9.36.2. Building Envelope

Module 2

BCBC 9.36.

2014

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9.36.2. Building Envelope

- Focus is on total building performance, not just thermal insulation
- Heat transfer and air leakage between conditioned space and unconditioned space
- Reference to many requirements already in Sections 9.7. and 9.25.

9.36.2. Building Envelope
Scope and Application

- The walls in skylight shafts are treated like exterior walls. 9.36.2.1.(3)
- Walls less than 60˚ from horizontal are considered as roof assemblies
- Windows must conform to section 9.7
- Properties of insulation, location and installation of air barriers, and vapour barriers must conform to section 9.25.

Scope and Application

- Any assembly that separates conditioned space from an adjoining *storage garage*, even if the garage is intended to be heated, must be insulated to the requirements for exterior assemblies. 9.36.2.1. (2)

9.36.2.2. Determination of Thermal Characteristics

- The thermal resistance of opaque assemblies uses **effective** thermal resistance – this is a change from nominal R-values that has been relied on up to now
- This takes into account all material layers in an assembly, and the thermal bridging of high conductivity materials – such as framing.
- Look-up tables are provided for most common assemblies, and information on how to calculate others (9.36.2.4.)

9.36.2.2. Determination of Thermal Characteristics

- Where a component of the building envelope is enclosed by unconditioned space, the effective R-value of the component can be reduced by 0.16
  - 9.36.2.4.(4)

9.36.2.2. Determination of Thermal Characteristics

- Thermal characteristics of materials are determined in accordance with listed product standards
- In absence of product standards, assemblies can be tested to ASTM-C1363 as an alternative using an indoor temperature of $21 \pm 1^{\circ}C$ and an outdoor air temperature of $-35 \pm 1^{\circ}C$
- Log wall R-values must be determined by calculation in accordance with Section 305 of ICC 400, “Design and Construction of Log Structures.”

9.36.2.2. Determination of Thermal Characteristics

- Product standards for many insulation materials are listed in the code
- New products not listed are acceptable, but must be tested in accordance with ASTM-C177 or ASTM- C518
- Calculations and tests at an average temperature of 24±2˚C and a temperature differential of 22±2˚C

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

- Heat transfer depends on the heat flow through a given area with a temperature difference across the element
- The NECB requires all building envelope assemblies and components to comply with the maximum U-values (overall thermal transmittance).
- Requirements in 9.36.2. are stated in RSI values which are the reciprocal of U-values.

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

- The same nominal insulation can produce different effective thermal resistance values depending framing type and material configurations
- To calculate effective thermal resistance, contributions from all portions of an assembly, including heat flow through studs and insulation are taken into account.

Difference Between Nominal and Effective Thermal Resistance of Assemblies

Assembly	Nominal R-value	Effective R-value
Conventional 2x6 wood stud @ 16” o/c; R-20 batt insul; gyp bd interior; ply sheathing; wood siding	20 (RSI 3.52)	17.2 (RSI 3.02)
Advanced 2x6 framing, studs @ 24” o/c, R-20 batt insul; gyp bd interior; ply sheathing; wood siding	20 (RSI 3.52)	18.2 (RSI 3.20)
2x4 wood studs @ 16” o/c; R12 batt insul; plus R-10 XPS, gyp bd interior; ply sheathing; wood siding	22 (3.87)	22.4 (RSI 3.94)
2x6 steel studs @ 16” o/c, ; R-20 batt insul.; gyp bd interior; ply sheathing; wood siding	20 (RSI 3.52)	11.35 (RSI 1.99)

9.36.2.6. Thermal Characteristics of Above Ground Opaque Assemblies

- Prescriptive path: Requirements vary whether or not an HRV is installed
  - Table with minimum *effective* R-values
    - Look-up tables for most common assemblies, and information on how to calculate others provided in the Appendix

9.36.2.6. Thermal Characteristics of Above Ground Opaque Assemblies
Table 9.36.2.6.A

Effective RSI-values – without *HRV*

Assembly	Climate Zone (Heating Degree Days ˚C)				
	Zone 4 < 3,000	Zone 5 3,001 to 3,999	Zone 6 4,000 to 4,999	Zone 7A 5,000 to 5,999	Zone 7B 6,000 to 6,999
Ceilings	6.91 (39.23)	*8.67* *(49.2)*	*8.67* *(49.2)*	*10.43* *(59.2)*	*10.43* *(59.2)*
Cathedral ceilings	4.67 (26.5)	4.67 (26.5)	4.67 (26.5)	5.02 (28.5)	5.02 (28.5)
Walls (2x6 @ 16”)	2.78 (15.78)	3.08 (17.48)	3.08 (17.48)	3.08 (17.48)	3.85 (21.86)
Floors over unheated space	4.67 (26.5)	4.67 (26.5)	4.67 (26.5)	5.02 (28.5)	5.02 (28.5)

9.36.2.6. Thermal Characteristics of Above Ground Opaque Assemblies
Table 9.36.2.6.B

Effective RSI-values – with *HRV*

Assembly	Climate Zone (Heating Degree Days ˚C)				
	Zone 4 < 3,000	Zone 5 3,001 to 3,999	Zone 6 4,000 to 4,999	Zone 7A 5,000 to 5,999	Zone 7B 6,000 to 6,999
Ceilings	6.91 (39.23)	6.91 (39.23)	*8.67* *(49.2)*	*8.67* *(49.2)*	*10.43* *(59.2)*
Cathedral ceilings	4.67 (26.5)	4.67 (26.5)	4.67 (26.5)	5.02 (28.5)	5.02 (28.5)
Walls (2x6 @ 16”)	2.78 (15.78)	2.97 (16.86)	2.97 (16.86)	2.97 (16.86)	3.08 (17.48)
Floors over unheated space	4.67 (26.5)	4.67 (26.5)	4.67 (26.5)	5.02 (28.5)	5.02 (28.5)

