit, choir	5	1	15	I
Retail				
dressing/fitting room	30	2.5	40	C
mall concourse	20	1	30	C
sales area	30	2.5	40	C
Sports arena				
audience seating	5	0	30	B
court sports area – class 4	5	1.5	90	B
court sports area – class 3	5	1.5	90	B
court sports area – class 2	5	1.5	90	B
court sports area – class 1	5	1.5	90	B
ring sports area	5	1.5	90	B
Transportation				
air/train/bus – baggage area	20	2.5	65	H
airport – concourse	20	0	65	H
seating area	10	0	65	H
terminal – ticket counter	10	2.5	65	H
Warehouse				
fine material storage	50	1	65	A
medium/bulky material	100	1	65	A
medium/bulky material with permanent shelving that is > 60% of ceiling height	100	1	65	A

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Table A-8.4.3.3.(1)B. (Continued)

Notes to Table A-8.4.3.3.(1)B.:

(1) An asterisk (*) in this column indicates that there is no recommended default schedule for the space type listed. In general, such space types will be simulated using a schedule that is similar to the adjacent spaces served: e.g. a corridor space serving an adjacent office space will be simulated using a schedule that is similar to that of the office space.

A-8.4.3.4.(2) Interior Shading. Interior shading provided by devices such as blinds is typically not modeled, unless the devices are part of an automated control system.

A-8.4.3.4.(3) Building Envelope Components. The air leakage value of 0.25 L/s·m², which is a typical infiltration rate at 5 Pa, is for calculation purposes and may not reflect the real value encountered under actual operating conditions; it is based on assumed typical operating pressure differentials.

A-8.4.3.6. Purchased Energy. Purchased energy is typically defined as thermal energy produced from a source external to the scope of the proposed building assessment. It is used as heating and/or cooling energy in an HVAC or service water heating system—as a heat source and/or sink—that is provided either directly or through a heat exchanger or other equipment.

A-8.4.3.6.(6) Secondary Use of Purchased Energy. Figure A-8.4.3.6.(6) shows an example of secondary use of purchased energy.

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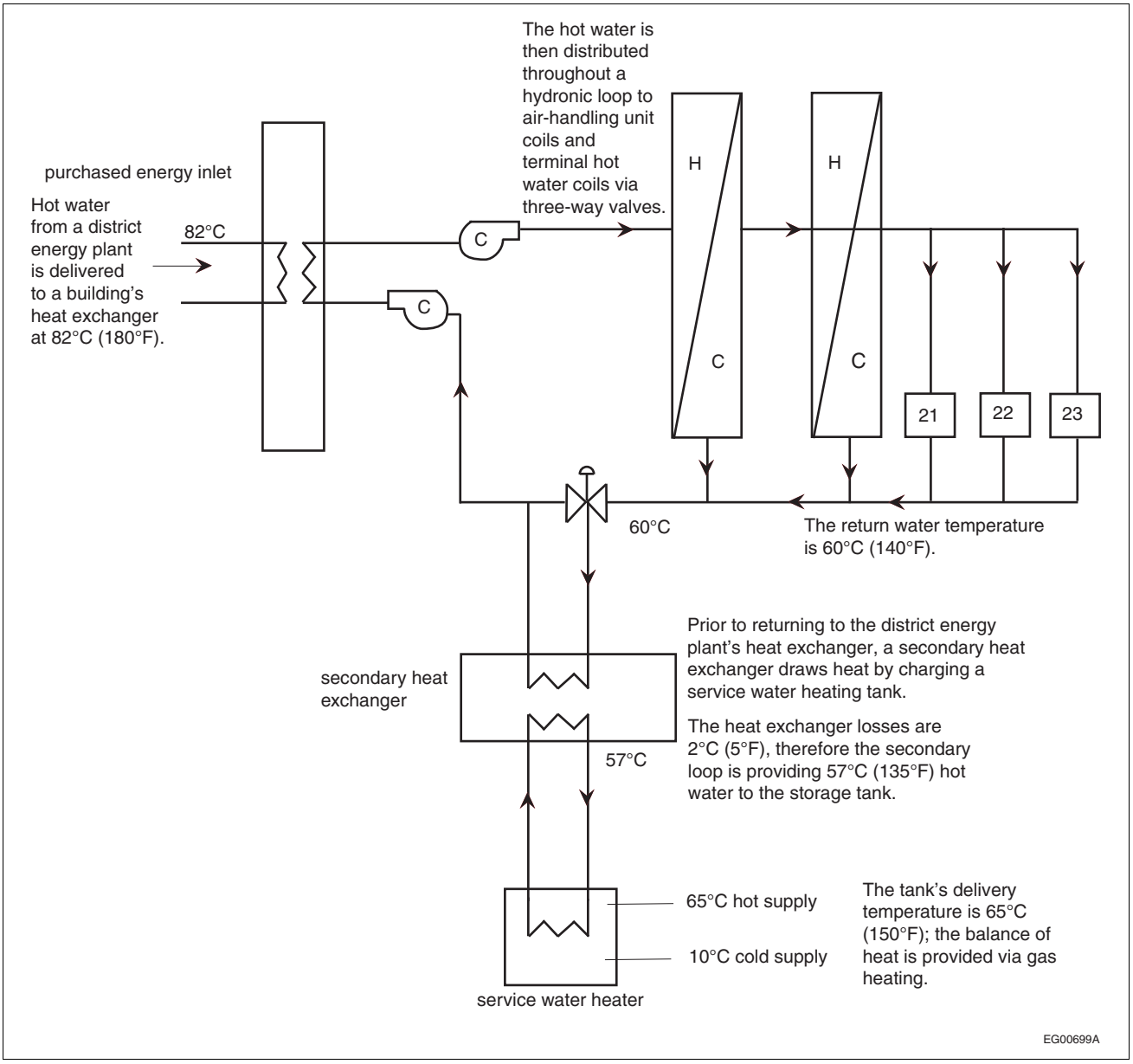

