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Part 9 — Housing and Small Buildings
Section 9.36. Energy Efficiency

9.36.1. General

9.36.1.1. Scope

1) This Section is concerned with the energy used by *buildings* as a result of

   a. the design and construction of the *building* envelope, and
   b. the design and construction or specification of systems and equipment for
      i. heating, ventilating or air-conditioning, and
      ii. service water heating.

(See Appendix A.)

9.36.1.2. Definitions

1) For the purpose of this Section, the term "common space" shall mean all spaces required to be *conditioned spaces* by Article 9.33.2.1. that are not within a *suite* but shall not include crawl spaces and *vertical service spaces*. (See A-9.36.1.3.(3) in Appendix A.)

2) For the purpose of this Section, the term "overall thermal transmittance," or U-value, shall mean the rate, in $W/(m^2{\cdot}K)$, at which heat is transferred through a *building* assembly that is subject to temperature differences. (See Appendix A.)

3) For the purpose of this Section, the term "effective thermal resistance," or RSI value, shall mean the inverse of the overall thermal transmittance of an assembly, in $(m^2{\cdot}K)/W$. (See Appendix A.)

4) For the purpose of this Section, the term "fenestration" shall mean all *building* envelope assemblies, including their frames, that transfer visible light, such as windows, clerestories, skylights, translucent wall panels, glass block assemblies, transoms, sidelights, sliding, overhead or swinging glass doors, and glazed inserts in doors, etc. (See Appendix A.)

9.36.1.3. Compliance and Application

(See Appendix A.)

1) Except as provided in Sentences (2) to (5), *buildings* shall comply with

a) the prescriptive or trade-off requirements in Subsections 9.36.2. to 9.36.4.,

b) the performance requirements in Subsection 9.36.5., or

c) the NECB.

2) Subsections 9.36.2. to 9.36.4. apply to

a) *buildings* of *residential occupancy* to which Part 9 applies,

b) *buildings* containing *business and personal services*, *mercantile* or *low-hazard industrial occupancies* to which Part 9 applies whose combined total *floor area* does not exceed 300 m^2, excluding parking garages that serve *residential occupancies*, and

c) *buildings* containing a mix of the *residential* and non-*residential occupancies* described in Clauses (a) and (b).

3) Subsection 9.36.5. applies only to

a) houses with or without a *secondary suite*, and

b) *buildings* containing only *dwelling units* and common spaces whose total *floor area* does not exceed 20% of the total *floor area* of the *building*.

c) (See Appendix A.)

4) *Buildings* containing non-*residential occupancies* whose combined total *floor area* exceeds 300 m^2 or *medium-hazard industrial occupancies* shall comply with the NECB.

5) The following are exempted from the requirements of this Section:

a) *buildings* or portions of *buildings* that are not *conditioned spaces*, and

b) residential *buildings* that are not intended for use in the winter months on a continuing basis.

c) (See Appendix A.)

9.36.2. BUILDING ENVELOPE

9.36.2.1. Scope and Application

1) Except as provided in Sentence (2), this Subsection is concerned with the loss of energy due to heat transfer and air leakage through materials, components and assemblies, including their interfaces, forming part of the *building* envelope where it separates *conditioned space* from unconditioned space, the exterior air or the ground.

2) The requirements of this Subsection also apply to components of a *building* envelope assembly that separate a *conditioned space* from an adjoining*storage garage*, even if the *storage garage* is intended to be heated. (See Appendix A and A-9.36.1.3.(5) in Appendix A.)

3) Except for skylight shafts addressed in Sentence 9.36.2.6.(4), for the purpose of this Subsection, 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.

4) The properties, performance and installation of windows, doors and skylights shall also conform to Section 9.7.

5) The properties, location and installation of thermal insulation, *air barrier systems*, *vapour barriers*, and materials with low air or vapour permeance shall also conform to Section 9.25.

9.36.2.2. Determination of Thermal Characteristics of Materials, Components and Assemblies

1) The thermal characteristics of materials shall be determined by calculation or by testing in accordance with the applicable product standards listed in the Code or, in the absence of such standards or where such standards do not address the determination of thermal resistance, 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."

1) (See Table A-9.36.2.4.(1)D. in Appendix A for the thermal characteristics of commonly used materials.)

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 differential of 22±2°C.

3) The thermal characteristics of windows, doors and skylights shall be determined by calculation or testing in accordance with

a) CSA A440.2/A440.3, "Fenestration Energy Performance/User Guide to CSA A440.2-09, Fenestration Energy Performance" for the reference sizes listed therein, or

b) NFRC 100, "Determining Fenestration Product U-factors" and NFRC 200, "Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence" for the reference sizes listed therein. (See Appendix A.)

4) The effective thermal resistance of opaque *building* assemblies shall be determined from

a) calculations conforming to Article 9.36.2.4., 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 −35±1°C.

5) The thermal characteristics of log walls shall be determined by calculation in accordance with Section 305 of ICC 400, "Design and Construction of Log Structures." (See Appendix A.)

9.36.2.3. Calculation of Ceiling, Wall, Fenestration and Door Areas

1) The gross roof-ceiling assembly area shall be calculated as the sum of the interior surface areas of insulated roof-ceiling assemblies and of skylight openings.

2) Except as permitted by Sentence (3), the gross wall area shall be calculated as the sum of the interior surface areas of all exterior *building* envelope assemblies above the finished ground level that are inclined 60° or more from the horizontal, including

a) *rim joists*,

b) fenestration and opaque portions of doors,

c) insulated walls extending from finished ground level to the interior side of the insulated roof-ceiling assembly, and

d) the exposed areas of below-ground *building* envelope assemblies, where fenestration or doors are located below the plane of the adjacent finished ground.

(See Appendix A.)

3) Where a *building* of *residential occupancy* contains more than 2 *dwelling units*, the gross wall area enclosing *conditioned space* shall be permitted to include the interior surface areas of walls that enclose a *suite*, measured from the top surface of the lowest floor to the underside of the highest ceiling in the *suite*. (See Appendix A.)

4) Fenestration and door areas shall be the actual sizes of windows, doors and skylights including all related frame and sash members.

5) 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.)

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

1) In calculating the effective thermal resistance of assemblies for the purpose of comparison with the requirements of Articles 9.36.2.6. and 9.36.2.8., 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. (See Appendix A.)

2) Minor penetrations through assemblies, such as pipes, ducts, equipment with through-the-wall venting, packaged terminal air conditioners or heat pumps, shelf angles, anchors and ties and associated fasteners, and minor structural members that must partially or completely penetrate the *building* envelope to perform their intended function need not be taken into account in the calculation of the effective thermal resistance of that assembly.

3) Major structural penetrations, such as balcony and canopy slabs, beams, columns and ornamentation or appendages that must completely penetrate the building envelope to perform their intended function, need not be taken into account in the calculation of the effective thermal resistance of the penetrated assembly, provided

a) the insulation is installed tight against the outline of the penetration, and

b) the sum of the areas of all such major structural penetrations is limited to a maximum of 2% of the gross wall area calculated as described in Sentence.

(See Appendix A.)

4) Where a component of the *building* envelope is protected by an enclosed unconditioned space, such as a sun porch, enclosed veranda, vestibule or attached garage, the required effective thermal resistance of the *building* envelope component between the *building* and the unconditioned enclosure is permitted to be reduced by 0.16 $(m^2 \cdot K)/W$. (See Appendix A.)

9.36.2.5. Continuity of Insulation

1) Except as provided in Sentences (2) to (9) and in Sentence 9.36.2.4.(3) regarding balcony and canopy slabs, and except for clearances around components required for fire safety reasons, interior *building* components that meet *building* envelope components and major structural members that partly penetrate the *building* envelope shall not break the continuity of the insulation and shall not decrease the effective thermal resistance at their projected area to less than that required in Articles 9.36.2.6. and 9.36.2.8. (See Appendix A.)

2) Where an interior wall, *foundation* wall, *firewall*, *party wall* or structural element penetrates an exterior wall or insulated roof or ceiling and breaks the continuity of the plane of insulation, the penetrating element shall be insulated

  a) on both of its sides, inward or outward from the *building* envelope, for a distance equal to 4 times its uninsulated thickness to an effective thermal resistance not less than that required for exterior walls as stated in Table 9.36.2.6.A. or 9.36.2.6.B.,

  b) within the plane of insulation of the penetrated element to an effective thermal resistance not less than 60% of that required for the penetrated element, or

  c) within itself to an effective thermal resistance not less than that required for the penetrated element. (See Appendix A.)

3) Where a masonry fireplace or flue penetrates an exterior wall and breaks the continuity of the plane of insulation, it shall be insulated within the plane of insulation of the wall or within itself to an effective thermal resistance not less than 55% of that required for the exterior wall as stated in Table 9.36.2.6.A.or 9.36.2.6.B. (See Appendix A.)

4) Where an ornamentation or appendage penetrates an exterior wall and breaks the continuity of the plane of insulation, the penetrating element shall be insulated

  d) on both of its sides, inward or outward from the *building* envelope, for a distance equal to 4 times the insulated thickness of the exterior wall to an effective thermal resistance not less than that required for the wall as stated in Table 9.36.2.6.A. or 9.36.2.6.B.,

  e) within the plane of insulation of the wall to an effective thermal resistance not less than 55% of that required for the exterior wall, or

  f) within the penetrating element to an effective thermal resistance not less than that required for the exterior wall.

5) Except as provided in Sentences (8) and (9), where two planes of insulation are separated by a *building* envelope assembly and cannot be physically joined, one of the planes of insulation shall be extended for a distance equal to at least 4 times the thickness of the assembly separating the two planes. (See Appendix A.)

6) Except as permitted by Article 9.36.2.11., where mechanical, plumbing or electrical system components, such as pipes, ducts, conduits, cabinets, chases, panels or recessed heaters, are placed within and parallel to a wall assembly required to be insulated, the effective thermal resistance of that wall at the projected area of the system component shall be not less than that required by Tables 9.36.2.6.A., 9.36.2.6.B., 9.36.2.8.A. and 9.36.2.8.B. (See Appendix.)

7) Except as permitted by Article 9.36.2.11., where mechanical ducts, plumbing pipes, conduits for electrical services or communication cables are placed within the insulated portion of a floor or ceiling assembly, the effective thermal resistance of the assembly at the projected area of the ducts, pipes, conduits or cables shall be not less than 2.78 $(m^2 \cdot K)/W$.

8) Joints and junctions between walls and other *building* envelope components shall be insulated in a manner that provides an effective thermal resistance that is no less than the lower of the minimum values required for the respective adjoining components. (See Appendix A.)

9) Sentence (1) does not apply where the continuity of the insulation is interrupted

a) between the insulation in the *foundation* wall and that of the floor slab,

b) by an integral perimeter footing of a slab-on-grade (see Sentences 9.25.2.3.(5) and 9.36.2.8.(8)), or

c) at the horizontal portion of a *foundation* wall that supports masonry veneer and is insulated on the exterior.

9.36.2.6. Thermal Characteristics of Above-ground Opaque Building Assemblies

1) Except as provided in Sentences (2) and 9.36.2.8.(3) and Articles 9.36.2.5. and 9.36.2.11., the effective thermal resistance of above-ground opaque *building* assemblies or portions thereof shall be not less than that shown for the applicable heating degree-day category in

a) Table 9.36.2.6.A., where the ventilation system does not include heat-recovery equipment, or

b) Table 9.36.2.6.B., where the ventilation system includes heat-recovery equipment conforming to Article 9.36.3.9. (See Appendix A.)

Table 9.36.2.6.A.
Effective Thermal Resistance of Above-ground Opaque Assemblies in Buildings without a Heat-Recovery Ventilator
Forming part of Sentence 9.36.2.6.(1)

Above-ground Opaque *Building* Assembly	Heating Degree-Days of *Building* Location,[(1)] in Celsius Degree-Days					
	Zone 4 < 3000	Zone 5 3000 to 3999	Zone 6 4000 to 4999	Zone 7A 5000 to 5999	Zone 7B 6000 to 6999	Zone 8 ≥ 7000
	Minimum Effective Thermal Resistance (RSI), $(m^2 \cdot K)/W$					
Ceilings below attics	6.91	8.67	8.67	10.43	10.43	10.43
Cathedral ceilings and flat roofs	4.67	4.67	4.67	5.02	5.02	5.02
Walls[(2)]	2.78	3.08	3.08	3.08	3.85	3.85
Floors over unheated spaces	4.67	4.67	4.67	5.02	5.02	5.02

Notes to Table 9.36.2.6.A.:

1) See Article 1.1.3.1.
2) See Sentence 9.36.2.8.(3) for requirements concerning the above-ground portion of foundation walls.

Table 9.36.2.6.B.
Effective Thermal Resistance of Above-ground Opaque Assemblies in Buildings with a Heat-Recovery Ventilator
Forming part of Sentence 9.36.2.6.(1)

Above-ground Opaque *Building* Assembly	Heating Degree-Days of *Building* Location,[1] in Celsius Degree-Days					
	Zone 4 < 3000	Zone 5 3000 to 3999	Zone 6 4000 to 4999	Zone 7A 5000 to 5999	Zone 7B 6000 to 6999	Zone 8 ≥ 7000
	Minimum Effective Thermal Resistance (RSI), $(m^2{\cdot}K)/W$					
Ceilings below attics	6.91	6.91	8.67	8.67	10.43	10.43
Cathedral ceilings and flat roofs	4.67	4.67	4.67	5.02	5.02	5.02
Walls[2]	2.78	2.97	2.97	2.97	3.08	3.08
Floors over unheated spaces	4.67	4.67	4.67	5.02	5.02	5.02

Notes to Table 9.36.2.6.B.:

1) See Article 1.1.3.1.
2) See Sentence 9.36.2.8.(3) for requirements concerning the above-ground portion of foundation walls.

2) The effective thermal resistance of *rim joists* shall be not less than that required for above-ground walls in Table 9.36.2.6.A. or 9.36.2.6.B., as applicable.

3) A reduction in the effective thermal resistance of ceiling assemblies in attics under sloped roofs is permitted for a length no greater than 1 200 mm but only to the extent imposed by the roof slope and minimum venting clearance, provided the nominal thermal resistance of the insulation directly above the exterior wall is not less than 3.52 $(m^2{\cdot}K)/W$. (See Appendix A.)

4) Except for tubular daylighting devices, the minimum effective thermal resistance values for walls stated in Tables 9.36.2.6.A. and 9.36.2.6.B. shall also apply to shafts for skylights.

9.36.2.7. Thermal Characteristics of Fenestration, Doors and Skylights

1) Except as provided in Sentences (2) to (8) and Article 9.36.2.11., fenestration and doors shall have an overall thermal transmittance (U-value) not greater than the values listed in Table 9.36.2.7.A. for the applicable heating degree-day category. (See Appendix A.)

Table 9.36.2.7.A. Required Thermal Characteristics of Fenestration and Doors Forming part of Sentence 9.36.2.7.(1)							
Components	Thermal Characteristics[(1)]	Heating Degree-Days of *Building* Location,[(2)] in Celsius Degree-Days					
		Zone 4 < 3000	Zone 5 3000 to 3999	Zone 6 4000 to 4999	Zone 7A 5000 to 5999	Zone 7B 6000 to 6999	Zone 8 ≥ 7000
Fenestration[(3)] and doors	Max. U-value, W/(m^2·K)	1.80	1.80	1.60	1.60	1.40	1.40

Notes to Table 9.36.2.7.A.:

(1) See Appendix A.

(2) See Article 1.1.3.1.

(3) Except skylights (see Sentence (2)) and glass block assemblies (see Sentence (4)).

2) Skylights shall have an overall thermal transmittance not greater than the values listed in Table 9.36.2.7.B for the applicable heating degree-day category. (See Appendix A.)

Table 9.36.2.7.B Overall Thermal Transmittance of Skylights Forming part of Sentence 9.36.2.7.(2)						
Component	Heating Degree-Days of *Building* Location,[(1)] in Celsius Degree-Days					
	Zone 4 < 3000	Zone 5 3000 to 3999	Zone 6 4000 to 4999	Zone 7A 5000 to 5999	Zone 7B 6000 to 6999	Zone 8 ≥ 7000
	Maximum Overall Thermal Transmittance, W/(m^2·K)					
Skylights	2.90	2.90	2.70	2.70	2.40	2.40

Notes to Table 9.36.2.7.B:

(1) See Article 1.1.3.1.

3) Except for site-assembled or site-glazed factory-made fenestration products, curtain wall construction, and site-built windows and glazed doors that are tested in accordance with Sentence 9.36.2.2.(3), site-built windows and glazed doors need not comply with Sentence (1), provided they are constructed in accordance with one of the options presented in Table 9.36.2.7.C for the applicable climate zone. (See Appendix A.)

Table 9.36.2.7.C Compliance Options for Site-built Windows and Glazed Portion of Doors Forming part of Sentence 9.36.2.7.(3)									
Component	**Description of Component**	**Compliance Options**							
		Climate Zones 4 and 5			**Climate Zones 6 and 7A**			**Climate Zones 7B and 8**	
		≤ 3999 HDD			**4000 to 5999 HDD**			**≥ 6000 HDD**	
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**
Frame	non-metallic	✓	✓	—	✓	✓	—	✓	✓
	thermally broken metallic	—	—	✓	—	—	✓	—	—
Glazing	double	—	✓	—	—	—	—	—	—
	triple	✓	—	✓	✓	✓	✓	✓	✓
	argon-filled	—	✓	—	✓	—	✓	—	✓
Low-e coating	none	✓	—	—	—	—	—	—	—
	number of panes with ≤ 0.10	—	≥ 1	—	—	—	—	≥ 2	—
	number of panes with ≤ 0.20	—	—	2	≥ 1	2	≥ 2	—	≥ 2
Spacer	size, mm	12.7	—	12.7	≥ 12.7	12.7	≥ 12.7	≥ 12.7	≥ 12.7
	non-metallic	—	✓	—	—	—	—	—	—

4) Glass block assemblies separating *conditioned space* from unconditioned space or the exterior shall have

a) an overall thermal transmittance of not more than 2.9 W/(m^2·K), and

b) a total aggregate area of not more than 1.85 m^2.

5) [Reserved.]

6) Storm windows and doors need not comply with Sentence (1).

7) Vehicular access doors separating a *conditioned space* from an unconditioned space or the exterior shall have a nominal thermal resistance of not less than 1.1 (m^2·K)/W.

8) Access hatches separating a *conditioned space* from an unconditioned space shall be insulated to a nominal thermal resistance of not less than 2.6 (m^2·K)/W.

9) A door separating a *conditioned space* from an unconditioned space or the exterior is not required to conform to Sentence (1) if,

a) in the case of a *building* in a location with a heating degree-day value of less than or equal to 3999, the door is one of not more than three nonconforming doors, each of which has an overall thermal transmittance not greater than 2.10 W/m^2·K,

b) in the case of a *building* in a location with a heating degree-day value of at least 4000 and not greater than 5999, the door is one of not more than two nonconforming doors, each of which has an overall thermal transmittance not greater than 2.10 $W/m^2·K$,

c) in the case of a *building* in a location with a heating degree-day value of greater than or equal to 6000, the door is one of not more than two nonconforming doors, each of which has an overall thermal transmittance not greater than 2.00 $W/m^2·K$, or

d) in any case, the door is the only nonconforming door and has an overall thermal transmittance not greater than 2.60 $W/m^2·K$.

10) A *building* described in Clause (9)(a) or (b) is permitted to have an additional nonconforming door with an overall thermal transmittance not greater than 2.10 $W/m^2·K$ if the effective thermal resistance of the ceilings of the building is at least 0.88 $m^2·K/W$ greater than the relevant value shown in Table 9.36.2.6.A. or Table 9.36.2.6.B., as applicable.

9.36.2.8. Thermal Characteristics of Building Assemblies Below-Grade or in Contact with the Ground

1) Except as provided in Sentence (2) and Article 9.36.2.5., the effective thermal resistance of *building* assemblies that are below-*grade* or in contact with the ground shall be not less than that shown for the applicable heating degree-day category in

a) Table 9.36.2.8.A., where the ventilation system does not include heat-recovery equipment, or

b) Table 9.36.2.8.B., where the ventilation system includes heat-recovery equipment conforming to Article 9.36.3.9. (See Appendix A.)

Table 9.36.2.8.A.
Effective Thermal Resistance of Assemblies Below-Grade or in Contact with the Ground in Buildings without a Heat-Recovery Ventilator
Forming part of Sentences 9.36.2.8.(1) to (9)

***Building* Assembly Below-*Grade* or in Contact with the Ground[(1)]**	**Heating Degree-Days of *Building* Location,[(2)] in Celsius Degree-Days**					
	Zone 4 < 3000	**Zone 5 3000 to 3999**	**Zone 6 4000 to 4999**	**Zone 7A 5000 to 5999**	**Zone 7B 6000 to 6999**	**Zone 8 ≥ 7000**
	Minimum Effective Thermal Resistance (RSI), ($m^2 \cdot K$)/W					
Foundation walls	1.99	2.98	2.98	3.46	3.46	3.97
Unheated floors[(3)] below frost line[(4)(5)] above frost line[(5)]	 uninsulated 1.96	 uninsulated 1.96	 uninsulated 1.96	 uninsulated 1.96	 uninsulated 1.96	 uninsulated 1.96
Heated and unheated floors on permafrost	n/a	n/a	n/a	n/a	4.44	4.44
Heated floors[(6)]	2.32	2.32	2.32	2.84	2.84	2.84
Slabs-on-grade with an integral footing[(6)]	1.96	1.96	1.96	3.72	3.72	4.59

Notes to Table 9.36.2.8.A.:

(1) See Appendix A.
(2) See Article 1.1.3.1.
(3) Does not apply to below-grade floors over heated crawl spaces.
(4) Typically applies to floors-on-ground in full-height basements.
(5) Refers to undisturbed frost line before house is constructed.
(6) See Sentence 9.25.2.3.(5) for requirement on placement of insulation. The design of slabs-on-grade with an integral footing is addressed in Part 4 (see Article 9.16.1.2.).

Table 9.36.2.8.B.
Effective Thermal Resistance of Assemblies Below-Grade or in Contact with the Ground in Buildings with a Heat-Recovery Ventilator
Forming part of Sentences 9.36.2.8.(1) to (9)

Building **Assembly Below-Grader in Contact with the Ground**[(1)]	**Heating Degree-Days of *Building* Location,**[(2)] **in Celsius Degree-Days**					
	Zone 4 < 3000	**Zone 5 3000 to 3999**	**Zone 6 4000 to 4999**	**Zone 7A 5000 to 5999**	**Zone 7B 6000 to 6999**	**Zone 8 ≥ 7000**
	Minimum Effective Thermal Resistance (RSI), $(m^2·K)/W$					
Foundation walls	1.99	2.98	2.98	2.98	2.98	2.98
Unheated floors[(3)] below frost line[(4)(5)] above frost line[(5)]	uninsulated 1.96	uninsulated 1.96	uninsulated 1.96	uninsulated 1.96	uninsulated 1.96	uninsulated 1.96
Heated and unheated floors on permafrost	n/a	n/a	n/a	n/a	4.44	4.44
Heated floors[(6)]	2.32	2.32	2.32	2.84	2.84	2.84
Slabs-on-grade with an integral footing[(6)]	1.96	1.96	1.96	2.84	2.84	3.72

Notes to Table 9.36.2.8.B.:

(1) See Appendix A.

(2) See Article 1.1.3.1.

(3) Does not apply to below-grade floors over heated crawl spaces.

(4) Typically applies to floors-on-ground in full-height basements.

(5) Refers to undisturbed frost line before house is constructed.

(6) See Sentence 9.25.2.3.(5) for requirement on placement of insulation. The design of slabs-on-grade with an integral footing is addressed in Part 4 (see Article 9.16.1.2.).

2) Where an entire floor assembly falls into two of the categories listed in Tables 9.36.2.8.A. and 9.36.2.8.B., the more stringent value shall apply. (See Appendix.)

3) Where the top of a section of *foundation* wall is on average less than 600 mm above the adjoining ground level, the above-ground portion of that section of wall shall be insulated to the effective thermal resistance required in Table 9.36.2.8.A. or 9.36.2.8.B.

4) Unheated floors-on-ground that are above the frost line and have no embedded heating pipes, cables or ducts shall be insulated to the effective thermal resistance required in Table 9.36.2.8.A. or 9.36.2.8.B.

a) on the exterior of the *foundation* wall down to the footing, or

b) on the interior of the *foundation* wall and, as applicable,

i) beneath the slab for a distance not less than 1.2 m horizontally or vertically down from its perimeter with a thermal break along the edge of the slab that meets at least 50% of the required thermal resistance,

ii) on top of the slab for a distance not less than 1.2 m horizontally from its perimeter, or

iii) within the wooden sleepers below the floor for a distance not less than 1.2 m horizontally from its perimeter.

(See Appendix A.)

5) Except as provided in Sentence (6), floors-on-ground with embedded heating ducts, cables or pipes shall be insulated to the effective thermal resistance required in Table 9.36.2.8.A. or 9.36.2.8.B. under their full bottom surface including the edges.

6) Where only a portion of a floor-on-ground has embedded heating ducts, cables or pipes, that heated portion shall be insulated to the effective thermal resistance required in Table 9.36.2.8.A. or 9.36.2.8.B. under its full bottom surface to 1.2 m beyond its perimeter including exterior edges if applicable.

7) In addition to the requirements stated in Sentences (5) and (6), heated floors-on-ground shall be insulated to the effective thermal resistance required in Table or 9.36.2.8.B. vertically

a) around their perimeter, or

b) on the outside of the *foundation* wall, extending down to the level of the bottom of the floor.

8) Floors on permafrost shall be insulated to the effective thermal resistance required in Table 9.36.2.8.A. or 9.36.2.8.B. under the entire slab and around all edges, and under the integral perimeter footing.

9) Slabs-on-grade with an integral perimeter footing shall

a) be insulated to the effective thermal resistance required in Table 9.36.2.8.A. or 9.36.2.8.B. under the entire slab and around all edges, but not under the integral perimeter footing, and

b) be constructed with skirt insulation having the same effective thermal resistance as the insulation installed under the slab.

(See Appendix A.) (See also Sentences 9.25.2.3.(5) and 9.36.2.5.(8).)

10) Junctions between below-*grade* assemblies shall be protected from the ingress of *soil* gas in conformance with Subsection 9.25.3.

9.36.2.9. Airtightness

1) The leakage of air into and out of *conditioned spaces* shall be controlled by constructing

a) a continuous *air barrier system* in accordance with Sentences (2) to (6), Subsection 9.25.3. and Article 9.36.2.10.,

b) a continuous *air barrier system* in accordance with Sentences (2) to (6) and Subsection 9.25.3. and a *building* assembly having an air leakage rate not greater than 0.20 $L/(s \cdot m^2)$ (Type A4) when tested in accordance with CAN/ULC-S742, "Air Barrier Assemblies – Specification," at a pressure differential of 75 Pa, or

c) a continuous *air barrier system* in accordance with Sentences (2) to (6) and Subsection 9.25.3. and a *building* assembly having an air leakage rate not greater than 0.20 $L/(s \cdot m^2)$ when tested in accordance with ASTM E 2357, "Determining Air Leakage of Air Barrier Assemblies."

a) (See Appendix A.)

2) An *air barrier system* installed to meet the requirements of Sentence (1) shall be continuous

a) across construction, control and expansion joints,

b) across junctions between different *building* materials and assemblies, and

c) around penetrations through all *building* assemblies.