9.36.2.6. Thermal Characteristics of Above Ground Opaque Assemblies

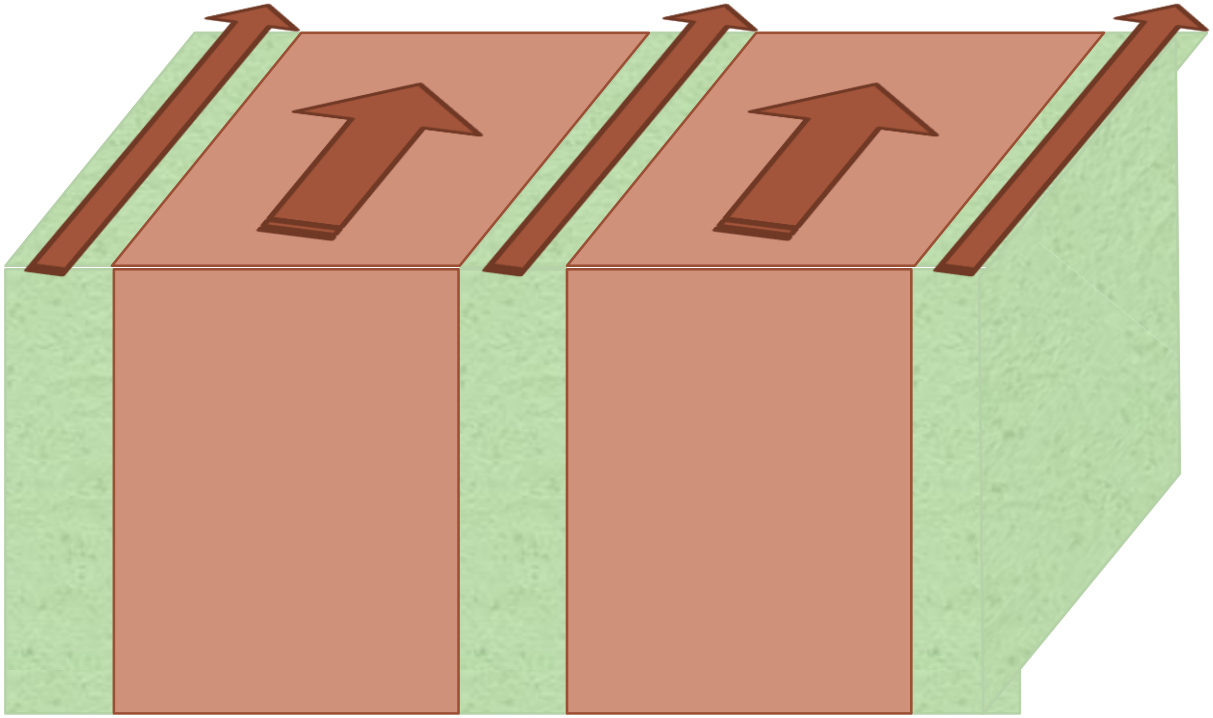
- Effective R-value can be reduced at the heel of sloped roofs for no more than 1200 mm in from the exterior to allow for framing; and attic venting
- The minimum nominal R-value directly over the outside wall must be no less than RSI 3.52 (R-20)

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

- Major structural penetrations through assemblies are permitted – but total area must not exceed 2%
  - Allowable penetrations include balcony slabs, beams, columns, and minor structural of ornamental elements.
  - Pipes, ducts, through-wall equipment vents are considered minor penetrations and are not considered.

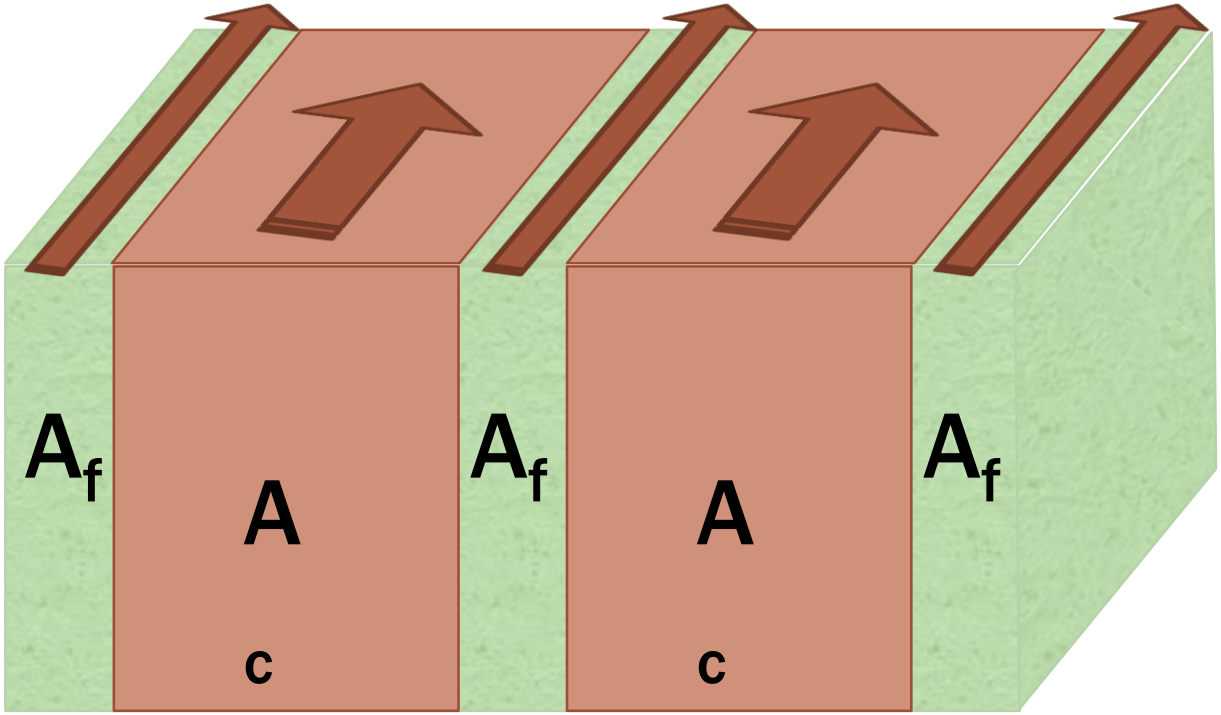
Parallel-Path Flow Method

Differing rates of heat loss thru various components of Building Assembly



Parallel-Path Flow Method

Need to determine cross sectional areas of the various components of Building Assembly