Figure A-8.4.3.6.(6)
Example of secondary use of purchased energy

The energy savings realized by providing hot water to a secondary heat exchanger, which is used to charge a service water heating tank of 150 L/day, is calculated using the following equation:

$$Q = c \cdot M \cdot dT$$

where

Q = energy, in MJ/day,
c = specific heat capacity of water, in 4 186 J/kg·K,
M = mass flow rate of water, in L/day, and
dT = temperature differential, in °C.

For the sake of simplicity, the example illustrated in Figure A-8.4.3.6.(6) assumes that the heat exchanger in the domestic hot water tank functions at 100% efficiency. The energy savings for this example are calculated as follows: Q = 4 186 J/kg·K·150 L/day·1 kg/L·(57°C – 10°C) = 29.5 MJ/day.

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A-8.4.3.7.(1) Outdoor Air. The effectiveness of demand control ventilation varies significantly according to occupant density and sensor type, placement and calibration.

In some building applications, outdoor air ventilation rates constitute a significant portion of the building's energy use. In such cases, ventilation rates that are significantly higher or lower than those specified in the NBC, when combined with energy efficiency measures differing from the requirements of the NECB, can lead to the offsetting of other energy-efficient measures or, worse, can create an artificially high energy-efficient measure.

Since such special cases are too numerous or specialized to describe, the Code requires that the outdoor air ventilation rates be set to the exact values stated in the applicable standards seeing as higher or lower values than those in the NBC are selected by the designers according to requirements not covered by those standards.

See ASHRAE publications for additional information.

A-8.4.3.10. Heat Recovery from Ice-Making Machines. A water-cooled, double-bundle water chiller with a load profile corresponding to the expected loading on the ice machine is adequate for the purposes of Part 8 and allows the modeling of heat recovery using most types of simulation software.

The following documents may be helpful in setting a more detailed model using refrigeration equipment rather than a water chiller and modeling the ice sheet itself and its interaction with adjacent components and spaces:

- Zmeureanu, R., E.M. Zelaya and D. Giguère. (2002). Simulation de la consommation d'énergie d'un aréna à l'aide du logiciel DOE-2.1E. ESim 2002 Conference, Montreal.
- Ouzzane, M. et al. Cooling Load and Environmental Measurements in a Canadian Indoor Ice Rink. ASHRAE Transactions, Vol. 112, Pt. 2, Paper no. QC-06-008, pp. 538-545, 2006.
- Sunyé, R. et al. ASHRAE Research Report 1289, Develop and Verify Methods For Determining Ice Sheet Cooling Loads, 2007.
- Teyssedou, G., R. Zmeureanu, and D. Giguère. (2009). Thermal Response of the Concrete Slab of an Indoor Ice Rink. ASHRAE HVAC&R Research, Vol. 15, No. 3, May 2009.

Since ice-making for rinks is often associated with resurfacing activities, which require a significant amount of heated service water, the energy models of the proposed and reference buildings should account for this load.