3) Windows, doors and skylights and their components shall comply with the minimum air leakage requirements stated in

a) AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights" (Harmonized Standard), and

b) CSA A440S1, "Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440, NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights" (Canadian Supplement).

4) Vehicular access doors that separate heated garages from unconditioned spaces or the exterior shall be weatherstripped around their perimeter to prevent air leakage.

5) Fireplaces shall be equipped with doors, enclosures or devices to restrict air movement through the *chimney* when the fireplace is not in use. (See Appendix.)

6) Where the airtight material used in the *air barrier system* is installed toward the exterior of the *building* envelope, its location and properties shall conform to Subsection 9.25.5. (See Appendix A.)

9.36.2.10. Construction of Air Barrier Details

1) Materials intended to provide the principal resistance to air leakage shall conform to CAN/ULC-S741, "Air Barrier Materials - Specification." (See A-9.25.5.1.(1) in Appendix A for air leakage characteristics and water vapour permeance values for a number of common materials.)

2) Materials referred to in Sentence (1) shall be

a) compatible with adjoining materials, and

b) free of holes and cracks.

1) (See A-9.36.2.10.(5)(b) in Appendix A.)

2) Where the *air barrier system* consists of rigid panel-type material, all joints shall be sealed. (See A-9.36.2.10.(5)(b) in Appendix A.)

3) Where the *air barrier system* consists of timber logs, all joints shall be sealed to resist airflow through gaps between logs that have shifted due to in-service conditions such as shrinkage and settling.

4) Where the *air barrier system* consists of flexible sheet material, all joints shall be

a) lapped not less than 50 mm,

b) sealed (see Appendix A), and

c) structurally supported.

5) Sealant material used for the purpose of creating a continuous *air barrier system* shall

a) be a non-hardening type, or

b) conform to

i) Subsection 9.27.4.,

ii) CAN/ULC-S710.1, "Thermal Insulation – Bead-Applied One Component Polyurethane Air Sealant Foam, Part 1: Material Specification," or

iii) CAN/ULC-S711.1, "Thermal Insulation – Bead-Applied Two Component Polyurethane Air Sealant Foam, Part 1: Material Specification."

6) Penetrations by electrical wiring, outlets, switches or recessed light fixtures through the plane of airtightness shall be constructed airtight

a) where the component is designed to provide a seal against air leakage, by sealing the component to the air barrier material (see Appendix A), or

b) where the component is not designed to provide a seal against air leakage, by covering the component with an air barrier material and sealing it to the adjacent air barrier material.

7) The joints between the *foundation* wall and the sill plate, between the sill plate and *rim joist*, between the *rim joist* and the subfloor material, and between the subfloor material and the bottom plate of the wall above shall be constructed airtight by

a) sealing all joints and junctions between the structural components, or

b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material.

8) The interfaces between windows, doors and skylights and wall/ceiling assemblies shall be constructed airtight by sealing all joints and junctions between the air barrier material in the wall and the window, door or skylight frame. (See Appendix A.) (See also Subsection 9.7.6.)

9) Cantilevered floors and floors over unheated spaces or over the exterior shall be constructed airtight by one of the following methods or a combination thereof:

a) sealing all joints and junctions between the structural components, or

b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material.

10) Interior walls that meet exterior walls or ceilings whose plane of airtightness is on the interior of the *building* envelope and knee walls that separate conditioned from unconditioned space shall be constructed airtight by

a) sealing all junctions between the structural components,

b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material, or

c) maintaining the continuity of the *air barrier system* above or through the interior wall or below or through the knee wall, as applicable.

11) Steel-lined *chimneys* that penetrate the *building* envelope shall be constructed airtight by blocking the void between required clearances for metal chimneys and surrounding construction with sheet metal and sealant capable of withstanding high temperatures.

12) *Masonry or concrete chimneys* that penetrate the *building* envelope shall be constructed airtight by mechanically fastening a metal flange or steel stud that extends not less than 75 mm out from the *chimney* and sealing the air barrier material to it with a sealant capable of withstanding high temperatures.

13) Ducts that penetrate the *building* envelope shall be constructed airtight by sealing the penetration through the *building* envelope. (See Appendix A.)

14) Plumbing vent stack pipes that penetrate the *building* envelope shall be constructed airtight by

a) sealing the air barrier material to the vent stack pipe with a compatible sealant or sheathing tape, or

b) installing a rubber gasket or prefabricated roof flashing at the penetration of the plane of airtightness then sealing it and mechanically fastening it to the top plate.

15) Where a *party wall* meets the plane of airtightness, that junction shall be constructed airtight by sealing any voids within the *party wall* at the perimeter to the adjacent air barrier material and by

a) sealing all junctions between the structural components, or

b) covering the structural components with an air barrier material and sealing it to the adjacent air barrier material.

16) Where the concrete in a flat insulating concrete form wall acts as the air barrier, the continuity of the plane of airtightness shall be maintained between the concrete and adjacent air barrier materials.

9.36.2.11. Trade-off Options for Above-ground Building Envelope Components and Assemblies

(See Appendix A.)

1) Subject to the limitations stated in Sentences (6) to (8), the trade-off options described in Sentences (2) to (4) apply only to above-ground building envelope components and assemblies, or portions thereof, of a single *building*.

2) The effective thermal resistance of one or more above-ground opaque *building* envelope assemblies is permitted to be less than that required in Article 9.36.2.6., provided

a) the total areas of all proposed and reference assemblies are equal,

b) the effective thermal resistance of one or more other proposed above-ground opaque *building* envelope assembly areas is increased to more than that required by Article 9.36.2.6., and

c) the sum of the areas of all traded above-ground opaque *building* envelope assemblies divided by their respective effective thermal resistance is less than or equal to what it would be if all assemblies complied with Article 9.36.2.6.

(See Appendix A and A-9.36.2.11.(2) and (3) in Appendix A.)

3) The effective thermal resistance of one or more windows, as calculated in accordance with Sentence (5), is permitted to be less than that required in Article, provided

a) the total areas of all traded windows are equal,

b) the traded windows are located in the same orientation,

c) the effective thermal resistance of one or more other windows is increased to more than that required by Article 9.36.2.7., and

d) the sum of the areas of all traded windows divided by their respective effective thermal resistance is less than or equal to what it would be if all windows complied with Article 9.36.2.7.

i) (See Appendix A and A-9.36.2.11.(2) and (3) in Appendix A.)

4) The effective thermal resistance of one or more portions of floor insulation or ceiling insulation in attics under sloped roofs in *buildings* that are one storey in *building height* is permitted to be less than that required in Article 9.36.2.6., provided

a) the total area of fenestration, excluding skylights, and doors does not exceed 15% of the above-ground gross wall area as calculated in accordance with Article 9.36.2.3.,

b) the floor-to-ceiling height measured from the top of the subfloor to the underside of the finished ceiling of the *storey* does not exceed 2.34 m,

c) the distance measured from the top of the subfloor to the underside of the bottom chord of the truss or joist of the roof is not more than 2.39 m, and

d) the difference between the sum of the proposed areas of ceilings or floors divided by their respective proposed effective thermal resistance and the sum of the reference areas of ceilings or floors divided by their respective thermal resistance required in Article 9.36.2.6. is not more than the difference between 17% fenestration and door area and the proposed fenestration and door areas divided by the required effective thermal resistance values for windows and doors in Article 9.36.2.7.

(See Appendix A and A-9.36.2.11.(2) and (3) in Appendix A.)

5) The effective thermal resistance of windows shall be determined using the following equation: RSI = 1/U.

6) The reduction in effective thermal resistance of above-ground opaque *building* envelope assemblies permitted by Sentences (2) and (4) shall result in an RSI value that is not less than

a) 55% of that required in Article 9.36.2.6. for above-ground walls and joist-type roofs (see Appendix A), and

b) 60% of that required in Article 9.36.2.6. for other opaque assemblies.

7) The effective thermal resistances of above-ground opaque assemblies with embedded heating cables, pipes or membranes are not permitted to be traded.

8) The effective thermal resistances of doors and access hatches described in Sentences 9.36.2.7.(3) to (7) are not permitted to be traded.

9.36.3. HVAC REQUIREMENTS

9.36.3.1. Scope and Application

1) This Subsection is concerned with the efficient use of energy by systems and equipment used for heating, ventilating and air-conditioning (HVAC).

2) Where HVAC systems, equipment or techniques other than those described in this Subsection are used, the *building* shall be designed and constructed in accordance with the energy efficiency requirements of the NECB.

9.36.3.2. Equipment and Ducts

1) HVAC systems shall be sized in accordance with good practice as described in Sections 9.32. and 9.33. (See Appendix A.)

2) Ducts shall be designed and installed in accordance with Sections 9.32. and 9.33. (See Appendix A.)

3) Except for *exhaust ducts* leading directly to the exterior, ducts and *plenums* carrying conditioned air and located outside the plane of insulation shall

- a) except as provided in Sentence (4), have all joints sealed against air infiltration and exfiltration with
  - i) sealants or gaskets made from liquids, mastics or heat-applied materials,
  - ii) mastic with embedded fabric, or
  - iii) foil-faced butyl tape, and
- b) except as provided in Sentence (5), be insulated to the same level as required in Subsection 9.36.2. for exterior above-ground walls.

4) Fabric-backed tape with rubber adhesives shall not be used as a primary sealant to meet the requirements of Clause (3)(a).

5) The underside of rectangular ducts installed under an insulated floor over an unconditioned space is permitted to be insulated to a lower level than required in Sentence (3) but not to less than 2.11 $(m^2 \cdot K)/W$, provided both sides of such ducts are insulated to a compensating higher thermal resistance so that the resulting heat loss does not exceed that of ducts complying with Sentence (3). (See Appendix A.)

9.36.3.3. Air Intake and Outlet Dampers

1) Except as provided in Sentences (3) and (4), every duct or opening intended to discharge air to the outdoors shall be equipped with

a) a motorized damper, or

b) a gravity- or spring-operated backflow damper.

2) Except as provided in Sentences (3) and (4) and except in locations with fewer than 3500 heating degree-days as listed in Appendix C, every outdoor air intake duct or opening shall be equipped with a motorized damper that remains in the "open" position if the damper fails.

3) Where other regulations are in effect that do not permit dampers, air intakes and outlets need not comply with Sentences (1) and (2).

4) Air intakes and outlets serving HVAC systems that are required to operate continuously need not comply with Sentences (1) and (2). (See Appendix A.)

9.36.3.4. Piping for Heating and Cooling Systems

1) Piping for heating and cooling systems shall be designed and installed in accordance with Subsection 9.33.8. (See Appendix A.)

2) Except for high-temperature refrigerant piping, all piping forming part of a heating or air-conditioning system shall be located

a) inside the plane of insulation, or

b) within or outside the plane of insulation, provided the piping is insulated to a thermal resistance not less than that required in Subsection 9.36.2. for exterior above-ground walls.

(See Appendix A.)

9.36.3.5. Equipment for Heating and Air-conditioning Systems

1) Equipment for heating and air-conditioning systems shall be located

a) inside the plane of insulation, or

b) outdoors or in an unconditioned space, provided the equipment is designated by the manufacturer for such installation.

(See Appendix A.)

9.36.3.6. Temperature Controls

1) Except for manually fuelled solid-fuel-fired *appliances*, the supply of heating and cooling energy to each *dwelling unit*, *suite* or common space shall be controlled by thermostatic controls that activate the appropriate supply when the temperature in a *conditioned space* fluctuates ±0.5°C from the set-point temperature for that space.

2) Where heating and cooling systems are controlled by separate thermostatic controls, means shall be provided to prevent these controls from simultaneously calling for heating and cooling.

3) Space temperature control devices used to control unitary electric resistance space heaters shall conform to CAN/CSA-C828, "Thermostats Used with Individual Room Electric Space Heating Devices."

4) Controls required by Sentence (1) shall be designed such that lowering the set-point temperature on the thermostat for the heating system will not cause cooling energy to be expended to reach the lowered setting, and raising the set-point temperature on the thermostat for the cooling system will not cause heating energy to be expended to reach the raised setting.

5) Automatic devices or manually operated dampers, valves or switches shall be provided, as appropriate for the heating system used, to allow the heating of each zone to be adjusted.

6) 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.

7) Heat pumps with a programmable thermostat shall be equipped with setback controls that will temporarily suppress electrical back-up or adaptive anticipation of the recovery point, in order to prevent the activation of supplementary heat during the heat pump's recovery.
(See Appendix A.)

9.36.3.7. Humidification

1) Where an HVAC system is equipped with a means for adding moisture to maintain specific humidity levels, an automatic humidity control device shall be provided.

9.36.3.8. Heat Recovery from Dehumidification in Spaces with an Indoor Pool or Hot Tub

(See Appendix A.)

1) Except as provided in Sentences (2) and (3), spaces containing an indoor pool or hot tub shall be equipped with air exhaust systems conforming to Sentence at design conditions. (See also Article 9.25.4.2.)

2) Spaces containing an indoor pool 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).

3) Spaces containing an indoor pool or hot tub having a total water surface area of less than 10 m^2 need not comply with Sentence (1), provided they are equipped with a cover having a nominal thermal resistance not less than 2.1 $(m^2 \cdot K)/W$.

4) Heat-recovery systems used to meet the requirements of Sentence (1) shall

- a) be capable of recovering at least 40% of the sensible heat from exhausted air when tested in accordance with ANSI/AHRI 1060, "Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation,"(see Appendix A), or
- b) have a sensible-heat-recovery efficiency complying with Sentence 9.36.3.9.(3) when tested in accordance with CAN/CSA-C439, "Rating the Performance of Heat/Energy-Recovery Ventilators."

5) The sensible heat, in kW, referred to in Clause (4)(a), which is the sensible heat content of the total quantity of exhausted air, shall be calculated as follows:

where

T_e= temperature of exhausted air before heat recovery, in °C,

T_o= outdoor 2.5% January design temperature as listed in Appendix C, in °C, and

Q= rated capacity of exhaust system at normal temperature of exhausted air, in L/s.

9.36.3.9. Heat Recovery from Ventilation Systems

1) This Article applies where a self-contained mechanical ventilation system is installed whose principal exhaust component is equipped with heat-recovery capability. (See Appendix A.)

2) Where an integrated mechanical system (IMS) with a heat-recovery ventilator provides the principal exhaust ventilation, the IMS shall

- a) be tested in accordance with CSA P.10, "Performance of Integrated Mechanical Systems for Residential Heating and Ventilation," and

b) have a minimum overall thermal performance factor conforming to Table 9.36.3.10.

3) 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" heat-recovery ventilators described in Sentence (1) shall have a sensible heat-recovery efficiency of

a) at least 60% at an outside air test temperature of 0°C for locations with a 2.5% January design temperature greater than or equal to −10°C, and

b) at least 60% at an outside air test temperature of 0°C and at least 55% at an outside air test temperature of −25°C for locations with a 2.5% January design temperature less than −10°C.

(See Appendix A.)

4) The requirements of Sentence (3) shall be met using a principal ventilation rate not less than that required in Section 9.32. (See A-9.36.3.9.(3) in Appendix A.)

9.36.3.10. Equipment Efficiency

1) HVAC equipment and components shall comply with the performance requirements stated in Table 9.36.3.10. (See Appendix A.)

Table 9.36.3.10.
HVAC Equipment Performance Requirements
Forming part of Sentences 9.36.3.9.(2) and 9.36.3.10.(1)

Component or Equipment	Heating or Cooling Capacity, kW	Standard	Minimum Performance[(1)]
Air-Cooled Unitary Air Conditioners and Heat Pumps – Electrically Operated			
Split system	≤ 19	CAN/CSA-C656	SEER = 14.5 EER = 11.5 HSPF = 7.1 (region 5 in standard)
Single-package system	≤ 19	CAN/CSA-C656 (including General Instruction No. 2)	SEER = 14 EER = 11 HSPF = 7.0 (region 5 in standard)
All systems	> 19	CAN/CSA-C746	See Level 2 in standard

Table 9.36.3.10. HVAC Equipment Performance Requirements Forming part of Sentences 9.36.3.9.(2) and 9.36.3.10.(1)			
Component or Equipment	**Heating or Cooling Capacity, kW**	**Standard**	**Minimum Performance[1]**
Water-Cooled Unitary Air Conditioners and Heat Pumps – Electrically Operated			
Ground-source and water-source heat pumps			
open loop	< 40	CAN/CSA-C13256-1	$COP_c \geq 4.75$, $COP_h \geq 3.6$
closed loop			$COP_c \geq 3.93$, $COP_h \geq 3.1$
Water-to-water heat pumps			
open loop	< 40	CAN/CSA-C13256-2	$COP_c \geq 5.60$, $COP_h \geq 3.4$
closed loop			$COP_c \geq 4.21$, $COP_h \geq 2.8$
Internal water-loop heat pumps	< 5	CAN/CSA-C13256-1	$COP_c \geq 3.28$, $COP_h \geq 4.2$
	≥ 5 and ≤ 40		$COP_c \geq 3.52$, $COP_h \geq 4.2$
Water-cooled air conditioners – all types	< 19	ANSI/AHRI 210/240 or CTI 201	COP = 3.54, ICOP = 3.60
Direct-Expansion Ground-Source Heat Pumps – Electrically Operated			
Direct-expansion ground-source heat pumps	≤ 21	CSA C748	EER = 13.0
			$COP_h = 3.1$
Room Air Conditioners and Room Air Conditioner Heat Pumps			
Room air conditioners with reverse cycle			
with louvered sides	< 10.55	ANSI/AHAM RAC-1	EER = 8.5
without louvered sides			EER = 8.0
Room air conditioners without reverse cycle and with louvered sides	< 1.8	CAN/CSA-C368.1	EER = 10.7
	≥ 1.8 and < 2.3		EER = 10.7
	≥ 2.3 and < 4.1		EER = 10.8
	≥ 4.1 and < 5.9		EER = 10.7
	≥ 5.9		EER = 9.4
Room air conditioner heat pumps with louvered sides	< 5.9		EER = 9.9
	≥ 5.9		EER = 9.5
Room air conditioners without louvered sides and without reverse cycle	< 1.8		EER = 9.9
	≥ 1.8 and < 2.3		EER = 9.9
	≥ 2.3 and < 4.1		EER = 9.4
	≥ 4.1 and < 5.9		EER = 9.4
	≥ 5.9		EER = 9.4

Table 9.36.3.10.
HVAC Equipment Performance Requirements
Forming part of Sentences 9.36.3.9.(2) and 9.36.3.10.(1)

Component or Equipment	Heating or Cooling Capacity, kW	Standard	Minimum Performance[1]
Room air conditioner heat pumps without louvered sides	< 4.1		EER = 9.2
	≥ 4.1		EER = 8.8
Room air conditioner, casement only	All capacities		EER = 9.5
Room air conditioner, casement slider	All capacities		EER = 9.5
Boilers			
Electric *boilers*	≤ 88	—	Must be equipped with automatic water temperature control[2]
Gas-fired *boilers*[3]	≤ 88	CAN/CSA-P.2	AFUE ≥ 90%
	> 88 and ≤ 117.23	AHRI BTS	E_t ≥ 83%
Oil-fired *boilers*	≤ 88	CSA B212 or ANSI/ASHRAE 103	AFUE ≥ 85%
Warm-Air Furnaces, Combination Warm-Air Furnace/Air-conditioning Units, Duct Furnaces and Unit Heaters			
Gas-fired warm-air *furnaces*[3]	≤ 65.9	CAN/CSA-P.2	AFUE ≥ 92%
	> 65.9 and ≤ 117.23	CAN/CSA-P.8	E_t ≥ 78.5%
Gas-fired duct *furnaces*[3]	≤ 117.23	ANSI Z83.8/CSA 2.6	E_t ≥ 81%
Gas-fired *unit heaters*[3]	≤ 117.23	CAN/CSA-P.11	E_t ≥ 82%
Oil-fired warm-air *furnaces*	≤ 66	CSA B212	AFUE ≥ 85%
Oil-fired duct *furnaces* and *unit heaters*	—	UL 731	E_c ≥ 80%
Combined space- and water-heating systems (combos)	≤ 87.9 if *boiler*-based	CAN/CSA-P.9[4]	TPF = 0.65
	≤ 73.2 if based on service		
Integrated mechanical systems	—	CSA-P.9	OTPF = 0.78
Other			
Gas-fired fireplaces and *stoves*[3]	—	—	[5]

Table 9.36.3.10. **HVAC Equipment Performance Requirements** Forming part of Sentences 9.36.3.9.(2) and 9.36.3.10.(1)			
Component or Equipment	**Heating or Cooling Capacity, kW**	**Standard**	**Minimum Performance**(1)
Solid-fuel-burning space-heating equipment	—	EPA 40 CFR, Part 60, Subpart AAA or CSA B415.1(6)	See standard(7)
Dehumidifiers	≤ 87.5 L/day	CAN/CSA-C749	See standard(7)

Notes to Table 9.36.3.10.:

(1) The symbols and abbreviations that appear in this column have the following meanings:

AFUE= annual fuel utilization efficiency
COP= coefficient of performance, in W/W (COPc = in cooling mode and COPh = in heating mode)
Ec= combustion efficiency, in %
EER= energy efficiency ratio, in (Btu/h)/W (no metric equivalent)
Et= thermal efficiency
FE= fireplace efficiency
HSPF= heating season performance factor, in watt-hours
ICOP= integrated coefficient of performance, in W/W
OTPF= overall thermal performance factor
SEER= seasonal energy efficiency ratio, in (Btu/h)/W (no metric equivalent)
TPF= thermal performance factor

(2) No standard addresses the performance efficiency of electric boilers; however, their efficiency typically approaches 100%.

(3) Includes propane.

(4) See the exception stated in Sentence (3).

(5) See Sentence (2).

(6) Minimum performance values are omitted from the Table in cases where the referenced standard itself contains such requirements.

(7) CSA B415.1-10, “Solid-Fuel-Burning Heating Appliances” does not apply to stoves with an oven whose volume is greater than 0.028 m3 and automatically fuelled appliances.

2) Natural gas and propane fireplaces shall be

a) direct-vent (sealed), and

b) pilot-on-demand, interrupted or intermittent ignition systems without a standing pilot light.

3) The heat source component of combined space- and service water heating systems that are not within the scope of CAN/CSA-P.9, "Performance of Combined Space and Water Heating Systems (Combos)" shall meet the performance requirements stated in Table 9.36.3.10. for the applicable equipment type. (See Appendix A.)

9.36.3.11. Solar Thermal Systems

1) Space-heating systems that use solar thermal technology shall conform to the manufacturer's design requirements and installation procedures.

2) Service water heating systems that use solar thermal technology shall be installed in accordance with Book II (Plumbing Systems) of this Code.

3) Hot water storage tanks associated with the systems referred to in Sentence (2) shall be installed in a *conditioned space*.

9.36.4. SERVICE WATER HEATING SYSTEMS

9.36.4.1. Scope and Application

1) This Subsection is concerned with the efficient use of energy by systems used to heat service water for household use as well as for indoor pools and hot tubs.

2) Where service water heating equipment or techniques other than those described in this Subsection are used, the *building* shall be designed and constructed in accordance with the energy efficiency requirements of the NECB.

9.36.4.2. Equipment Efficiency

1) *Service water heaters*, *boilers*, pool heaters and storage tanks shall comply with the performance requirements stated in Table 9.36.4.2. (See Appendix A.)

2) Hot service water storage tanks not listed in Table 9.36.4.2. shall be covered with insulation having a minimum thermal resistance of 1.8 $(m^2 \cdot K)/W$.

Table 9.36.4.2. Service Water Heating Equipment Performance Standards Forming part of Sentences 9.36.4.2.(1) and (2)			
Storage-Type Service Water Heaters			
Component	**Input[1]**	**Standard**	**Performance Requirement[2]**
Electric	≤ 12 kW (50 L to 270 L capacity)	CAN/CSA-C191	SL ≤ 25 + 0.20V (top inlet)
			SL ≤ 40 + 0.20V (bottom inlet)
	≤ 12 kW (> 270 L and ≤ 454 L capacity)		SL ≤ (0.472V) – 38.5 (top inlet)
			SL ≤ (0.472V) – 33.5 (bottom inlet)
Electric (continued)	>12 kW (> 75 L capacity)	ANSI Z21.10.3/CSA 4.3 and DOE 10 CFR, Part 431, Subpart G	$S = 0.30 + 27/V_m$
Heat pump water heaters	≤ 24 A and ≤ 250 V	CAN/CSA-C745	EF ≥ 2.0
Gas-fired[3]	< 22 kW	CAN/CSA-P.3	EF ≥ 0.67 – 0.0005V
	≥ 22 kW	ANSI Z21.10.3/CSA 4.3	E_t ≥ 80% and standby loss ≤ rated input[4]/(800 + 16.57·√V)
Oil-fired	≤ 30.5 kW	CAN/CSA-B211	EF ≥ 0.59 – 0.0005V
	> 30.5 kW	ANSI Z21.10.3/CSA 4.3 and DOE 10 CFR, Part 431, Subpart G	E_t ≥ 78% and standby loss ≤ rated input[4]/(800 + 16.57·√V)
Tankless Service Water Heaters			
Component	**Input[1]**	**Standard**	**Performance Requirement[2]**
Gas-fired[3]	≤ 73.2 kW	CAN/CSA-P.7	EF ≥ 0.8
	> 73.2 kW	ANSI Z21.10.3/CSA 4.3 and DOE 10 CFR, Part 431, Subpart G	E_t ≥ 80%
Oil-fired	≤ 61.5 kW[5]	DOE 10 CFR, Part 430, Subpart B, Appendix E	$EF \geq 0.59 - 0.0019V_m$
	Other	ANSI Z21.10.3/CSA 4.3 and DOE 10 CFR, Part 431, Subpart G	E_t ≥ 80%
Electric	—	—	[6]
Combined space- and water-heating systems (combos)	≤ 87.9 kW if *boiler*-based	CAN/CSA-P.9	TPF = 0.65
	≤ 73.2 kW if based on service		
Integrated mechanical systems	—	CSA P.10	OTPF = 0.78

Table 9.36.4.2. Service Water Heating Equipment Performance Standards Forming part of Sentences 9.36.4.2.(1) and (2)			
Storage-Type Service Water Heaters			
Component	**Input[(1)]**	**Standard**	**Performance Requirement[(2)]**
Pool Heaters			
Gas-fired[(3)]	< 117.2 kW	ANSI Z21.56/CSA 4.7 or CSA P.6	$E_t \geq 82\%$
Oil-fired	—	CSA B140.12	$E_t \geq 75\%$

Notes to Table 9.36.4.2.:

(1) 1 kW = 3 412 Btu/h

(2) The symbols and abbreviations used in this column have the following meanings:

EF= energy factor, in %/h

Et= thermal efficiency with 38.9°C water temperature difference

OTPF= overall thermal performance factor

S= standby loss, in %/h (percentage heat content of stored water per hour)

SL= standby loss, in W

TPF= thermal performance factor

V= storage volume, in L, as specified by the manufacturer

Vm= measured storage volume, in US gallons

(3) Includes propane.

(4) Rated input is measured in watts.

(5) Consistent with the US Congress National Appliance Energy Conservation Act of 1987.

(6) No standard addresses the performance efficiency of electric tankless service water heaters; however, their efficiency typically approaches 100%.

3) Except for components that are required to be installed outdoors, service water heating equipment shall be installed in a *conditioned space*. (See Appendix A.)