Calculating Assembly RSI values

- Continuous layers of insulation
  - Isothermal planes method – add RSI values of each layer
- Framed assemblies
  - Isothermal planes method – add RSI values of each Continuous layer **PLUS**
  - Parallel-path flow method – need to determine Effective Thermal Resistance (ETR) of Non-continuous layers

Effect of Thermal Bridging

- Where there is thermal bridging:
  - Effective R < Nominal
- Where there is NO thermal bridging:
  - Effective R = Nominal

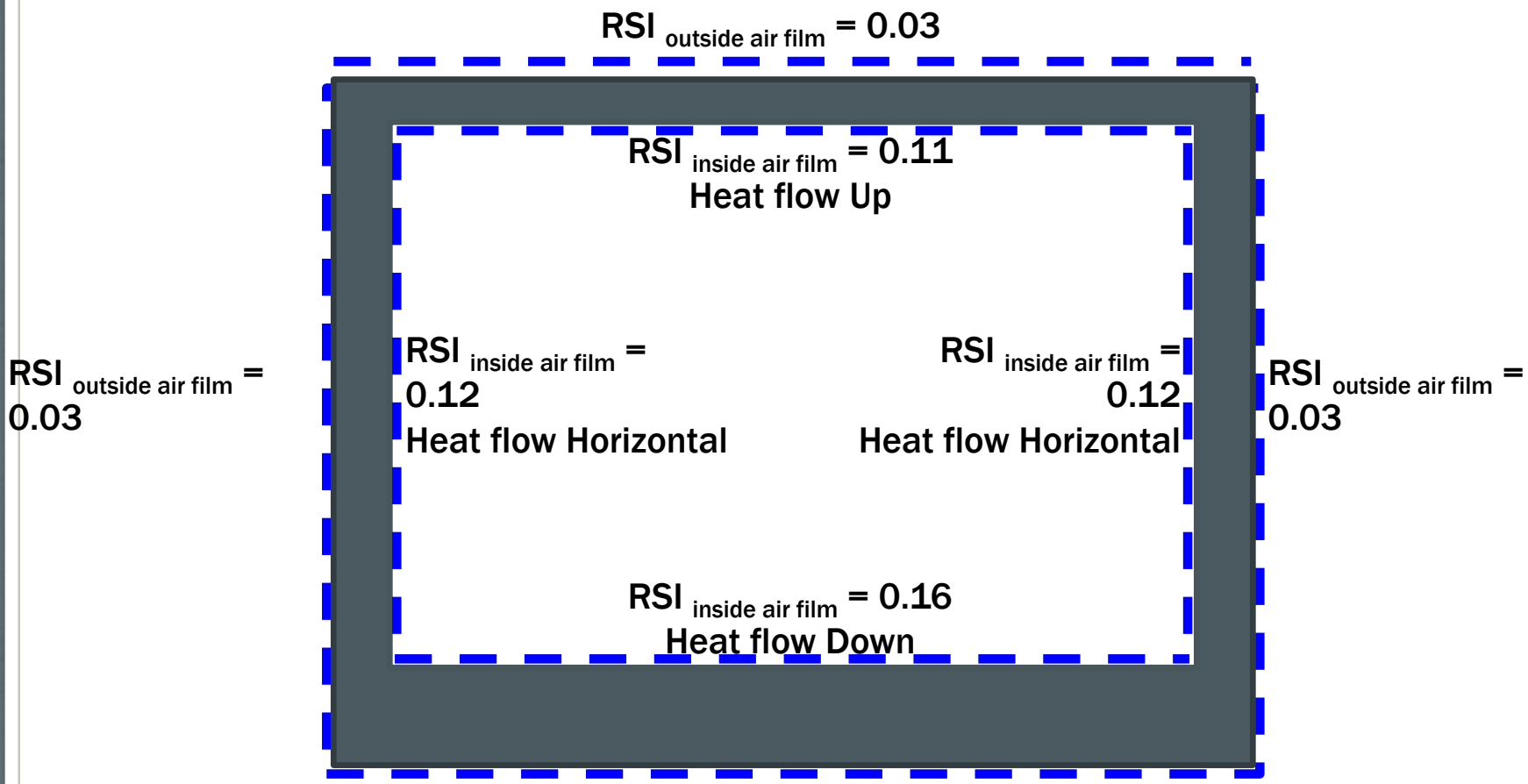
9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

$RSI_{effective}$ vs. $RSI_{nominal}$

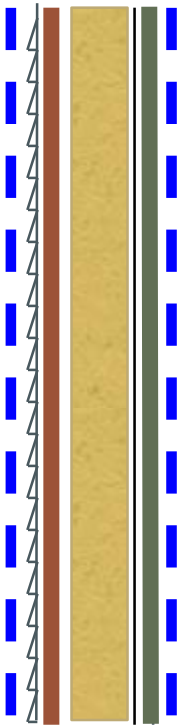
$RSI_{eff} \neq RSI_{nom}$

Include in calculation	Exclude from Calculations
Repetitive structural members - Studs - Joists, lintels - Sills, plates	Minor penetrations - pipes, ducts - Packaged air conditioners - Shelf angles, anchors, fasteners
Credit for adjoining unconditioned spaces	Major structural penetrations - Balcony slabs, beams, columns, ornamentation, Provided: insulation is tight to penetrating element - Total area of all major structural penetration is limited to max 2% of wall area

Insulating Effect of the Surface Air Films



Calculating Effective R-value: Walls above Grade



	Structure	insulation
Air film (interior)	0.12	0.12
1/2” gypsum board	0.08	0.08
Polyethylene barrier	0.00	0.00
2”x6” stud @ 16”o/c	1.19	3.52
7/16 OSB sheathing	0.11	0.11
Hollow backed vinyl siding	0.11	0.11
Air film (exterior)	0.03	0.03
Effective Thermal Resistance	**2.89**	**(R-16.37)**