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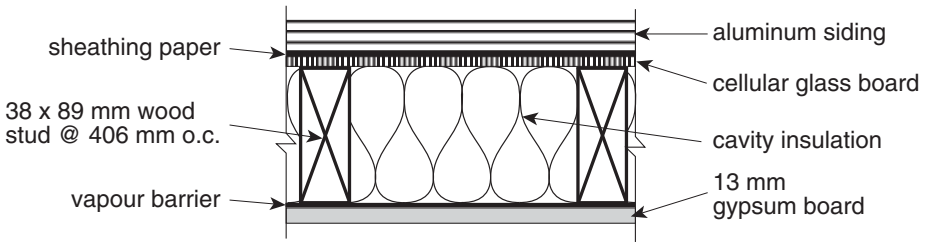
A-8.4.4.5.(1) Thermal Mass. The building envelope assemblies should follow the layer structure of the proposed building's assemblies (type and order) but the insulation thickness should be varied to match the U-value of Part 3. See ASHRAE Handbook – Fundamentals for examples of different types of construction.

Figures A-8.4.4.5.(1)-A and A-8.4.4.5.(1)-B show two examples of lightweight assemblies.



Component	Component Thickness, in mm	Nominal R-Value
Outside surface air film	n/a	0.030
Siding – aluminum or steel with sheathing	10	0.107
Sheathing paper	4	0.02
Insulation – cellular glass board	38	0.753
Insulation – mineral fibre, RSI 2.11(1)	89	2.110
Polyethylene vapour barrier	2	0
Gypsum sheathing	13	0.081
Inside surface air film	n/a	0.120

EG00724B

Figure A-8.4.4.5.(1)-A
11% wood-frame wall construction

Note to Figure A-8.4.4.5.(1)-A:
(1) The framing, whose R-value is 0.611, is installed with this component.

The overall weight of the assembly in Figure A-8.4.4.5.(1)-A is 40.8 kg/m^2 and its heat capacity is 45.5 kJ/m^2·°C.

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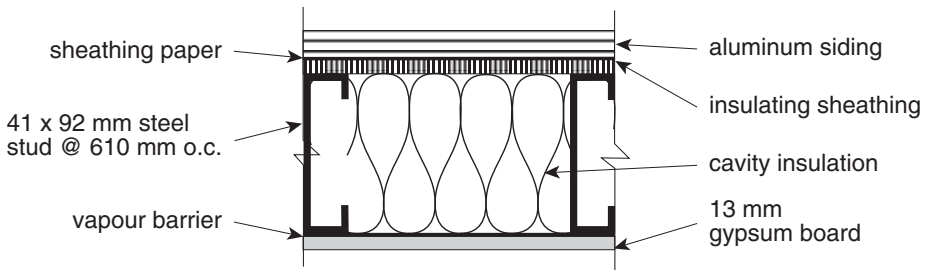

Component	Component Thickness, in mm	Nominal R-Value
Outside surface air film	n/a	0.030
Siding – aluminum or steel with sheathing	10	0.107
Sheathing paper	4	0.02
Insulation – polystyrene, smooth skin	38	1.317
Insulation – mineral fibre, RSI 2.11(1)	89	2.110
Polyethylene vapour barrier	2	0
Gypsum sheathing	13	0.081
Inside surface air film	n/a	0.120

EG00728B

Figure A-8.4.4.5.(1)-B
37% steel-frame wall construction

Note to Figure A-8.4.4.5.(1)-B:
(1) The framing is installed with this component, has an R-value of 0.001, is spaced < 500 mm and contains no insulation.

The overall weight of the assembly in Figure A-8.4.4.5.(1)-B is 33.9 kg/m^2 and its heat capacity is 35.3 kJ/ m^2·°C.

A-8.4.4.5.(2) Thermal Characteristics of the Space. The following are examples of space components that affect thermal mass: layout, furnishings, interior wall and floor construction, library stacks, etc.

A-8.4.4.14. Heat Pump Definitions. The following types of heat pump systems are the most commonly used:

- Water-loop heat pump system: a heat pump system connected to an internal water loop used as a heat source and/or sink. The loop may include an auxiliary heat source (e.g. a boiler) and/or heat rejection device (e.g. a cooling tower)
- Air-source heat pump system: a heat pump system using the outside air as a heat source and/or sink
- Water-source heat pump system: a water-loop heat pump system using surface water (e.g. river, pond or lake), groundwater, or a water loop carrying waste heat generated outside the building as a heat source and/or sink, either directly, or indirectly through the use of a heat exchanger that separates the source from an internal water loop
- Ground-source heat pump system: a heat pump system using the ground as a heat source and/or sink through the use of a ground-heat exchanger in which circulates either a refrigerant supplied by the heat pump or a heat transfer liquid coming from an internal water loop

A-8.4.4.14.(1) Use of Heat Pumps. Sentence 8.4.4.14.(1) is intended to apply to heat pump systems that are used for space conditioning, not for heat-recovery applications.