9.36.4.3. Solar Domestic Hot Water Systems

1) Service water heating systems that use solar thermal technology shall conform to the manufacturer’s design requirements and installation procedures.

2) Service water heating systems that use solar thermal technology shall be installed in accordance with Book II (Plumbing Systems) of this Code.

3) Hot water storage tanks associated with the systems referred to in Sentence (2) shall be installed in a *conditioned space*.

9.36.4.4. Piping

1) The first 2 m of outlet piping downstream and of inlet piping upstream leading from a storage tank or heating vessel shall be covered with piping insulation that is at least 12 mm thick.

2) All piping forming part of a continuously operating recirculating service water heating system shall be covered with piping insulation that is at least 12 mm thick.

3) Where piping forming part of the service water heating system is located outside the *building* envelope or in an unconditioned space, it shall be insulated to a thermal resistance not less than the effective thermal resistance required for the exterior above-ground walls.

9.36.4.5. Controls

1) Service water heating systems with storage tanks shall be equipped with automatic temperature controls capable of adjustment between the minimum and maximum temperature settings permitted for the intended use.

9.36.4.6. Indoor Swimming Pool Equipment Controls

1) Heaters for indoor swimming pools shall be equipped with

a) a thermostat, and

b) a readily accessible and clearly labeled device that allows the heater to be shut off without adjusting the thermostat setting.

2) Pumps and heaters for indoor swimming pools shall be equipped with time switches or other types of controls that can be set to automatically turn off the pumps and heaters when their operation is not required. (See Appendix A.)

9.36.5. ENERGY PERFORMANCE COMPLIANCE

9.36.5.1. Scope and Application

1) This Subsection is concerned with modeling the energy performance of components, systems and assemblies, including heat gains from internal loads described in Sentence 9.36.5.4.(4), that are addressed in the scope of the prescriptive requirements in Subsections 9.36.2. to 9.36.4. and that are installed in *buildings* described in Sentence 9.36.1.3.(3).

2) Internal loads other than those described in Sentence 9.36.5.4.(4) shall be excluded from the performance compliance calculations as they relate to

a) the lighting of unconditioned spaces,

b) exterior lighting, and

c) the ventilation of unconditioned spaces.

9.36.5.2. Definitions

(See Appendix A.)

1) For the purpose of this Subsection, the term "reference house" shall mean a hypothetical replica of the proposed house design using the same energy sources for the same functions and having the same environmental requirements, *occupancy*, climatic data and operating schedules, but made to comply with all applicable prescriptive requirements of Subsections 9.36.2. to 9.36.4.

2) For the purpose of this Subsection, the term "annual energy consumption" shall mean the annual sum of service water heating and space-conditioning energy consumption of the proposed house design, as calculated in accordance with this Subsection.

3) For the purpose of this Subsection, the term "house energy target" shall mean the annual energy consumption of the reference house, as calculated in accordance with this Subsection.

4) For the purpose of this Subsection, the term "principal ventilation rate" shall mean the normal operating exhaust capacity of the principal ventilation fan as required by Article 9.32.3.3.

9.36.5.3. Compliance

1) The performance compliance calculations shall determine

a) the annual energy consumption of the proposed house, and

b) the house energy target of a reference house.

2) The annual energy consumption of the proposed house shall not exceed the house energy target of the reference house. (See Appendix A.)

3) In establishing the house energy target, *building* components, systems and assemblies shall be accounted for in accordance with the prescriptive requirements of Subsections 9.36.2. to 9.36.4. for the climate zone under consideration.

4) In establishing the annual energy consumption, *building* components, systems and assemblies that are addressed in the scope of the prescriptive requirements of Subsections 9.36.2. to 9.36.4. shall be accounted for for the climate zone under consideration.

5) Where the construction techniques or *building* components, systems or assemblies 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.

6) Both the proposed and reference houses shall be modeled using the same climatic data, *soil* conditions, operating schedules in Article 9.36.5.4. and temperature set-points.

9.36.5.4. Calculation Methods

1) Except as provided in Sentence (2), the energy model calculations shall account for the annual energy consumption of systems and equipment required for

a) space heating,
b) ventilation,
c) service water heating, and
d) where installed, space cooling.

(See Appendix A.)

2) Redundant or back-up equipment for the systems and equipment listed in Sentence (1) is permitted to be excluded from the energy model, provided it is equipped with controls and is not required to meet the space-conditioning load of the house. (See Appendix A.)

3) The schedules used in the energy model shall

a) be based on a time interval not greater than one hour, where the energy model evaluates the performance of the house over hourly intervals, or
b) be applied in an hourly-bin model then averaged, where the energy model does not evaluate the performance of the house over hourly intervals.

4) The energy model calculations shall account for the loads due to heat gains from occupants, lighting and miscellaneous equipment using the default schedule provided in Table 9.36.5.4. for every day of the year and such loads shall be

a) multiplied by the following adjustment factors, as applicable:
   i) 1 for a house with or without a *secondary suite*,
   ii) 0.625 for each *suite* in a residential *building* containing 2 *suites*,

iii) 0.606 for each *suite* in a residential *building* containing 3 *suites*, or

iv) 0.598 for each *suite* in a residential *building* containing more than 3 *suites*, and

b) increased for each hour by 3.58 W per square metre of *floor area* in common spaces, if applicable.

Table 9.36.5.4.
Default Schedule for Internal Heat Gain Loads[(1)]
Forming part of Sentence 9.36.5.4.(4)

Average Load, in W, Before Noon											
12 a.m.	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.
786	552	549	523	521	547	634	726	847	880	906	986
Average Load, in W, After Noon											
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.
992	934	898	911	924	1 089	1 410	1 588	1 568	1 483	1 194	952

Notes to Table 9.36.5.4.:

(1) The schedule indicates at what time of day the heat gains from internal loads and hot water draws are present; it does not account for heat gains from exterior lighting and from lighting of unconditioned spaces.

5) The energy model calculations shall account for the following space-heating temperature set-points:

a) 21°C in all living spaces above the *basement*,

b) 19°C in *basements* and common spaces, and

c) 15°C in crawl spaces intended to be *conditioned spaces*.

6) The energy model calculations shall account for a space-cooling temperature set-point of 25°C in all *conditioned spaces* served by the cooling system.

7) The energy model calculations shall account for a thermostatic control that responds to fluctuations of ±0.5°C from the temperature set-point. (See Appendix.)

8) If a computer program is used to carry out the compliance calculations, the calculation methods employed in the energy model shall

a) be used for both the reference and proposed houses, and

b) be tested in accordance with ANSI/ASHRAE 140, "Evaluation of Building Energy Analysis Computer Programs" with variations in the computer program from the range recommended therein reported in accordance with Division C.

9) The proposed and reference houses shall both be modeled using the same approach and assumptions, except where *building* components or energy efficiency features are permitted by this Subsection to be different.

10) The energy model calculations shall account for the effect of airtightness in accordance with Sentence 9.36.5.10.(10) or (11), as applicable.

11) The energy model calculations shall account for heat transfer through elements separating *conditioned space* from unconditioned space, the exterior or the ground.

9.36.5.5. Climatic Data

1) To calculate the effect of heating and cooling consumption, the energy model calculations shall be performed using climatic data measured at time intervals no greater than one hour for one year (8 760 hours) based on the average of at least 10 years of measured data collected at the weather station nearest to the region in which the proposed house is located.
(See Appendix A.)

2) For urban regions with several climatic data sets and for locations for which climatic data are not available, the energy model calculations shall be performed using climatic data that best represent the climate at the *building* site.

3) The energy model calculations shall account for ground reflectance by

a) increasing ground reflectance due to snow cover in a ratio of 30% without snow cover and 70% with snow cover, or

b) taking into account changes in ground reflectance throughout the heating season.

9.36.5.6. Building Envelope Calculations

1) For each hour of the year, the energy model calculations shall account for heat transfer through wall assemblies, roof-ceiling assemblies, including attics where applicable, and exposed floor assemblies due to the thermal characteristics of the particular assembly and thermal bridging.

2) The following *building* envelope assemblies and components shall be addressed in the energy model calculations:

a) above-ground walls and roof-ceiling assemblies,

b) floors and walls in contact with the ground, and

c) doors, windows and skylights.

1) (See Subsection 9.36.2.)

2) For each wall assembly, fenestration component, roof-ceiling assembly and exposed floor assembly, the energy model calculations shall account for

a) the area of the interior side of the insulated surface,

b) emissivity, and

c) the effective thermal resistance or overall thermal transmittance, as applicable.

3) The energy model calculations shall account for the effect that each assembly in contact with the ground has on below-*grade* heat transfer due to

a) the geometry of the *foundation*,

b) *soil* conditions (see A-1.1.3.1.(1) in Appendix A), and

c) the configuration of the insulation.

4) The energy model calculations shall account for heat transfer through fenestration separating *conditioned spaces* from the outdoors, including skylights, while accounting for both temperature difference and transmission of solar radiation based on

a) orientation as a function of azimuth and tilt of the surface,

b) area of frame opening and glazed area,

c) overall thermal transmittance, and

d) solar heat gain coefficient.

5) Where the energy model calculations account for the effect of thermal mass, the contents of the house shall be excluded. (See Appendix A.)

6) The energy model calculations shall account for the presence of thermally active walls, floors and ceilings with embedded conditioning systems that form part of the *building* envelope.

7) Where skylights are installed in the roof, the gross roof area shall be determined in accordance with Sentence 9.36.2.3.(3).

8) Skylights shall be considered to have no shading.

9) The energy model calculations shall account for the effects of exterior permanent and fixed shading only on solar heat gain from fenestration.

10) The ratio of fenestration area to opaque area of doors shall be the same for the proposed and reference houses. (See Appendix A.)

9.36.5.7. HVAC System Calculations

1) The energy model calculations shall account for the energy consumption of each heating, ventilating and, where installed, cooling system for each hour of the year. (See Appendix A.)

2) Each heating system and, where installed, cooling system shall be accounted for separately in the energy model calculations.

3) *Conditioned spaces* in both the reference and proposed houses shall be modeled as being

- a) heated, where only heating systems are provided in the proposed house,
- b) cooled, where only cooling systems are provided in the proposed house, or
- c) heated and cooled, where complete heating and cooling systems are provided in the proposed house.

4) The performance requirements stated in Table 9.36.3.10. shall be used in the energy model calculations.

5) Where duct and piping losses are accounted for in the energy model calculations, they shall be included for both the proposed and reference houses and calculated the same way for both houses. (See Appendix A.)

6) The same time periods shall be used in the simulation of the operation of the ventilation system for both the proposed and reference houses.

7) During the heating season, any solar and internal heat gains that cause an increase in space temperature beyond 5.5°C above the setpoint shall be

- a) excluded from the energy model calculations, or
- b) calculated as being vented from the house.

8) The energy model calculations shall account for the part-load performance of equipment, including electrical consumption.

9) The energy model calculations shall account for the heat-recovery efficiency of heat-recovery ventilators using a minimum of 2 data test points derived from testing in accordance with Clause 9.36.3.9.(3)(a) or (b), as applicable.

9.36.5.8. Service Water Heating System Calculations

1) The energy model calculations shall account for the energy consumption of all service water heating systems.

2) The performance requirements stated in Table 9.36.4.2. shall be used in the energy model calculations.

3) Where piping or standby losses are accounted for in the energy model calculations, they shall be included for both the proposed and reference houses, including their effect on space heating and cooling, and calculated the same way for both houses.

4) The energy model calculations shall use a supply cold water temperature, in °C, that is

a) equal to −0.002 (HDD) + 20.3, where HDD < 7 999,

b) equal to 4.3, where HDD ≥ 8 000, or

c) determined based on the ground and air temperatures in the climatic data file.

5) The energy model calculations shall use a service water delivery temperature of 55°C. (See Appendix A.)

6) The energy model calculations shall take into account the service water heating use schedule presented in Table 9.36.5.8. using a load of

a) 225 L/ day for houses with or without a *secondary suite*, or

b) 140 L/day per *dwelling unit* for other types of residential *buildings*.

Table 9.36.5.8.
Default Schedule of Service Water Heating Use
Forming part of Sentence 9.36.5.8.(6)

Type of Small Residential *Building*	Distribution of Hourly Draws on Service Water Heating, L/h											
Houses with or without a *secondary suite* (225 L/day/house)	12 a.m.	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.
	0	0	0	0	0	0	0	5	20	30	55	27.5
	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.
	7.5	2.5	5	12.5	22.5	15	15	5	2.5	0	0	0
Dwelling units in other types of residential *buildings* (140 L/day/*dwelling unit*)	12 a.m.	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.
	0	0	0	0	0	0	0	3.1	12.4	18.7	34.2	17.1
	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.
	4.7	1.6	3.1	7.8	14	9.3	9.3	3.1	1.6	0	0	0

9.36.5.9. General Requirements for Modeling the Proposed House

1) Except where permitted by Articles 9.36.5.10. to 9.36.5.12., the energy model calculations for the proposed house shall be consistent with the proposed construction specifications for that house with regard to

a) fenestration and opaque *building* envelope assembly type, effective thermal resistance and areas,

b) HVAC system types and capacities, and

c) service water heating system types and capacities.

(See Appendix A.)

9.36.5.10. Modeling Building Envelope of Proposed House

1) Except as provided in Sentences (2) and (3), the energy model calculations for the proposed house shall be consistent with the proposed construction specifications for that house with regard to

a) the area of the above-ground portion of *foundation* walls,

b) the effective thermal resistance of above-ground walls, ceilings below attics, roof assemblies and *rim joists*,

c) the maximum overall thermal transmittance of doors, as calculated in accordance with Sentence 9.36.2.2.(3),

d) the effective thermal resistance of below-ground walls and slabs-on-ground,

e) exterior walls, roof-ceiling assembly, doors, walls, exposed floors, and floors in contact with the ground,

f) distribution, orientation and area of fenestration and doors, as calculated in accordance with Article 9.36.2.3.,

g) solar heat gain coefficient and overall thermal transmittance of fenestration, as calculated in accordance with Sentence 9.36.2.2.(3),

h) configuration of insulation in assemblies in contact with the ground, and

i) effective thermal resistance of *foundation* walls.

2) Except for penetrations, slab-on-ground edge insulation and assemblies with embedded heating pipes, where a *building* envelope component or assembly covers less than 2% of the total area of the assembly type to which it belongs, its thermal characteristics are not required to be calculated as belonging to a distinct assembly, provided the area of the component or assembly is included in an adjacent assembly having the same orientation (See Appendix A.)

3) *Building* envelope assemblies with the same thermal characteristics and orientation are not required to be calculated as distinct assemblies, provided their area is included in an adjacent assembly.

4) *Building* envelope assemblies and components separating *conditioned space* from enclosed unconditioned space shall have a solar heat gain coefficient equal to 0.

5) Except as stated in Sentence 9.36.5.6.(9), the energy model calculations for the proposed house shall account for the effects of exterior permanent and fixed shading devices, including fins, overhangs, and light shelves, on solar heat gain.

6) Where thermal mass is included in the energy model calculations for the proposed house, it shall be set as

a) the specified mass up to the inside edge of insulation in exterior walls, the mass of interior walls, the mass up to the centre-line of *party walls*, and the mass of floors, as applicable,

b) the specified mass of the *building* envelope assembly, where the energy model calculations include a transient analysis of thermal transfer of the entire *building* envelope assembly, or

c) a default value of 0.060 $MJ/m^2 \cdot °C$.

7) Exterior walls, roofs and exposed floors shall have a solar absorptance of 0.4.

8) The orientation of the *foundation* of the proposed house as constructed shall be within 22.5° of the orientation used in the energy model calculations.

9) The airtightness value used in the energy model calculations for the proposed house shall be

a) 3.2 air changes per hour at 50 Pa pressure differential, where the construction complies with Section 9.25.,

b) 2.5 air changes per hour at 50 Pa pressure differential, where it can be shown that the *air barrier system* is constructed in accordance with Subsection and Articles 9.36.2.9. and 9.36.2.10., or

c) where airtightness is tested in accordance with Sentence (11),

i. the number of air changes per hour at 50 Pa pressure differential, and

ii. the equivalent leakage area (see Appendix A).

10) A design airtightness shall be assigned for use in the energy model calculations until the actual airtightness has been measured in accordance with Sentence.

11) Where measured airtightness is used in the energy model calculations, it shall be determined in accordance with CAN/CGSB-149.10, "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method"

a) as written, or

b) excluding Clause 6.1.6, which allows intentional openings for mechanical equipment to be left unsealed.

(See Appendix A.)

12) Where airtightness is determined in accordance with Sentence (11) using air changes per hour, the result obtained at an air pressure differential of 50 Pa shall be used in the energy model calculations.

13) Where airtightness is determined in accordance with Clause (11)(b), its rate shall be adjusted in the energy model calculations to account for air leakage through mechanical equipment.

9.36.5.11. Modeling HVAC System of Proposed House

1) Where multiple HVAC systems serve a single space, the energy model calculations for the proposed house shall call each system in the order of priority established by the system control in the proposed house.

2) Where a heat pump is included in the proposed house, the energy model calculations shall include

a) the effect of the source temperature on the heat pump's efficiency, and

b) the temperature at which the heat pump shuts down.

3) Permanent supplementary heating systems that are operated by a thermostat or automatic control shall be included in the energy model calculations for the proposed house.

4) The performance characteristics of the heat-recovery ventilation system of the proposed house shall be as specified at not less than the principal ventilation rate required for a system designed in accordance with Section 9.32.

5) The ventilation system shall be modeled as operating 8 hours a day at the principal ventilation rate.

6) [Reserved.]

7) The energy model calculations may include duct and piping losses, taking into account the properties of the specified duct and piping insulation of the proposed house.

8) The energy model calculations shall include a heating system and, where installed, a cooling system sized according to the specifications for the proposed house.

9) The energy model calculations shall include the effect of part-load performance of equipment using

a) the same modeled part-load performance data used for the reference house as per Clause 9.36.5.15.(6)(a),

b) the default part-load performance characteristics stated in Clause 9.36.5.15.(6)(b), or

c) measured data for the specified equipment.

c) (See Appendix A.)

10) Where a heat-recovery ventilator is installed in the proposed house, the energy model calculations shall only account for the recovery of sensible heat using the efficiency ratings in Sentence 9.36.3.9.(3). (See Appendix A.)

11) Except as provided in Sentence (12), where a forced-air system is installed in the proposed house, the energy model calculations shall assume the circulation fan operates when the heating, cooling or principal ventilation system is operating. (See Appendix A.)

12) Where a forced-air system is installed in the proposed house and where the principal ventilation system in the proposed house is a separate, fully ducted ventilation system, the energy model calculations shall assume the circulation fan operates only when the heating or cooling system is operating.

13) Where the proposed house contains multiple HVAC systems, the circulation fan power shall be the sum of the circulation fan power capacity of each system.

14) The ventilation fan power consumption shall be modeled

a) as being 2.32 W/L/s for each ventilation fan on the exhaust side and, where applicable, on the supply side, or

b) as specified, where a heat-recovery ventilator is used.

15) Where a forced-air system is installed in the proposed house, the energy model calculations shall determine the flow rate, in L/s, of the circulation fan in the reference house by multiplying the capacity, in W, of the heating system in the proposed house by

a) 0.0604 for heat pumps, and

b) 0.0251 for all other types of heating systems.

16) Where a forced-air system is installed in the proposed house, the energy model calculations shall determine the minimum electricity requirement, in W, of the circulation fan by multiplying the flow rate, in L/s, of the circulation fan in the reference house, determined in accordance with Sentence (15), by a factor of 2.30.

17) Where a forced-air system is installed in the proposed house, the flow rate of the circulation fan shall be modeled as being the larger of

a) the flow rate of the circulation fan of the reference house, determined in accordance with Sentence (15), or

b) the flow rate of the circulation fan for the forced-air system specified in the design for the proposed house.

18) Except as provided in Sentence (19), where a forced-air system is installed in the proposed house, the power capacity of the circulation fan shall be modeled as specified in the design for the proposed house.

19) Where the design for the proposed house specifies a forced-air system with a circulation fan flow rate that is lower than that of the flow rate of the circulation fan in the reference house, as determined in accordance with Sentence (15), the electricity capacity, in W, of the circulation fan shall be modeled as being the larger of

a) the electricity capacity specified for the circulation fan in the proposed forced-air system, or

b) the minimum circulation fan electricity capacity determined in accordance with Sentence (16).

20) For natural gas-, oil-, propane- and wood-burning heating systems, the energy model calculations shall set the auxiliary electricity requirements, including that of combustion fans, to those specified for the proposed house.

9.36.5.12. Modeling Service Water Heating System of Proposed House

1) The service water heating system used in the energy model calculations shall be sized as specified in the design for the proposed house.

2) The energy model calculations may include

a) piping losses, and

b) drain-water heat recovery, provided the calculation of the heat recovered is based on the efficiency of the drain-water heat-recovery unit specified for the proposed house and the energy savings are determined using a drain-water

i) inlet temperature to the recovery system of 36°C,

ii) flow rate of 9.5 L/min, and

iii) flow that is available for recovery 15 min/day for a house and 10 min/day per *suite* for a multi-unit residential *building* with more than 2 *suites*. (See Appendix A.)

9.36.5.13. General Requirements for Modeling the Reference House

1) Except as provided in Sentence (2) and Articles 9.36.5.14. to 9.36.5.16., the energy model calculations for the reference house shall be consistent with the prescriptive requirements of Subsections 9.36.2. to 9.36.4. with regard to

a) fenestration and opaque *building* envelope assembly types and areas,

b) HVAC system types and capacities, and

c) service water heating system types and capacities.

(See A-9.36.5.9.(1) in Appendix A.)

2) The energy model calculations for the reference house shall include the same values as those used for the proposed house with regard to

a) *floor area*,

b) heated volume, and

c) number and types of rooms.

9.36.5.14. Modeling Building Envelope of Reference House

1) The energy model calculations for the reference house shall include the same values as those used for the proposed house with regard to

a) the gross area of above-ground portion of *foundation* walls,

b) *soil* conditions,

c) the orientation of the *foundation*, and

d) the ratio of fenestration area to opaque area of doors.

2) The energy model calculations for the reference house shall use the following set values:

a) 0.060 $MJ/m^2 \cdot °C$ for thermal mass,

b) a solar absorptance of 0.4 for the exterior walls, roofs and exposed floors,

c) 0.26 for the solar heat gain coefficient of fenestration, and

d) 2.5 air changes per hour at 50 Pa pressure differential for airtightness.

3) The effective thermal resistance and overall thermal transmittance values, as applicable, used in the energy model calculations for the reference house shall be determined for the applicable heating degree-day zone in accordance with

a) Table 9.36.2.6.A. for walls, ceilings below attics, roof assemblies and *rim joists*,

b) Table 9.36.2.7.A. for doors, and

c) Table 9.36.2.8.A. for below-*grade* walls and slabs-on-ground.

4) Except as provided in Sentences (5) and (6), the exterior walls, roof-ceiling assembly, doors, walls, exposed floors, and floors of the reference house that are in contact with the ground shall have the same area as those of the proposed house.

5) The area and orientation of fenestration and doors of the reference house shall be modeled as being equally distributed on all sides of the house.

6) The gross wall area and the area of fenestration and doors of the reference house shall be determined in accordance with Article 9.36.2.3.

7) Windows and other glazed components in the reference house shall have a maximum overall thermal transmittance as required in Table 9.36.2.7.A. for the applicable heating degree-day category.

8) The configuration of insulation in assemblies of the reference house that are in contact with the ground shall be modeled as conforming to Article 9.36.2.8.

9) *Foundation* walls shall be modeled using the applicable effective thermal resistance values in Table 9.36.2.8.A. and as conforming to Sentence 9.36.2.8.(2).

10) The fenestration and door area to gross wall area ratio (FDWR) of the reference house shall be

a) for houses containing 1 or 2 *dwelling units*,

  i. as per the proposed house, where its FDWR is between 17% and 22%,

  ii. 17%, where the FDWR of the proposed house is less than 17%, or

  iii. 22%, where the FDWR of the proposed house is greater than 22%, and

b) for *buildings* of *residential occupancy* containing more than 2 *dwelling units*,

  i. the FDWR determined in Clause (a) for the areas determined in accordance with Sentence 9.36.2.3.(2) and, where the FDWR determined in accordance with the calculation in Sentence 9.36.2.3.(3) only does not exceed 40%, or

  ii. 40% of the gross wall area enclosing *conditioned space* where the area of fenestration and doors is greater than 40% of the gross wall area enclosing *conditioned space* determined in accordance with Sentence 9.36.2.3.(2).

(See Appendix A.)

9.36.5.15. Modeling HVAC System of Reference House

1) Where multiple HVAC systems serve a single space, the energy model calculations for the reference house shall use the same order of priority as that used for the proposed house. (See Sentence 9.36.5.11.(1).)

2) The energy model calculations for the reference house shall include the same features as those used for the proposed house with regard to

a) the principal heating and cooling energy sources, which are gas, electricity, oil, propane, wood or a heat pump,

b) the primary and secondary energy sources, which are gas, electricity, oil, propane, wood or a heat pump, and

c) the ventilation rate (see Sentence 9.36.5.11.(6)).

3) Except as required in Sentence 9.36.3.8.(1), the reference house shall be modeled without a heat-recovery ventilator.

4) The ventilation system shall be modeled as operating 8 hours a day.

5) The heating system and, where installed, the cooling system shall be sized in accordance with Article 9.33.5.1. with regard to total heat output capacity and nominal cooling capacity. (See Appendix A.)

6) The part-load performance of HVAC equipment in the reference house shall be calculated using

a) modeled part-load performance characteristics, where applicable, or

b) the performance values for each type of system multiplied by an adjustment factor from Table 9.36.5.15.A, 9.36.5.15.B or 9.36.5.15.C as follows:

i. for *furnaces*, by multiplying the *furnace* steady-state efficiency by the adjustment factor given in Table 9.36.5.15.A,

ii. for heat pumps and air conditioners, by multiplying the heat pump steady-state coefficient of performance by the adjustment factor given in Table 9.36.5.15.B, and

iii. for *boilers*, combination space-heating and service water heating systems, and integrated mechanical systems, by multiplying the net-full-load heating efficiency by the adjustment factor given in Table 9.36.5.15.C (See Appendix A.)

Table 9.36.5.15.A
Part-Load Adjustment Factors for Furnaces
Forming part of Subclause (6)(b)(i)

Fuel Source	Type of Equipment	Capacity	Part-Load Ratio		
			0.15	**0.4**	**1.0**
			Adjustment Factors		
Gas	Warm-air *furnaces*	≤ 65.9 kW	1.03	1.02	1.0
		> 65.9 kW	0.91	0.97	1.0
	Duct *furnaces* and *unit heaters*	All capacities	0.91	0.97	1.0
Oil	All types	All capacities	0.95	0.98	1.0

Table 9.36.5.15.B **Part-Load Adjustment Factors for Heat Pumps and Air Conditioners** Forming part of Subclause (b)(ii)			
Type of Equipment	**Part-Load Ratio**		
	0.15	**0.4**	**1.0**
	Adjustment Factors		
Air-source heat pumps and air conditioners	0.72	0.86	1.0
Water-source heat pumps	0.93	0.98	1.0
Ground-source heat pumps	0.93	0.98	1.0

Table 9.36.5.15.C **Part-Load Adjustment Factors for Boilers, Combination Systems and Integrated Mechanical Systems** Forming part of Subclause (b)(iii)				
Fuel Source	**Type of Equipment**	**Part-Load Ratio**		
		0.15	**0.4**	**1.0**
		Adjustment Factors		
Gas	*Boiler*	1.03	1.02	1.0
	Integrated mechanical systems[(1)] within the scope of CSA P.10[(2)]	N/A	N/A	N/A
	Combination space- and service water heating systems within the scope of CAN/CSA-P.9[(2)]	N/A	N/A	N/A
	Combination space- and service water heating systems not within the scope of CAN/CSA-P.9	Same as gas *boiler*		
Oil	*Boiler*	1.03	1.02	1.0
	Combination space- and service water heating systems within the scope of CAN/CSA-P.9[(2)]	N/A	N/A	N/A
	Combination space- and service water heating systems not within the scope of CAN/CSA-P.9	Same as oil *boiler*		

Notes to Table 9.36.5.15.C:

(1) Integrated mechanical systems perform all three functions of space-heating, water-heating and heat-recovery ventilation.