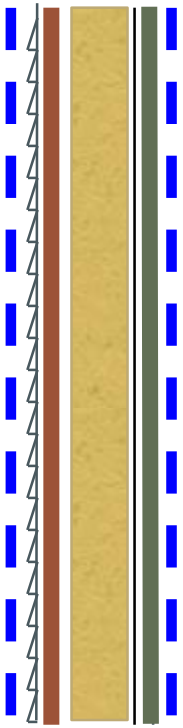
New Code Requirement zone 4 (less than 3,000 DDC):
Eff. R 2.78 (R 15.78)

R 20 batt Insulation

Parallel-Path Flow Method

$$RSI_{parallel} = \frac{100}{\frac{\%\ \text{area of framing } (A_f)}{RSI_f} + \frac{\%\text{area of cavity } (A_c)}{RSI_c}}$$

Calculating Effective R-value: Walls above Grade



	Structure	insulation
Air film (interior)	0.12	0.12
1/2” gypsum board	0.08	0.08
Polyethylene barrier	0.00	0.00
2”x6” stud @ 16” o/c	1.19	3.52
7/16 OSB sheathing	0.11	0.11
Hollow backed vinyl siding	0.11	0.11
Air film (exterior)	0.03	0.03

Effective Thermal Resistance **2.89 (R-16.37)**

Code Requirement zone 4 (less than 3,000 DDC):
Eff. R 2.78 (R 15.78)

Code Requirement zone 5 (3,000 to 4,000 DDC):
Eff. R 2.97 (R 16.86) – with HRV
Eff. R 3.08 (R 17.48) – without HRV

R 20 batt Insulation

Walls above Grade

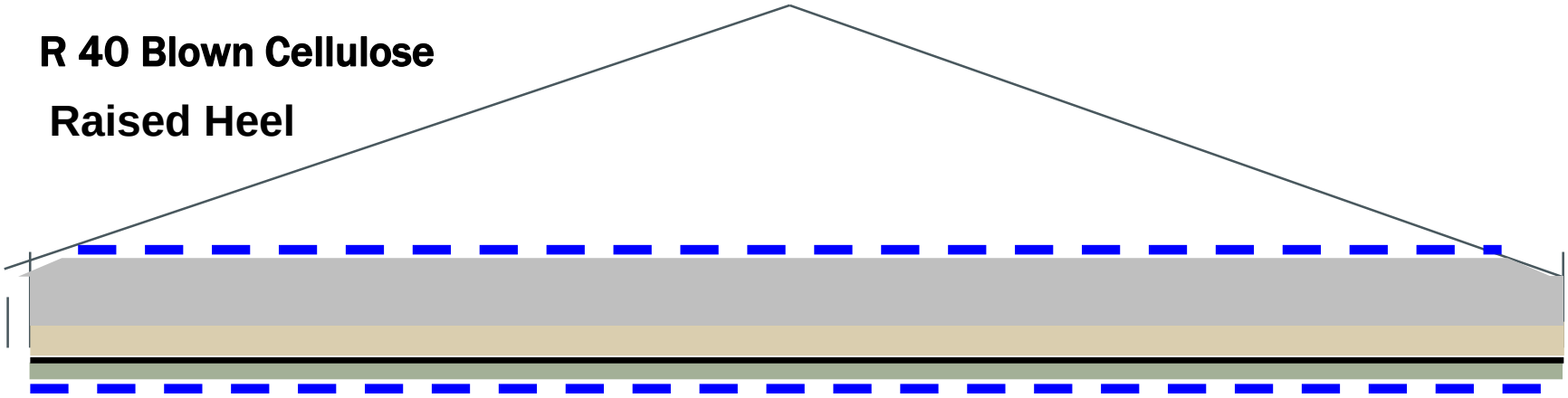
Code Requirement zone 5 & 6 (3,000 to 4,999 DDC):
Eff. R 2.97 (R 16.86) – with HRV
Eff. R 3.08 (R 17.48) – without HRV

	$RSI_{effective}$	$R_{effective}$	
2x6 @ 16” R-22 batt insulation	3.11	17.63	✓
2x4 @ 16” R14 batt insul + R-5 rigid insulation	3.19	18.09	✓
2x4 @ 16” R14 batt insul + R-7.5 rigid insulation	3.66	20.78	✓

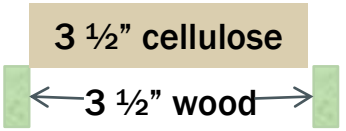
Calculating Effective R-value: Ceilings with Attic Space