A-8.4.4.15.(2) Hydronic Systems with Multiple Pumps. Where the proposed building uses multiple pumps in its hydronic systems (for example, a primary-secondary hot water hydronic system), representing these pumps as a single pump in the reference building must ensure that the same peak power is demanded by adjusting the pump head accordingly, based on a flow-weighted average pump efficiency (in order to correctly account for the heat gain due to water passing through the system).

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If the proposed building has the following characteristics:

- a boiler plant with an output capacity of 200 kW that uses a primary-secondary pumping system having the following three pumps:
  - a primary pump (boiler plant) with 86 L/min with a head of 60 kPa and 60% efficiency,
  - secondary pump (north wing) with 78 L/min with a head of 100 kPa and 50% efficiency,
  - a secondary pump (south wing) with 103 L/min with a head of 120 kPa and 45% efficiency, and
- a total shaft power demand of 861 W,

then, assuming the same output capacity of the reference building, the pump would be modeled with the following characteristics:

- a flow rate of 179.4 L/min (at a 16°C temperature differential),
- 54.2% efficiency,
- a shaft power demand of 861 W (which is the same as for the proposed building), and
- a pump head of 156.1 kPa.

A-8.4.4.18.(1) Exhaust Fans. Sentence 8.4.4.18.(1) refers to exhaust fans such as, but not limited to, those used to exhaust laboratory hoods, smoke, grease-laden vapours, toxic, flammable, paint or corrosive fumes or dust directly to the outside. Since such fans don't count against the fan power limitations stated in Sentences 5.2.3.2.(1) and 5.2.3.3.(1) and are not required to have their exhaust airstream equipped with a heat recovery system, they can be modeled identically in the reference building. Otherwise, the reference building model should either count them against the fan power limitation or equip them with heat recovery systems, as appropriate.

A-8.4.4.18.(2) Fan Part-Load Curves. Figure A-8.4.4.18.(2) illustrates the equations for fan power versus flow rate as a graph.