(2) The part-load characteristics of these types of systems shall not be accounted for in the energy model calculations.

7) The performance of the HVAC equipment in the reference house shall be modeled

a) as conforming to Table 9.36.3.10. for the corresponding type, fuel source and capacity of equipment in the proposed house, or

b) where the HVAC equipment for the proposed house is not addressed in Table 9.36.3.10., as a gas warm-air *furnace* with a minimum performance rating of 92% annual fuel utilization efficiency.

8) Where a heat-recovery ventilator is installed in the reference house, the energy model calculations shall only account for the recovery of sensible heat using the efficiency ratings in Sentence 9.36.3.9.(3). (See Appendix A.)

9) The energy model calculations shall assume all ventilation and circulation fans required to be modeled in the reference house are equipped with permanent-split capacitor (PSC) motors.

10) Where a forced-air system is installed in the reference house, the energy model calculations shall assume the circulation fan operates when the heating, cooling or principal ventilation system is called for.

11) Where the reference house contains multiple HVAC systems, the circulation fan power shall be the sum of the circulation fan power capacity of each system.

12) The principal ventilation flow rate, in L/s, prescribed in Section 9.32. shall be multiplied by 2.32 W/L/s to determine the ventilation fan power capacity, in W, to be used in the energy model calculations for each fan on the exhaust side and, where applicable, on the supply side.

13) Where a heat-recovery ventilator is required in the reference house in accordance with Article 9.36.3.8., the ventilation flow rate, in L/s, in the zone served by the pool or hot tub shall be multiplied by 4.18 W/L/s to determine the heat-recovery ventilator power, in W, to be used in the energy model calculations.

14) Where a forced-air system is installed in the reference house, the system's capacity, in W, shall be multiplied by one of the following factors to determine the circulation fan flow rate, in L/s:

a) 0.0604 for heat pumps, and

b) 0.0251 for all other types of heating systems.

15) Where a forced-air system is installed in the reference house, the circulation fan flow rate, in L/s, shall be multiplied by 2.30 W/L/s to determine the circulation fan power capacity, in W.

16) For natural gas-, oil-, propane- and wood-burning heating systems, the energy model calculations shall set the auxiliary electricity capacity, including that of combustion fans, to 208 W during operation.

9.36.5.16. Modeling Service Water Heating System of Reference House

1) The energy source of the reference house's service water heating system, which is gas, electricity, oil, propane, wood or a heat pump, shall be the same as that for the system in the proposed house.

2) The service water heating system in the reference house shall be sized in accordance with Subsection 9.31.6. with regard to output capacity.

3) Except as required by Table 9.36.5.16., the performance of the service water heating equipment in the reference house shall be modeled as conforming to Table for the energy source, capacity and type of service water heating equipment in the proposed house.

Table 9.36.5.16.
Performance of Service Water Heating (SWH) Equipment in the Reference House
Forming part of Sentence 9.36.5.16.(3)

<table>
<tr><th>Type of SWH Equipment in Proposed House</th><th>Input for Proposed SWH Equipment</th><th>Type of SWH Equipment to be Used for Reference House</th><th>Input for Reference SWH Equipment</th></tr>
<tr><td rowspan="2">Gas-fired tankless service water heater</td><td>≤ 73.2 kW</td><td rowspan="2">Gas-fired storage type</td><td>≤ 22 kW</td></tr>
<tr><td>> 73.2 kW</td><td>> 22 kW</td></tr>
<tr><td rowspan="2">Oil-fired tankless service water heater</td><td>≤ 61.5 kW(1)</td><td rowspan="2">Oil-fired storage type</td><td>≤ 30.5 kW(1)</td></tr>
<tr><td>Other</td><td>> 30.5 kW</td></tr>
<tr><td>Not listed in Table 9.36.4.2.</td><td>—</td><td>Gas-fired storage type</td><td>≥ 22 kW (E_t ≥ 80%)</td></tr>
</table>

Notes to Table 9.36.5.16.:

(1) Consistent with the US Congress National Appliance Energy Conservation Act of 1987.

Appendix to Section 9.36.

A-9.36.1.1.(1) Energy Used by the Building

Table A-9.36.1.1.(1)		
Energy used by the building	=	space-heating energy lost and gained through building envelope
	+	losses due to inefficiencies of heating equipment
	+	energy necessary to heat outdoor air to ventilate the building
	+	energy used to heat service water

A-9.36.1.2.(2) Overall Thermal Transmittance

The U-value 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 thermal transmittance of each component is determined: for example, the thermal transmittance values of the glazing and the frame of a window are combined to determine the overall thermal transmittance (U-value) of the window.

A-9.36.1.2.(3) Conversion of Metric Values to Imperial Values

To convert a metric RSI value to an imperial R-value, use 1 $(m^2 \cdot K)/W = 5.678263\ h \cdot ft^2 \cdot °F/Btu$. "R-value," or simply the prefix "R" (e.g. R20 insulation), is often used in the housing industry to refer to the imperial equivalent of "RSI value." Note that R-values in Section 9.36. are provided for information purposes only; the stated metric RSI values are in fact the legally binding requirements.

A-9.36.1.2.(4) Fenestration

The term "fenestration" is intentionally used in Articles 9.36.2.3. (prescriptive provisions) and 9.36.2.11. (trade-off provisions), and in Subsection 9.36.5.(performance provisions) as opposed to the terms "window," "door" and "skylight," which are used in the prescriptive provisions in Subsections 9.36.2. to 9.36.4.that address these components individually. The term "fenestration" is sometimes used in conjunction with the term "doors" depending on the context and the intent of the requirement.

A-9.36.1.3. Compliance Options According to Building Type and Size

Table A-9.36.1.3. describes the types and sizes of Part 9 buildings to which Section 9.36. and the NECB apply.

Table A-9.36.1.3. Energy Efficiency Compliance Options for Part 9 Buildings			
Building Types and Sizes	**Energy Efficiency Compliance Options**		
	9.36.2.to 9.36.4. (Prescriptive)	**9.36.5. (Performance)**	**NECB**
• houses with or without a secondary suite • buildings containing only dwelling units with common spaces ≤ 20% of building's total floor area(1)	✓	✓	✓
• Group C occupancies • buildings containing Group D, E or F3 occupancies whose combined total floor area ≤ 300 m^2 (excluding parking garages that serve residential occupancies) • buildings with a mix of Group C and Group D, E or F3 occupancies where the non-residential portion's combined total floor area ≤ 300 m^2 (excluding parking garages that serve residential occupancies)	✓	X	✓
• buildings containing Group D, E or F3 occupancies whose combined total floor area > 300 m^2 • buildings containing F2 occupancies of any size	X	X	✓

Notes to Table A-9.36.1.3.:

(1) The walls that enclose a common space are excluded from the calculation of floor area of that common space.

A-9.36.1.3.(3) Houses and Common Spaces

Houses

For the purpose of Sentence 9.36.1.3.(3), the term "houses" includes detached houses, semi-detached houses, duplexes, triplexes, townhouses, row houses and boarding houses.

Common spaces

The walls that enclose a common space are excluded from the calculation of floor area of that common space.

A-9.36.1.3.(5) Exemptions

Examples of buildings and spaces that are exempted from the requirements of Section 9.36. include

- seasonally occupied buildings,

- storage and parking garages,
- service buildings and service rooms,
- unconditioned buildings such as storage warehouses, and
- unconditioned spaces in buildings.

However, note that, where a building envelope assembly of an exempted building is adjacent to a conditioned space, this assembly must meet the requirements of Section 9.36.

A-9.36.2.1.(2) Wall or Floor between a Garage and a Conditioned Space

A wall or a floor between a conditioned space and a residential garage must be airtight and insulated because, even if the garage is equipped with space-heating equipment, it may in fact be kept unheated most of the time.

A-9.36.2.2.(3) Calculation Tools

The thermal characteristics of windows, doors and skylights can be calculated using software tools such as THERM and WINDOW.

A-9.36.2.2.(5) Calculating Effective Thermal Resistance of Log Walls

ICC 400, "Design and Construction of Log Structures," defines log wall thickness as the "average cross sectional area divided by the stack height." This approach equalizes all log profiles regardless of their size or shape by eliminating the need to vary, average or round out log thickness measurements, which would otherwise be necessary to determine applicable profile factors for different log shapes. The ICC 400 standard lists R-values for log walls, including the exterior and interior air film coefficients, based on wall thickness and wood species' specific gravity.

A-9.36.2.3.(2) and (3) Calculating Gross Wall Area

Where the structure of the lowest floor and rim joist assembly is above the finished ground level or where the above-grade portion of foundation walls separates conditioned space from unconditioned space, they should be included in the calculation of gross wall area. Figure A-9.36.2.3.(2) and (3) shows the intended measurements for the most common type of housing construction.

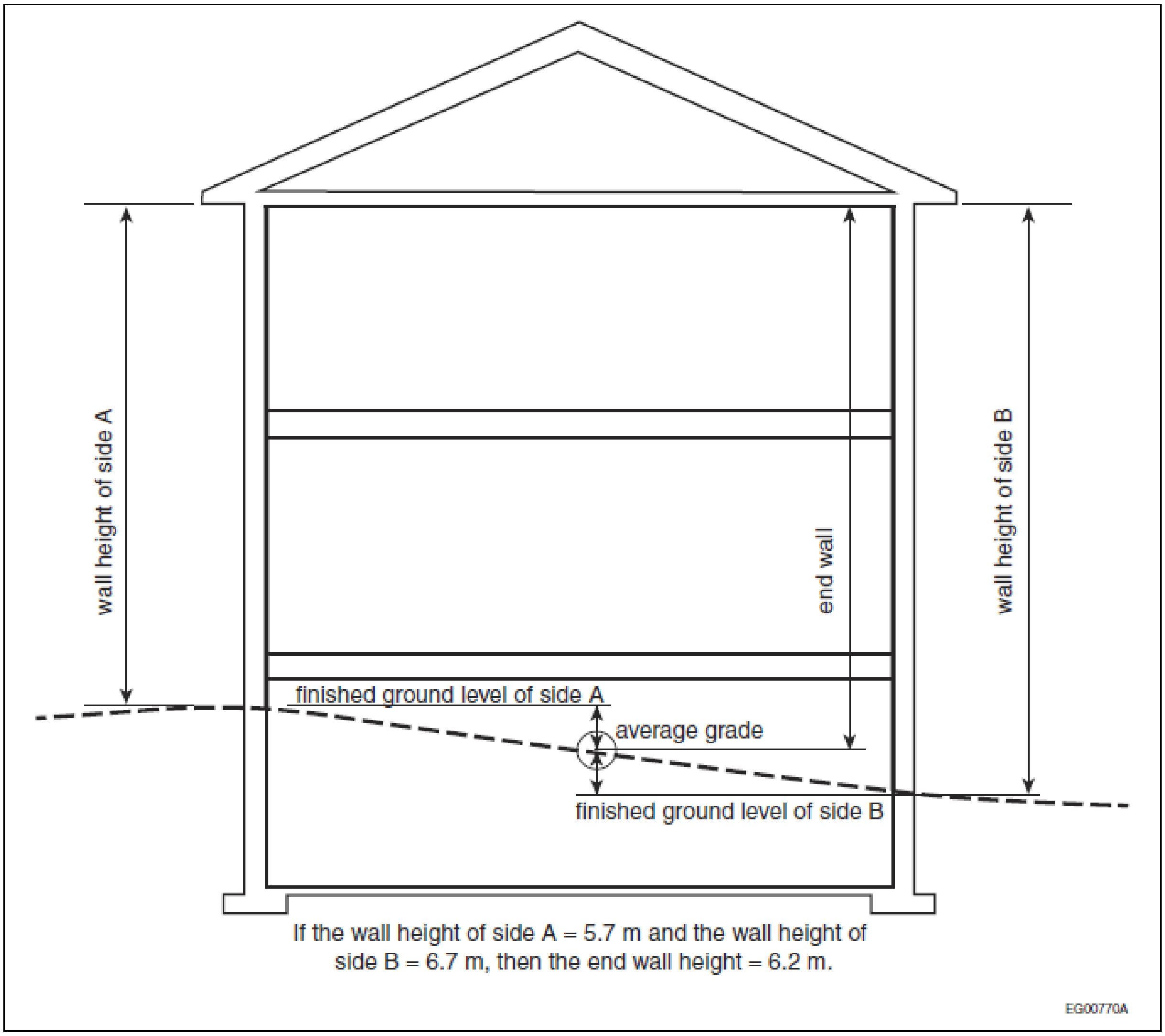


Figure A-9.36.2.3.(2) and (3)

Example of interior wall height to be used in the calculation of gross wall area

A-9.36.2.3.(5) Areas of Other Fenestration

Figure A-9.36.2.3.(5) illustrates how to measure the area of glass panes as described in Sentence 9.36.2.3.(5).

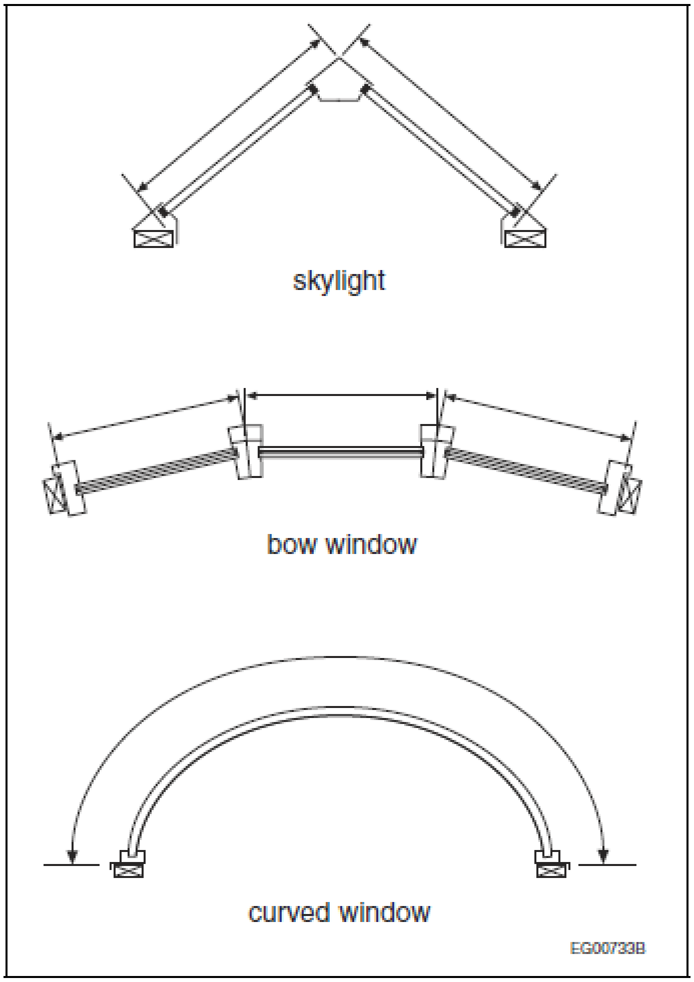


Figure A-9.36.2.3.(5)

Measuring the area of glazing that is not in the same plane

A-9.36.2.4.(1) Calculating the Effective Thermal Resistance of Building Envelope Assemblies

The general theory of heat transfer is based on the concept of the thermal transmittance through an element over a given surface area under the temperature difference across the element (see Sentence 9.36.1.2.(2)). As such, the NECB requires all building envelope assemblies and components to comply with the maximum U-values (overall thermal transmittance) stated therein. However, the requirements in Subsection 9.36.2. are stated in RSI values (effective thermal resistance values), which are the reciprocal of U-values.

To calculate effective thermal resistance, Section 9.36. requires that contributions from all portions of an assembly—including heat flow through studs and insulation—be taken into account because the same insulation product (nominal insulation value) can produce different effective thermal resistance values in different framing configurations. The resulting effective thermal resistance of an assembly also depends on the thermal properties and thickness of the building materials used and their respective location.

The following paragraphs provide the calculations to determine the effective thermal resistance values for certain assemblies and the thermal characteristics of common building materials. The Tables in Appendix Notes A-9.36.2.6.(1) and A-9.36.2.8.(1) confirm the compliance of common building assemblies.

Calculating the Effective Thermal Resistance of an Assembly with Continuous Insulation: Isothermal-Planes Method

To calculate the effective thermal resistance of a building envelope assembly containing only continuous materials—for example, a fully insulated floor slab—simply add up the RSI values for each material. This procedure is described as the "isothermal-planes method" in the ASHRAE 2009, "ASHRAE Handbook – Fundamentals."

Calculating the Effective Thermal Resistance of a Wood-frame Assembly: Isothermal-Planes and Parallel-Path Flow Methods

To calculate the effective thermal resistance of a building envelope assembly containing wood framing, RSI_{eff}, add up the results of the following calculations:

$$RSI_{parallel} = \frac{100}{\frac{\text{\% area of framing}}{RSI_F} + \frac{\text{\% area of cavity}}{RSI_C}}$$

A. calculate the effective thermal resistance of all layers with continuous materials using the isothermal-planes method, and

B. calculate the effective thermal resistance of the framing portion, $RSI_{parallel}$, using the following equation, which is taken from the parallel-path flow method described in the ASHRAE 2009, "ASHRAE Handbook – Fundamentals.":

where

RSI_F= thermal resistance of the framing member obtained from Table A-9.36.2.4.(1)D.,

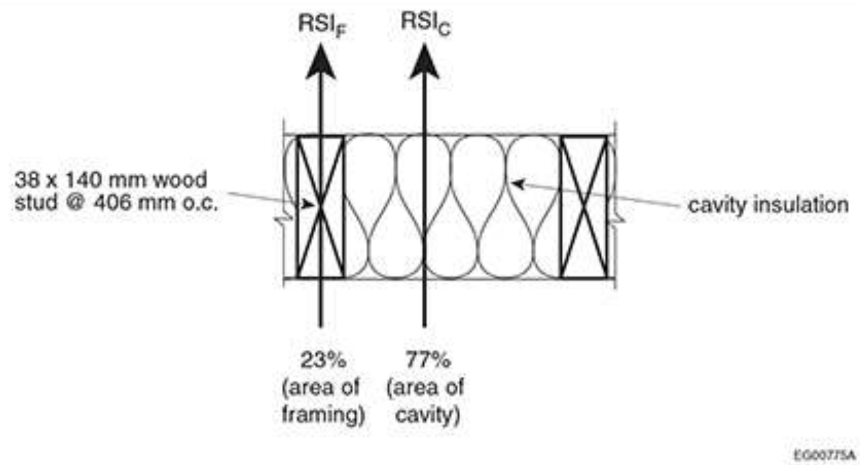
RSI_C= thermal resistance of the cavity (usually filled with insulation) obtained from Table A-9.36.2.4.(1)D.,

% area of framing= value between 0 and 100 obtained from Table A-9.36.2.4.(1)A. or by calculation, and

% area of cavity= value between 0 and 100 obtained from Table A-9.36.2.4.(1)A. or by calculation.

When the values in Table A-9.36.2.4.(1)D. are used in the calculation of effective thermal resistance of assemblies, they must not be rounded; only the final result, RSI_{eff}, can be rounded to the nearest significant digit.

Example of Calculation of RSI_{eff} for a Typical 38 x 140 mm Wood-frame Wall Assembly Using the Isothermal-Planes and Parallel-Path Flow Methods



1. Determine the thermal resistance of each continuous material layer incorporated in the assembly using Table A-9.36.2.4.(1)D.
2. Calculate the thermal resistance of a section of framing and adjacent cavity portion, $RSI_{parallel}$, using the parallel-path flow method as follows:
   (i) along a line that goes through the framing, which is designated RSI_F, and
   (ii) along a line that goes through the cavity (usually filled with insulation), which is designated RSI_C.

   Look up the % area of framing and cavity for a typical 38 x 140 mm wood-frame wall assembly with studs 400 mm o.c. using Table A-9.36.2.4.(1)A.:
   % area of framing = 23%, and
   % area of cavity = 77%

   Then, combine the sums of RSI_F and RSI_C in proportion to the relative areas of framing and insulation to calculate the value of $RSI_{parallel}$ (thermal resistance of the framing portion):

$$\mathrm{RSI_{parallel}} = \frac{100}{\left(\frac{23}{1.19}\right)+\left(\frac{77}{3.34}\right)} = 2.36\,(\mathrm{m^2\cdot K})/\mathrm{W} \qquad (\mathrm{U\text{-}value} = 0.42\mathrm{W}/(\mathrm{m^2\cdot K}))$$

3. Add up the values obtained in steps 1 and 2 to determine the effective thermal resistance of the wall assembly, RSI_{eff}.

Layers in 38 x 140 mm Wood-frame Wall Assembly with Studs Spaced 400 mm o.c.:			RSI, $(m^2 \cdot K)/W$
Outside air film			0.03
Metal siding			0.11
Sheathing paper			—
Gypsum sheathing (12.7 mm)			0.08
Stud (140 mm x 0.0085 RSI/mm)	RSI_F = 1.19	% area of framing = 23%	$RSI_{parallel}$ = 2.36 (U-value = 0.42 $W/(m^2 \cdot K)$)
Insulation (140 mm thick; RSI 3.34)	RSI_C = 3.34	% area of cavity = 77%	
Polyethylene (vapour barrier)			—
Gypsum (12.7 mm)			0.08
Interior air film			0.12
			RSI_{eff} = 2.78 $(m^2 \cdot K)/W$ (U-value = 0.36 $W/(m^2 \cdot K)$)

Table A-9.36.2.4.(1)A. Framing and Cavity Percentages for Typical Wood-frame Assemblies[(1)]											
Wood-frame Assemblies		**Frame Spacing, mm o.c.**									
		304		**406**		**488**		**610**		**1220**	
		% Area Framing	**% Area Cavity**	**% Area Framing**	**% Area Cavity**	**% Area Framing**	**% Area Cavity**	**% Area Framing**	**% Area Cavity**	**% Area Framing**	**% Area Cavity**
Floors	lumber joists	–	–	13	87	11.5	88.5	10	90	–	–
	I-joists and truss	–	–	9	91	7.5	92.5	6	94	–	–
Roofs/ Ceilings	ceilings with typical trusses	–	–	14	86	12.5	87.5	11	89	–	–
	ceilings with raised heel trusses	–	–	10	90	8.5	91.5	7	93	–	–
	roofs with lumber rafters and ceilings with lumber joists	–	–	13	87	11.5	88.5	10	90	–	–
	roofs with I-joist rafters and ceilings with I-joists	–	–	9	91	7.5	92.5	6	94	–	–
	roofs with structural insulated panels (SIPs)	–	–	–	–	–	–	–	–	9	91
Walls	typical wood-frame	24.5	75.5	23	77	21.5	78.5	20	80	–	–
	advanced wood-frame with double top plate[(2)]	–	–	19	81	17.5	82.5	16	84	–	–
	SIPs	–	–	–	–	–	–	–	–	14	86
	basement wood-frame inside concrete foundation wall	–	–	16	84	14.5	85.5	13	87	–	–

Notes to Table A-9.36.2.4.(1)A.:

(1) The framing percentages given in this Table account not just for the repetitive framing components but also for common framing practices, such as lintels, double top plates, cripple studs, etc., and include an allowance for typical mixes of studs, lintels and plates. The values listed represent the percentage of wall area taken up by framing and are based on the net wall area (i.e. gross wall area minus fenestration and door area). If the actual % areas of framing and cavity are known, those should be used rather than the ones in this Table. Rim joists are not accounted for in this Table because they are addressed separately in Sentence 9.36.2.6.(2).

(2) "Advanced framing" refers to a variety of framing techniques designed to reduce the thermal bridging and therefore increase the energy efficiency of a building. Some advanced framing solutions require that some framing components be insulated or eliminated; in such cases, it may be appropriate to calculate the actual % area of framing. Note that using an advanced framing technique may require additional engineering of the framing system.

The framing percentage values listed in this Table for advanced framing are based on constructions with insulated lintels or framing designed without lintels, corners with one or two studs, no cripple or jack studs, and double top plates.

Calculating the Effective Thermal Resistance of a Steel-frame Assembly

The parallel-path flow method described above for wood-frame assemblies involves simple one-dimensional heat flow calculations based on two assumptions:

- that the heat flow through the thermal bridge (the stud) is parallel to the heat flow through the insulation, and
- that the temperature at each plane is constant.

Tests performed on steel-frame walls have shown that neither of these assumptions properly represents the highly two-dimensional heat flow that actually occurs. The difference between what is assumed and what actually occurs is even more significant in steel-frame assemblies. The results achieved using the calculation method below compare well with those achieved from actual tests. The method provides a good approximation if a thermal resistance value of 0.0000161 $(m^2 \cdot K)/W$ per mm (or a conductivity of 62 $(W \cdot m)/(m^2 \cdot °C)$) is used (this value is associated with galvanized steel with a carbon content of 0.14%).

To calculate the effective thermal resistance of a building envelope assembly consisting of steel framing, RSI_{eff}, use the following equation:

$$RSI_{eff} = K_1 \cdot RSI_{T1} + K_2 \cdot RSI_{T3}$$

where

RSI_{T1}= effective thermal resistance of building envelope assembly determined using parallel-path flow method for wood-frame assemblies (use framing and cavity percentages in Table A-9.36.2.4.(1)C.),

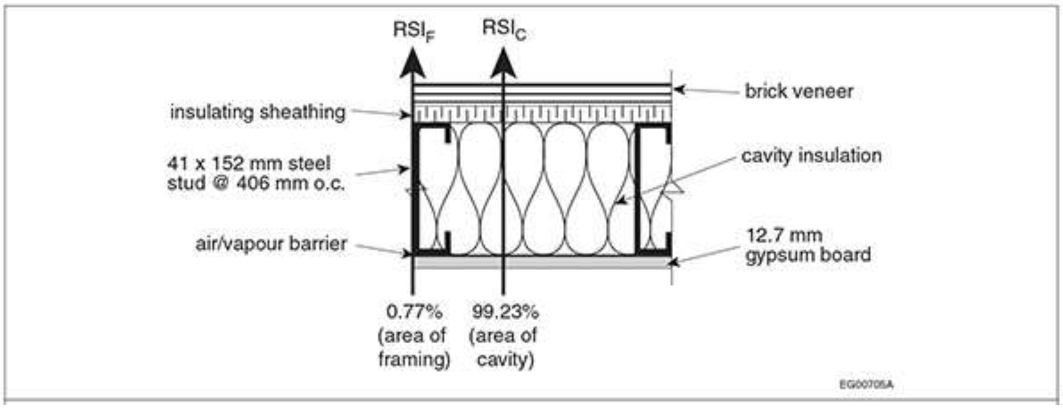
RSI_{T3}= RSI_{T2} + thermal resistance values of all other components except steel studs and insulation, where RSI_{T2} = effective thermal resistance of steel studs and insulation determined using parallel-path flow method for wood-frame assemblies,

K_1= applicable value from Table A-9.36.2.4.(1)B., and

K_2= applicable value from Table A-9.36.2.4.(1)B.