R 40 Blown Cellulose

Raised Heel

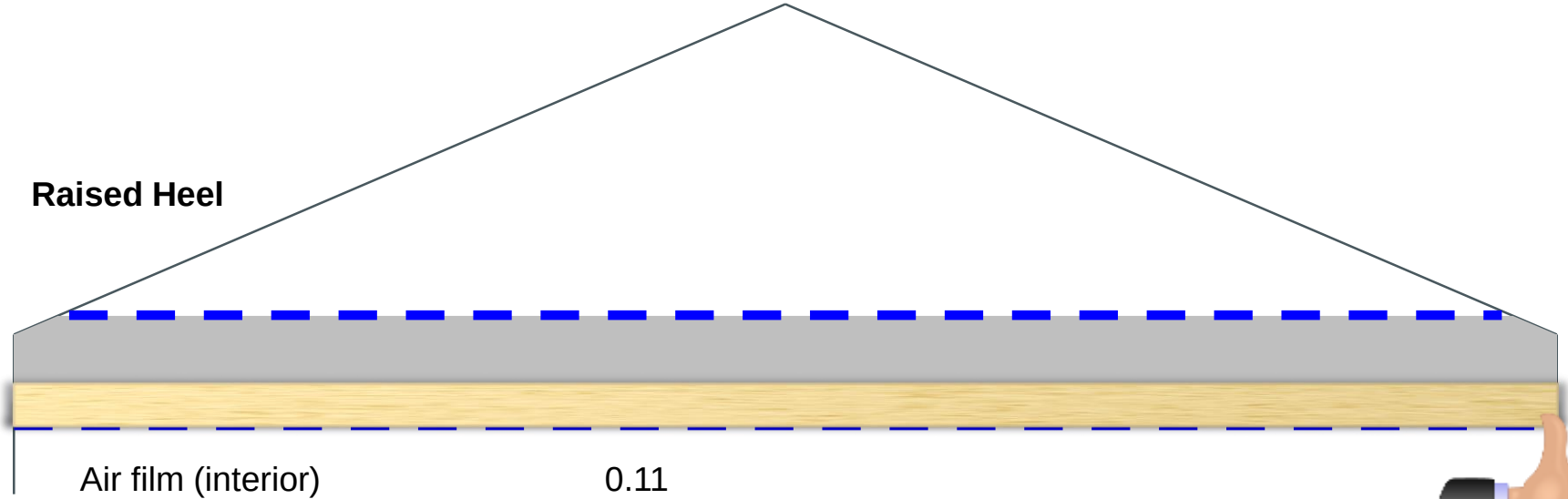


Air film (interior)	0.11
1/2” gypsum board	0.08
Polyethylene barrier	0.00
2”x4” bottom chord cavity	1.96
Continuous layer of cellulose	4.82
Air film (exterior)	0.03
Effective Thermal Resistance	**7.00**



Code Requirement zone 4 (less than 3,000 DDC):
Eff. R 6.91 (R 39.23)

Calculating Effective R-value: Ceilings with Attic Space



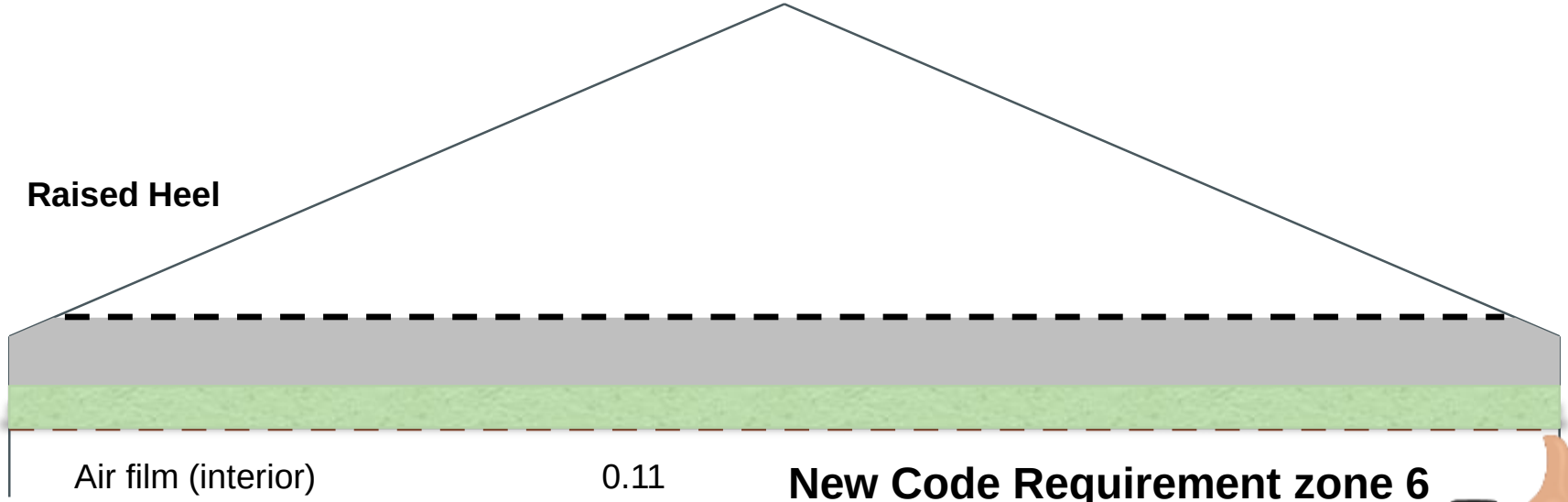
Air film (interior)	0.11
1/2” gypsum board	0.08
Polyethylene barrier	0.00
2”x4” bottom chord cavity	1.96
Continuous layer of cellulose	4.82
Air film (exterior)	0.03
Effective Thermal Resistance	**7.00**

R 40 Blown Cellulose

New Code Requirement zone 5 (3,000-3,999 DDC):
Eff. RSI 6.91 (R-39.23) with HRV

Eff. RSI 8.67 (R-49.2) without HRV
(requires R-50 cellulose)

Calculating Effective R-value: Ceilings with Attic Space



Air film (interior)	0.11
1/2” gypsum board	0.08
Polyethylene barrier	0.00
2”x4” bottom chord cavity	1.96
Continuous layer of cellulose	6.59
Air film (exterior)	0.03
Effective Thermal Resistance	**8.77**

New Code Requirement zone 6 (4,000-4,999 DDC):
Eff. RSI 8.67 (R-49.2) with HRV

Eff. RSI 8.67 (R-49.2) with HRV
(requires R-50 cellulose)

R 50 Blown Cellulose

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

- Appendix provides examples of calculations and data tables:
  - Framing & cavity percentages for typical wood frame assemblies [Table A-9.36.2.4.(1)A]
  - Factors for steel framing to address higher thermal bridging through steel studs [Table A-9.36.2.4.(1)B]
  - Thermal resistance values for common materials [Table A-9.36.2.4.(1)D]

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

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

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 9.36.2.6. 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[4]	0.61	0.72	1.49
		1.32 (R7.5)	[illegible]	—	—	—	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