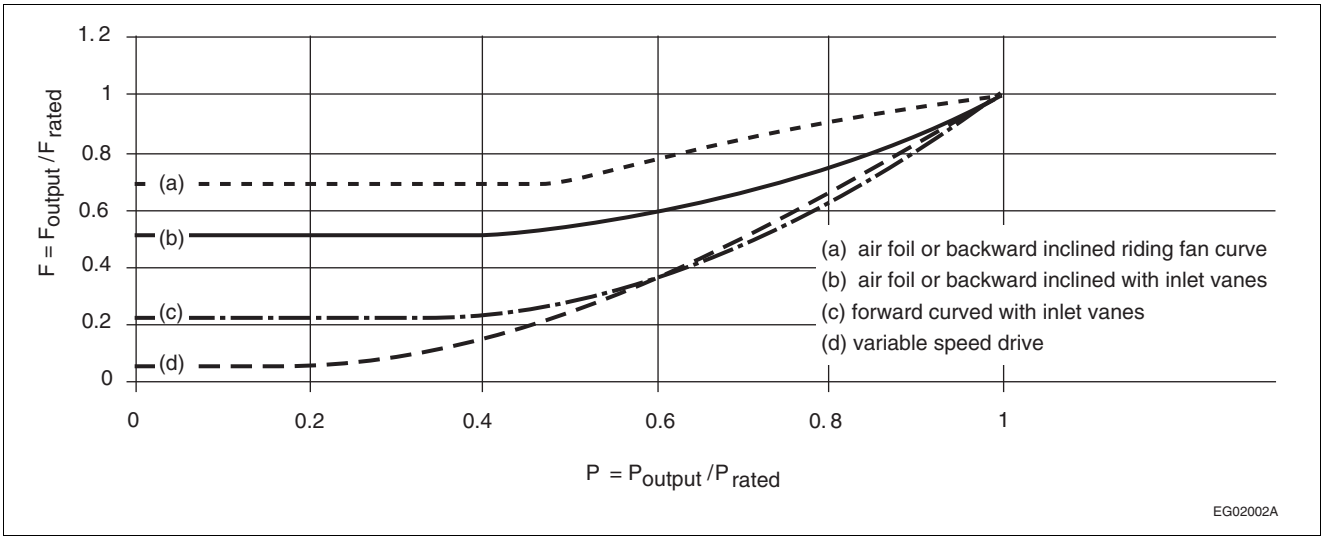

Figure A-8.4.4.18.(2)
Fan part-load curves

A-8.4.4.21.(6) Service Water Heating System Supply Temperature. Article 2.2.10.7. of Division B of the NPC contains maximum temperature requirements based on type of fixture.

A-8.4.4.21.(7) Service Water Heating System Storage Temperature. Article 2.6.1.12. of Division B of the NPC establishes the minimum storage temperature of water in certain service water heating systems.

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Division C

Administrative Provisions

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Part 1
General

Section 1.1. Application

1.1.1. Application

1.1.1.1. Application

1) This Part applies to all *buildings* and *building* systems covered in this Code. (See Article 1.1.1.1. of Division A.)

Section 1.2. Terms and Abbreviations

1.2.1. Definitions of Words and Phrases

1.2.1.1. Non-defined Terms

1) Words and phrases used in Division C that are not included in the list of definitions in Article 1.4.1.2. of Division A shall have the meanings that are 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.

2) Where objectives and functional statements are referred to in Division C, they shall be the objectives and functional statements described in Parts 2 and 3 of Division A.

3) Where acceptable solutions are referred to in Division C, they shall be the provisions stated in Parts 3 to 8 of Division B.

4) Where alternative solutions are referred to in Division C, they shall be the alternative solutions mentioned in Clause 1.2.1.1.(1)(b) of Division A.

1.2.1.2. Defined Terms

1) The words and terms in italics in Division C shall have the meanings assigned to them in Article 1.4.1.2. of Division A.

1.2.2. Symbols and Other Abbreviations

1.2.2.1. Symbols and Other Abbreviations

1) The symbols and other abbreviations in Division C shall have the meanings assigned to them in Article 1.4.2.1. of Division A.

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Part 2
Administrative Provisions

Section 2.1. Application

2.1.1. Application

2.1.1.1. Application

1) This Part applies to all *building*s and *building* systems covered in this Code. (See Article 1.1.1.1. of Division A.)

Section 2.2. Administration

2.2.1. Administration

2.2.1.1. Conformance with Administrative Requirements

1) This Code shall be administered in conformance with the appropriate federal, provincial or territorial regulations or municipal bylaws or, in the absence of such regulations or bylaws, in conformance with the Administrative Requirements for Use with the National Building Code of Canada 1985.

2) The *authority having jurisdiction* may exempt a *building* or part thereof from some or all of the requirements of this Code where it can be shown that the nature or duration of the *occupancy* makes it impractical to apply them. (See Appendix A.)

2.2.2. Information Required for Proposed Work

2.2.2.1. General Information Required

1) Sufficient information shall be provided to show that the proposed work will conform to this Code and whether or not it will affect adjacent property. (See Appendix A.)

2) Plans shall be drawn to scale and shall indicate the nature and extent of the work and proposed *occupancy* in sufficient detail to establish that, when completed, the work and the proposed *occupancy* will conform to this Code.

3) If proposed work is changed during construction, information on the changes shall comply with the requirements of this Section for proposed work.

2.2.2.2. Design Calculations and Analysis

1) The calculations and analysis carried out in the process of ensuring conformity with the requirements of this Code shall be available for inspection upon request.

2.2.2.3. Documentation on the Building Envelope

1) The following documentation on the *building envelope* shall be provided for the proposed *building* and, if Section 3.3. of Division B is applied, for the reference *building* as well:

a) gross wall area,
b) total window area,
c) total exterior door area,

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d) gross roof area,
e) total *skylight* area,
f) ratio of total *skylight* area to gross roof area,
g) exposed floor areas,
h) ratio of total vertical *fenestration* and door area to gross wall area,
i) *overall thermal transmittance* of
   i) opaque walls (above and below *grade*),
   ii) roofs (above and below *grade*),
   iii) floors (exposed floors and floors in contact with the ground)
   iv) *fenestration*,
   v) doors forming part of the *building envelope*,
   vi) *skylights*,
j) description and location of *air barrier assemblies* in *opaque building assemblies*,
k) air leakage characteristics of *fenestration* and doors that act as environmental separators,
l) heat loss coefficient for the *building*, determined as the sum of the products of area and *overall thermal transmittance* for all above-ground *building envelope* components, and
m) heat loss coefficient for the *building*, normalized by dividing the value from Clause (l) by the total floor area.