Table A-9.36.2.4.(1)B. Values for K_1 and K_2		
Framing Spacing, mm	**K_1**	**K_2**
< 500 without insulating sheathing	0.33	0.67
< 500 with insulating sheathing	0.40	0.60
≥ 500	0.50	0.50

Example of Calculation of RSI_{eff} for a 41 x 152 mm Steel-frame Wall Assembly with Studs 406 mm o.c.



1. Calculate RSI_{T1}

Materials in Assembly		RSI_F (thermal resistance through framing)	RSI_C (thermal resistance through cavity)
Outside air film		0.03	0.03
Brick veneer		0.07	0.07
Air space (25 mm thick)		0.18	0.18
Extruded polystyrene (38 mm thick x RSI 0.035/mm)		1.33	1.33
Steel stud (152 mm thick x RSI 0.0000161/mm)		0.0023	—
Insulation (152 mm thick; RSI 3.52 (R20) batts)		—	3.52
Polyethylene (vapour barrier)		—	—
Gypsum (12.7 mm thick)		0.08	0.08
Interior air film		0.12	0.12
	Total	1.81	5.33
% area framing and cavity from Table A-9.36.2.4.(1)C.		0.77%	99.23%

$$RSI_{T1} = \frac{100}{\left(\frac{0.77}{1.81}\right) + \left(\frac{99.23}{5.33}\right)} = 5.25\ (m^2 \cdot K)/W$$

(U-value = 0.19 W/(m²·K))

2. Calculate RSI_{T2}

Materials in Assembly	RSI_F (thermal resistance through framing)	RSI_C (thermal resistance through cavity)
Steel stud (152 mm thick x RSI 0.0000161/mm)	0.0023	—
Insulation (152 mm thick; RSI 3.52 (R20) batts)	—	3.52
Total	0.0023	3.52
% area framing and cavity from Table A-9.36.2.4.(1)C.	0.77%	99.23%

$$RSI_{T2} = \frac{100}{\left(\frac{0.77}{0.0023}\right) + \left(\frac{99.23}{3.52}\right)} = 0.27\ (m^2 \cdot K)/W$$

(U-value = 3.69 W/(m²·K))

3. Calculate RSI_{T3}

Materials in Assembly	RSI through Assembly
Outside air film	0.03
Brick veneer	0.07
Air space (25 mm thick)	0.18
Extruded polystyrene (38 mm thick x RSI 0.035/mm)	1.33
RSI_{T2}	0.27
Polyethylene (vapour barrier)	—
Gypsum (12.7 mm thick)	0.08
Interior air film	0.12
	RSI_{T3} = 2.08 (m²·K)/W (U-value = 0.48 W/(m²·K))

4. Calculate RSI_{eff}

$RSI_{eff} = (K_1 \cdot RSI_{T1}) + (K_2 \cdot RSI_{T3}) = (0.40 \cdot 5.25) + (0.60 \cdot 2.08) = 3.35\ (m^2 \cdot K)/W$ (U-value = 0.30 W/(m²·K))

Table A-9.36.2.4.(1)C.
Framing and Cavity Percentages for Typical Steel-frame Assemblies[(1)]

Steel-frame Assemblies	Frame Spacing, mm o.c.							
	< 500		≥ 500		< 2100		≥ 2100	
	% Area Framing	% Area Cavity	% Area Framing	% Area Cavity	% Area Framing	% Area Cavity	% Area Framing	% Area Cavity
Roofs, ceilings, floors	0.43	99.57	0.33	99.67	—	—	—	—
Above-grade walls and strapping	0.77	99.23	0.67	99.33	—	—	—	—
Below-grade walls and strapping	0.57	99.43	0.33	99.67	—	—	—	—
Sheet steel wall	—	—	—	—	0.08	99.92	0.06	99.94

Notes to Table A-9.36.2.4.(1)C.:

(1) The framing percentages given in this Table are based on common framing practices and not simply on the width of the studs and cavity. They are based on 18-gauge (1.2 mm) steel; however, test results indicate that, for the range of thicknesses normally used in light-steel framing, the actual thickness has very little effect on the effective thermal resistance. If the actual % areas of framing and cavity are known, those should be used rather than the ones in this Table.

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ per mm	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ for thickness listed
Air Films			
Exterior:			
ceiling, floors and walls wind 6.7 m/s (winter)	—	—	0.03
Interior:			
ceiling (heat flow up)	—	—	0.11
floor (heat flow down)	—	—	0.16
walls (heat flow horizontal)	—	—	0.12
Air Cavities[(2)(3)]	Thickness of Air Space		
Ceiling (heat flow up) faced with non-reflective material[(4)]	13 mm	—	0.15
	20 mm	—	0.15
	40 mm	—	0.16
	90 mm	—	0.16
Floors (heat flow down) faced with non-reflective material[(4)]	13 mm	—	0.16
	20 mm	—	0.18
	40 mm	—	0.20
	90 mm	—	0.22
Walls (heat flow horizontal) faced with non-reflective material[(4)]	9.5 mm	—	0.15
	13 mm	—	0.16
	20 mm	—	0.18
	40 mm	—	0.18
	90 mm	—	0.18
Cladding Materials	Thickness of Material		
Brick:			
fired clay (2400 kg/m^2)	100 mm	0.0007	0.07
concrete: sand and gravel, or stone (2400 kg/m^2)	100 mm	0.0004	0.04
Cement/lime, mortar, and stucco	—	0.0009	—
Wood shingles:			
400 mm, 190 mm exposure	—	—	0.15
400 mm, 300 mm exposure (double exposure)	—	—	0.21
insulating backer board	8 mm	—	0.25
Siding:			
Metal or vinyl siding over sheathing:			
hollow-backed	—	—	0.11
insulating-board-backed	9.5 mm nominal	—	0.32

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2·K)/W$ per mm	Thermal Resistance (RSI), $(m^2·K)/W$ for thickness listed
foiled-backed	9.5 mm nominal	—	0.52
Wood:			
bevel, 200 mm, lapped	13 mm	—	0.14
bevel, 250 mm, lapped	20 mm	—	0.18
drop, 200 mm	20 mm	—	0.14
hardboard	11 mm	—	0.12
plywood, lapped	9.5 mm	—	0.10
Stone:			
quartzitic and sandstone (2240 kg/m^3)	—	0.0003	—
calcitic, dolomitic, limestone, marble, and granite (2240 kg/m^3)	—	0.0004	—
Fibre-cement: single-faced, cellulose fibre-reinforced cement	6.35 mm	0.003	0.023
	8 mm	0.003	0.026
Roofing Materials[(5)]	Thickness of Material		
Asphalt roll roofing	—	—	0.03
Asphalt/tar	—	0.0014	—
Built-up roofing	10 mm	—	0.06
Crushed stone	—	0.0006	—
Metal deck	—	—	negligible
Shingle:			
asphalt	—	—	0.08
wood	—	—	0.17
Slate	13 mm	—	0.01
Sheathing Materials	Thickness of Material		
Gypsum sheathing	12.7 mm	0.0063	0.08
Insulating fibreboard	—	0.016	—
Particleboard:			
low density (593 kg/m^3)	—	0.0098	—
medium density (800 kg/m^3)	—	0.0077	—
high density (993 kg/m^3)	—	0.0059	—
Plywood – generic softwood	9.5 mm	0.0087	0.083
	11 mm		0.096
	12.5 mm		0.109
	15.5 mm		0.135
	18.5 mm		0.161

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2·K)/W$ per mm	Thermal Resistance (RSI), $(m^2·K)/W$ for thickness listed
Plywood – Douglas fir	9.5 mm	0.0111	0.105
	11 mm		0.122
	12.5 mm		0.139
	15.5 mm		0.172
	18.5 mm		0.205
Sheet materials:			
permeable felt	—	—	0.011
seal, 2 layers of mopped (0.73 kg/m^3)	—	—	0.210
seal, plastic film	—	—	negligible
Waferboard (705 kg/m^3)	—	0.0095	—
Oriented strandboard (OSB)	9.5 mm	0.0098	0.093
	11 mm		0.108
Insulation Materials[(6)]	Thickness of Material	Thermal Resistance (RSI), $(m^2·K)/W$ per mm	Thermal Resistance (RSI), $(m^2·K)/W$ for thickness listed
Blanket and batt: rock or glass mineral fibre (CAN/ULC-S702)			
R12	89/92 mm	—	2.11
R14	89/92 mm	—	2.46
R19[(7)] (R20 compressed)	140 mm	—	3.34
R20	152 mm	—	3.52
R22	140/152 mm	—	3.87
R22.5	152 mm	—	3.96
R24	140/152 mm	—	4.23
R28	178/216 mm	—	4.93
R31	241 mm	—	5.46
R35	267 mm	—	6.16
R40	279/300 mm	—	7.04
Boards and slabs:			
Roof board	—	0.018	—
Building board or ceiling tile, lay-in panel	—	0.016	—

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ per mm	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ for thickness listed
Polyisocyanurate/polyurethane-faced sheathing: Types 1, 2 and 3 (CAN/ULC-S704)			
permeably faced	25 mm	0.03818	0.97
	50 mm	0.0360	1.80
impermeably faced	25 mm	0.03937	1.00
	50 mm	0.0374	1.87
Expanded polystyrene (CAN/ULC-S701)[(8)]			
Type 1	25 mm	0.026	0.65
Type 2	25 mm	0.028	0.71
Type 3	25 mm	0.030	0.76
Extruded polystyrene: Types 2, 3 and 4 (CAN/ULC-S701)	25 mm	0.035	0.88
	50 mm	0.0336	1.68
Semi-rigid glass fibre wall/roof insulation (48 kg/m^3)	25 mm	0.0298	0.757
Semi-rigid rock wool wall insulation (56 kg/m^3)	25 mm	0.0277	0.704
Loose-fill insulation			
Cellulose (CAN/ULC-S703)	—	0.025	—
Glass fibre loose fill insulation for attics (CAN/ULC-S702)	112 to 565 mm	0.01875	—
Glass fibre loose fill insulation for walls (CAN/ULC-S702)	89 mm	0.02865	2.55
	140 mm	0.0289	4.05
	152 mm	0.030	4.23
Perlite	—	0.019	—
Vermiculite	—	0.015	—
Spray-applied insulation			
Sprayed polyurethane foam			
medium density (CAN/ULC-S705.1)	25 mm	0.036	0.90
	50 mm	0.036	1.80
light density (CAN/ULC-S712.1)	25 mm	0.026	0.65
Sprayed cellulosic fibre (CAN/ULC-S703)	settled thickness	0.024	—

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2·K)/W$ per mm	Thermal Resistance (RSI), $(m^2·K)/W$ for thickness listed
Spray-applied glass-fibre insulation (CAN/ULC-S702)			
density: 16 kg/m^3	89 mm	0.025	2.30
	140 mm	0.025	3.53
density: 28.8 kg/m^3	89 mm	0.029	2.64
	140 mm	0.029	4.06
Structural Materials	Thickness of Material		
Concrete			
Low-density aggregate			
expanded shale, clay, slate or slags, cinders (1 600 kg/m^3)	—	0.0013	—
perlite, vermiculite, and polystyrene bead (480 kg/m^3)	—	0.0063	—
Normal-density aggregate			
sand and gravel or stone aggregate (2 400 kg/m^3)	—	0.0004	—
Hardwood [(9)(10)]			
Ash	—	0.0063	—
Birch	—	0.0055	—
Maple	—	0.0063	—
Oak	—	0.0056	—
Softwood[(9)(10)]			
Amabilis fir	—	0.0080	—
California redwood	—	0.0089	—
Douglas fir-larch	—	0.0069	—
Eastern white cedar	—	0.0099	—
Eastern white pine	—	0.0092	—
Hemlock-fir	—	0.0084	—
Lodgepole pine	—	0.0082	—
Red pine	—	0.0077	—
Western hemlock	—	0.0074	—
Western red cedar	—	0.0102	—
White spruce	—	0.0097	—
Yellow cyprus-cedar	—	0.0077	—
Wood, structural framing, spruce-pine-fir [(11)]	—	0.0085	—
Steel, galvanized sheet, 0.14% carbon content	—	0.0000161	—

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ per mm	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ for thickness listed
Concrete Blocks	Thickness of Material		
Limestone aggregate with 2 cores			
cores filled with perlite	190 mm	—	0.37
	290 mm	—	0.65
Light-weight units (expanded shale, clay, slate or slag aggregate) with 2 or 3 cores			
no insulation in cores	90 mm	—	0.24
	140 mm	—	0.30
	190 mm	—	0.32
	240 mm	—	0.33
	290 mm	—	0.41
cores filled with perlite	140 mm	—	0.74
	190 mm	—	0.99
	290 mm	—	1.35
cores filled with vermiculite	140 mm	—	0.58
	190 mm	—	0.81
	240 mm	—	0.98
	290 mm	—	1.06
cores filled with molded EPS beads	190 mm	—	0.85
molded EPS inserts in cores	190 mm	—	0.62
Medium-weight units (combination of normal- and low-mass aggregate) with 2 or 3 cores			
no insulation in cores	190 mm	—	0.26
cores filled with molded EPS beads	190 mm	—	0.56
molded EPS inserts in cores	190 mm	—	0.47
cores filled with perlite	190 mm	—	0.53
cores filled with vermiculite	190 mm	—	0.58
Normal-weight units (sand and gravel aggregate) with 2 or 3 cores			
no insulation in cores	90 mm	—	0.17
	140 mm	—	0.19
	190 mm	—	0.21
	240 mm	—	0.24
	290 mm	—	0.26
cores filled with perlite	190 mm	—	0.35

Table A-9.36.2.4.(1)D. Thermal Resistance Values of Common Building Materials(1)			
	Thickness of Material	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ per mm	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ for thickness listed
cores filled with vermiculite	140 mm	—	0.40
	190 mm	—	0.51
	240 mm	—	0.61
	290 mm	—	0.69
Hollow Clay Bricks	Thickness of Material		
Multi-cored without insulation in cores	90 mm	—	0.27
Rectangular 2-core			
no insulation in cores	140 mm	—	0.39
	190 mm	—	0.41
	290 mm	—	0.47
cores filled with vermiculite	140 mm	—	0.65
	190 mm	—	0.86
	290 mm	—	1.29
Rectangular 3-core			
no insulation in cores	90 mm	—	0.35
	140 mm	—	0.38
	190 mm	—	0.41
	240 mm	—	0.43
	290 mm	—	0.45
cores filled with vermiculite	140 mm	—	0.68
	190 mm	—	0.86
	240 mm	—	1.06
	290 mm	—	1.19
Interior Finish Materials(12)	Thickness of Material		
Gypsum board	—	0.0061	—
Hardboard – medium-density (800 kg/m^3)	—	0.0095	—
Interior finish (plank, tile) board	—	0.0198	—
Particleboard			
low-density (590 kg/m^3)	—	0.0098	—
medium-density (800 kg/m^3)	—	0.0074	—
high-density (1 000 kg/m^3)	—	0.0059	—
underlay	15.9 mm	—	0.140
Plywood	—	0.0087	—

Table A-9.36.2.4.(1)D. **Thermal Resistance Values of Common Building Materials**[(1)]			
	Thickness of Material	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ per mm	Thermal Resistance (RSI), $(m^2 \cdot K)/W$ for thickness listed
Flooring material			
Carpet and fibrous pad	—	—	0.370
Carpet and rubber pad	—	—	0.220
Cork tile	3.2 mm	—	0.049
Hardwood flooring	19 mm	—	0.120
Terrazzo	25 mm	—	0.014
Tile (linoleum, vinyl, rubber)	—	—	0.009
Tile (ceramic)	9.5 mm	—	0.005
Wood subfloor	19 mm	—	0.170
Plastering			
Cement plaster: sand aggregate	—	0.0014	—
Gypsum plaster			
low-density aggregate	—	0.0044	—
sand aggregate	—	0.0012	—

Notes to Table A-9.36.2.4.(1)D.:

(1) The thermal resistance values given in Table A-9.36.2.4.(1)D. are generic values for the materials listed or minimum acceptable values taken from the standards listed. Values published by manufacturers for their proprietary materials may differ slightly but are permitted to be used, provided they were obtained in accordance with the test methods referenced in Article 9.36.2.2. For materials not listed in the Table or where the listed value does not reflect the thickness of the product, the thermal resistance value has to be calculated by dividing the material's thickness, in m, by its conductivity, in W/(m·K), which can be found in the manufacturer's literature.

(2) RSI values can be interpolated for air cavity sizes that fall between 9.5 and 90 mm, and they can be moderately extrapolated for air cavities measuring more than 90 mm. However, air cavities measuring less than 9.5 mm cannot be included in the calculation of effective thermal resistance of the assembly.

(3) Where strapping is installed, use the RSI value for an air layer of equivalent thickness.

(4) Reflective insulation material may contribute a thermal property value depending on its location and installation within an assembly. Where a value is obtained through evaluation carried out in accordance with Clause 9.36.2.2.(4)(b), it may be included in the calculation of the thermal resistance or transmittance of the specific assembly.

(5) Materials installed towards the exterior of a vented air space in a roof assembly cannot be included in the calculation of effective thermal resistance of the assembly.

(6) All types of cellular foam plastic insulation manufactured to be able to retain a blowing agent, other than air, for a period longer than 180 days shall be tested for long-term thermal resistance (LTTR) in accordance with CAN/ULC-S770, "Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulating Foams." This LTTR value shall be input

as the design thermal resistance value for the purpose of energy calculations in Section 9.36. Product standards contain a baseline LTTR for a thickness of 50 mm, from which the LTTR for other thicknesses can be calculated.

(7) An RSI 3.52 (R20) batt compressed into a 140 mm cavity has a thermal resistance value of 3.34 (R19); if installed uncompressed in a 152 mm cavity (e.g. in a metal stud assembly), it will retain its full thermal resistance value of 3.52 (m2·K)/W.

(8) Expanded polystyrene insulation is not manufactured to be able to retain a blowing agent; it is therefore not necessary to test its LTTR. See (9).

(9) The thermal resistance values for wood species are based on a moisture content (MC) of 12%. In Canada, equilibrium moisture content for wood in buildings ranges from 8-14%. The difference between the thermal properties of wood species with 12% MC and those with 14% MC is negligible.

(10) For wood species not listed in the Table, the RSI value of a wood species of equal or greater density (or specific gravity (relative density)) can be used since the thermal resistance of wood is directly related to its density (higher density wood has a lower thermal resistance).

(11) 0.0085 is considered a common value for structural softwood (see also ASHRAE 2009, "ASHRAE Handbook – Fundamentals").

(12) Materials installed towards the interior of a conditioned air space cannot be included in the calculation of effective thermal resistance of the assembly.

A-9.36.2.4.(3) Calculating Thermal Resistance of Major Structural Penetrations

Projecting slabs contribute a large area to the 2% exclusion so calculation and analysis of the heat loss through the area they penetrate should be carried out; where construction features only occasional penetrations by beams or joists, the heat loss is less critical to the overall energy performance of a building. Although the 2% exemption is based on gross wall area, it applies to penetrations through any building envelope assembly.

A-9.36.2.4.(4) Credit for Unheated Spaces Protecting the Building Envelope

The reduction in RSI afforded by Sentence 9.36.2.4.(4) is intended to provide a simple credit under the prescriptive path for any unheated space that protects a component of the building envelope. The credited value is conservative because it cannot take into account the construction of the enclosure surrounding the unheated space, which may or may not comply with the Code; as such, too many variables, such as its size or airtightness, may negate any higher credit that could be allowed.

There may be simulation tools that can be used under the performance path to provide a better assessment of the effect of an indirectly heated space; these tools may be used to calculate the credit more accurately when an unheated space is designed to provide significantly better protection than the worst-case situation assumed here. Vented spaces, such as attic and roof spaces or crawl spaces, are considered as exterior spaces; the RSI-value credit allowed in Sentence 9.36.2.4.(4) can therefore not be applied in the calculation of the effective thermal resistance of assemblies separating conditioned spaces from vented spaces.

A-9.36.2.5.(1) Continuity of Insulation

Sentence 9.36.2.5.(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 effective thermal resistance of such assemblies, which is described in Appendix Note A-9.36.2.4.(1), takes their presence into consideration.

The rest of Article 9.36.2.5. contains exceptions to Sentence (1): Sentences (2) to (8) introduce relaxations for various construction details while Sentence (9)allows a complete exemption to the requirements in Sentence (1) for three specific construction details. Balcony and canopy slabs are also exempt from the requirements in Sentence (1) because their presence is permitted to be disregarded when calculating the overall effective thermal resistance of walls they penetrate.

A-9.36.2.5.(2) Thermal Bridging

Sentence 9.36.2.5.(2) aims to minimize thermal bridging within the building envelope, which occurs when building elements conduct more heat than the insulated portion of the building envelope, which can lead to significant heat loss through the thermal bridge. The most typical case to which Clause 9.36.2.5.(2)(a) applies is that of a firewall that must completely penetrate the building envelope (see Figure A-9.36.2.5.(2)-A). Figures A-9.36.2.5.(2)-B and A-9.36.2.5.(2)-C illustrate the insulation options presented in Clauses 9.36.2.5.(2)(b) and (c).

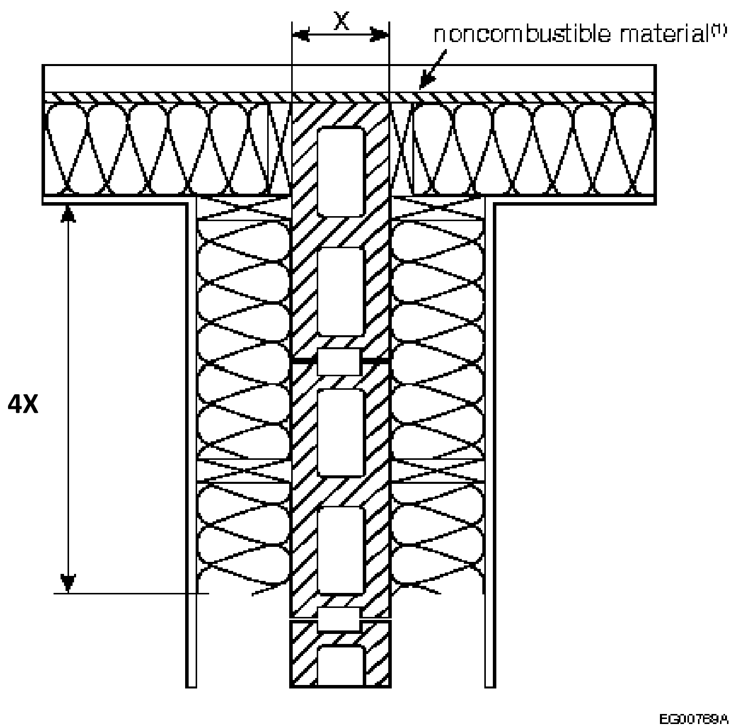


Figure A-9.36.2.5.(2)-A - Penetrating element insulated on both sides

Note to Figure A-9.36.2.5.(2)-A:

(1) See Article 3.1.10.7.

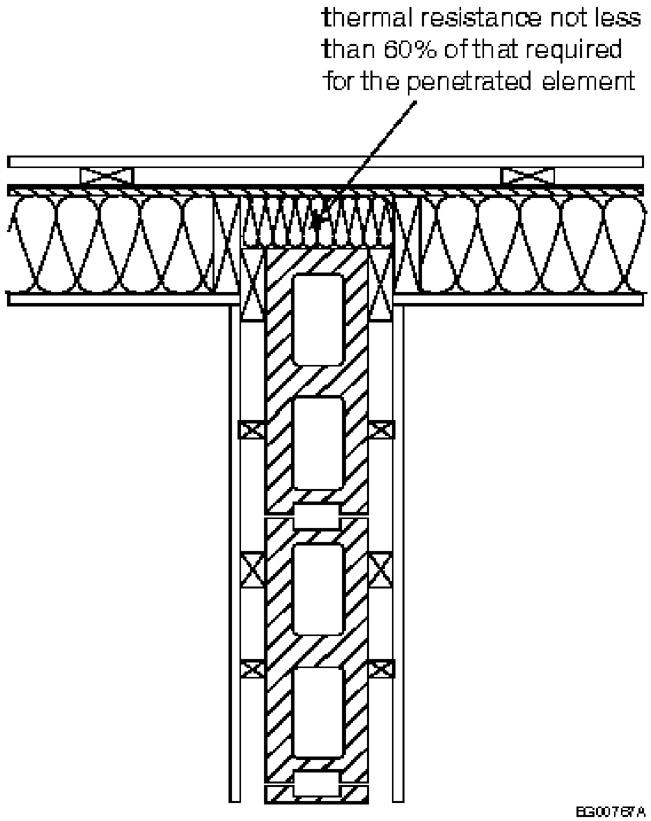


Figure A-9.36.2.5.(2)-B
Penetrating element insulated within exterior wall

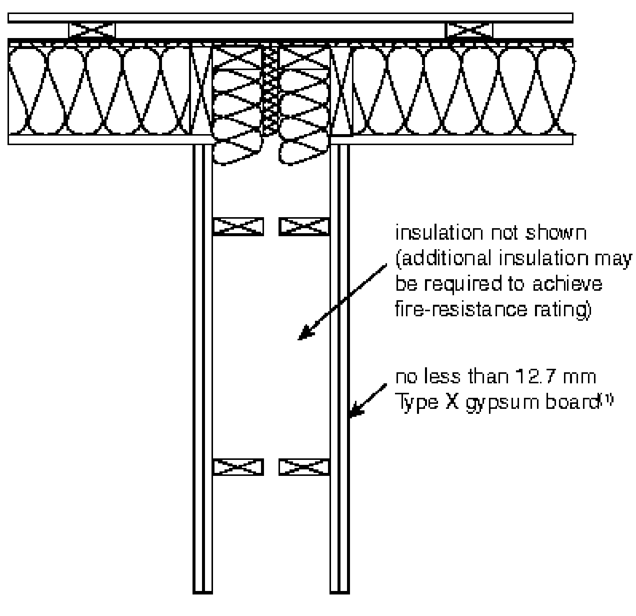


Figure A-9.36.2.5.(2)-C
Penetrating element insulated within itself

Note to Figure A-9.36.2.5.(2)-C:

(1) See Article 9.10.11.2.

A-9.36.2.5.(3) Insulation of Masonry Fireplaces

The two insulation options for masonry fireplaces and flues presented in Sentence 9.36.2.5.(3) are consistent with those presented in Sentences 9.36.2.5.(2) and (4) with the exception of the option to insulate the sides of the penetrating element to 4 times the thickness of the penetrated wall, which would not be an energy-efficient option in cases where the penetration by the fireplace or flue is several feet wide. Figures and A-9.36.2.5.(3)-B illustrate the options for achieving a continuously insulated exterior wall where it is penetrated by a masonry fireplace or flue.