9.36.2.4. Calculation of Effective Thermal Resistance of Assemblies

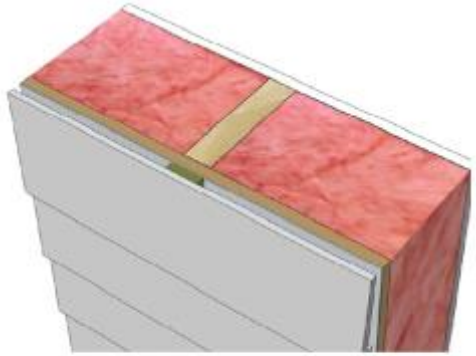
- Example using Table A-9.36.2.6.(1)A.
  - Required effective RSI-value is 2.78
  - 38 x 140 mm studs @ 406 mm o.c. with R-19 batt insulation.
  - R value of structural assembly is 2.36.
  - Minimum additional required is 0.42

- Other components in wall assembly:

Interior air film:	0.12
12.7 mm gyp board	0.08
12.7 mm ply sheathing	0.10
Rain screen cavity	0.15
stucco	0.013
Exterior air film	0.03
Total RSI of other components	0.49

9.36.2.5. Continuity of Insulation

- Insulation must be continuous across the entire envelope – but this does not mean continuous insulation across face.
- This applies 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 dealt with by the calculation method for determining effective R-values.



Insulation in the framing cavity achieves continuity of effective insulation.

HPO Illustrated Guide: Energy Efficiency Requirements for Houses in British Columbia

9.36.2.5. Continuity of Insulation

- Article 9.36.2.5. (2) to (8) introduces relaxations for various details
- Article 9.36.2.5. (9) allows complete exemption to sentence (1) for three specific details:
  - At junction between foundation wall and floor slab
  - The perimeter of a floating slab-on-grade
  - Foundation wall portion that supports masonry veneer

9.36.2.5. Continuity of Insulation

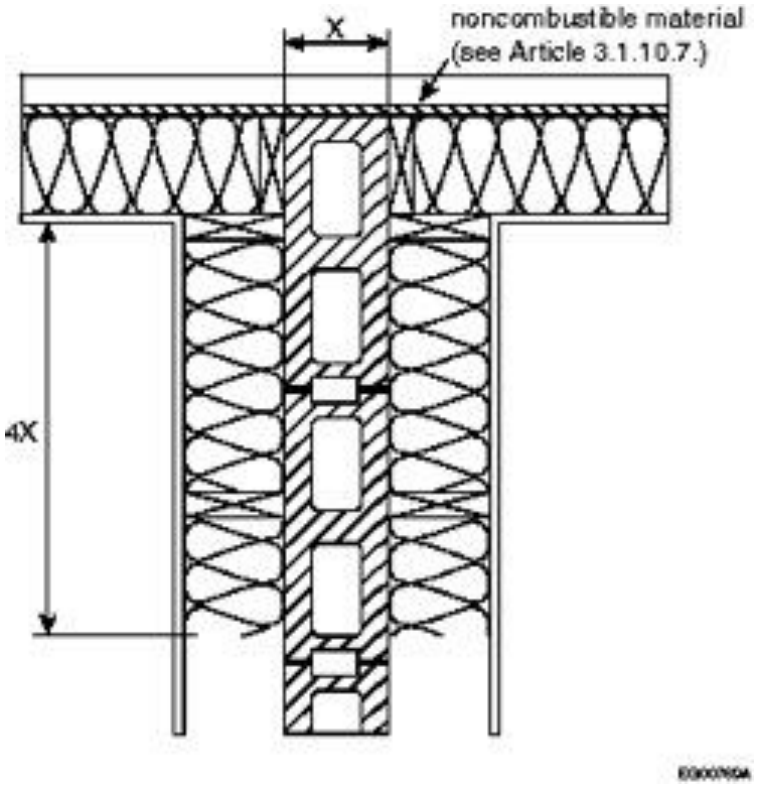
- Allowable exemptions:
  - Required fire safety clearances
  - Major structural components that penetrate the envelope (e.g. structural beams, balcony & canopy slabs) provided
    - total area is not more than 2% of gross wall area
    - Insulation is installed tight against the penetration

9.36.2.5. Continuity of Insulation

- **9.36.2.5.(2) minimizing thermal bridging**
- Where a wall or structural element penetrates exterior envelope, it must be insulated.
- Note that continuity of air barrier must also be maintained at these details.

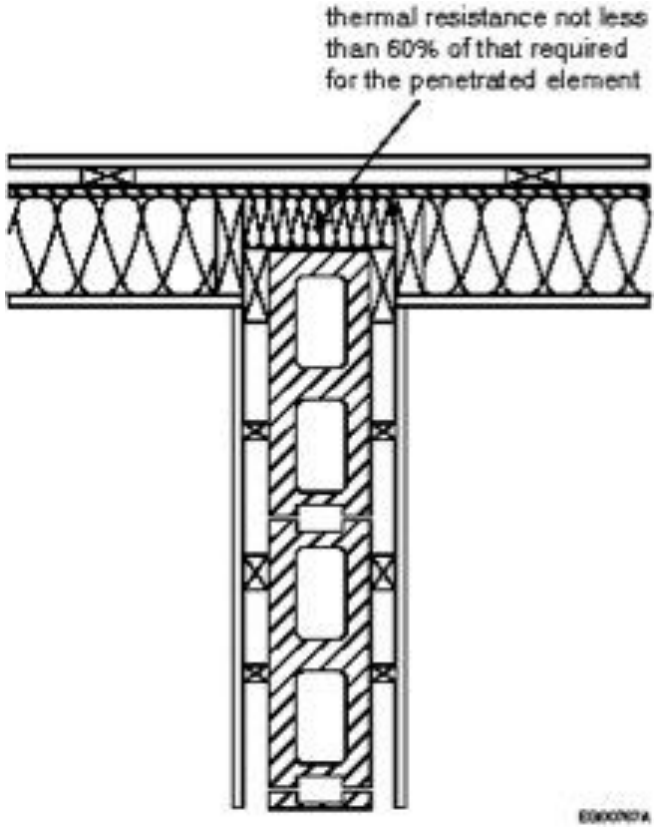
9.36.2.5. Continuity of Insulation

- 9.36.2.5.(2)(a)
- **Minimizing thermal bridging** where a wall or structural element penetrates exterior envelope, it must be insulated on interior (or exterior if element projects outward).