2.2.2.4. Documentation on Lighting Systems

1) The following documentation on the lighting systems shall be provided:
a) an as-built single-line diagram of the lighting control system showing the location of each illuminated zone and associated switches and controls,
b) *installed interior lighting power* in *conditioned spaces*, in kW,
c) average lighting power density, in W/m², obtained by dividing the *installed interior lighting power* by the total floor area,
d) if the *building* area method is used to determine the *interior lighting power allowance*, the associated lighting power density, in W/m², and the *gross lighted area*, in m²,
e) if the space-by-space method is used to determine the *interior lighting power allowance*, a detailed line-by-line breakdown of spaces, their floor area, in m², the associated lighting power densities, in W/m², and the resulting lighting power allowances, in kW,
f) *interior lighting power allowance*, in kW,
g) installed interior automatic controls and justification for spaces exempted,
h) *exterior lighting* power, in kW, including a detailed line-by-line breakdown of spaces and/or functions, and
i) installed exterior automatic controls and justification for spaces and/or functions exempted.

2.2.2.5. Documentation on HVAC Systems

1) The following documentation on the HVAC system shall be provided:
a) a description of each system, detailing its function, design details, performance characteristics and distribution arrangement,
b) schematic and control diagrams and sequence of operation, and
c) start/stop and adjustment procedures.

2.2.2.6. Documentation on Service Water Heating Systems

1) The following documentation on the *service water* heating system shall be provided:
a) a description of each system detailing its function, design details, performance characteristics and distribution arrangement,
b) schematic and control diagrams and sequence of operation, and
c) start/stop and adjustment procedures.

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2.2.2.7. Documentation on Electrical Power Systems and Motors

1) The following documentation on the electrical power systems and motors shall be provided:

a) an as-built single-line diagram of the *building*'s electrical distribution system indicating the locations of means to monitor energy consumption,
b) schematic diagrams of electrical control systems for systems other than heating, ventilating and air-conditioning, *service water* heating, and lighting, and
c) the manufacturers' operational manuals for all electrical equipment.

2.2.2.8. Documentation Requirements for Building Performance Compliance

1) If Part 8 of Division B is used to demonstrate compliance with Parts 3 to 7 of Division B, a *building* performance compliance calculation report shall be produced in accordance with this Article in addition to the documentation required by Articles 2.2.2.3. to 2.2.2.7.

2) The header of each page of the *building* performance compliance calculation report shall contain the following information:

a) project name,
b) date of analysis,
c) unique run number to identify all report pages as being the result of that analysis run,
d) report title, and
e) page number (consecutive within each report).

3) The following information shall be included in the *building* performance compliance calculation report:

a) the project information section of the report shall contain:
   i) project name or identifier,
   ii) project description,
   iii) project address,
   iv) geographic region in which proposed design is to be built,
   v) identifier for climate data set used for analysis, and
   vi) floor area of *conditioned spaces* of the proposed design,
b) the *building envelope* data summary section of the report shall contain the documentation required in Article 2.2.2.3. for both the proposed *building* and the reference *building*,
c) the lighting systems data summary section of the report shall contain the following data for both the proposed *building* and the reference *building*:
   i) *installed interior lighting power* in *conditioned spaces*, in kW,
   ii) average installed lighting power density, in W/m^2, obtained by dividing the *installed interior lighting power* by the total floor area,
   iii) *interior lighting power allowance*, in kW,
   iv) average lighting power allowance density, in W/m^2, obtained by dividing the *interior lighting power allowance* by the total floor area,
   v) *exterior lighting* power, and
   vi) if daylighting calculations are performed, the method of calculation and the results,
d) the HVAC data summary section of the report shall contain the following data for both the proposed *building* and the reference *building*:
   i) total heating capacity, by energy source used for heating,
   ii) total cooling capacity, by energy source used for cooling,
   iii) total supply airflow, in L/s,
   iv) total supply fan power at design, in kW,
   v) total return fan power at design, in kW,
   vi) sum of supply fan power plus return fan power divided by total supply airflow, in W per L/s,
   vii) type of HVAC system, and
   viii) the design basis for the ventilation rates,