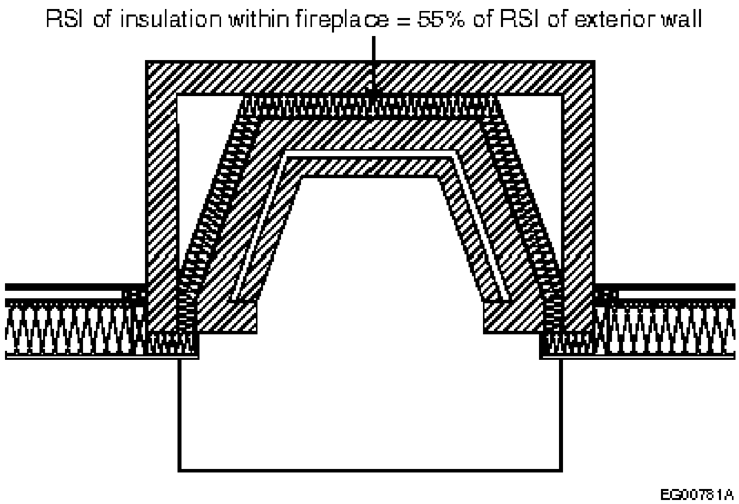


Figure A-9.36.2.5.(3)-A

Masonry fireplace insulated within itself

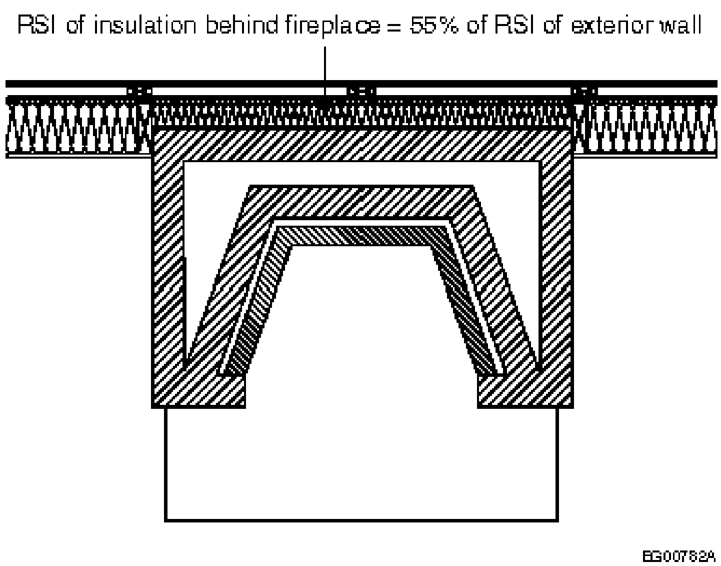


Figure A-9.36.2.5.(3)-B

Masonry fireplace insulated within plane of insulation of exterior wall

A-9.36.2.5.(5) Maintaining Continuity of Insulation

An example to which Sentence 9.36.2.5.(5) does not apply is that of a foundation wall that is insulated on the inside and the insulation continues through the joist cavity and into the wall assembly. An example to which Sentence (5) does apply is a foundation wall that is insulated on the outside below grade and on the inside above grade, in which case the distance separating the two planes of insulation is the thickness of the foundation wall.

In the configuration described in Sentence (5), the top of the foundation wall might also be required to be insulated to reduce the effect of thermal bridging through it. Insulation is not required to be overlapped as stated in Sentence (5) in cases where the joist cavities on top of the foundation wall are filled with insulation.

For cast-in-place concrete foundation walls, Sentence (5) ensures that the continuity of the insulation is maintained at every section across the wall.

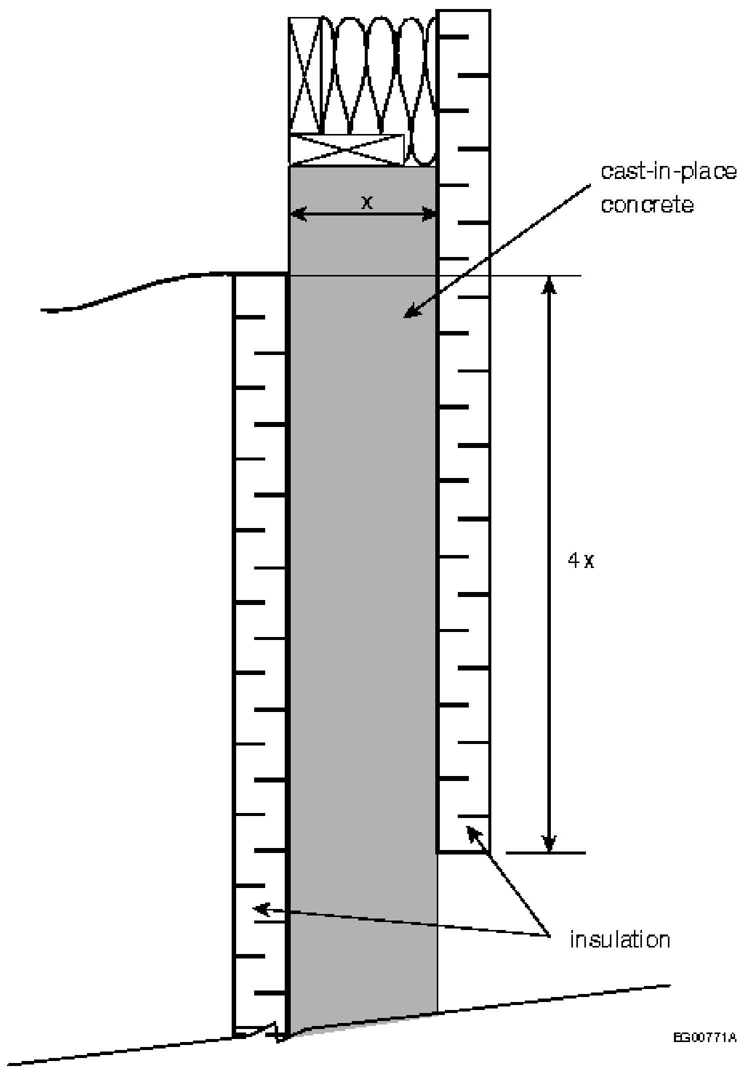


Figure A-9.36.2.5.(5)-A

Application of Sentence 9.36.2.5.(5) to a cast-in-place concrete foundation wall

In the case of hollow-core masonry walls, the effect of convection in the cores needs to be addressed. The cores of the block course that coincide with the respective lowest and highest ends of each plane of insulation should be filled with grout, mortar or insulation to reduce convection within the cores, which could short-circuit the insulation’s function.

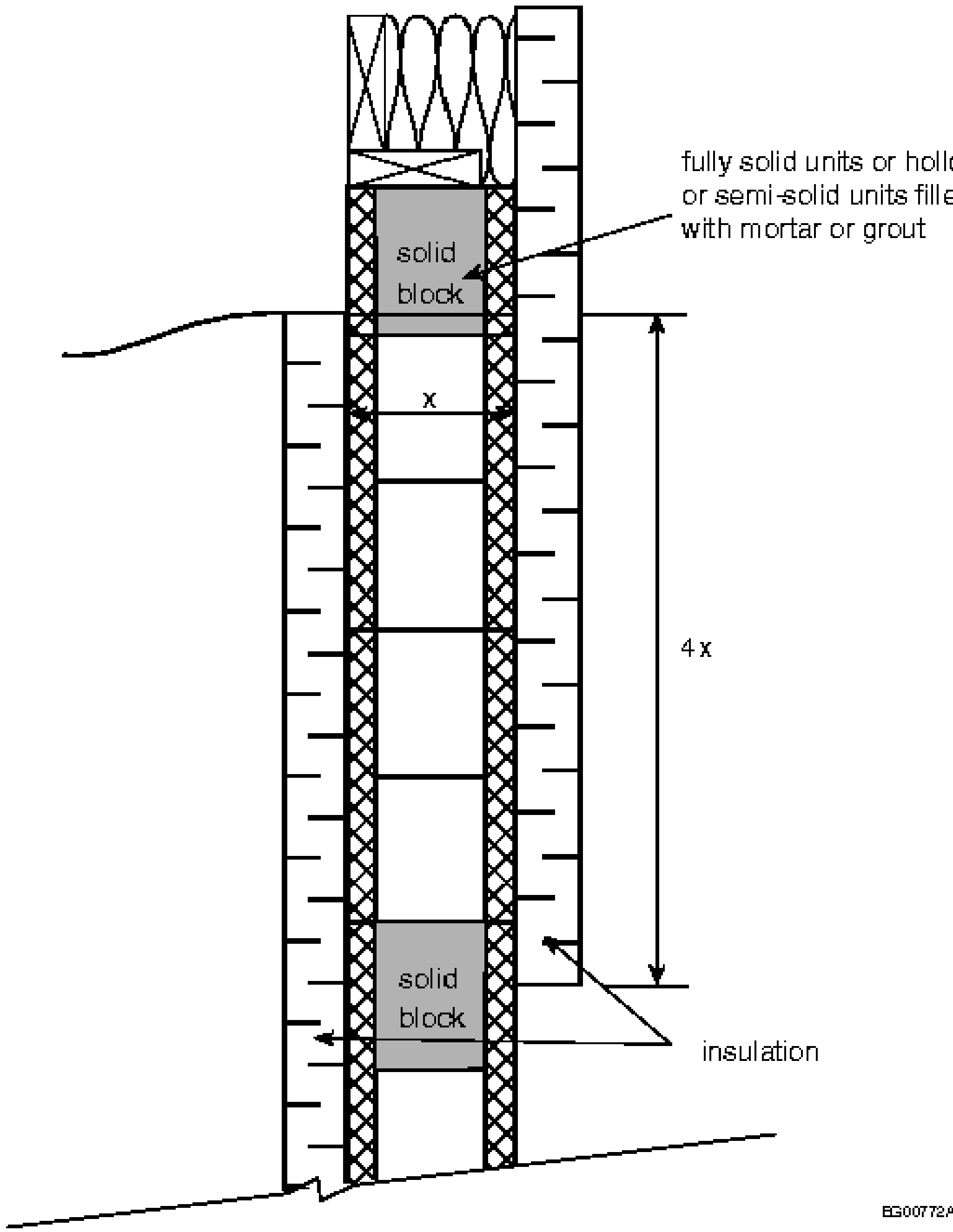


Figure A-9.36.2.5.(5)-B

Application of Sentence 9.36.2.5.(5) to a hollow-core masonry foundation wall

A-9.36.2.5.(6) Effective Thermal Resistance at Projected Area

Sentence 9.36.2.5.(6) does not apply to components that completely penetrate the building envelope, such as air intake or exhaust ducts. However, it does apply to components that are installed within or partially within the building envelope but that don't penetrate to the outdoors, and to any piece of equipment that is merely recessed into the wall.

A-9.36.2.5.(8) Effective Thermal Resistance at Joints in the Building Envelope

Sentence 9.36.2.5.(8) calls for continuity of the effective thermal resistance at the junction between two components of the building envelope, such as a wall with another wall, a wall with a roof, or a wall with a window. For example, where the gap is between a door frame (required U-value 1.8 = RSI value 0.56) and the rough framing members (required RSI value 2.93), it would have to be insulated to the RSI value of the door as a minimum. However, completely filling the gap with insulation may not be necessary as this may in fact compromise the rainscreen principle where required. Care should therefore be taken when installing insulation between windows, doors and walls.

A-9.36.2.6.(1) Thermal Characteristics of Above-ground Opaque Building Assemblies

Building Envelope Insulation and Ventilation Options

Although the Code does not present any formal trade-off options between the building envelope requirements and the ventilation or water-heating requirements, Tables 9.36.2.6.A. and 9.36.2.6.B. recognize that the same level of energy performance can be achieved through two different combinations of building envelope insulation levels and different ventilation strategies. The insulation values in Table 9.36.2.6.A. are based on mechanical ventilation solutions without heat recovery, while those in Table 9.36.2.6.B. are based on a heat recovery ventilator (HRV) that operates for at least 8 hours a day throughout the year at the minimum required ventilation capacity. The operation of the HRV affords a reduction in the RSI values for some assemblies, most notably for walls and rim joists.

Nominal Insulation Values for Above-ground Walls

Tables A-9.36.2.6.(1)A. and A-9.36.2.6.(1)B. are provided to help Code users assess the compliance of above-ground walls with Table 9.36.2.6.A. or 9.36.2.6.B. Table A-9.36.2.6.(1)A. presents the minimum nominal thermal resistance to be made up in a given wall assembly for it to achieve the applicable RSI value required by Table 9.36.2.6.A. or 9.36.2.6.B. The amount of additional materials needed to meet the prescribed RSI value can then be estimated using the thermal resistance values listed in Table A-9.36.2.4.(1)D. for the rest of the building materials in the assembly, any finishing materials, sheathing or insulation, if applicable, and the interior and exterior air films. See the example given in Note (4) of Table A-9.36.2.6.(1)A.

Note that the wall assemblies described in Table A-9.36.2.6.(1)A. do not necessarily address other building envelope requirements (see Section 9.25.).

Table A-9.36.2.6.(1)A.
Minimum Nominal Thermal Resistance (RSI) to be Made up by Insulation, Sheathing or Other Materials and Air Films in Above-ground Wall Assemblies

Description of Framing or Material	Thermal Resistance of Insulated Assembly			Minimum Effective Thermal Resistance Required by Article for Above-ground Wall Assemblies, (m²·K)/W			
	Nominal, (m²·K)/W (ft²·°F·h/Btu)		Effective, (m²·K)/W	2.78	2.97	3.08	3.85
	Insulation in Framing Cavity	Continuous Materials	Entire Assembly	Minimum Nominal Thermal Resistance,[(1)] in (m²·K)/W, to be Made up by Insulation, Sheathing[(2)] or Other Materials and Air Film Coefficients			
38 x 140 mm wood at 406 mm o.c.	3.34 (R19)[(3)]	None	2.36	0.42[(5)]	0.61	0.72	1.49
		1.32 (R7.5)	3.68	—	—	—	0.17
	3.87 (R22)	None	2.55	0.23	0.42	0.54	1.30
		0.88 (R5)	3.43	—	—	—	0.42
	4.23 (R24)	None	2.66	0.12	0.30	0.42	1.18
38 x 140 mm wood at 610 mm o.c.	3.34 (R19)[(3)]	None	2.45	0.33	0.52	0.63	1.40
		0.88 (R5)	3.33	—	—	—	0.52
		1.32 (R7.5)	3.77	—	—	—	0.08
	3.87 (R22)	None	2.67	0.11	0.30	0.42	1.18
	4.23 (R24)	None	2.80	—	0.17	0.28	1.05
38 x 89 mm wood at 406 mm o.c.	2.11 (R12)	0.88 (R5)	2.37	0.40	0.59	0.71	1.47
		1.32 (R7.5)	2.81	—	0.15	0.27	1.03
		1.76 (R10)	3.25	—	—	—	0.59
	2.46 (R14)	0.88 (R5)	2.50	0.28	0.47	0.58	1.35
		1.76 (R10)	3.38	—	—	—	0.47
38 x 89 mm wood at 610 mm o.c.	2.11 (R12)	0.88 (R5)	2.43	0.35	0.54	0.65	1.42
		1.32 (R7.5)	2.87	—	0.10	0.21	0.98
	2.46 (R14)	1.76 (R10)	3.46	—	—	—	0.39
Insulating concrete form (ICF), 150 mm thick[(4)]	n/a	3.52 (R20)	3.58	—	—	—	0.27
		3.73 (R21.2)	3.79	—	—	—	0.06
Concrete block masonry: lightweight, 190 mm thick	n/a	1.76 (R10)	2.08	0.70	0.89	1.00	1.77
		2.64 (R15)	2.96	—	0.01	0.12	0.89
		3.52 (R20)	3.84	—	—	—	0.01
Concrete block masonry: normal-weight, 190 mm thick	n/a	1.76 (R10)	1.97	0.81	1.00	1.11	1.88
		2.64 (R15)	2.85	—	0.12	0.23	1.00
		3.52 (R20)	3.73	—	—	—	0.12

Notes to Table A-9.36.2.6.(1)A.:

(1) A dash (—) means that no additional materials are needed in order to meet the minimum required effective thermal resistance for the assembly in question; however, sheathing may be required for fastening of cladding or lateral bracing.

(2) Where insulating sheathing is installed towards the exterior of the assembly, low permeance requirements addressed in Article 9.25.5.2. must be taken into consideration.

(3) When RSI 3.52 (R20) insulation batts are installed in 140 mm wood framing, they undergo some compression, which reduces their original RSI value to 3.34 (m2·K)/W (R19). However, when they are installed in 152 mm metal framing, R20 batts retain their original thermal resistance value.

(4) There are many types of ICF designs with different form thicknesses and tie configurations. Where ICF systems incorporate metal ties, thermal bridging should be accounted for. Where permanent wood blocking (bucks) for windows and doors is not covered by the same interior and exterior levels of insulation, it shall be accounted for in the calculation of effective thermal resistance.

(5) Example: To determine what additional materials would be needed to make up 0.42 (m2·K)/W, the RSI values of the other components in the wall assembly are added up as follows:
   - interior air film coefficient (walls): 0.12 (m2·K)/W
   - 12.7 mm gypsum board interior finish: 0.08 (m2·K)/W
   - 12.7 mm gypsum board exterior sheathing: 0.08 (m2·K)/W
   - metal or vinyl siding: 0.11 (m2·K)/W
   - exterior air film coefficient (walls): 0.03 (m2·K)/W
   - RSI of other components in assembly: 0.12 + 0.08 + 0.08 + 0.11 + 0.03 = 0.42 (m2·K)/W

Result: no additional materials are needed to meet the effective thermal resistance required for this particular wall assembly.

Table A-9.36.2.6.(1)B. can be used to determine the total effective thermal resistance (RSI) value of the framing/cavity portion of a number of typical above-ground wall assemblies as well as some atypical ones not covered in Table A-9.36.2.6.(1)A. Additional configurations and assembly types are listed in EnergyStar tables available online at http://ENERGYSTARforNewHomesStandard.NRCan.gc.ca.

Select the applicable stud/joist size and spacing and the RSI/R-value of the insulation to obtain the resultant effective RSI value for that frame configuration. If the RSI/R-value of the insulation product to be installed falls between two RSI/R-values listed in the Table, the lower value must be used. Once the effective RSI value of the framing/cavity portion is known, add up the nominal RSI values of all other materials in the assembly (see Table A-9.36.2.4.(1)D.) to obtain the total effective RSI value for the entire assembly. See the calculation examples in Appendix Note A-9.36.2.4.(1) for further guidance.

Table A-9.36.2.6.(1)B. Effective Thermal Resistance (RSI) Values of the Framing/Cavity Portion of Above-Ground Wall Assemblies										
Nominal Thermal Resistance of Cavity Insulation		Size, mm, and Spacing, mm o.c., of Above-ground Wood-frame Wall Assembly								
		38 x 89				38 x 140				
		304	406	488	610	304	406	488	610
RSI, $(m^2·K)/W$	R, $ft^2·°F·h/Btu$	Effective Thermal Resistance of Framing/Cavity Portion,[(1)] $(m^2·K)/W$							
1.94	11	1.40	1.43	1.45	1.48	—	—	—	—
2.11	12	1.47	1.49	1.52	1.55	—	—	—	—
2.29	13	1.53	1.56	1.59	1.63	—	—	—	—
2.47	14	1.59	1.62	1.66	1.70	1.95	1.98	2.01	2.03
2.64	15	1.64	1.68	1.72	1.76	2.03	2.06	2.09	2.12
2.82	16	1.69	1.73	1.78	1.82	2.11	2.14	2.18	2.21
2.99	17	1.74	1.78	1.83	1.88	2.18	2.22	2.26	2.30
3.17	18	1.78	1.83	1.88	1.94	2.25	2.29	2.33	2.38
3.34	19	1.82	1.87	1.93	1.98	2.32	2.36	2.41	2.45
3.52	20	1.86	1.91	1.97	2.03	2.38	2.43	2.48	2.53
3.70	21	—	—	—	—	2.44	2.49	2.55	2.60
3.87	22	—	—	—	—	2.49	2.55	2.61	2.67
4.05	23	—	—	—	—	2.55	2.61	2.67	2.74
4.23	24	—	—	—	—	2.60	2.66	2.73	2.80
4.40	25	—	—	—	—	2.65	2.72	2.78	2.86
4.58	26	—	—	—	—	2.70	2.77	2.84	2.92
4.76	27	—	—	—	—	2.74	2.82	2.89	2.98
4.93	28	—	—	—	—	2.79	2.86	2.94	3.03
5.11	29	—	—	—	—	2.83	2.91	2.99	3.08
5.28	30	—	—	—	—	2.87	2.95	3.04	3.13

Notes to Table A-9.36.2.6.(1)B.:

(1) These RSI values are valid where the cavity is completely filled with insulation and they do not account for air space in the cavity. A dash (—) means that it is not feasible to install the cavity insulation listed within the frame configuration in question.

A-9.36.2.6.(3) Reduced Effective Thermal Resistance Near the Eaves of Sloped Roofs
Minimum thermal resistance values for attic-type roofs are significantly higher than those for walls. The exemption in Sentence 9.36.2.6.(3) recognizes that the effective thermal resistance of a ceiling below an attic near its perimeter will be affected by roof slope, truss design and required ventilation of the attic space. It is assumed that the thickness of the insulation will be increased as the roof slope increases until there is enough space to allow for the installation of the full thickness of insulation required.

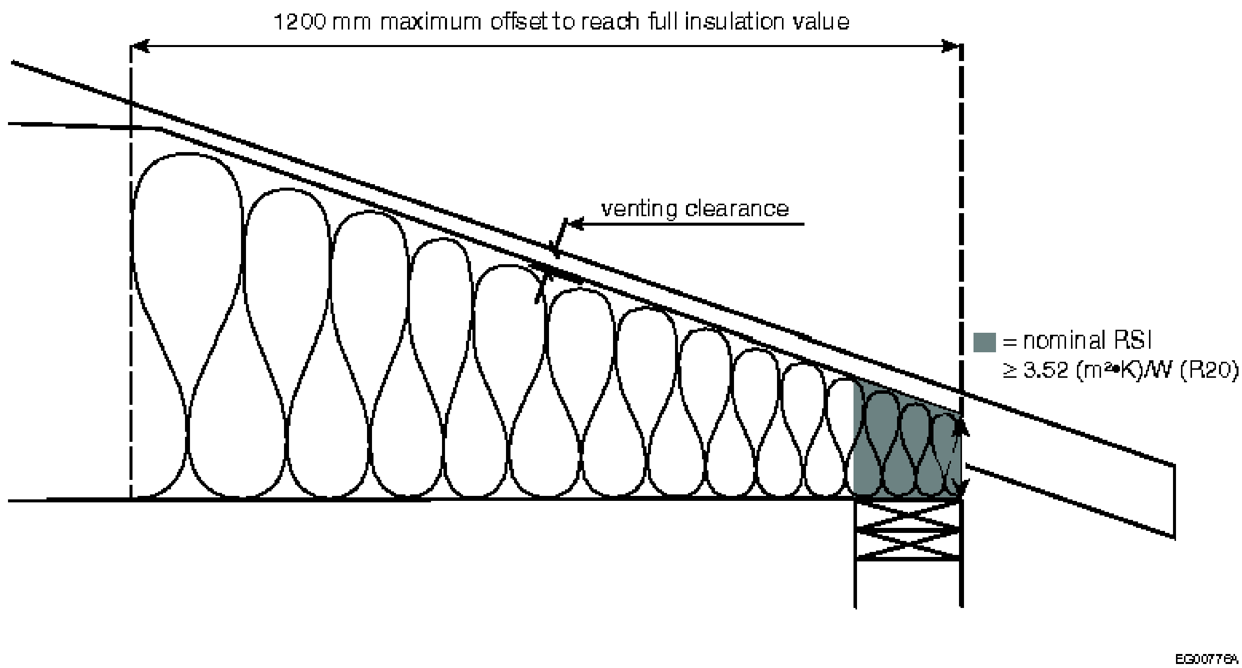


Figure A-9.36.2.6.(3)

Area of ceiling assemblies in attics permitted to have reduced thermal resistance

A-9.36.2.7.(1) and (2) Design of Windows, Glazed Doors and Skylights
The design of windows, glazed doors and skylights involves many variables that impact their energy performance and their compliance with the Code's energy efficiency requirements, such as the type of framing material, number of glass layers, type and position of low-emissivity (low-e) coating, type and size of spacer between glass layers, type of gas used to fill the glass unit, and additionally for glazed doors, type of materials used to construct the door slab.

Here are a few examples of common window and glazed door constructions:

- a U-value of about 1.8 is typically achieved using argon-filled glazing units with a low-e coating and energy-efficient spacer materials installed in a frame chosen mostly for aesthetic reasons;
- a U-value of about 1.6 is typically achieved using triple glazing but may be achieved using double glazing with an optimized gas, spacer and coating configuration installed in an insulated frame;
- a U-value of about 1.4 is typically achieved using triple glazing and multiple low-e coatings.

U-values and Energy Ratings (ER) for manufactured windows, glazed doors and skylights are obtained through testing in accordance with the standards referenced in Sentence 9.36.2.2.(3). The U-value and/or ER number for a proprietary product that has been tested can be found in the manufacturer's literature or on a label affixed to the product.

A-Table 9.36.2.7.A. Thermal Characteristics of Windows and Doors

Energy Ratings, also known as ER numbers, are based on CSA A440.2/A440.3CSA A440.2/A440.3, "Fenestration Energy Performance/User Guide to CSA A440.2-09, Fenestration Energy Performance."

They are derived from a formula that measures the overall performance of windows or doors based on solar heat gain, heat loss and air leakage through frames, spacers and glass. The ER formula produces a single unitless ER number between 0 and 50 for each of the specified sample sizes found in CSA A440.2/A440.3 (the number only applies to the product at the sample size and not to a particular proprietary window or door). The higher the ER number, the more energy-efficient the product. Note that the ER formula does not apply to sloped glazing so skylights do not have an ER value.

The maximum U-values specified in Table 9.36.2.7.A. are based on the following assumptions:

- that of moderate solar gain for each window and glazed door,
- that houses have a mix of picture and sash windows, each of which performs differently from an energy-efficiency perspective, and
- that fenestration area to gross wall area ratios typically vary between 8% and 25%.

A-9.36.2.7.(3) Site-built Windows

Site-built windows are often installed in custom-built homes or in unique configurations for which manufactured units are not available. Article 9.7.4.1. requires windows, doors and skylights to conform to either the standards referenced in Article 9.7.4.2. or to Part 5. Regardless of the compliance path chosen, the requirements of Section 9.7. and the remainder of Section 9.37. must also be met. Windows, doors and skylights and other glazed products that comply with Part 5 and are installed in a Part 9 building may use the site-built provisions of Sentence 9.36.2.7.(3) rather than complying with the requirements in Sentence 9.37.2.7.(1).

A-9.36.2.8.(1) Nominal Insulation Values for Walls Below-Grade or in Contact with the Ground

Tables A-9.36.2.8.(1)A., A-9.36.2.8.(1)B. and A-9.36.2.8.(1)C. are provided to help Code users assess the compliance of walls that are below-grade or in contact with the ground with Table 9.36.2.8.A. or 9.36.2.8.B. Table A-9.36.2.8.(1)A. presents the minimum nominal thermal resistance to be made up in a given wall assembly for it to achieve the applicable RSI value required by Table 9.36.2.8.A. or 9.36.2.8.B. The amount of additional materials needed to meet the prescribed RSI value can then be estimated using the thermal resistance values listed in Table A-9.36.2.4.(1)D. for the rest of the building materials in the assembly, any finishing materials, sheathing or insulation, if applicable, and the interior air film. For example, an RSI value of 0.20 $(m^2 \cdot K)/W$ needed to achieve the minimum RSI for a given assembly could be made up by installing 12.7 mm gypsum board, which has an RSI value of 0.0775 (m²·K)/W, and by taking into account the air film coefficient on the interior side of the wall, which is 0.12 (m²·K)/W.