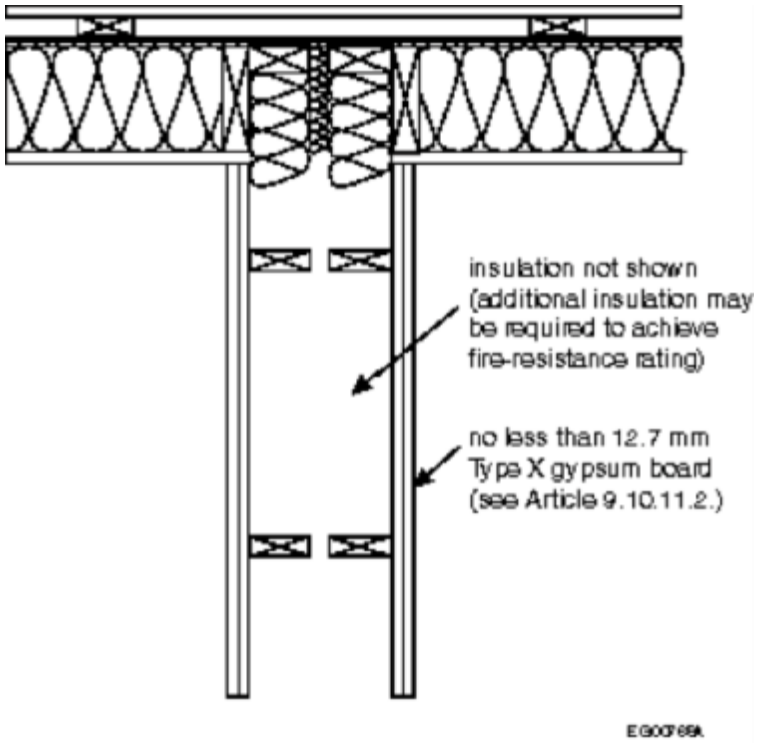
9.36.2.5. Continuity of Insulation

- 9.36.2.5.(2)(b)
- **Minimizing thermal bridging of** a wall or structural element at exterior envelope, where insulation is within plane of wall.



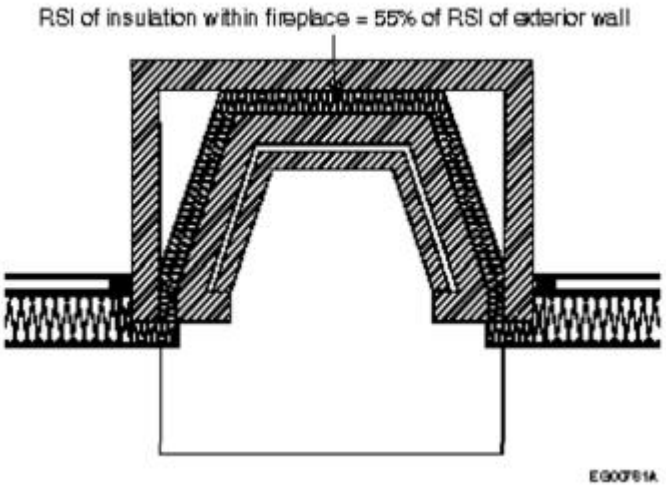
9.36.2.5. Continuity of Insulation

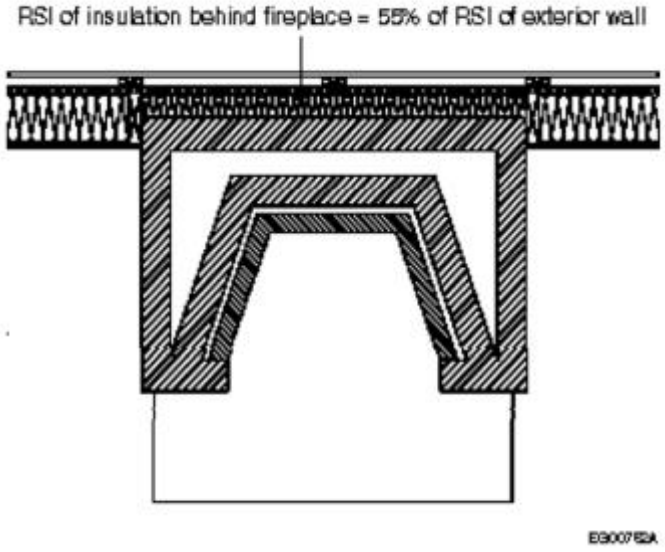
- 9.36.2.5.(2)(c)
- **Minimizing thermal bridging of** a wall or structural element at exterior envelope, where insulation is within plane of wall.



9.36.2.5. Continuity of Insulation

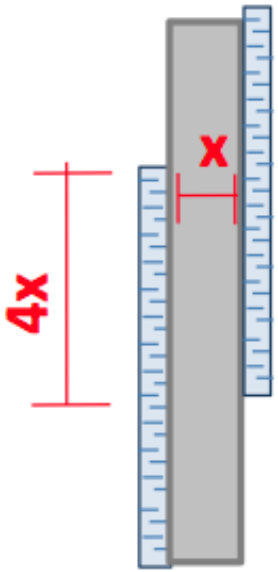
9.36.2.5.3. A masonry fireplace or flue on an exterior wall must be insulated to an effective R-value not less than 55% of that required for the exterior wall





9.36.2.5. Continuity of Insulation

- Insulation placement can be inside or outside; if there is a cross-over, the over lap must be 4 times the thickness of the wall
  - i.e. for 8” wall, the minimum overlap will be 32”



General Requirement

9.36.2.5. Continuity of Insulation

- 9.36.2.5. (6) **mechanical, plumbing or electrical system components (such as pipes, ducts, conduits, cabinets, chases, panels or recessed heaters) within or parallel to wall assembly must be insulated to the same effective insulation level as required for the wall**