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e) the *service water* heating data summary section of the report shall contain the following data:
   i) whether or not the *service water* heating systems of the proposed *building* have been taken into account in the simulation, and
   ii) if *service water* heating systems are part of the *building* performance calculation, the total heating capacity for both the proposed *building* and the reference *building*, and

f) the energy performance data summary section of the report shall contain the results of the following *building* performance calculations:
   i) the amount of each energy source used by the proposed *building*, in MJ,
   ii) the amount of each energy source used by the reference *building*, in MJ,
   iii) the *annual energy consumption* of the proposed *building* (sum of all energy sources), in MJ,
   iv) the *building energy target* of the reference *building* (sum of all energy sources), in MJ, and
   v) a breakdown of energy usage, per energy source, for the following *building* components and systems: space-heating equipment, space-cooling equipment, *interior lighting*, *service water* heating equipment, elevators and escalators, fans, pumps and other HVAC equipment, miscellaneous equipment and receptacle power equipment.

4) The report shall identify which *building* characteristics fail to meet, which ones meet, and which ones exceed the performance levels of the prescriptive requirements of Parts 3 to 7 of Division B.

5) If the energy usage of the proposed *building* is no greater than the energy usage of the reference *building*, the report shall state that the proposed *building* satisfies the *building energy target* calculation requirements and complies with the Code, exclusive of verification of the limitations contained in Parts 3 to 7 of Division B.

6) The report shall contain a certification section stating that
a) the analysis was performed in accordance with Part 8 of Division B of the NECB,
b) the input for the analysis is a true representation of the proposed *building* submitted for approval, and
c) all other requirements of Part 8 of Division B have been satisfied.

7) The report shall contain a complete list of all the inputs on which the compliance analysis for both the proposed *building* and reference *building* is based.

8) The report shall contain a list of system data that were excluded for both the reference *building* and the proposed *building*, citing one of the following reasons:
a) system was excluded because it complies with the prescriptive requirements of the Code and has no effect on other *building* components, or
b) system was excluded because of an exemption permitted by the Code.

9) The report shall contain a description of any adaptations made to the compliance calculations, if applicable.

Section 2.3. Alternative Solutions

2.3.1. Documentation of Alternative Solutions

(See Appendix A.)

2.3.1.1. Documentation

1) Documentation conforming to this Subsection shall be provided by the person requesting the use of an alternative solution to demonstrate that the proposed alternative solution complies with this Code.

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2) The documentation referred to in Sentence (1) shall include

a) a Code analysis outlining the analytical methods and rationales used to determine that a proposed alternative solution will achieve at least the level of performance required by Clause 1.2.1.1.(1)(b) of Division A, and

b) information concerning any special maintenance or operational requirements, including any *building* component commissioning requirements, that are necessary for the alternative solution to achieve compliance with the Code after the *building* is constructed.

3) The Code analysis referred to in Clause (2)(a) shall identify the objective, functional statements and acceptable solutions, and any assumptions, limiting or restricting factors, testing procedures, engineering studies or *building* performance parameters that will support a Code compliance assessment.

4) The Code analysis referred to in Clause (2)(a) shall include information about the qualifications, experience and background of the person or persons taking responsibility for the design.

5) The information provided under Sentence (3) shall be in sufficient detail to convey the design intent and to support the validity, accuracy, relevance and precision of the Code analysis.

6) Where the design of a *building* includes proposed alternative solutions that involve more than one person taking responsibility for different aspects of the design, the applicant for the permit shall identify a single person to co-ordinate the preparation of the design, Code analysis and documentation referred to in this Subsection.

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Appendix A
Explanatory Material

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A-2.2.1.1.(2) Exemptions Due to Special Occupancy Requirements. The intended use or nature of the occupancy of some buildings may be such that compliance with certain Code requirements could limit or prevent these buildings from performing their intended function.

Sentence 2.2.1.1.(2) 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, should be considered in permitting such deviations.

As it would be difficult and onerous to include every single potential exemption in this Code, Sentence 2.2.1.1.(2) addresses unforeseen circumstances with a general statement. The following lists of possible exemptions to requirements in Parts 3, 4 and 5 of Division B are not exhaustive.

Examples of buildings that could be exempted from complying with some Part 3 requirements:

- horticultural, silvicultural and botanical greenhouses, and greenhouses used for research could be exempted from the requirements related to fenestration performance and area;
- buildings in which permanent processes continuously produce enough heat such that no other heating source is required could have their insulation requirements reduced to the extent that the processes can still provide all of the required heating;
- industrial buildings where processes impose large ventilation requirements could be exempted from airtightness requirements;
- buildings in which only sufficient radiant heating is provided to improve conditions locally for the occupants without temperature control of the ambient air, such as bus shelters or bleacher areas in some ice arenas.