Note that the wall assemblies described in Table A-9.36.2.8.(1)A. do not necessarily address other structural or building envelope requirements (see Section 9.25.).

Table A-9.36.2.8.(1)A.
Minimum Nominal Thermal Resistance (RSI) to be Made up by Insulation, Sheathing or Other Materials and Air Films in Wall Assemblies Below-Grade or in Contact with the Ground

Description of Framing or Material	Size and Spacing of Wood Framing	Thermal Resistance of Insulated Assembly			Minimum Effective Thermal Resistance Required by Article 9.36.2.8. for Wall Assemblies Below-Grade or in Contact with the Ground, (m²·K)/W			
		Nominal, (m²·K)/W (ft²·°F·h/Btu)		Effective, (m²·K)/W	1.99	2.98	3.46	3.97
		Insulation in Framing Cavity	Continuous Materials	Entire Assembly	Minimum Nominal Thermal Resistance,[(1)] in (m²·K)/W, to be Made up by Insulation, Sheathing[(2)] or Other Materials and Air Film Coefficients			
200 mm cast-in-place concrete	38 x 89 mm, 610 mm o.c.	2.11 (R12)	None	1.79	0.20	1.19	1.67	2.18
			1.41 (R8)	3.20	—	—	0.26	0.77
		2.46 (R14)	1.76 (R10)	3.75	—	—	—	0.22
	38 x 140 mm, 610 mm o.c.	3.34 (R19)[(3)]	None	2.78	—	0.20	0.68	1.19
		4.23 (R24)	None	3.26	—	—	0.20	0.71
	None	n/a	1.76 (R10)	1.84	0.15	1.14	1.62	2.13
			2.64 (R15)	2.72	—	0.26	0.74	1.25
			3.52 (R20)[(3)]	3.60	—	—	—	0.37
190 mm concrete block masonry: normal-weight, no insulation in cores	38 x 89 mm, 610 mm o.c.	2.11 (R12)	None	1.92	0.07	1.06	1.54	2.05
			1.41 (R8)	3.33	—	—	0.13	0.64
			2.11 (R12)	4.03	—	—	—	—
	38 x 140 mm, 610 mm o.c.	3.34 (R19)[(3)]	None	2.91	—	0.07	0.55	1.06
		4.23 (R24)	None	3.39	—	—	0.07	0.58
	None	n/a	1.76 (R10)	1.97	0.02	1.01	1.49	2.00
			2.64 (R15)	2.85	—	0.13	0.61	1.12
			3.52 (R20)[(3)]	3.73	—	—	—	0.24
190 mm concrete block masonry: light-weight, no insulation in cores	38 x 89 mm, 610 mm o.c.	2.11 (R12)	None	2.03	—	0.95	1.43	1.94
			1.41 (R8)	3.44	—	—	0.02	0.53
			2.11 (R12)	4.14	—	—	—	—
	38 x 140 mm, 610 mm o.c.	3.34 (R19)[(3)]	None	3.02	—	—	0.44	0.95
		4.23 (R24)	None	3.50	—	—	—	0.47

Table A-9.36.2.8.(1)A. Minimum Nominal Thermal Resistance (RSI) to be Made up by Insulation, Sheathing or Other Materials and Air Films in Wall Assemblies Below-Grade or in Contact with the Ground								
Description of Framing or Material	Size and Spacing of Wood Framing	Thermal Resistance of Insulated Assembly			Minimum Effective Thermal Resistance Required by Article 9.36.2.8. for Wall Assemblies Below-Grade or in Contact with the Ground, $(m^2 \cdot K)/W$			
		Nominal, $(m^2 \cdot K)/W$ $(ft^2 \cdot °F \cdot h/Btu)$		Effective, $(m^2 \cdot K)/W$	1.99	2.98	3.46	3.97
		Insulation in Framing Cavity	Continuous Materials	Entire Assembly	Minimum Nominal Thermal Resistance,[(1)] in $(m^2 \cdot K)/W$, to be Made up by Insulation, Sheathing[(2)] or Other Materials and Air Film Coefficients			
190 mm concrete block masonry: light-weight, no insulation in cores	None	n/a	1.76 (R10)	2.08	—	0.90	1.38	1.89
			2.64 (R15)	2.96	—	0.02	0.50	1.01
			3.52 (R20)	3.84	—	—	—	0.13
Insulating concrete form (ICF):[(4)] 150 mm concrete	n/a	n/a	3.52 (R20)[(3)]	3.58	—	—	—	0.39
			3.73 (R21.2)	3.79	—	—	—	0.18
Pressure-treated wood frame	38 x 140 mm, 203 mm o.c.	3.34 (R19)[(3)]	None	2.33	—	0.65	1.13	1.64
		4.23 (R24)	None	2.62	—	0.36	0.84	1.35
	38 x 186 mm, 203 mm o.c.	4.93 (R28)	None	2.81	—	0.17	0.65	1.16
	38 x 235 mm, 203 mm o.c.	5.28 (R31)	None	3.86	—	—	—	0.11
	38 x 140 mm, 406 mm o.c.	3.34 (R19)[(3)]	None	2.59	—	0.39	0.87	1.38
		4.23 (R24)	None	3.00	—	—	0.46	0.97
	38 x 186 mm, 406 mm o.c.	4.93 (R28)	None	3.85	—	—	—	0.12
	38 x 235 mm, 406 mm o.c.	5.28 (R31)	None	4.11	—	—	—	—

Notes to Table A-9.36.2.8.(1)A.:

(1) A dash (—) means that no additional materials are needed in order to meet the minimum required effective thermal resistance for the assembly in question; however, sheathing may be required for fastening of cladding or lateral bracing.

(2) Wood-based sheathing ≥ 11 mm thick generally has a thermal resistance of 0.11 (m2·K)/W (R0.62). However, thicker sheathing may be required for structural stability or fastening of cladding. Note that thinner R0.62 wood-based sheathing products are also

available (see Table A-9.36.2.4.(1)D.).

(3) When RSI 3.52 (R20) insulation batts are installed in 140 mm wood framing, they undergo some compression, which reduces their original RSI value to 3.34 (m2·K)/W (R19). However, when they are installed in 152 mm metal framing or in a wood frame that is offset from the back-up wall, R20 batts retain their original thermal resistance value.

(4) There are many types of ICF designs with different form thicknesses and tie configurations. Where ICF systems incorporate metal ties, thermal bridging should be accounted for.

Tables A-9.36.2.8.(1)B. and A-9.36.2.8.(1)C. can be used to determine the total effective thermal resistance (RSI) value of the framing/cavity portion of a number of typical below-grade wall assemblies as well as some atypical ones not covered in Table A-9.36.2.8.(1)A. Additional configurations and assembly types are listed in EnergyStar tables available online at http://ENERGYSTARforNewHomesStandard.NRCan.gc.ca.

Select the applicable stud/joist size and spacing and the RSI/R-value of the insulation to obtain the resultant effective RSI value for that frame configuration. If the RSI/R-value of the insulation product to be installed falls between two RSI/R-values listed in the Table, the lower value must be used. Once the effective RSI value of the framing/cavity portion is known, add up the nominal RSI values of all other materials in the assembly (see Table A-9.36.2.4.(1)D.) to obtain the total effective RSI value of the entire assembly. See the calculation examples in Appendix Note A-9.36.2.4.(1) for further guidance.

Table A-9.36.2.8.(1)B. Effective Thermal Resistance (RSI) Values of the Framing/Cavity Portion of Pressure-treated Foundation Wall Assemblies							
Nominal Thermal Resistance of Cavity Insulation		Size, mm, and Spacing, mm o.c., of Pressure-treated Wood-frame Foundation Wall Assembly					
		38 x 185			38 x 235		
		203	304	406	203	304	406
RSI, $(m^2 \cdot K)/W$	R, $ft^2 \cdot {}^\circ F \cdot h/Btu$	Effective Thermal Resistance of Framing/Cavity Portion,[(1)] $(m^2 \cdot K)/W$					
2.11	12	1.95	1.98	2.00	2.08	2.09	2.09
2.29	13	2.06	2.10	2.13	2.21	2.23	2.24
2.47	14	2.17	2.23	2.26	2.34	2.36	2.38
2.64	15	2.27	2.33	2.38	2.45	2.49	2.51
2.82	16	2.36	2.45	2.50	2.57	2.62	2.65
2.99	17	2.45	2.55	2.61	2.67	2.73	2.77
3.17	18	2.54	2.65	2.72	2.78	2.85	2.90
3.34	19	2.62	2.75	2.83	2.88	2.96	3.02
3.52	20	2.71	2.84	2.93	2.98	3.07	3.14
3.70	21	2.79	2.94	3.04	3.07	3.18	3.26
3.87	22	2.86	3.02	3.13	3.16	3.28	3.37
4.05	23	2.93	3.11	3.23	3.25	3.39	3.48
4.23	24	3.00	3.20	3.32	3.34	3.49	3.59
4.40	25	3.07	3.27	3.41	3.41	3.58	3.69
4.58	26	3.13	3.35	3.50	3.50	3.68	3.79
4.76	27	3.19	3.43	3.59	3.57	3.77	3.90
4.93	28	3.25	3.50	3.67	3.65	3.85	3.99
5.11	29	3.31	3.57	3.75	3.72	3.94	4.09
5.28	30	3.36	3.64	3.83	3.79	4.02	4.18
5.46	31	3.42	3.71	3.90	3.86	4.11	4.27

Notes to Table A-9.36.2.8.(1)B.:

(1) These RSI values are valid where the cavity is completely filled with insulation and they do not account for air space in the cavity.

Table A-9.36.2.8.(1)C. Effective Thermal Resistance (RSI) Values of the Framing/Cavity Portion of Below-Grade Interior Non-loadbearing Wood-frame Wall Assemblies									
Nominal Thermal Resistance of Cavity Insulation		Size, mm, and Spacing, mm o.c., of Below-Grade Interior Non-loadbearing Wood-frame Wall Assembly							
		38 x 89				38 x 140			
		203	304	406	610	203	304	406	610
RSI, $(m^2 \cdot K)/W$	R, $ft^2 \cdot {}^\circ F \cdot h/Btu$	Effective Thermal Resistance of Framing/Cavity Portion,(1) $(m^2 \cdot K)/W$							
0.00	0	0.22	0.21	0.20	0.20	—	—	—	—
1.41	8	1.17	1.21	1.24	1.27	—	—	—	—
1.94	11	1.41	1.50	1.55	1.61	—	—	—	—
2.11	12	1.48	1.57	1.64	1.71	—	—	—	—
2.29	13	1.54	1.65	1.73	1.81	—	—	—	—
2.47	14	1.60	1.73	1.81	1.91	—	—	—	—
2.64	15	1.65	1.79	1.89	1.99	—	—	—	—
2.82	16	1.70	1.86	1.96	2.08	2.12	2.24	2.31	2.39
2.99	17	1.75	1.92	2.03	2.16	2.19	2.32	2.41	2.50
3.17	18	1.80	1.97	2.10	2.24	2.27	2.41	2.50	2.61
3.34	19	1.84	2.03	2.16	2.31	2.33	2.49	2.59	2.70
3.52	20	1.88	2.08	2.22	2.39	2.39	2.57	2.68	2.81
3.70	21	1.91	2.13	2.28	2.46	2.46	2.64	2.77	2.90
3.87	22	1.95	2.17	2.33	2.52	2.51	2.71	2.84	2.99
4.05	23	1.98	2.22	2.39	2.59	2.57	2.78	2.93	3.09
4.23	24	2.01	2.26	2.44	2.65	2.62	2.85	3.00	3.18
4.40	25	—	—	—	—	2.67	2.91	3.07	3.26
4.58	26	—	—	—	—	2.72	2.97	3.15	3.34
4.76	27	—	—	—	—	2.77	3.03	3.22	3.42
4.93	28	—	—	—	—	2.81	3.09	3.28	3.50

Notes to Table A-9.36.2.8.(1)C.:

(1) These RSI values are valid where the cavity is completely filled with insulation and they do not account for air space in the cavity. A dash (—) means that it is not feasible to install the cavity insulation listed within the frame configuration in question.

A-Tables 9.36.2.8.A. and B. Multiple Applicable Requirements
In cases where a single floor assembly is made up of several types of the floor assemblies listed in Tables 9.36.2.8.A. and 9.36.2.8.B., each portion of that floor must comply with its respective applicable RSI value. For example, in the case of a walkout basement, the portion of floor that is above the frost line—i.e. the walkout portion—should be insulated in accordance with the values listed in the applicable Table whereas the portion below the frost line can remain uninsulated.

A-9.36.2.8.(2) Combination Floor Assemblies
An example of a floor assembly to which Sentence 9.36.2.8.(2) would apply is a heated slab-on-grade with an integral footing.

A-9.36.2.8.(4) Unheated Floors-on-ground Above the Frost Line
Figure A-9.36.2.8.(4) illustrates the insulation options for unheated floors-on-ground that are above the frost line.

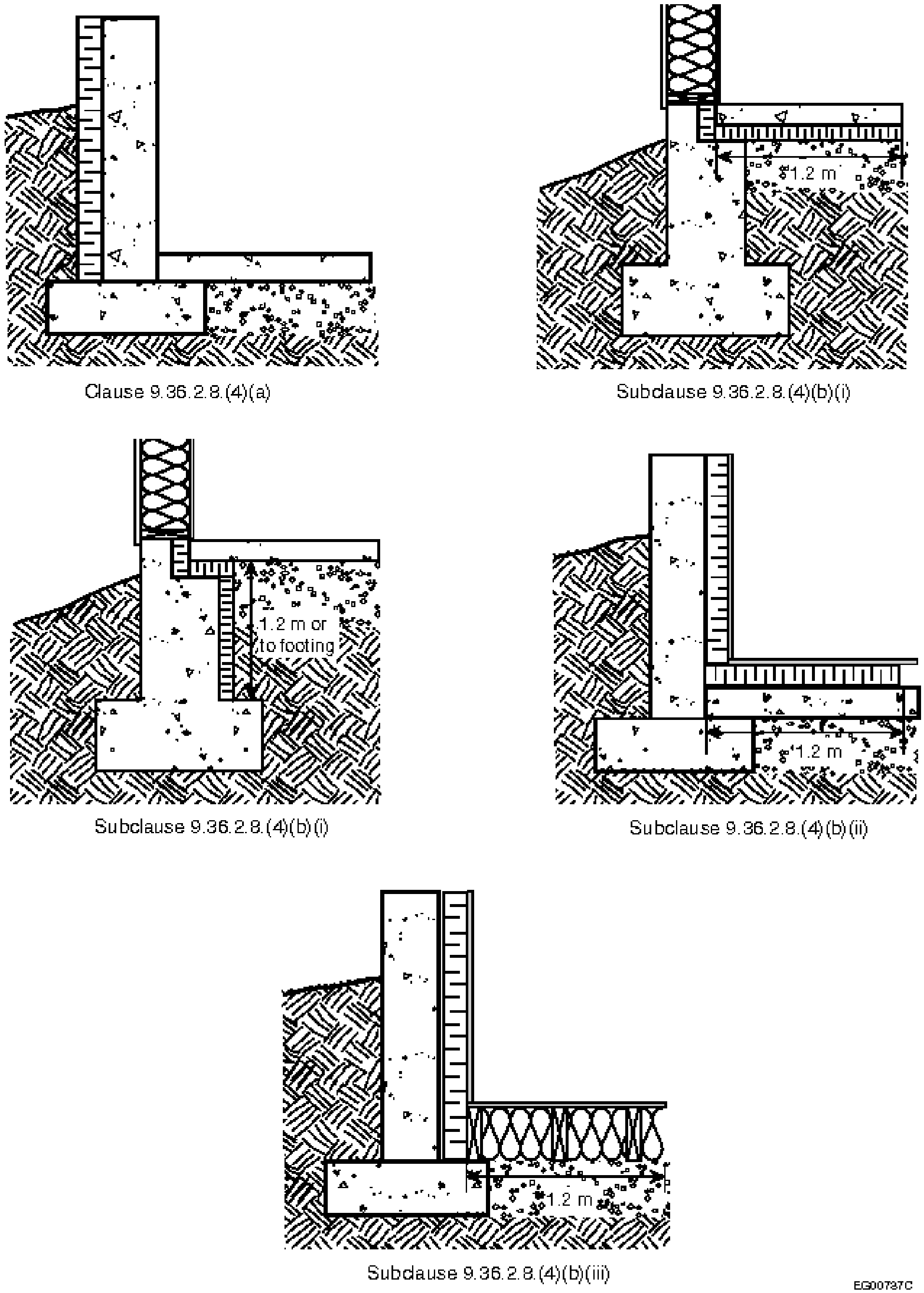


Figure A-9.36.2.8.(4)

Options for insulating unheated floors-on-ground

A-9.36.2.8.(9) Skirt Insulation

"Skirt insulation" refers to insulation installed on the exterior perimeter of the foundation and extended outward horizontally or at a slope away from the foundation. In cold climates, skirt insulation is typically extended 600 to 1000 mm out from the vertical foundation wall over the footings to reduce heat loss from the house into the ground and to reduce the chance of frost forming under the footings.

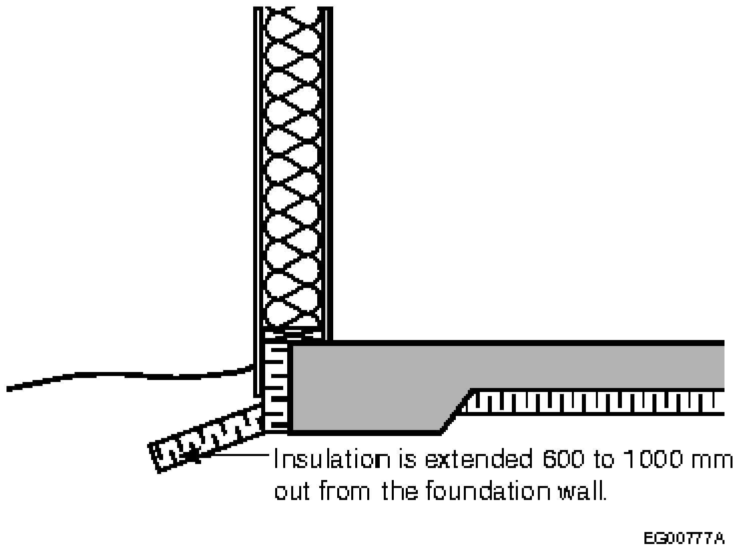


Figure A-9.36.2.8.(9)

Skirt insulation

A-9.36.2.9.(1) Controlling air leakage

Airtightness Options

Sentence 9.36.2.9.(1) presents three options for achieving an airtight building envelope: one prescriptive option (Clause (a)) and two testing options (Clauses (b) and (c)).

Air Barrier System Approaches

For an air barrier system to be effective, all critical junctions and penetrations addressed in Articles 9.36.2.9. and 9.36.2.10. must be sealed using either an interior or exterior air barrier approach or a combination of both.

The following are examples of typical materials and techniques used to construct an interior air barrier system:

- airtight-drywall approach
- sealed polyethylene approach
- joint sealant method
- rigid panel material (i.e. extruded polystyrene)
- spray-applied foams
- paint or parging on concrete masonry walls or cast-in-place concrete

Where the air barrier and vapour barrier functions are provided by the same layer, it must be installed toward the warm (in winter) side of the assembly or, in the case of mass walls such as those made of cast-in place concrete, provide resistance to air leakage through much of the thickness of the assembly. Where these functions are provided by separate elements, the vapour barrier is required to be installed toward the interior of the assembly while the airtight element can be installed toward the interior or exterior depending on its vapour permeance.

The following are examples of typical materials and techniques used to construct an exterior air barrier system:

- rigid panel material (i.e. extruded polystyrene)
- house wraps
- peel-and-stick membranes
- liquid-applied membranes

When designing an exterior air barrier system, consideration should be given to the strength of the vapour barrier and expected relative humidity levels as well as to the climatic conditions at the building's location and the properties of adjoining materials.

A-9.36.2.9.(5) Making Fireplaces Airtight
Besides fireplace doors, other means to reduce air leakage through fireplaces are available; for example, installing a glass-enclosed fireplace.

A-9.36.2.9.(6) Exterior Air Barrier Design Considerations
Any airtight assembly—whether interior or exterior—will control air leakage for the purpose of energy efficiency. However, the materials selected and their location in the assembly can have a significant impact on their effectiveness with regard to moisture control and the resistance to deterioration of the entire building envelope.

A-9.36.2.10.(5)(b) Sealing the Air Barrier System with Sheathing Tape
One method of sealing air barrier materials at joints and junctions is to apply sheathing tape that has an acceptable air leakage characteristic, is compatible with the air barrier material and resistant to the mechanisms of deterioration to which the air barrier material will be exposed. Where an assembly tested to CAN/ULC-S742, "Air Barrier Assemblies – Specification," includes sheathing tape as a component, the sheathing tape will have been tested for compatibility and resistance to deterioration and will be referenced in the manufacturer's literature as acceptable for use with that air barrier assembly.

A-9.36.2.10.(7)(a) Components Designed to Provide a Seal at Penetrations
An example of the component referred to in Clause 9.36.2.10.(7)(a) is a plastic surround for electrical outlet boxes that has a flange to which sealant can be applied or that has an integrated seal.

A-9.36.2.10.(9) Sealing the Air Barrier around Windows, Doors and Skylights

A continuous seal between windows, doors and skylights and adjacent air barrier materials can be achieved by various means including applying exterior sealant, interior sealant, low-expansion foam or sheathing tape in combination with drywall, polyethylene, a closed-cell backer rod, or a wood liner.

A-9.36.2.10.(14) Sealing Duct Penetrations

Article 9.32.3.11. requires that joints in all ventilation system ducting be sealed with mastic, metal foil duct tape or sealants specified by the manufacturer.Sentence 9.36.2.10.(14) requires that penetrations made by ducts through ceilings or walls be sealed with appropriate sealant materials and techniques to prevent air leakage. Mechanical fastening of the duct at the penetration may further reduce the likelihood of air leakage through the penetration.

A-9.36.2.11. Concept of Trade-offs

The trade-off options presented in Sentences 9.36.2.11.(2) to (4) afford some degree of flexibility in the design and construction of energy-efficient features in houses and buildings as they allow a builder/designer to install one or more assemblies with a lower RSI value than that required in Articles 9.36.2.1. to 9.36.2.7.as long as the discrepancy in RSI value is made up by other assemblies and that the total area of the traded assemblies remains the same.

Limitations to Using Trade-off Options

In some cases, the energy-conserving impact of requirements cannot be easily quantified and allowing trade-offs would be unenforceable: this is the case, for instance, for airtightness requirements (Article 9.36.2.10.). In other cases, no credit can be given for improving energy performance where the Code permits reduced performance: for example, the Code allows insulation to be reduced at the eaves under a sloped roof so no credit can be given for installing raised heel trusses to accommodate the full insulation value otherwise required by the Code; in other words, the increased RSI value that would be achieved with the raised truss cannot be traded.

Furthermore, the trade-off calculations only address conductive heat loss through the building envelope and are therefore limited in their effectiveness at keeping the calculated energy performance of a building in line with its actual energy performance, which includes solar heat gains. The limitations stated inSentence 9.36.2.11.(6) address this by ensuring that the thermal resistances are relatively evenly distributed across all building assemblies.

Terms Used in Trade-off Provisions

For the purposes of Article 9.36.2.11., the term “reference” (e.g. reference assembly) refers to a building element that complies with the prescriptive requirements of Articles 9.36.2.1. to 9.36.2.7., whereas the term “proposed” refers to a building element whose RSI value can be traded in accordance with Sentence 9.36.2.11.(2), (3) or (4), as applicable.

A-9.36.2.11.(2) Trading RSI Values of Above-Ground Opaque Building Envelope Assemblies

Sentence 9.36.2.11.(2) applies where a designer wants to use a wall or ceiling assembly with a lower effective thermal resistance than required by Subsection 9.36.2. in one building envelope area and an assembly with a compensating higher effective thermal resistance in another building envelope area to achieve the same energy performance through the combined total areas as would be achieved by complying with Subsection 9.36.2.

<table>
<tr><th colspan="6">Table A-9.36.2.11.(2)
Example</th></tr>
<tr><td colspan="6">A designer wants to reduce the insulation in 40 m^2 of wall area in the proposed design from the required effective RSI value of 3.27 (R24 batts in a 38 x 140 mm frame, 406 mm o.c.) to a value of 2.93 (R20 batts). The proposed design has 200 m^2 of attic space where more insulation could be added to compensate for the lower RSI value in the 40 m^2 of wall.</td></tr>
<tr><td rowspan="2">Assemblies Being Traded</td><td rowspan="2">Area of Each Assembly (A)</td><td colspan="2">Reference Design Values</td><td colspan="2">Proposed Design Values</td></tr>
<tr><td>RSI values (R)</td><td>A/R Values</td><td>RSI values (R)</td><td>A/R Values</td></tr>
<tr><td>Attic</td><td>200 m^2</td><td>8.66 $(m^2{\cdot}K)/W$</td><td>23.09 W/K</td><td>8.66 $(m^2{\cdot}K)/W$</td><td>23.09 W/K</td></tr>
<tr><td>Wall</td><td>40 m^2</td><td>3.27 $(m^2{\cdot}K)/W$</td><td>12.23 W/K</td><td>2.93 $(m^2{\cdot}K)/W$</td><td>13.65 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 35.32 W/K</td><td colspan="2">Total A/R value: 36.74 W/K</td></tr>
<tr><td colspan="6">The increased total A/R value for the attic and wall assemblies of the proposed design, which is caused by less insulation in the wall, now has to be compensated for by an increase in attic insulation while keeping the respective areas of the building assemblies constant. To determine the RSI value to be made up by insulation in the attic (i.e. increase in effective thermal resistance of attic assembly), first calculate the difference between the two total A/R values:</td></tr>
<tr><td colspan="6">36.74 W/K – 35.32 W/K = 1.42 W/K</td></tr>
<tr><td colspan="6">Then, subtract this residual A/R value from the A/R value required for the attic insulation:</td></tr>
<tr><td colspan="6">23.09 W/K – 1.42 W/K = 21.67 W/K</td></tr>
<tr><td colspan="6">Adding this decreased A/R value for the proposed attic to the increased A/R value for the proposed wall now gives a total A/R value that is less than or equal to that of the reference design:</td></tr>
<tr><td colspan="6">21.67 W/K + 13.65 W/K = 35.32 W/K</td></tr>
<tr><td colspan="6">To determine the RSI value to be made up by insulation in the attic of the proposed design, divide the area of the attic by the decreased A/R value required for the attic of the proposed design (21.67 W/K):</td></tr>
<tr><td colspan="6">200 m^2/21.67 W/K = 9.23 $(m^2{\cdot}K)/W$ (R52.4)</td></tr>
<tr><td rowspan="2">Assemblies Being Traded</td><td rowspan="2">Area of Each Assembly (A)</td><td colspan="2">Reference Design Values</td><td colspan="2">Proposed Design Trade-off Values</td></tr>
<tr><td>RSI values (R)</td><td>A/R Values</td><td>RSI values (R)</td><td>A/R Values</td></tr>
<tr><td>Attic</td><td>200 m^2</td><td>8.66 $(m^2{\cdot}K)/W$</td><td>23.09 W/K</td><td>9.23 $(m^2{\cdot}K)/W$</td><td>21.67 W/K</td></tr>
<tr><td>Wall</td><td>40 m^2</td><td>3.27 $(m^2{\cdot}K)/W$</td><td>12.23 W/K</td><td>2.93 $(m^2{\cdot}K)/W$</td><td>13.65 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 35.32 W/K</td><td colspan="2">Total A/R value: 35.32 W/K</td></tr>
</table>

A-9.36.2.11.(2) and (3) Calculating Trade-off Values

To trade effective thermal resistance values between above-ground building envelope components or assemblies, the ratios of area and effective thermal resistance of all such components or assemblies for the reference case (in which all components and assemblies comply with Article

9.36.2.6.) and the proposed case (in which the effective thermal resistance values of some areas are traded) must be added up and compared using the following equation:

where

R_{ir}= effective thermal resistance of assembly i of the reference case,

A_{ir}= area of assembly i of the reference case,

R_{ip}= effective thermal resistance of assembly i of the proposed case,

A_{ip}= area of assembly i of the proposed case,

n= total number of above-ground components or assemblies, and

i= 1, 2, 3, …, n.