9.36.2.5. Continuity of Insulation

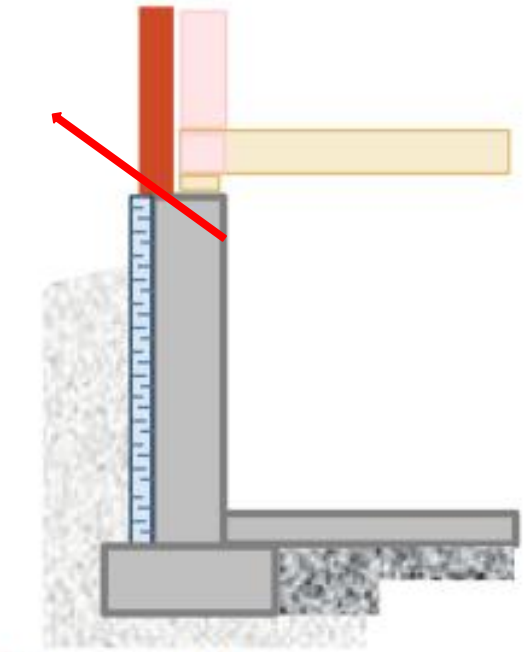
- 9.36.2.5. (7) **ducts, plumbing pipes, electrical or communication conduits placed within the insulated portion of a floor or ceiling assembly must have an effective insulation level not less than RSI 2.78 (R-15.78)**

9.36.2.5. Continuity of Insulation

- Ducts <u>outside</u> the heated envelope must be insulated to the same effective insulation level as required for walls above grade

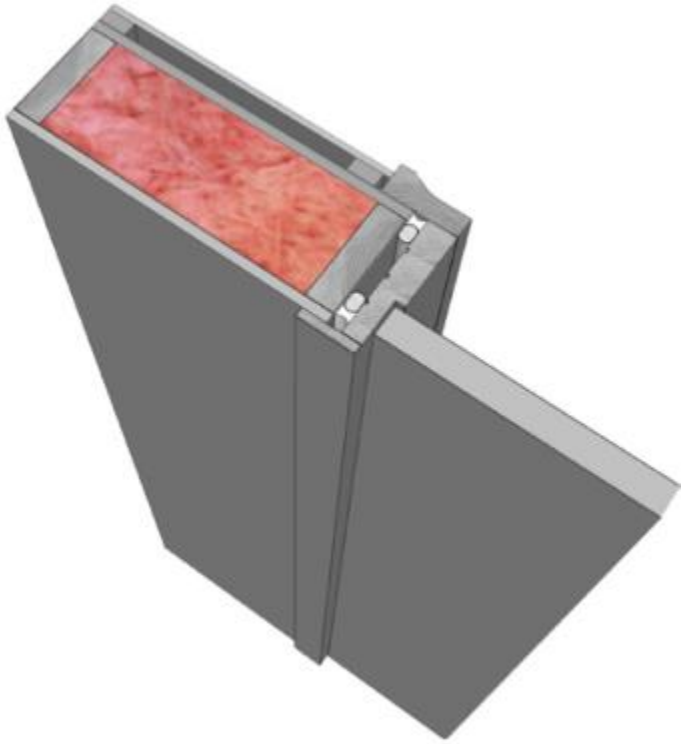
9.36.2.5. Continuity of Insulation

- EXCEPTION: does not apply where cladding is masonry and foundation wall is insulated on the exterior [9.36.2.5.(9)c]



9.36.2.5. Continuity of Insulation

- 9.36.2.5.(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.



9.36.2.7. Fenestration, Doors & Skylights

- Fenestration and doors must have a U-value no greater than that in table 9.36.2.7.A, and skylights as in table 9.36.2.7B

	Climate Zone (Heating Degree Days ˚C)					
	Zone 4 < 3,000	Zone 5 3,001 to 3,999	Zone 6 4,000 to 4,999	Zone 7A 5,000 to 5,999	Zone 7B 6,000 to 6,999	Zone 8 >7,000
Windows & doors	1.80	1.80	1.60	1.60	1.40	1.40
skylights	2.90	2.90	2.70	2.70	2.40	2.40

9.36.2.7. Fenestration, Doors & Skylights

- Site assembled, or site glazed factory-made products, curtain walls, and site built windows must be tested or calculated
- Garage vehicular doors must have nominal RSI 1.1.
- Access hatches to unconditioned space: the U-value not to exceed 2.6

9.36.2.7. Fenestration, Doors & Skylights Exceptions

- An exemption to requirements in table 9.36.2.7.A was made for site-built windows and glazed doors, but they must comply with properties laid out in Table 9.36.2.7.C
- Max U-value for glass block in an exterior wall must be not more than 2.9, and total area of glass block must not exceed 1.85 m (19.9 sq.ft.)
- One exterior door is permitted to have U-value of 2.6
  - (this allows for a feature entry door)
- Storm windows are exempt form these requirements

9.36.2.8. Assemblies In Contact With Ground

- Full height basement wall insulation required
- Top of foundation wall - up to 600 mm above grade is insulated as a foundation wall.
- Appendix table lists typical assemblies

9.36.2.8. Assemblies In Contact With Ground

- Effective R-values requirements vary whether HRV is installed or not
  - Table 9.36.2.8.A. or 9.36.2.8.B
- Example – [required RSI effective is 1.99]:
  - Concrete foundation wall, 38x89 (2x4) furring, RSI-2.11 (R-12) insulation.
  - From table A-9.36.2.8 (1)A the effective R-value of assembly is 1.79. Minimum additional required is 0.20
  - This can be made up by installing 12.7 mm gyp board (0.0775) plus interior air film (0.12)

9.36.2.8. Assemblies In Contact With Ground

- Heated floor slabs must be insulated under entire area, including the edges
- Floating slabs must be insulated under entire floor slab, but not under integral perimeter footing, but skirt insulation is required to same value as under the slab

9.36.2.8. Assemblies In Contact With Ground

- Floor slab insulation depends whether or not it is a heated slab, and above or below frost line
- If entire floor fits into two categories, the more restrictive applies.

9.36.2.8. Assemblies In Contact With Ground

- Unheated floor slabs must be insulated min. 1.2m horizontally or vertically down from its perimeter, with a thermal break along edge of slab a min. 50% of required insulation