Examples of buildings that could be exempted from complying with some Part 4 requirements:

- The application of the lighting requirements in Part 4 may adversely affect the use of spaces with special functional requirements; as such, some exceptions to these requirements may be necessary. Except for particular types of process lighting, however, it is unlikely that a space or lighting system would be exempt from all the requirements in Part 4. Some necessary exceptions to particular requirements are identified in the Code. Exemption should be determined on a case-by-case basis, taking into consideration the space's function, available technologies and cost-effectiveness.

Example of buildings that could be exempted from complying with some Part 5 requirements:

- buildings or rooms in which the processes or activities call for temperature or humidity conditions outside the normal range required for comfort.

A-2.2.2.1.(1) General Information Required. The information documenting the conformity of a building to this Code must describe the essential characteristics of the building and its systems. To this end, the authority having jurisdiction may require access to the following information:

- floor plan of the building giving the floor area of conditioned spaces and gross lighted area of each storey,
- elevations of all the building's faces, giving finished floor and ground levels,
- typical cross-sections of foundations, exterior walls, roofs, ceilings and floors that separate conditioned space from unconditioned space or the exterior, describing their construction and giving the thermal resistance of each material and the overall thermal transmittance of each assembly of the building,
- indoor design temperatures for all spaces,
- required vestibules,
- descriptions of the different types of air barrier assemblies and their location,
- window dimensions,
- characteristics of fenestration, sliding glass doors and other doors separating conditioned space from unconditioned space or the exterior (e.g. overall thermal transmittance and air leakage control),
- required report on trade-offs, if applicable,
- details of required exterior lighting controls and exterior lighting power for exits, entrances and facades,

- details of required interior lighting controls and interior lighting power,
- identification of static pressure class and leakage class of ducts,
- thermal insulation of pipes and air ducts,
- location of required dampers and of thermostatic controls and cut-offs,
- location and extent of the airflow control areas and temperature-control zones,
- efficiency of unitary and packaged heating and cooling equipment,
- power requirements for the operation of heating, ventilating and cooling systems, with air volumes, and the type of control used for ventilation,
- types and capacities of and controls for the heating and cooling systems, including cooling with exterior air,
- details of pumping systems with variable flow,
- characteristics of heat-recovery ventilators, where required,
- efficiency of service water heating equipment,
- service water distribution layouts and controls,
- required report on performance compliance, if applicable,
- basis for ventilation design and justification for any variance from good practice, where applicable.

A-2.3.1. Documentation of Alternative Solutions. Beyond the purposes of demonstrating compliance and acquiring a building permit, there are other important reasons for requiring that the proponent of an alternative solution submit project documentation (i.e. a compliance report) to the authority having jurisdiction and for the authority having jurisdiction to retain that documentation for a substantial period following the construction of a building:

- Most jurisdictions require that a building be maintained in compliance with the codes under which it was built. Alternative solutions made possible by objective-based codes may have special maintenance requirements, which would be described in the documentation.
- Documentation helps consultants perform code compliance assessments of existing buildings before they are sold and informs current owners or prospective buyers of existing buildings of any limitations pertaining to their future use or development.
- Documentation provides design professionals with the basic information necessary to design changes to an existing building.
- An alternative solution could be invalidated by a proposed alteration to a building. Designers and regulators must therefore know the details of the particular alternative solutions that were integral to the original design. Complete documentation should provide insight as to why one alternative solution was chosen over another.
- Documentation is the "paper trail" of the alternative solution negotiated between the designer and the regulator and should demonstrate that a rational process led to the acceptance of the alternative solution as an equivalency.
- It is possible that over time a particular alternative solution may be shown to be inadequate. It would be advantageous for a jurisdiction to know which buildings included that alternative solution as part of their design: documentation will facilitate this type of analysis.
- Project documentation provides important information to a forensic team that is called to investigate an accident or why a design failed to provide the level of performance expected.

This subject is discussed in further detail in "Recommended Documentation Requirements for Projects Using Alternative Solutions in the Context of Objective-Based Codes," which was prepared for the CCBFC Task Group on Implementation of Objective-Based Codes and is available at www.nationalcodes.ca.

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[A] – Reference occurs in Division A. [C] – Reference occurs in Division C. All other references occur in Division B.

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