The sum of the areas of the above-ground assemblies being traded in the proposed case (A_{ip}) must remain the same as the sum of the areas of the corresponding above-ground assemblies in the reference case (A_{ir}). Only the trade-off option described in Sentence 9.36.2.11.(4) allows a credit for a reduction in window area where the window to gross wall area ratio is less than 17%.

A-9.36.2.11.(3) Trading R-values of Windows

Sentence 9.36.2.11.(3) applies where a designer wants to install one or more windows having a U-value above the maximum permitted by Article 9.36.2.7. and reduce the U-value of other windows to achieve the same overall energy performance through the combined total area of all windows as would be achieved by complying with Article 9.36.2.7. (Note that R-values, not U-values as are typically used in relation to windows, are used in this Appendix Note.)

<table>
<tr><th colspan="4">Table A-9.36.2.11.(3)
Example</th></tr>
<tr><td colspan="4">A designer wants to install a large stained glass window on the south side of the proposed house as well as other windows for a total 12 m^2 in area. The designer wants the stained glass window to have a U-value of 2.7 $W/(m^2·K)$ (R-value 0.37 $(m^2·K)/W$), which is higher than the maximum permitted by Subsection 9.7.3. for condensation resistance, and proposes to compensate for its reduced energy performance by reducing the U-value of the remaining windows on that side, which total 10 m^2.</td></tr>
<tr><td rowspan="2">Assemblies on South Side</td><td rowspan="2">Total Area of Assemblies (A)</td><td colspan="2">Reference Design Values</td></tr>
<tr><td>R-value (R)</td><td>A/R Value</td></tr>
<tr><td>Windows</td><td>12 m^2</td><td>0.56 $(m^2·K)/W$</td><td>21.54 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 21.54 W/K</td></tr>
<tr><td rowspan="2">Assemblies Being Traded on South Side</td><td rowspan="2">Total Area of Assemblies (A)</td><td colspan="2">Proposed Design Values</td></tr>
<tr><td>R-value (R)</td><td>A/R Values</td></tr>
<tr><td>Stained glass window</td><td>2 m^2</td><td>0.37 $(m^2·K)/W$</td><td>5.41 W/K</td></tr>
<tr><td>Other windows</td><td>10 m^2</td><td>0.56 $(m^2·K)/W$</td><td>17.86 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 23.27 W/K</td></tr>
<tr><td colspan="4">The increased total A/R value for the window assemblies on the south side of the proposed house, which is due to the stained glass window, now has to be compensated for by better windows (i.e. with a lower U-value than the maximum allowed) while keeping the total area of windows in the house constant (12 m^2). To determine the R-value required to be made up by the rest of the windows on the south side, first calculate the difference between the two total A/R values:</td></tr>
<tr><td colspan="4">23.27 W/K – 21.54 W/K = 1.73 W/K</td></tr>
<tr><td colspan="4">This value (1.73 W/K) now has to be subtracted from the A/R value for the 10 m^2 of windows to determine the compensating energy performance needed:</td></tr>
<tr><td colspan="4">17.86 W/K – 1.73 W/K = 16.13 W/K</td></tr>
<tr><td colspan="4">Adding this decreased A/R value for the windows to the increased A/R value for the stained glass window will now give a total A/R value that is less than or equal to that of the reference design:</td></tr>
<tr><td colspan="4">16.13 W/K + 5.41 W/K = 21.54 W/K</td></tr>
<tr><td colspan="4">To determine the R-value to be made up by the rest of the windows on the south side of the proposed house, divide the area of the remaining windows by the decreased A/R value for the 10 m^2 of windows:</td></tr>
<tr><td colspan="4">10 m^2/16.13 W/K = 0.62 $(m^2·K)/W$ (or a U-value of 1.6 $W/(m^2·K)$)</td></tr>
<tr><td rowspan="2">Assemblies Being Traded on South Side</td><td rowspan="2">Total Area of Assemblies (A)</td><td colspan="2">Proposed Design Trade-off Values</td></tr>
<tr><td>R-values (R)</td><td>A/R Values</td></tr>
<tr><td>Stained glass window</td><td>2 m^2</td><td>0.37 $(m^2·K)/W$</td><td>5.41 W/K</td></tr>
<tr><td>Other windows</td><td>10 m^2</td><td>0.62 $(m^2·K)/W$</td><td>16.13 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 21.54 W/K</td></tr>
</table>

A-9.36.2.11.(4) RSI Values of Insulation in Attics under Sloped Roofs

Trade-off Option for Buildings with Low Ceilings

The trade-off option presented in Sentence 9.36.2.11.(4) relating to buildings with a low floor-to-ceiling height and a relatively low window and door area to wall area ratio recognizes the proven energy performance of single-section factory-constructed buildings, which have very low sloped roofs in order to comply with transportation height limitations. This option is provided to avoid unnecessarily imposing performance modeling costs. It is unlikely to be applied to site-constructed buildings or to factory-constructed buildings that are not subject to stringent transportation height restrictions because low ceilings are not the preferred choice, and the cost of cutting framing and interior finish panel products to size would exceed the cost of meeting the prescriptive attic and floor insulation levels.

Trade-off Calculation

The trade-off option presented in Sentence 9.36.2.11.(4) allows the trading of a credit based on the difference between the reference (prescriptive) and actual (proposed) window and door area. This credit can be used to reduce the required effective thermal resistance of all ceiling or floor assemblies (attics).
where

$R_{i,c/f,r}$= effective thermal resistance of ceiling/floor assembly i of the reference case,

$A_{i,c/f,r}$= area of ceiling/floor assembly i of the reference case,

$R_{i,c/f,p}$= effective thermal resistance of ceiling/floor assembly i of the proposed case,

$A_{i,c/f,p}$= area of ceiling/floor assembly i of the proposed case,

$A_{w,r\ (17\%)}$= area of windows constituting 17% of gross wall area (see Article 9.36.2.3.),

$R_{w,r}$= effective thermal resistance of windows (see Article 9.36.2.7.),

$A_{w,p\ (max.15\%)}$= area of windows constituting 15% or less of gross wall area (see Article 9.36.2.3.),

n= total number of ceiling/floor assemblies, and

i= 1, 2, 3,…, n.

The sum of $A_{i,c/f,p}$ must equal the sum of $A_{i,c/f,r}$. The sum of the areas of all other building envelope assemblies must remain the same in both the proposed and reference cases.

Trading Window Area for Reduced Attic Insulation

Sentence 9.36.2.11.(4) applies where a proposed design has a fenestration and door area to gross wall area ratio (FDWR) of 15% or less. The resulting reduction in energy loss due to the fact that there are fewer windows is traded for a reduction in R-value for a specific area in the attic where it is impossible to install the required insulation level due to roof slope.

<table>
<tr><th colspan="4">Table A-9.36.2.11.(4)
Example</th></tr>
<tr><td colspan="4">A designer wants to use a FDWR of 12% in the proposed design in order to be able to install less insulation in the 100 m^2 of attic space.</td></tr>
<tr><td rowspan="2">Assemblies Being Traded</td><td rowspan="2">Area of Each Assembly (A)</td><td colspan="2">Reference Design Values (FDWR 17%)</td></tr>
<tr><td>RSI values (R)</td><td>A/R Values</td></tr>
<tr><td>Attic</td><td>100 m^2</td><td>8.67 $(m^2·K)/W$</td><td>11.5 W/K</td></tr>
<tr><td>Windows</td><td>25 m^2</td><td>0.63 $(m^2·K)/W$</td><td>39.7 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 51.2 W/K</td></tr>
<tr><td rowspan="2">Assemblies Being Traded</td><td rowspan="2">Area of Each Assembly (A)</td><td colspan="2">Proposed Design Values (FDWR 12%)</td></tr>
<tr><td>RSI values (R)</td><td>A/R Values</td></tr>
<tr><td>Attic</td><td>100 m^2</td><td>8.67 $(m^2·K)/W$</td><td>11.5 W/K</td></tr>
<tr><td>Windows</td><td>18 m^2</td><td>0.63 $(m^2·K)/W$</td><td>28.6 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 40.1 W/K</td></tr>
<tr><td colspan="4">To determine the reduction in RSI value permitted for the attic insulation in the proposed design, first calculate the difference between the two A/R values:</td></tr>
<tr><td colspan="4">51.2 W/K – 40.1 W/K = 11.1 W/K</td></tr>
<tr><td colspan="4">This residual A/R value can now be used as a credit towards the A/R value of the attic insulation in the proposed design:</td></tr>
<tr><td colspan="4">11.1 W/K + 11.5 W/K = 22.6 W/K</td></tr>
<tr><td colspan="4">Adding this increased A/R value for the proposed attic to the A/R value for the proposed window area will now give a total A/R value that is less than or equal to that of the reference design:</td></tr>
<tr><td colspan="4">22.6 W/K + 28.6 W/K = 51.2 W/K</td></tr>
<tr><td colspan="4">To determine the new RSI value of the attic insulation, divide the area of the attic by its new increased A/R value:</td></tr>
<tr><td colspan="4">100 m^2/22.6 W/K = 4.42 $(m^2·K)/W$</td></tr>
<tr><td colspan="4">Because Clause 9.36.2.11.(6)(b) limits the reduction of a traded RSI value for opaque building envelope assemblies—in this case, an attic—to 60% of the minimum RSI value permitted by Article 9.36.2.6., this new RSI value of 4.42 $(m^2·K)/W$ for the attic is too low (60% x 8.67 = 5.20 $(m^2·K)/W$). Therefore, the full potential trade-off for this example cannot be used.</td></tr>
<tr><td rowspan="2">Assemblies Being Traded</td><td rowspan="2">Area of Each Assembly (A)</td><td colspan="2">Proposed Design Trade-off Values (FDWR 12%)</td></tr>
<tr><td>RSI values (R)</td><td>A/R Values</td></tr>
<tr><td>Attic</td><td>100 m^2</td><td>5.20 $(m^2·K)/W$</td><td>19.2 W/K</td></tr>
<tr><td>Windows</td><td>18 m^2</td><td>0.63 $(m^2·K)/W$</td><td>28.6 W/K</td></tr>
<tr><td></td><td></td><td colspan="2">Total A/R value: 47.8 W/K (< 51.2 W/K)</td></tr>
</table>

A-9.36.2.11.(6)(a) Reduction in Thermal Resistance of Ceilings in Buildings with Low Ceilings

Sentence 9.36.2.11.(4) allows insulation in attics under sloped roofs to be reduced to less than the prescriptive level required for the exterior walls, which may be less than 55% of the required values for the attic insulation.

A-9.36.3.2.(1) Load Calculations

Subsection 9.33.5. requires that heating systems serving single dwelling units be sized in accordance with CSA F280, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances" The HRAI Digest is also a useful source of information on the sizing of HVAC systems for residential buildings.

A-9.36.3.2.(2) Design and Installation of Ducts

The following publications contain useful information on this subject:

- the ASHRAE Handbooks
- the HRAI Digest
- the ANSI/SMACNA 006, "HVAC Duct Construction Standards – Metal and Flexible"

A-9.36.3.2.(5) Increasing the Insulation on Sides of Ducts

Table A-9.36.3.2.(5) can be used to determine the level of insulation needed on the sides of ducts that are 127 mm deep to compensate for a reduced level of insulation on their underside.

Table A-9.36.3.2.(5)
RSI Required on Sides of Ducts where RSI on Underside is Reduced

RSI Required for Exterior Walls,(1) $(m^2 \cdot K)/W$	RSI(2) on Underside of 127 mm Deep Duct, $(m^2 \cdot K)/W$	Width of Duct, mm						
		304	356	406	457	483	508	533
		RSI Required on Sides of Ducts, $(m^2 \cdot K)/W$						
2.78	2.11	4.47	4.98	5.61	6.43	6.94	n/a	n/a
	2.29	3.74	3.97	4.23	4.52	4.69	4.86	5.05
	2.64	2.97	3.00	3.03	3.07	3.09	3.10	3.12
2.96	2.11	5.70	6.75	8.25	n/a	n/a	n/a	n/a
	2.29	4.56	5.02	5.58	6.27	6.68	n/a	n/a
	2.64	3.46	3.57	3.67	3.78	3.84	3.90	3.97
3.08	2.29	5.26	5.96	6.88	n/a	n/a	n/a	n/a
	2.64	3.85	4.02	4.20	4.40	4.50	4.62	4.73
3.85	3.43	4.67	4.84	5.03	5.23	5.34	5.45	5.56

Notes to Table A-9.36.3.2.(5):

(1) See Article 9.36.2.6.
(2) See Appendix Note A-9.36.1.2.(3) for the formula to convert metric RSI values to imperial R values.

A-9.36.3.3.(4) Exemption

The exemption in Sentence 9.36.3.3.(4) typically applies to heat-recovery ventilators and ventilation systems that are designed to run or are capable of running continuously for specific applications. See also .

A-9.36.3.4.(1) Piping for Heating and Cooling Systems

CAN/CSA-B214, "Installation Code for Hydronic Heating Systems," the ASHRAE Handbooks, the HRAI Digest, and publications of the Hydronics Institute are useful sources of information on the design and installation of piping for heating and cooling systems.

A-9.36.3.4.(2) High-Temperature Refrigerant Piping

Piping for heat pumps is an example of high-temperature refrigerant piping.

A-9.36.3.5.(1) Location of Heating and Air-conditioning Equipment

Locating certain types of equipment for heating and air-conditioning systems—for example, heat-recovery ventilators or furnaces—outdoors or in an unconditioned space may result in lower efficiencies and higher heat loss. Where components of a system are intended to be installed outside— for example, portions of heat pump systems and wood-fired boilers—efficiency losses, if any, have already been accounted for in their design.

A-9.36.3.6.(7) Heat Pump Controls for Recovery from Setback

The requirements of Sentence 9.36.3.6.(7) can be achieved through several methods:

- installation of a separate exterior temperature sensor,
- setting a gradual rise of the control point,
- installation of controls that "learn" when to start recovery based on stored data.

A-9.36.3.8. Application

Article 9.36.3.8. is intended to apply to any vessel containing open water in an indoor setting, not only swimming pools and hot tubs; however, it does not apply to bathtubs. In the context of this Article, the terms "hot tub" and "spa" are interchangeable.

A-9.36.3.8.(4)(a) Heat Recovery from Dehumidification in Spaces with an Indoor Pool or Hot Tub

Sentence 9.36.3.8.(4) is not intended to require that all air exhausted from a swimming pool or hot tub 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 exhausted 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-9.36.3.9.(1) Heat Recovery in Dwelling Units

Whereas Section 9.32. addresses the effectiveness of mechanical ventilation systems in dwelling units from a health and safety perspective, Section 9.36. is concerned with their functioning from an energy efficiency perspective.

The requirements of Subsection 9.32.3. can be met using one of several types of ventilation equipment, among them heat-recovery ventilators (HRVs), which are typically the system of choice in cases where heat recovery from the exhaust component of the ventilation system is required. As such, Article 9.36.3.9. should be read in conjunction with the provisions in Subsection 9.32.3. that deal with HRVs.

A-9.36.3.9.(3) Efficiency of Heat-Recovery Ventilators (HRVs)
HRVs are required to be tested in conformance with CAN/CSA-C439, "Rating the Performance of Heat/Energy-Recovery Ventilators," under different conditions to obtain a rating: to be rated for colder locations, HRVs must be tested at two different temperatures, as stated in Clause 9.36.3.9.(3)(b), whereas their rating for locations in mild climates relies only on the 0°C test temperature, as stated in Clause 9.36.3.9.(3)(a).

The performance of an HRV product and its compliance with Sentence 9.36.3.9.(3) can be verified using the sensible heat recovery at the 0°C and/or –25°C test station (i.e. location where the temperature is measured) published in the manufacturer's literature or in product directories, such as HVI's Certified Home Ventilating Products Directory.

The rating of HRVs also depends on the flow rate used during testing. Therefore, the minimum flow rate required in Section 9.32. needs to be taken into consideration when selecting an HRV product.

A-9.36.3.10.(1) Unit and Packaged Equipment
The minimum performance values stated in Table 9.36.3.10. were developed based on values and technologies found in the Model National Energy Code of Canada for Houses 1997, the NECB, federal, provincial and territorial energy efficiency regulations as well as in applicable standards on equipment typically installed in housing and small buildings.

In some cases—after a review of current industry practices (industry sales figures)—the performance requirements were increased from regulated minimums where it could be shown that the cost and availability of the equipment are acceptable. Some of the performance requirements are based on anticipated efficiency improvements in the energy efficiency regulations and revisions to standards.

A-9.36.3.10.(3) Multiple Component Manufacturers
Where components from more than one manufacturer are used as parts of a heating, ventilating or air-conditioning system, the system should be designed in accordance with good practice using component efficiency data provided by the component manufacturers to achieve the overall efficiency required by Article 9.36.3.10.

A-9.36.4.2.(1) Unit and Packaged Equipment
The minimum performance values stated in Table 9.36.4.2. were developed based on values and technologies found in the Model National Energy Code of Canada for Houses 1997, the NECB, federal, provincial and territorial energy efficiency acts as well as in applicable standards on equipment typically installed in housing and small buildings.

In some cases—after a review of current industry practices (industry sales figures)—the performance requirements were increased from regulated minimums where it could be shown that the cost and availability of the equipment are acceptable.

A-9.36.4.2.(3) Exception

Components of solar hot water systems and heat pump systems are examples of service water heating equipment that is required to be installed outdoors.

A-9.36.4.6.(2) Required Operation of Pump

The water in indoor pools is pumped through filtration equipment at rates that will help prevent the build-up of harmful bacteria and algae based on water volume and temperature, frequency of pool use, number of swimmers, etc.

A-9.36.5.2. Use of Terms "Building" and "House"

Although the word "house" is used in the terms "proposed house" and "reference house," it is intended to include other types of residential buildings addressed bySubsection 9.36.5. The terms "proposed building" and "reference building" used in the NECB apply to other types of buildings.

A-9.36.5.3.(2) Concept of Comparing Performance

Comparing the performance of a reference house to that of a proposed house is one way to benchmark the performance of a proposed house in relation to Code requirements. There are other ways to benchmark energy consumption models: for example, by setting a quantitative energy target or using a benchmark design. In the performance compliance option presented in Subsection 9.36.5., the user must demonstrate that their design results in a similar level of performance to that of the prescriptive requirements— an approach that is consistent with the concept of objective-based codes.

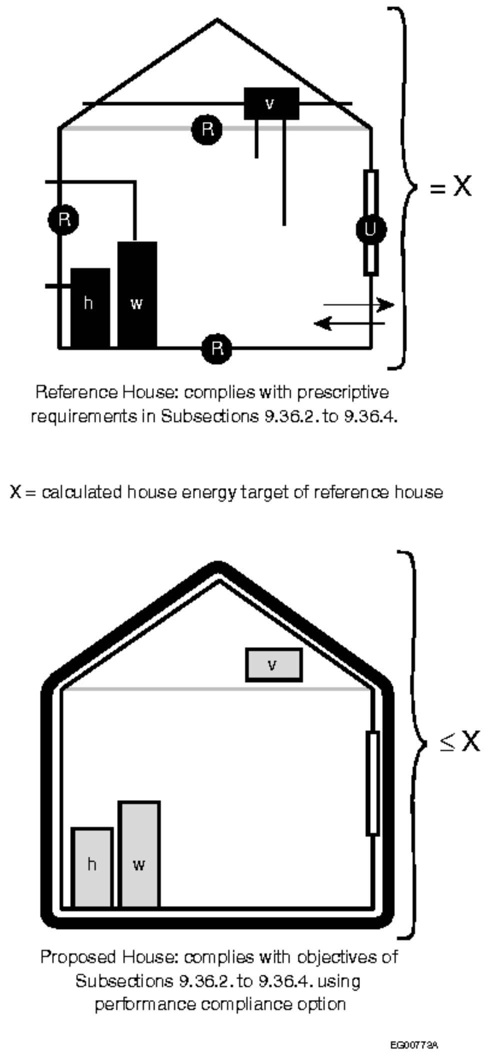


Figure A-9.36.5.3.(2)

Energy consumption of proposed house versus that of reference house

A-9.36.5.4.(1) Calculation Procedure

It is important to characterize actual heat transfer pathways such as areas of fenestration, walls, floors, ceilings, etc. An accurate geometric model of a house, including volume, captures such information, but modeling can be carried out with other calculations.

A-9.36.5.4.(2) Space-Conditioning Load

Supplementary heating systems form part of the principal heating system and must be able to meet the space-conditioning load of the house.

A-9.36.5.4.(7) Thermostatic Control

The thermostat's response to temperature fluctuations described in Sentence 9.36.5.4.(7) represents a thermostat deadband of ±0.5°C.

A-9.36.5.5.(1) Source of Climatic Data
Climatic data sources include the Canadian Weather Year for Energy Calculations (CWEC) and the Canadian Weather Energy and Engineering Data Sets (CWEEDS). 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 same criteria (see Appendix C). 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-9.36.5.6.(6) Contents of the House
In the context of Subsection 9.36.5., "contents of the house" refers to cabinets, furniture and other elements that are not part of the building structure and whose removal or replacement would not require a building permit.

A-9.36.5.6.(11) Application
Sentence 9.36.5.6.(11) is not intended to apply to the fenestration area to wall area ratio.

A-9.36.5.7.(1) Consumption of HVAC systems
The energy consumption of HVAC systems typically includes the distribution system and the effect of controls.

A-9.36.5.7.(5) Zoned Air Handlers
Zoned air handler systems may also have duct and piping losses.

A-9.36.5.8.(5) Water Delivery Temperature
A value of 55°C is used in the energy model calculations; Article 2.2.10.7. of Division B of Book II (Plumbing Systems) of this Code contains different requirements relating to water delivery temperature.

A-9.36.5.9.(1) Modeling the Proposed House

Completeness of the Energy Model Calculations

The specifications for a building typically include the following inputs and variables, among others, which are needed for modeling:

- space-heating and domestic hot water (DHW) systems
- air-, ground- and water-source heat pumps
- central air-conditioning systems
- primary and secondary DHW systems

- efficiencies of heating and cooling equipment
- solar gain through windows facing each cardinal direction
- sloped glazing, including skylights
- overhangs, taking into account the hourly position of the sun with respect to each window and overhang on a typical day each month
- the various levels of thermal mass
- slab-on-grade, crawl space (open, ventilated or closed), basement and walkout foundations, taking into account dimensions, thermal resistance and placement of insulation, soil conductivity, depth of water table, and weather/climate, and
- heat transfer between the three zones of the house, i.e. the attic, main floor and foundation

Opaque Building Envelope Assemblies

In the context of Sentence 9.36.5.9.(1), the term "opaque building envelope assembly" includes above-ground assemblies and those that are in contact with the ground.

A-9.36.5.10.(2) Assembly Type

Sentence 9.36.5.10.(2) sets a limit on the size of building envelope assemblies that have to be considered separately in the energy model calculations. In this context, assembly type is intended to mean either walls, roof, fenestration, exposed floors, or foundation walls and is intended to include the respective assembly type areas of the entire building.

A-9.36.5.10.(9)(c)(ii) Equivalent Leakage Area (ELA)

The ELA is the size of an imaginary hole through which the same amount of air would pass that passes through all of the unintended openings in the building envelope if the pressure across all those openings were equal. This value is needed in the calculation because it is a good indicator of the airtightness of the house: a leaky house will have a large ELA and a very tight house will have a small ELA. For example, an energy-efficient house might have an ELA as low as 200 cm^2 whereas a very leaky house can have an ELA of more than 3000 cm^2.

A-9.36.5.10.(11) Timing of the Airtightness Test

The blower door test described in CAN/CGSB-149.10, "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method," should be carried out once the building is substantially completed. Sufficient time should be allotted before completion to allow for subsequent air sealing in the event the desired airtightness is not achieved. Interim testing while the air barrier is still accessible for service can also be helpful.

A-9.36.5.11.(9) Part-Load Performance of Equipment

Measured Data

Where available, the measured part-load performance data are provided by the equipment manufacturer.

Modeled Part-Load Performance Data

Part-load performance ratings differ depending on the equipment. The intent of Sentence 9.36.5.11.(9) is to indicate that the same modeled data source should be used for both the proposed and reference houses.

A-9.36.5.11.(10) Sensible Heat Recovery

Treatment of Humidity in the Calculations

The calculations using sensible heat do not take latent heat (humidity) into account.

Energy-Recovery Ventilators

Energy-recovery ventilators can be used in lieu of heat-recovery ventilators.

A-9.36.5.11.(11) Circulation Fans

Sentences 9.36.5.11.(12) to (19) calculate the energy consumption of the circulation fan. The results are intended to be used in energy model calculations only and are not intended to address the performance of the ventilation system. The actual sizing of ventilation systems must comply with Section 9.32.

A-9.36.5.12.(2) Assumptions Relating to Drain-Water Heat Recovery

Energy savings associated with drain water heat recovery depend on the duration of showers and the vertical drop in the drain pipe. Similar to the service water heating load distribution, the length of showers depends on occupant behaviour. The values provided in Sentence 9.36.5.12.(2) are intended to be used in the energy model calculations only and take into consideration the loads stated in Table 9.36.5.8. The efficiency of a drain-water heat-recovery unit must be modelled using the same physical configuration intended for installation.

A-9.36.5.14.(10) Above-Ground Gross Wall Area

The determination of above-ground gross wall area is consistent with the prescriptive requirements of Article 9.36.2.3. in that it is based on the measurement of the distance between interior grade and the uppermost ceiling and on interior areas of insulated wall assemblies.

A-9.36.5.15.(5) Sizing of Heating and Cooling Systems

The intent of Sentence 9.36.5.15.(5) is that the cooling system be sized only for the portion of the house that is cooled.

Article 9.33.5.1. references CSA F280, "Determining the Required Capacity of Residential Space Heating and Cooling Appliances" which contains a number of different methods for determining the capacity of heating appliances. The intent of Sentence 9.36.5.15.(5) is that the equipment be sized according to the methods for total heat output capacity and nominal cooling capacity without being oversized.

A-9.36.5.15.(6) Default Settings

The default settings in energy performance modeling software for houses are an appropriate source of part-load performance values of equipment.

A-9.36.5.15.(8) Treatment of Humidity in the Calculations

The calculations using sensible heat do not take latent heat (humidity) into account.